The Collateral Channel and Bank Credit

Arun Gupta* **Horacio Sapriza†** **Vladimir Yankov‡**

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Abstract

We identify the firm-level and aggregate effects of the collateral channel using detailed bank-firm-loan level data that allow us to observe the pledging of real estate collateral and to control for credit demand and supply conditions. At the firm level, a 1 percent increase in collateral values leads to a 12 bps higher credit growth, whereas, in the cross-section of MSAs, the average elasticity of credit to collateral values is 7 times larger. Our estimates imply that as much as 37 percent of employment growth over the period from 2013 to 2019 can be attributed to the relaxation of borrowing constraints at bank-dependent borrowers.

JEL Classification: E44, G21
Keywords: Collateral channel, firm borrowing constraints, bank credit allocation, corporate investment, macro-finance, transmission mechanism

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*Federal Reserve Board, E-mail: arun.gupta@frb.gov
†Federal Reserve Bank of Richmond, E-mail: Horacio.Sapriza@rich.frb.org
‡Federal Reserve Board, E-mail: vladimir.l.yankov@frb.gov

1 Introduction

The pledging of real estate collateral often mitigates problems of asymmetric information and incompleteness in debt contracts. In such contractual situations, fluctuations in the values of real estate collateral determine borrowing capacity and credit allocations. Higher asset values relax collateral constraints, allowing firms to secure more credit and increase investment, leading to an expansion of economic activity. This amplification mechanism, known as the *collateral channel*, is frequently featured in theoretical models of financial frictions and macroeconomic fluctuations. While the predictions of theory about the role of collateral values for credit allocations and business cycles are unambiguous, empirical analysis on the role of real estate values for firm borrowing capacity has been limited by data availability. Empirical studies have either focused on large publicly-listed firms, have relied on aggregate data, or lacked information on the pledging of collateral, instead relying only on measures of firm ownership of real estate. However, we show that the decision to pledge real estate as collateral is important, because it is concentrated in private and high bank-dependent firms, and that increases in collateral values relax the borrowing constraints of those firms pledging real estate, leading to significant expansion in bank credit and economic activity.

Our study attempts to fill in these gaps in the literature by examining the role of pledging of commercial real estate collateral for bank credit and by quantifying the real effects of bank credit allocations that result from the relaxation of borrowing constraints. We use confidential supervisory bank-firm-loan data derived from supervisory reports, FR Y-14Q, for both publicly traded and private firms in the United States covering the period from 2013:Q1 to 2019:Q4. Our data allow us to quantify the collateral channel conditioning on both borrower and lender characteristics. On the borrower side, we capture a diverse set of firms. We identify firms that are credit constrained and highly dependent on bank funding, which we refer to as high bank-dependent borrowers. Our data allow us to observe the pledging of different types of collateral and compare the relative relaxation of borrowing constraints based on the collateral use. Importantly, in our analysis, we distinguish between the pledging and the ownership of real estate. On the lender side, our data include the largest banking organizations in the United States, which provide a significant fraction of bank credit to corporate borrowers of different sizes and across different geographic regions. These unique features of our data allow us to distinguish between the collateral channel and the broad net worth and demand channel effects of changes in real estate values. Importantly, we condition on bank credit supply conditions, which could be observationally equivalent to relaxation of firm-level borrowing constraints.

The identification of the collateral channel at the level of the firm is equivalent to

describing the extent to which the firm's borrowing constraint binds and restricts the firm from achieving its optimal level of capital. A binding collateral constraint creates a tight link between asset values and credit growth. The identification challenge is that such associations can be confounded with changes in credit demand and credit supply that co-move with real estate values. To address these endogeneity issues, we use a two-pronged approach. First, we use real estate supply elasticities constructed by Saiz (2010) as instruments for real estate values. Second, we exploit the richness of the data to decompose changes in bank lending into borrower-specific loan demand factors and lender-specific credit supply factors following Amiti and Weinstein (2018). Such a decomposition allows us to identify the collateral channel separately from other credit allocation channels. In particular, we show that bank-level credit supply shocks affect credit constrained borrowers more than less constrained borrowers. Furthermore, consistent with the presence of credit constraints, bank lending is significantly more sensitive to the credit demand conditions of less bank-dependent borrowers than to the credit demand conditions of high bank-dependent borrowers.

The next step in our identification strategy is to characterize the determinants of the choice of pledging real estate collateral, which we then use as controls in our estimation. We establish several stylized facts on the use of real estate collateral. First, the use of real estate collateral is higher in price-inelastic markets that are more likely to experience rapid appreciation in real estate values in economic expansion periods. Second, we control for the ownership of real estate using the share of fixed assets owned by the firm. We establish that firms with higher shares of fixed assets are more likely to pledge real estate collateral following increases in real estate values. Third, we document that smaller, high bank-dependent firms are significantly more likely to pledge real estate than larger firms that have access to market-based funding. Fourth, the use of real estate collateral declines monotonically with firm size. We document that, on the margin, as firms increase in size, the use of real estate collateral is replaced with the pledging of inventories and accounts receivables. This is consistent with larger and older firms having longer histories and more predictable tangible cash flows based on established customer relationships that can be reliably pledged as collateral, whereas smaller and younger firms are more opaque to external investors and limited in their ability to generate pledgeable income. Fifth, consistent with the stylized facts in Lian and Ma (2021), we find that large, publicly traded firms are more likely to use earnings-based types of collateral or be subject to no collateral requirements. Unlike the universe of publicly traded firms, in our sample, 68 percent of borrowers use asset-based forms of collateral, and 37 percent of borrowers pledge real estate.

We identify the magnitude of the relaxation of borrowing constraints following increases in real estate collateral values. We find that a 1 percentage point increase in values contributes to a 7 to 12 basis points annual increase in credit growth, which is significantly larger

than estimates in the literature using a sample of publicly traded firms (e.g. Chaney et al. (2012)). Consistent with more binding credit constraints, we document that the collateral channel has a higher effect on high bank-dependent borrowers and in most specifications, we do not find statistically significant effects for the sample of publicly-traded firms. Our firm-level estimates also show a clear rank order of tightness of borrowing constraints based on collateral use. Borrowing constrains are progressively relaxed for firms that pledge fixed assets, blanket liens, cash and securities, and accounts receivable. Firms that are able to borrow on an unsecured basis experience the highest growth in credit. All else equal, firms that pledge real estate collateral are the most constrained, if those firms operate in markets in which collateral values remain stagnant or decline. In contrast, firms that pledge real estate collateral in markets with the largest appreciation of real estate collateral experience the largest relaxation of borrowing constraints.

Apart from increases in bank credit, the collateral channel also manifests itself in reductions in credit spreads and increases in the maturity of newly originated loans. However, higher collateral values do not have a statistically significant effect on banks' expected default probabilities or loss given default, because, on the margin, the higher value of collateral is counterbalanced with firms increasing their leverage. We also document that the relaxation of borrowing constraints has significant real effects both at the firm level and at the market level. At the firm level, the increases in bank credit and the reductions in the cost of credit allow firms to boost capital expenditures and grow in size. A 1 percentage point increase in real estate values increases investment expenditures of high bank-dependent firms by about 7 basis points and their asset growth by about 9 basis points.

Although the firm-level effects are concentrated in high bank-dependent borrowers, they are economically important for the aggregate. We find that the collateral channel has the largest effect on economic activity in geographic markets with large shares of high bank-dependent borrowers that pledge real estate collateral. The relaxation of borrowing constraints increases overall bank credit in a geographic area, reduces the unemployment rate, and stimulates growth in employment and establishments. Our estimates imply that, following a 1 percentage point increase in real estate values, the median market experiences about a 0.8 basis point decrease in unemployment rate, about a 14 basis point increase in total employment, and a 4 basis point higher growth rate in the number of business establishments. Consistent with the relatively smaller firm-size and high bank-dependence of nontradable firms, we document significant improvements in employment growth at firms in the nontradable sectors in markets with increasing collateral values. The collateral channel also affects the growth in the number of small establishments mainly in the nontradable sector employing between 1 and 9 individuals.

We organize the remainder of our paper as follows. In section 2, we summarize the

relevant literature on the collateral channel. In section 3, we describe the data sources and our sample construction. In section 4, we develop our conceptual and empirical framework as well as the identification strategies and approaches to control for endogeneity. In section 5, we present the estimation results and discuss their economic importance. Finally, we conclude in section 6 with a discussion of potential future research.

2 Related literature

A large theoretical strand of the literature including studies by Barro (1976), Stiglitz and Weiss (1981), Bernanke and Gertler (1989), Hart and Moore (1994), Kiyotaki and Moore (1997), Holmstrom and Tirole (1997), Bernanke et al. (1999), and Miao and Wang (2018), among others, explores the role of the collateral channel for macroeconomic fluctuations. This theoretical body of work is unambiguous and places the *collateral channel* and the closely related *financial acceleration mechanism* as a main amplification mechanism for aggregate fluctuations. Increases in asset values boost firms' net worth and expand borrowing capacities leading to significant increases in aggregate activity. However, the empirical analysis on the role of the collateral channel has been less clear-cut.

One of the first empirical studies based on micro-level data was Gertler and Gilchrist (1994), which provided indirect evidence of the role of the collateral channel by documenting that small manufacturing firms are more cyclical and reduce their activity by more following contractionary monetary policy shocks. A more direct evidence for the effects of the collateral channel is presented in Benmelech and Bergman (2011), which documents that following bankruptcies of airlines, the non-defaulting airlines experience tighter credit conditions because of a reduction in collateral values triggered by fire-sales of similar collateral.

A more systematic study that quantifies the collateral channel effects was provided by Chaney et al. (2012), which examines the effects of changes in value of commercial real estate holdings on investment of large publicly traded firms. They estimate an increase in investment of six cents for every dollar increase in the value of a firm's commercial real estate. This empirical finding has been replicated by a number of more recent studies that use the same sample of publicly-traded firms. For example, Cvijanovic (2014) documents that changes in real estate values have persistent effects on firm leverage and capital structure. Similarly, Campello et al. (2021) estimate the sensitivity of corporate investment and capital structure to changes in real estate values taking into account the location of companies' real estate holdings. However, as pointed out by Lian and Ma (2021), none of these studies explicitly conditions on whether those large publicly traded firms are in fact pledging their real estate to backup debt issuance.

The effects of the collateral channel have been documented in a few studies that use non-U.S. data. Gan (2007) documents the effects of the collateral channel on firm investment decisions following the real estate price collapse in Japan in the early 1990s. Bednarek et al. (2021) find evidence that foreign capital inflows into Germany during the European debt crisis impacted local economic growth for firms owning real estate. Cerqueiro et al. (2016) examine how a change in bankruptcy laws in Sweden, which lowered collateral values and reduced expected recovery values of lenders in bankruptcy, impacted firm borrowing capacity, increased bank monitoring, and increased cost of credit. Banerjee and Blickle (2021) study the positive relationship between changes in housing prices and the growth of small firms across European countries. They find that these correlations are significantly higher for more opaque borrowers and in countries with more complex and costlier bankruptcy resolution frameworks.

A number of studies have also examined bank lending to small bank-dependent firms using bank-firm-loan level data. However, none of these studies uses data that have information on all three components needed to identify the effects of the collateral channel—the collateral use, the credit demand condition of the borrower, and the credit supply condition of the lender—and, therefore, the evidence provided in these studies for the effects of the collateral channel is indirect. Berger and Udell (1990) study the role of collateral using the Federal Reserve's Survey of Terms of Business Lending (STBL) and document that riskier borrowers are more likely to pledge real estate collateral. Glancy (2021) uses loan portfolio data from the Community Reinvestment Act to show how real estate losses on banks' books affected the supply of credit and employment for young firms and bank-dependent industries during the Great Recession.

Our paper is not the first to use FR Y-14Q data to characterize bank lending to private firms. However, the focus of existing work is different from ours. For example, Luck and Santos (2019) examine how the use of different collateral types affects the interest rates banks set on loans. Caglio et al. (2021) study the effect of monetary policy on bank risk-taking behavior and how changes in policy rates affect bank credit and risk-taking through different collateral constraints. Haque et al. (2022) document that private equity funds can influence the collateral choice and allow for sponsored firms in leveraged buyouts to obtain unsecured credit. Chodorow-Reich et al. (2021) study how banks set price and nonprice terms on credit facilities across the size distribution of firms. They document that while large firms were able to draw on their credit lines during the pandemic, small firms were significantly more restricted in their access to bank credit and relied more on government programs such as the Paycheck Protection Program (PPP). Greenwald et al. (2020) similarly examine crowding out effects of large firm drawdowns of credit lines on small firms access to credit.

The existing empirical evidence for the role of the collateral channel has been challenged recently. Mian and Sufi (2011) and Mian and Sufi (2014), who argue that the main transmission channel of financial shocks to the real economy during the Great Recession was the significant reduction in aggregate demand driven by declines in household net worth. These studies document that the reduction in house values was a primary driver of unemployment, whereas a tightening of firm borrowing constraints was a less likely cause. Lian and Ma (2021) document that most publicly-traded firms do not pledge real estate as collateral even if a firm owns real estate properties. Instead, most large firms have debt contracts that are unsecured or based on earnings-based collateral, whose recovery value depends on the continuation value of the firm rather than specific assets. One potential reason for the low use of assets as collateral is that the bankruptcy code in the United States makes it harder to liquidate the assets of large corporations and instead restructurings are the preferred method of bankruptcy resolution. Furthermore, Benmelech et al. (2020) document a secular decline in the share of secured debt by publicly traded firms citing a number of factors behind these trends including financial and technological improvements that reduced uncertainty regarding repayments of debt. Kermani and Ma (2020) highlight the cross-sectional factors behind the choice of asset-based or cash-flow-based collateral use by public firms including the role of liquidation values and lender monitoring.

Additional studies that question the relevance of the collateral channel using data on small firms are Crouzet and Mehrotra (2020) and Greenstone et al. (2020). Crouzet and Mehrotra (2020) re-examine the evidence on the higher cyclicality of small firms using confidential Census data on firms from four sectors—manufacturing, mining, wholesale and retail trade. However, in contrast to Gertler and Gilchrist (1994), they conclude that financial frictions and proxies for financial constraints do not explain the differences in cyclicality between small and large firms. Greenstone et al. (2020) use data from the Small Business Administration to examine the role of bank lending during the Great Recession and document that small businesses were less likely to switch lenders and were disproportionately more likely to be credit constrained following a credit supply shock affecting their bank. However, the restricted access to credit did not have a significant effect on economic activity.

Unlike these studies, we provide a more direct micro-level evidence for workings of the collateral channel in a broader set of firms covering all nonfinancial industries and both public and private firms. Importantly, we document that the micro-level effects aggregate to economically significant macroeconomic effects consistent with the collateral channel. In this regard, our results are closest to Adelino et al. (2015), who use the County Business Patterns (CBP) data, document that small businesses in geographic markets with greater increases in house prices experienced stronger growth in employment than large firms in

the same areas and industries.[1] They attribute this finding to the workings of the collateral channel that explains 15 to 25 percent of employment variation across geographic markets. However, none of these studies provide *direct* evidence for the presence or lack thereof of the collateral channel, because none of these studies uses granular enough data to document the actual pledging of collateral. In contrast, our analysis provides direct evidence for the workings of the collateral channel and its manifestation in both quantities and the cost of credit as well as in its real effects on investment, employment, and establishment growth. Our aggregate estimates imply that as much as 37 percent of employment variation over our sample period from 2013 to 2019 can be attributed to the relaxation of borrowing constraints and increases in bank credit to high bank-dependent borrowers.

3 Data

Our analysis is based on data collected by the Federal Reserve for the purposes of the annual Dodd-Frank Act Stress Test (DFAST) and the Comprehensive Capital Analysis and Review (CCAR). Schedule H1 of the FR-Y14Q report collects detailed loan-level and borrower-level information on the commercial and industrial (C&I) loans of the largest bank holding companies operating in the United States with total consolidated assets exceeding $100 billion.[2] The data contain information on all corporate credit facilities with committed balances exceeding $1 million of both term loans and credit lines.[3]

We restrict our sample to U.S. domiciled nonfinancial borrowers, for which we observe consistent balance sheet and income statement information. We also focus on borrowers

[1] There are also several related studies that link housing prices to small business investment. Bahaj et al. (2020) document that appreciation of home values of a firm's directors lead to higher investment. Schmalz et al. (2017) and Corradin and Popov (2015) present evidence that higher house prices predict entrepreneurial choice and business start-ups. However, those studies are indirect evidence because they do not observe the collateral pledged in debt contracts.

[2] More detailed information is contained in the instructions to the FR Y-14Q reporting forms. Because of the confidentiality of the data, our analysis presents only aggregated results that do not reveal the identities of the individual banks or borrowers in our sample.

[3] The $1 million leaves a large number of very small borrowers. Bank lending to those borrowers is reported in a separate schedule–FR Y-14Q Schedule A. This schedule, however, collects only loan portfolio data with no individual borrower information or information on the use of collateral, which limits their usefulness for our analysis. Furthermore, those borrowers are likely to include the smallest businesses and sole proprietorship that are likely to pledge residential properties as collateral as proposed by Adelino et al. (2015). The loans in our sample are large enough, so that we can rule out that they are collateralized by the value of a house. Furthermore, the FR Y14Q distinguishes between C&I loans, which are reported in schedule H1, and commercial real estate (CRE) loans, which are reported in schedule H2. The commercial real estate properties, that are used as collateral in C&I schedule, are properties occupied by the owner. In contrast, all CRE loans are secured by properties that are eventually used for the purpose of generating rental income and are not owner occupied. Although our focus is on the FR Y-14Q H1 schedule, it does not contain well populated information on the market values of the properties used as collateral to construct reliable loan-to-value (LTV) ratios. To obtain such estimates, we use the H2 schedule, which contains information on the LTV at origination.

that operate in one of 68 major metropolitan statistical areas (MSAs) for which we have commercial real estate prices and real estate supply elasticities, which we obtain from Saiz (2010). Our final analysis sample spans the period from 2013:Q1 to 2019:Q4 and consists of 32 bank holding companies, 92,069 borrowers across 68 MSA-level markets.

Insert Table 1.

Panel A of Table 1 provides summary statistics of the borrower characteristics in our sample. The median firm has total assets of about $17 million, which is significantly smaller than a publicly-traded firm. For example, the median publicly-traded firm in Compustat has total consolidated assets close to $900 million, and the median firm that obtains credit through loan syndication recorded in DealScan has total assets of $2.4 billion. Compared with those datasets, our sample is representative of small and medium-sized enterprises. Borrowers with $6 million in total assets make up 25 percent of our sample, and 5 percent of our sample are firms with total assets of $2 million or less.[4]

The median firm obtains about $4 million in committed bank credit, which could be either in the form of a credit line or a term loan. Because larger firms are more likely to obtain credit lines, the average committed amount on credit lines is more than twice the size of a term loan. The average utilization rates of credit lines are about 50 percent, with more than a quarter of credit lines remaining fully undrawn. In addition, banks report the expected utilization at default, which takes into account covenants and other contractual characteristics of credit lines that would allow a firm to utilize its credit lines even in distress. The average expected utilization at default is about 73 percent, indicating a significant additional borrowing capacity for firms that have credit lines.

For the average borrower, bank credit represents about half of overall liabilities. We define high bank-dependent borrowers as all nonpublic firms whose bank credit comprises more than 50 percent of their reported liabilities. High bank-dependent borrowers comprise close to 45 percent of our sample.[5] In terms of credit risk, the median firm in our sample has a bank-assessed internal credit rating that corresponds to an S&P credit rating of BB. Banks also report expected probability of default (PD) and expected loss given default (LGD) for each loan. The median loan in our sample has an expected PD of 70 basis points

[4]To validate balance sheet and income statement information for the largest firms in FR Y-14Q, we use Compustat data. For the small and nonpublic companies, we rely on reports submitted by the banks. We employ a multi-step procedure described in the appendix to construct and validate the data. See our data appendix A for further details on our data construction.

[5]Our definition of high bank-dependence takes into account the unused portion of credit lines. We define the total credit of a firm as the sum of all of its on-balance sheet liabilities, funded bank loans and other corporate debt, and the unused portion of credit lines. We also classify borrowers with missing information on total liabilities as high bank-dependent.

and an LGD of 34 percent.[6] Finally, the average debt-to-asset ratio of firms in our sample is 60 percent.

Panel B summarizes information on the average characteristics of banks in our sample based on FR Y-9C data. Our sample contains the largest banking holding companies that become subject to enhanced capital and liquidity regulation in the period following the Great Recession. All banks operate with common equity tier 1 (CET1) capital well above the regulatory requirements under the Basel III capital requirements. Similarly, banks in our sample have large stocks of high-quality liquid assets (HQLA) and comply with the liquidity coverage ratio (LCR) requirement with significant liquidity buffers. The average bank originated about $90 billion in C&I credit to about 3,400 borrowers and operated in about 60 out of the 68 markets in our sample. Banks have geographically diversified loan portfolios with an average Herfindahl–Hirschman (HHI) index of about 7 percent. The largest market share in a single geographic area is, on average, 21 percent of a bank's portfolio and the share of the largest three markets is 34 percent. If we group markets based on the quartiles of the real estate supply elasticities, about 40 percent of bank credit is allocated to the lowest quartile, and 16 percent are allocated to the highest quartile, indicating larger credit allocations to the low supply elasticity markets.

The real estate supply elasticities from Saiz (2010) are based on the topography of a geographic area that takes into account the presence of large bodies of water or steep terrains that make additional land development and construction increasingly costly. We combine information on supply elasticities with quarterly market-level commercial real estate prices from CBRE Econometric Advisors. We construct an aggregate commercial real estate price index based on the prices of office, industrial, hotels, and retail properties. Panel A of Figure 1 shows the time-series variation in the commercial real estate price index across the 68 geographic areas in our sample. Over our sample period, the median market experiences about a 42 percent cumulative increase in commercial real estate prices. Markets with low supply elasticities experience larger price increases of about 51 percent, whereas prices in markets with low supply elasticities reach 41 percent cumulative appreciation over our sample period.

Insert Figure 1.

Table 2 provides further information on the 68 MSAs that are part of our sample. In panel A, we document that market-level bank credit grew by about 7 percent on an annual

[6] Each bank uses its own internal credit rating system. The loan-level internal credit ratings are mapped into S&P rating equivalents and aggregated to the firm level.

basis with some significant dispersion in growth rates across markets and over time. On average, the credit growth to high bank-dependent borrowers is higher and more volatile than the credit growth to low bank-dependent borrowers. Similarly, the decomposition of credit growth into credit supply and demand factors, which we describe in detail in section (B) of the Appendix, reveals that the growth in credit demand by high bank-dependent borrowers is higher and more volatile compared with the average growth and volatility of demand by low bank-dependent borrowers. In terms of loan volumes, about 80 percent of aggregate credit is to low-bank dependent borrowers. This significant share is explained by the fact that high bank-dependent borrowers, even if more numerous, are significantly smaller firms than low bank-dependent borrowers. When broken down by tradable and nontradable sectors, around 55 percent of high bank-dependent firms are in the nontradable sector, compared to only 37 percent of low bank-dependent borrowers.

Insert Table 2.

Moving to panel B, the average market receives about $31 billion in credit from 28 banks in our sample. In comparison, C&I credit originated by small regional banks is less than $3 billion for the average market. For the average market, 86 percent of C&I credit comes from the sample of large multi-market banks indicating the importance of those banks for market-level bank credit. The within-market concentration of lending is also relatively low, with the HHI index at around 11 percent for the average market. In terms of supply elasticities, the average market has a supply elasticity of about 1.74. We define markets with a supply elasticity of less than 1, the bottom quartile, as low supply-elasticity markets, and those with a supply elasticity exceeding 2.35, the top quartile, as high supply-elasticity markets. Markets experience significant variations in the average annual growth rate in real estate prices. The annualized quarterly growth in commercial real estate prices is 6.4 percent for the average market with some notable cross-sectional and time-series variation. Some markets experience declines in commercial real estate prices, whereas other markets experience growth in prices that exceeds 15 percent.

Panel C documents the distributions of the market-level shares of firms that use the different collateral types that we observe in the data. The average share of real estate collateral is 21 percent with across market variation ranging from 9 percent for the 5th percentile market to 35 percent for the 95th percentile market. The second most common form of collateral is accounts receivable followed by blanket lien, non-real estate fixed assets, and cash and securities. For the average market, about 18 percent of firms obtain unsecured bank credit. We provide further details on those collateral types and their firm-level determinants in section (4.5).

We obtain information on market-level economic activity from the Quarterly Census of Employment and Wages published by the Bureau of Labor Statistics as well as the County Business Patterns (CBP) dataset published by the Census Bureau. Panel D shows summary statistics of the three economic activity measures—unemployment rate, growth in employment, and growth in establishments. The bulk of economic activity is concentrated in nontradable sectors and in small firms, which tend to be high bank-dependent borrowers. For example, the average market has 72 percent of employment and 77 percent of establishments in nontradable sectors. Overall, employment and establishment growth in the tradable sector is twice as volatile compared to the nontradable sector. Small firms also represent a significant portion of employment with more than 70 percent of establishments employing no more than 9 employees. In most markets, around a quarter of establishments have between 10 and 99 employees, and less than a percent of establishments have more than 500 employees. Finally, it is worth highlighting that our sample period from 2013:Q1 until 2019:Q4 covers the recovery period from the Great Recession, and most markets experience improvements in their unemployment rates and positive growth in employment and establishments. However, there is significant heterogeneity in those growth rates in the cross section of markets, and around one-fourth of our sample includes periods in which some markets experience declines in total employment and establishment growth.

4 Empirical framework

4.1 Conceptual framework

To motivate our empirical analysis, consider a geographic area hit by a temporary positive aggregate demand shock. Following the shock, real estate values increase, expanding the borrowing capacity of credit-constrained firms that pledge real estate as collateral. The higher borrowing leads to stronger asset demand and further increases in collateral values. In addition, agents revise up their expectations about future borrowing capacity and asset demand, and those revised expectations further increase collateral values. This is the standard relationship between asset prices and borrowing capacity described in Kiyotaki and Moore (1997).

Our empirical framework takes this aggregate channel as given and examines the behavior of a credit-constrained firm f, which pledges its capital K_f (real estate properties) located in market m to obtain a loan from bank b. Even though each geographic area has its own asset price dynamics and firm investment opportunity set, our firm-level identification relies on the assumption that the representative firm is small enough that its asset demand and pledging of collateral do not affect the market price of collateral. The borrowing

constraint that the firm faces has the following form

$$L_{f,b,m,t+1} \leq \psi_{b,m,t} \quad \times \quad \underbrace{P_{m,t+1} \times K_{f,t+1}}_{\text{Market value of collateral}} \quad . \tag{1}$$

The credit constraint indicates that the loan amount $L_{f,b,m,t+1}$ from bank b cannot exceed the market value of the firm's real estate collateral. A novel element in this constraint is that we assume that a bank that operates in multiple markets follows a credit policy summarized by a loan-to-value ratio $\psi_{b,m,t} \in (0,1]$ that may vary with the bank's liquidity and capital constraints, its monitoring activity in the market, or the lending opportunities in the other markets the bank operates in.

The firm has an investment opportunity in the next period characterized by a production function $F(A_{f,m,t+1}, K_{f,m,t+1}) = A_{f,m,t+1}K^{\eta}_{f,m,t+1}$ with $\eta < 1$, where capital follows a law of motion $K_{f,m,t+1} = (1-\delta)K_{f,m,t} + I_{f,m,t}$. We have normalized the price of capital at time t to one i.e. $P_{m,t} = 1$. The firm's productivity parameter $A_{f,m,t+1} \geq 0$ is correlated with the price of capital and is known to the firm. The firm obtains credit from its bank to both cover the cost of investments in capital as well as to roll over existing debt $L_{f,b,t+1} = L_{f,b,t} + I_{f,m,t}$. For simplicity, we assume that the price of real estate and firm productivity can be perfectly predicted based on information at time t, so we rule out loan default.

The firm solves a one period problem that maximizes the net worth of the firm at the end of the period composed of the cashflow it generates and the value of its assets net of the repayment of the loan and interest to the bank.

$$max_{K_{f,t+1}, L_{f,b,m,t+1}} \Big\{ A_{f,m,t+1}K^{\eta}_{f,t+1} - R_{f,b,t}L_{f,b,m,t+1} + P_{m,t+1}K_{f,t+1} \Big\},$$

$$\begin{aligned} &\text{subject to:} \\ K_{f,t+1} =& (1-\delta)K_{f,t} + I_{f,t} \\ L_{f,b,t+1} =& L_{f,b,t} + I_{f,t} \\ L_{b,f,t+1} \leq& \psi_{b,m,t} \quad \times \quad \underbrace{P_{m,t+1} \times K_{f,t+1}}_{\text{Market value of collateral}} \quad , \end{aligned}$$

where $\eta, \delta, \psi_{b,m,t} \in (0,1)$.

If we assign $\lambda_{f,t}$ to be the Lagrangian multiplier on the borrowing constraint, we can express the optimal growth in borrowing of the firm $\Delta L_{f,b,m,t+1} \equiv L_{f,b,m,t+1} - L_{f,b,m,t}$ as follows

$$\Delta L_{f,b,m,t+1} = \begin{cases} \left(\frac{\eta A_{f,m,t+1}}{R_{f,b,t} - (1+\lambda_{f,t}(1-\psi_{b,m,t}))P_{m,t+1}} \right)^{\frac{1}{1-\eta}} - (1-\delta)K_{f,t}, & \text{constrained } \lambda_{f,t} > 0 \\ \left(\frac{\eta A_{f,m,t+1}}{R_{f,b,t} - P_{m,t+1}} \right)^{\frac{1}{1-\eta}} - (1-\delta)K_{f,t}, & \lambda_{f,t} = 0. \end{cases} \tag{2}$$

It is easy to verify that, all else equal, constrained firms with binding borrowing constraints (i.e. $\lambda_{f,t} > 0$) borrow less than unconstrained firms. In the empirical analysis, we will use the subset of bank-dependent borrowers as firms with more binding borrowing constraints. While borrowing increases in the price of capital regardless of whether the firm is constrained or not, the sensitivity of borrowing to the price of capital is higher for the constrained firm and increases with the shadow cost of the borrowing constraint ($\lambda_{f,t}$). Therefore, more bank-dependent borrowers should experience higher sensitivity of their borrowing to changes in collateral values conditioning on credit supply and demand conditions.

The sensitivity of borrowing to collateral values also increases with less restrictive underwriting policies of the bank (higher $\psi_{b,m,t}$). Therefore, changes in bank credit supply conditions are observationally equivalent to changes in firm level credit constraints. To account for this, in our empirical framework, we need to control both for the credit supply conditions of banks and the credit demand conditions of borrowers, as well as the potential confounding factors that drive both loan demand, credit supply, and collateral values. Finally, the credit constraint can be modified to include other forms of asset-based or earnings-based collateral, which, however, would not be directly related to the value of real estate. In our empirical specification, we control for the endogeneity of the collateral choice and the presence of alternative forms of collateral. This allows us to rank order the degree to which pledging real estate and changes in real estate values relax borrowing constraints relative to those alternative forms of collateral.

Even though our model is static and arguably the pledging of collateral is a dynamic choice, our framework addresses a few important identification challenges in interpreting the association of collateral values and credit, which have not been emphasized in the literature, and which we address in our empirical framework. For example, Rampini and Vishwanathan (2020) highlight an important distinction between secured debt and unsecured debt. Secured debt uses explicit collateral, whereas unsecured debt is a claim on the unencumbered assets of the firm and, thus, implicitly collateralized. Although explicitly collateralized debt is costlier, it enables higher borrowing capacity. Therefore, constrained firms are more likely to issue collateralized debt and experience higher borrowing capacity following appreciation of commercial real estate values, which is consistent with our empirical findings on both the use of real estate collateral and its effects on borrowing. Furthermore, in the context of bank-dependent firms, pledging of specific assets is also optimal for the bank, because an increase in the value of a pledged asset would accrue exclusively to the bank in the case of borrower default, whereas an increase in the value of unencumbered assets not explicitly pledged to the bank would be diluted across all debt holders, leading to a more uncertain debt recovery in bankruptcy. Therefore, the effect of the collateral channel on firm borrowing constraints is more likely to be identified, if the pledging of collateral is observed in the

data and also if proper controls for credit supply are introduced. We go into more details of our identification strategy next.

4.2 Identification of the collateral channel at the firm level

Our empirical specification can be derived by linearizing the optimality condition (2) as follows

$$\begin{aligned}\Delta L_{f,b,m,t} = \theta_0 \mathbb{I}\{\text{Real estate}_{f,b,m,t}\} + \theta_1 P_{m,t} \times \mathbb{I}\{\text{Real estate}_{f,b,m,t}\} + \\ \Theta' \mathbb{I}\{\text{Non-real estate}_{f,b,m,t}\} + \Gamma' \mathbf{X}_{f,t-1} + \phi_f + \gamma_\alpha \alpha_{f,t} + \psi_{b,m,t} + \epsilon_{f,b,m,t}.\end{aligned} \tag{3}$$

The left-hand side variable $\Delta L_{f,b,m,t} = \frac{L_{f,b,m,t} - L_{f,b,m,t-4}}{L_{f,b,m,t-4}}$ is the year-over-year growth in bank credit to firm f located in market m borrowing from bank b. $P_{m,t}$ is the cumulative growth in commercial real estate prices. The indicator $\mathbb{I}\{\text{Real estate}_{f,b,m,t}\}$ equals to one, if the borrower pledges commercial real estate as collateral and zero otherwise. We also include as controls a vector of dummy variables for the use of other forms of collateral that are not real estate $\mathbb{I}\{\text{Non-real estate}_{f,b,m,t}\}$. This allows us to gauge the relative importance of real estate collateral for credit growth vis-à-vis other forms of collateral. The coefficient θ_0 quantifies the relationship between the pledging of real estate collateral and the firm's credit growth relative to those other forms of collateral.

The coefficient θ_1 captures the sensitivity of bank credit to changes in real estate values and is the main object of interest. Because our empirical specification absorbs bank-market-time variation through the fixed effect $\psi_{b,m,t}$, we control for macroeconomic factors, as well as bank-specific and bank-market-specific credit supply conditions. Therefore, we are left to explain an across-firm and within-firm variation. In particular, our empirical specification compares two firms located in the same market and borrowing from the same bank. One firm pledges real estate collateral, and the other firm pledges a different form of collateral or borrows unsecured. An alternative interpretation is to examine the regression from the perspective of firms in the cross-section of markets. The regression specification compares two firms borrowing from the same bank, but each firm operates in a different market with different real estate values. The coefficient θ_1 captures the additional relaxation of credit constraints for firms in markets with the higher collateral values. Finally, the regression compares the same firm over time. In some periods, the firm is not pledging real estate, but in others it pledges real estate collateral. The additional borrowing capacity of the firm when pledging real estate is captured by the combined effect of using real estate as collateral and the collateral value at the time of pledging i.e. $\theta_0 + \theta_1 P_{m,t}$.

We expect θ_1 to be positive, because firms pledging real estate collateral benefit from

the relaxation of borrowing constraints when collateral prices increase. The coefficient θ_1 is a function of the mass of credit constrained firms (an extensive margin) and the degree to which credit constraints are binding (intensive margin). Therefore, a test on the statistical significance of θ_1 is a test for the presence of credit constrained firms that use real estate collateral to relax borrowing constraints. At the same time, the magnitude of the θ_1 coefficient captures both the mass of credit constrained firms and the degree to which collateral constraints are binding. We do not directly observe the degree to which credit constraints are binding in the cross-section of firms and over time. However, we expect this coefficient to be larger for high bank-dependent firms, because those firms are likely to have limited access to nonbank financing. Furthermore, the degree to which credit constraints are binding also depends on credit demand. All else being equal, firms with a higher marginal product of capital and, hence, higher loan demand are more likely to be credit constrained compared with firms without good investment opportunities. To control for loan demand, we include a credit demand factor $\alpha_{f,t}$ based on Amiti and Weinstein (2018) decomposition.[7] We also control for lagged observable firm characteristics $\mathbf{X}_{f,t-1}$ that incorporate several measures of firm creditworthiness, such as leverage, investment-grade status, the share of fixed assets, and profitability measured by return on assets. Finally, we use firm fixed-effects ϕ_f to condition on unobservable and time-invariant firm characteristics.

The credit supply conditions could also lead to restrictions of credit that could be observationally equivalent to binding collateral constraints. We use bank-market-time fixed effects $\psi_{b,m,t}$ to absorb credit supply effects including the role of banks' internal capital markets in allocating credit across geographic markets. Furthermore, the market-time dimension of $\psi_{b,m,t}$ controls for local economic conditions and also allows us to compare borrowers across markets that obtain credit from the same bank but each borrower experiences different changes in its collateral values as discussed above.

We use the same regression framework to also examine the effects of relaxation of collateral constraints on firms' investment decisions and asset growth. We also explore the effect of the real estate values on the terms of newly originated credit facilities such as the credit spread, the maturity, the bank-reported expected loss given default (LGD), and the expected probability of default (PD).

4.3 Identification of the aggregate effects

To quantify effects of the collateral channel on macroeconomic outcomes, we aggregate the micro-level empirical specification to the market level. We exploit the large heterogeneity in the cross section of market characteristics documented in Table 2 to identify the ag-

[7] See the appendix for details of the implementation of the identification of the credit supply and demand factors.

gregate and potential agglomeration effects of the collateral channel stemming from the feedback loop between asset prices, collateral constraints, and bank credit. In particular, the regression framework for this analysis takes the following form

$$\begin{aligned} Y_{m,t} =& \theta_0^m \text{Share real estate}_{m,t-1} + \theta_1^m P_{m,t-1} \times \text{Share real estate}_{m,t-1} + \\ & \Theta^{m\prime} \text{Share non-real estate}_{m,t-1} + \gamma_\beta^m \beta_{m,t} + \gamma_\alpha^m \alpha_{m,t} + \mu_m + \tau_t + \epsilon_{m,t}^m. \end{aligned} \tag{4}$$

The aggregation to the market level transforms the firm-level collateral use indicators into shares of firms pledging a particular type of collateral as summarized in panel C of Table 2. Those shares represent the relative composition of collateral constraints faced by borrowers in each market. We aggregate the firm-level credit demand factor $\alpha_{m,t}$ using the lagged loan amounts at time as weights. We similarly construct a market-level credit supply factor $\beta_{m,t}$. Finally, to control for unobservable market-level effects and macroeconomic conditions, we use market and time-fixed effects, respectively.

With those controls in place, our identification strategy relies on examining the cross section of markets. Markets with higher shares of firms that pledge real estate collateral are expected to experience a larger relaxation of borrowing constraints following increases in collateral values and this expanded borrowing capacity is expected to allow for increases in investment, employment, and business creation. We consider market-level outcomes $Y_{m,t}$ such as credit growth, unemployment rates, growth rates in employment and business creation. We identify the effects of the collateral channel as the sensitivity of the outcome variable to the share of firms that pledge real estate collateral and the interaction of this share with the commercial real estate values.

The coefficient of interest θ_1^m captures both the aggregated firm-level and any agglomeration effects of the collateral channel and easily maps into the the credit multiplier framework of Mian et al. (2021). In particular, we can think of the coefficient θ_1^m as reflecting the aggregation of the effects of relaxation of firm-level borrowing constraints θ_1 from equation (3), as well as general equilibrium agglomeration effects that occur within a geographic market with the expansion of credit supply to that market and the feedback loops between credit and asset prices. The coefficient estimates of equations (3) and (4) allow us to compute a market-level credit multiplier defined as the ratio of the micro-level and the market-level elasticity estimates and scaled by the average share of firms pledging real estate i.e. $\kappa \equiv \frac{\theta_1^m}{\theta_1} \times \text{Share real estate}$. The credit multiplier, which captures the general equilibrium effects of the feedback loop between asset prices, collateral constraints, and bank credit, is expected to exceed one.

4.4 Endogeneity of commercial real estate values

The main endogeneity issue in identifying the coefficients of interest in equation (3) is that firm loan demand and collateral values could be jointly determined by local economic conditions. Therefore, the ordinary least squares (OLS) coefficient estimates would pick a positive correlation between collateral values and bank credit even without the presence of credit constraints as illustrated in equation (2). In other words, the OLS estimate of θ_1 would be positively biased if such associations are not controlled for.

We address this concern using Saiz (2010) supply elasticities as instruments for commercial real estate values. This instrument is by now standard in the literature and has been applied in a number of studies such as Himmelberg et al. (2005), Mian and Sufi (2011), Chaney et al. (2012), Adelino et al. (2015), and Campello et al. (2021). Compared with the existing literature, which has relied mainly on house prices, our work relies on commercial real estate prices, which are more likely to be relevant for corporate borrowers in our sample. Figure 2 shows the supply elasticities across the geographic areas in our sample. Coastal areas and areas close to mountains have significantly lower supply elasticities and are shown in dark red. Those lower supply elasticities indeed translate into notable differences in real estate prices between low and high elasticity markets as shown in Figure 1.

Insert Figure 2.

The real estate supply elasticity measure is a static characteristic of a geographic area. We create time-series variation in the local demand for real estate properties by interacting the supply elasticity with the 30-year national mortgage rate similar to Chaney et al. (2012). All else equal, lower interest rates increase demand for real estate properties. In markets with high supply elasticities, the higher demand translates into a higher supply of properties, whereas in the low supply-elasticity markets, higher demand translates into higher prices. We capture this mechanism through our first-stage regression, which takes the following form

$$P_{m,t} = \mu_m + \beta \times \text{Elasticity}_m \times \text{30Y-Mortgage rate}_t + u_{m,t}, \tag{5}$$

where μ_m are market fixed effects. The interaction of the mortgage interest rate and the supply elasticity identifies the differential price response across markets to a common aggregate demand shock. The results of the first-stage regression are summarized in Table 5. In column (1), we show the coefficient estimate of our baseline specification, which implies that

a 100 basis point decrease in mortgage rates leads to a 5 basis point increase in the prices of commercial real estate properties. To account for nonlinearity, in specification (2), we fit a linear spline function with different slope coefficients for the lowest quartile, the interquartile range, and the upper quartile. As expected, markets with lowest supply elasticities have highest sensitivities of real estate values to changes in interest rates. Specifically, for a 100 basis point decrease in mortgage rates, markets with supply elasticities in the lowest quartile experience an average price appreciation of 18 basis points, whereas high supply-elasticity markets appreciate by less than 4 basis points. Based on the goodness-of-fit and F-test statistic, we pick the nonlinear model in column (2) as our preferred specification for the fist stage.

Because most papers in the literature use house prices, it is useful to compare our estimates based on the commercial real estate prices to the estimates based on house prices. Columns (3) and (4) of Table 5 present the results of the baseline specifications using house prices. First, the coefficient estimates reveal that house prices are less sensitive to changes in aggregate interest rates as compared to commercial real estate prices, and especially in the low supply-elasticity markets. Following a 100 basis point decrease in mortgage rates, house prices increase about 12 basis points compared with the 18 basis points increase in commercial real estate prices. Second, in terms of model fit as measured by the F-test, the regressions with commercial real estate prices dominate the house price regressions, further validating the use of commercial real estate prices in our analysis and the relevance of the Saiz (2010) supply elasticity instrument for commercial real estate prices.[8]

Insert Table 5.

Panel B of Figure 1 presents the fitted commercial real estate prices based on specification (2) of Table 5. The fitted values do not have the upward trend in the underlying price indices. Consistent with differences in the slope coefficients between low and high supply-elasticity markets, the average gap in the commercial real estate values between low and high supply-elasticity markets is time-varying and varies between 1 and 6 percentage points over our sample period.

[8]The validity of the real estate supply elasticities constructed from geographic constraints has been questioned by recent studies. For example, Davidoff (2013) and Guren et al. (2021) discuss potential problems with those supply elasticities and offer alternative measures. Our empirical framework addresses the concerns raised with Saiz (2010) supply elasticity estimator by controlling for industry composition, firm-level credit demand, and bank-level credit supply conditions.

4.5 Endogenous choice of real estate as collateral

A credit constrained firm would choose to pledge real estate if it is the optimal form of collateral that would allow the firm to optimize its current and future borrowing capacity. The borrowing capacity of the firm increases with the real estate values and, hence, higher real estate values should also increase the use of real estate collateral. However, the decision to pledge real estate collateral could also depend on the firm's investment opportunities and loan demand. Therefore, a positive association between the pledging of real estate, real estate values, and bank credit could reflect high loan demand and not necessarily the relaxation of borrowing constraints. To control for the endogeneity of the collateral choice, we begin by identifying a set of firm-specific, market-specific, and bank-specific factors that determine the decision to pledge real estate, and subsequently include these factors as controls in the baseline regression.

We first document in Figure 3 that the use of real estate collateral declines monotonically with firm asset size. Close to 60 percent of credit to firms in the first decile of the firm size distribution is collateralized with real estate. As size increases, firms substitute away from real estate and increase the use of accounts receivable and inventories. As firms grow in size, they also increase their pledgeable income generating sources reflected in their customer relationships and accounts receivable as well as inventories. The third category of collateral is blanket lien, which gives the lender the power to seize and liquidate all assets that are not already encumbered by other liens and pledged to other lenders. The use of blanket liens is relatively constant across the size distribution except for the largest firms. Borrowers in the top decile have more than 60 percent of bank credit in the form of unsecured loans, which is in stark contrast to the significant reliance on real estate collateral for very small firms but is in line with findings for large publicly-traded firms in Lian and Ma (2021).

Insert Figure 3.

We next put the choice of pledging real estate as collateral in the broader context of the choice between asset-based or earnings-based collateral types following the taxonomy of Lian and Ma (2021). Lian and Ma (2021) document that, for the sample of publicly traded firms, around 80 percent of debt contracts use earnings-based forms of collateral and only 20 percent of debt contracts are secured by specific assets. In contrast, in our data, 68 percent of borrowers use some form of asset-based collateral and about 37 percent of borrowers use real estate collateral. The use of asset-based collateral by bank dependent borrowers is consistent with previous studies (e.g. Berger and Udell (1990)).

We group collateral types into asset-based collateral summarized in Table 3 and earnings-based collateral summarized in Table 4. Asset-based collateral includes real estate, accounts receivable and inventories, fixed assets other than real estate, and cash and securities, whereas earnings based collateral is based on blanket lien and unsecured loans.[9] Loans secured by asset-based collateral involve the pledging of specific assets, whose liquidation values determine the recovery value to the lender in case of default. Earnings-based collateral involves unsecured loans or blanket-lien loans the recovery value of which is determined at default of the borrower by the residual value of the borrower's unencumbered assets or the value of the reorganized firm in a chapter 11 bankruptcy filing.

Even within the group of asset-based borrowers, firms that pledge real estate are different from the rest of the group. The median firm that pledges real estate has $4 million in total assets, which is less than half of the size of the median firm that pledges accounts receivable and more than 15 times smaller than the median firm that borrows unsecured. The firms that pledge real estate have higher shares of fixed assets in total assets, lower share of accounts receivable, higher dependence on bank credit, and are also more likely to have a below-investment grade status. Even though the firms that pledge real estate are riskier borrowers, banks expect that losses given default on loans secured by real estate to be lower than losses on loans secured by other fixed assets or loans that are not secured. This is consistent with the idea that commercial real estate collateral is relatively easy to repossess in bankruptcy, and its value is easy to assess and is not specific to the business model of the borrower.

We model the choice of pledging real estate collateral in the following probit regression specification as determined by market, firm, and bank characteristics. We explore the significant heterogeneity in firm characteristics as primary determinants of the choice of pledging real estate collateral.

$$\begin{aligned}\mathbb{E}\,\mathbb{I}\{\text{RE collateral}_{f,b,m,t}\} = \Phi(&\beta_1 \text{Elasticity}_m + \beta_2 \widehat{P_{m,t}} + \\ &\beta_3 \text{Share fixed assets}_{f,t-1} + \\ &\beta_4 \widehat{P_{m,t}} \times \text{Share fixed assets}_{f,t-1} + \\ &\Gamma' X_{f,m,t-1} + \zeta' Z_{b,m,t-1}).\end{aligned} \tag{6}$$

As firm controls, we use the share of fixed assets (property, plant, and equipment) in total

[9] Although accounts receivable and inventories could be viewed as an earnings-based collateral, because those accounts involve the pledging of specific tangible assets, they are considered an asset-based collateral in Lian and Ma (2021). This classification is also consistent with the treatment of such collateral by bank supervisors as discussed in the Comptroller's Handbook OCC (2000). See Caglio et al. (2021) for an alternative treatment of accounts receivable and inventories. As a result, their conclusions on the use of asset-based collateral for nonpublic firms in FR Y14 differ from ours.

assets as a proxy for the firms' ownership of real estate assets. We also interact the share of fixed assets with the instrumented commercial real estate price to control for changes in networth due to changes in real estate values.[10] As additional firm controls $X_{f,m,t-1}$, we include firm size, leverage, profitability as measured by the return on assets, the share of bank credit in firm's liabilities, and an indicator for high bank-dependence.

We control for bank characteristics $Z_{b,m,t-1}$ such as regulatory capital buffers above regulatory requirements, liquidity ratios, and the bank-market LTV ratios. These bank characteristics capture potential capital and liquidity constraints that banks face as well as differences in underwriting standards across banks and within a bank across markets. Finally, we also control for market characteristics such as the real estate supply elasticity and the instrumented commercial real estate prices.

The results of the analysis are summarized in Table 6. The first two specifications examine market characteristics only. Firms operating in geographic markets with lower supply elasticities are more likely to pledge real estate as collateral. The use of real estate collateral also increases when interest rates are low. However, higher prices of real estate do not increase the pledging of real estate. The coefficient estimate of the instrumented commercial real estate price is negative in (2). In specification (3), we can see that a necessary condition for a positive effect of prices on real estate collateral use is a sufficiently high share of fixed assets. This is consistent with the fact that only firms that own real estate can take advantage of higher real estate values. Higher shares of fixed assets are both a predictor for the ownership of real estate and its use as collateral. The use of real estate collateral is concentrated at smaller firms and declines with size as already shown in Figure 3. Furthermore, firms that rely more on bank credit, use more leverage, and have lower profitability, all of which suggests higher credit risk and tighter credit constraints, are more likely to pledge commercial real estate collateral.

Finally, in specification (4), we examine the role of bank characteristics. Conditioning on bank capital and liquidity, looser credit policies in terms of higher LTV ratios in a market lead to higher use of real estate collateral. Examining the log-likelihood ratios of the different specifications as a measure of the goodness-of-fit, we can see that adding firm characteristics leads to significantly higher log likelihood ratios. Introducing bank controls only marginally increases the log-likelihood ratio. Therefore, in our baseline empirical estimation we focus on those firm-level controls as predictors of real estate collateral use and apply bank-time

[10]Unfortunately, we do not measure the book or market value of firms' real estate holdings separately from the total fixed assets (property, plant, and equipment). Beginning with Chaney et al. (2012), the empirical literature has relied on proxies of firm market values computed from a subset of Compustat firms that last report depreciation of real estate holdings in 1993. Using using data from Compustat and Real Capital Analytics for a limited sample of firms in FR Y14, we were able to verify the ownership of real estate properties of firms pledging real estate, and document that the bulk of the reported fixed assets in FR Y14 are in the form of commercial real estate.

fixed effects as controls for underwriting policies.

Insert Table 6.

5 Estimation results

5.1 Firm-level effects of the collateral channel

We present a summary of the estimates of our baseline specification (3) in Table 7. The first three columns are based on an OLS estimation using the raw commercial real estate price indices. The last three columns present regression results using the instrumented price indices. To simplify the notation and the interpretation of the economic magnitudes of the estimates, we have expressed the price indices in decimals as in Figure 1, whereas the growth in lending is expressed in annualized percentage points. Therefore, the estimate of θ_1 in column (1) implies that a 1 percentage point appreciation in the commercial real estate prices results in about 14 basis points higher annual growth in credit.

Although the OLS regression controls for loan demand, this control may not completely purge associations between loan demand and commercial real estate values. There could still be a positive bias in the θ_1 estimate due to the correlation between real estate values and loan demand. Comparing the OLS estimates in column (1) with the IV estimates in column (4), we observe that indeed the sensitivity of bank lending to collateral values declines by half. The IV estimate implies that, on average, lending increases by about 7 basis points for every percentage point increase in real estate values for firms that pledge real estate collateral.

The specifications in columns (2) and (5) include the borrowers' share of fixed assets and the interaction of this share with the price index. The OLS estimate uncovers that, on average, a percentage point increase in the price index leads to about a 3 basis point increase in borrowing for a firm with 50 percent share of fixed assets. However, the effect disappears once we introduce the IV estimation in column (5) or reintroduce the real estate collateral terms in columns (3) and (6). This confirms that collateral values impact firms' borrowing capacities through the pledging of real estate collateral and not necessarily through a broader net worth channel based on the ownership of real estate alone.

Similar to the reasoning in Rampini and Vishwanathan (2020), when a specific asset such as real estate is pledged, any increase in the collateral value would accrue exclusively to the bank in the case of borrower default. However, any increase in the value of an unencumbered real estate asset or any other fixed asset not explicitly pledged to the bank would accrue to

all debt holders in a bankruptcy. If borrowing was exclusive to one bank, then pledging a specific asset is not different from borrowing unsecured as the exclusive lender would have a recouse on all assets of the firm in bankruptcy. However, when borrowers obtain credit from multiple lenders, pledging of a specific asset to a lender improves on the expected recovery rate of the loan to that specific lender, and saves the costs associated with uncertainties and delays in assessing and liquidating unencumbered assets inherent in the bankruptcy process that general creditors have to go through. Similar to the arguments in Lian and Ma (2021), we interpret the evidence in columns (2) and (5) as capturing the collateral channel mechanism and highlighting the importance of observing the actual collateral used rather than simply the ownership of real estate and its market value.

Insert Table 7.

Our next specifications explore the extent to which credit constraints change the magnitude of the collateral channel estimates. Recall that we categorize all firms that are not publicly traded and have more than 50 percent of their committed credit coming from banks in our sample as high bank-dependent borrowers. We treat this sample as a set of borrowers that are more likely to be credit constrained and dependent on their bank for credit. In Table 8, we present results for sample splits based on low versus high bank dependence. Consistent with the hypothesis that high bank-dependent borrowers are more credit constrained, the coefficient estimates of θ_1 are economically and statistically larger for high bank-dependent borrowers. High bank-dependent borrowers experience larger relaxation of borrowing constraints compared with low bank-dependent borrowers following appreciation of real estate collateral. In the first two columns, the OLS estimates show that a 1 percentage point increase in real estate values increases the borrowing of high bank-dependent borrowers by 18 basis points compared with 12 basis points for low bank-dependent borrowers. Consistent with a positive bias of the OLS estimates, the IV coefficient estimates are smaller, but, nevertheless, still statistically and economically significant for high bank-dependent borrowers. A 1 percentage point increase in collateral values increases the borrowing of high bank-dependent borrowers by 10 basis points. The coefficient for low bank-dependent borrowers is 7 basis points and is no longer statistically significant. The coefficient estimates of the demand factor reveal further evidence for differences in credit constraints between high and low bank-dependent borrowers. Bank lending is almost three times more sensitive to the loan demand of low bank-dependent borrowers than it is for high bank-dependent borrowers.

It is also worth highlighting the coefficient estimates on some of the firm controls and compared them to the effects of the collateral channel. For example, higher profitability as

measured by the borrower's return-on-assets, lower leverage as measured by the borrower's debt-to-assets ratio, and an investment-grade rating all increase borrowing. All else equal, a firm, that has or obtains an investment-grade rating, has a 140 basis point higher credit growth than a firm that is below investment grade. In comparison, a below-investment-grade high bank-dependent borrower, that pledges real estate collateral, would achieve the same relaxation of borrowing constraints equivalent to obtaining an investment-grade rating, if its real estate collateral appreciated by about 14 percent.

Insert Table 8.

To further gauge the relative magnitude of the collateral channel, we examine the effect of other forms of collateral on bank lending growth, and we also examine the growth in utilized amounts of credit lines. Table 9 summarizes results from this analysis, where we extend the results of our baseline regression and those in Table 8 by including all six major types of collateral as controls. We show results for the full sample and the split between high and low bank-dependent borrowers. First, the estimate of the collateral channel elasticity θ_1 is now higher at 12 basis points. Second, there is a clear rank-order in the sensitivity of bank credit to collateral types. Holding other things constant, borrowers that obtain unsecured loans are the least constrained and experience the fastest average growth in credit of about 11 percent. Pledging cash and securities, accounts receivable, or a blanket lien, lead to similar average growth rates of about 6 percent. Pledging fixed assets other than real estate leads to the lowest average growth of about 1 percent. Finally, pledging real estate collateral, keeping the growth in price of real estate unchanged, leads to about 3 percentage points growth in lending. This rank order of collateral constraints reveals that firms that pledge real estate collateral are relatively credit constrained compared with other asset-based collateral categories such as accounts receivable. This rank order is consistent with the patterns in Figure 3 showing that smaller firms, which tend to be more credit constrained, rely more heavily on real estate collateral to secure funding.

The last three columns of Table 9 examine the utilization of credit lines. Normally larger and investment-grade borrowers are able to obtain committed credit lines and such borrowers are less likely to be constrained. Furthermore, most credit lines are fully committed and borrowers can draw and repay those credit lines without much restrictions, if relevant covenants are satisfied. Because FR Y-14 does not contain information on the existing covenants, we cannot assess the degree to which a borrower's credit line drawdowns are constrained by covenants, and if covenants are more binding for high bank-dependent borrowers. Nevertheless, the estimates imply, that for low bank-dependent firms that pledge

real estate collateral, changes in real estate values do not impact the utilization of credit lines. In contrast, high bank-dependent firms that pledge real estate collateral experience significant growth in utilized amounts due to higher real estate valuations. For every percentage point increase in real estate values, high bank-dependent borrowers increase utilized amounts on credit lines by about 60 basis points. This sensitivity could reflect both relaxation of covenants that govern the ability of firms to draw on credit lines and the general increase in committed credit to the firm. Consistent with utilization of credit lines absorbing credit demand conditions of firms, there is no significant difference in the sensitivity of utilized amounts to changes in the credit demand factor across the two groups of firms.

Insert Table 9.

We next examine how the collateral channel affects credit spreads, maturity, and expected losses on newly originated loans. Results of this analysis, shown in Table 10, reveal that higher collateral values reduce the cost of credit for firms that pledge real estate collateral. A 10 percentage points increase in real estate values leads to about a 5 basis point decline in credit spreads. Banks also increase the maturity of new loans to firms that pledge real estate collateral in markets experiencing real estate values appreciation. For every 10 percentage point increase in collateral values, banks increase the maturity of newly originated loans by about a month and a half. Somewhat surprisingly, the expected loss-given default and the expected probability of default are not sensitive to the real estate values. A likely explanation for this result is that the relaxation of borrowing constraints leads to increases in firm leverage. At the margin, the improvements in net worth due to higher collateral values of borrowers pledging real estate are counterbalanced with the increase in leverage. Finally, consistent with the relative ease in repossessing and liquidating real estate collateral, pledging of real estate collateral reduces the expected loss given default by about 3 percentage points. As a comparison, pledging accounts receivable and inventories or other fixed assets have a smaller effect on the loss given default. In contrast, unsecured loans increase the loss given default, because the bank has a claim only on the unencumbered assets of the borrower, which it needs to share with other lenders in case of bankruptcy of the firm.

Insert Table 10.

Finally, we examine the effect of the collateral values on firm capital expenditures and asset growth. Table 11 reports the results of this estimation. Similar to the loan growth

regressions, firms that pledge real estate collateral in markets with higher real estate values experience higher investment rates, and the effect of the collateral channel is statistically significant for high bank-dependent borrowers. A 1 percent increase in real estate collateral values increases investment rates about 3 basis points for all firms and by about 7 basis points for high bank-dependent borrowers. Because this regression explains variation at the firm level, we drop the bank-market-time fixed effects and instead, following Amiti and Weinstein (2018), we include both the credit supply and demand factors in this regression. Credit supply has a significant effect on firm capital expenditures and especially for high bank-dependent borrowers. A 1 percent increase in the credit supply increases capital expenditures by about 1 basis point for all firms and for low bank-dependent borrowers, and by about 3 basis points for high bank-dependent borrowers. Those estimates provide further validation of our treatment of high bank-dependent borrowers as more credit constrained borrowers.

The last three columns of the table show the effects of the collateral channel on asset growth. Consistent with increased borrowing and higher capital expenditures, assets of high bank-dependent borrowers that pledge real estate collateral grow by about 9 basis points for every percentage point increase in collateral values. The effects of the collateral channel are statistically significant both for the full sample and for the sample of low bank-dependent borrowers, but are smaller in magnitudes of about 6 basis points and 4 basis points, respectively.

Insert Table 11.

5.2 Market-level effects

In this section, we examine whether the firm-level effects of the collateral channel lead to statistically and economically significant aggregate effects. To begin, let us examine Figure 4. Panel A shows that in the cross-section of geographic markets, the cumulative bank credit is positively associated with the appreciation in commercial real estate prices. Furthermore, by the end of the sample period, low-supply-elasticity markets have both notably higher commercial real estate prices as well as higher bank credit growth compared with high-supply-elasticity markets. Panel B reveals further that markets with low supply elasticities experienced larger increases in bank credit compared with markets with high supply elasticities. The divergence in cumulative credit growth exceeds 20 percentage points by the end of 2019. Panel C shows the same comparison but restricts the sample to high bank-dependent borrowers. The figure reveals that high bank-dependent borrowers in low

supply elasticity markets experienced larger increases in bank credit both compared with borrowers in high supply elasticity markets as well as compared with other borrowers in low supply elasticity markets. The divergence in cumulative credit growth for this group of borrowers across the two types of markets is even more stark reaching close to 60 percentage points by the end of 2019. Finally, panel D reveals that higher cumulative growth in bank credit has positive association with employment growth in both low- and high-supply-elasticity markets.

Insert Figure 4.

The correlations in Figure 4 are suggestive for a strong statistical relationship between commercial real estate values, credit allocations, and economic activity. However, they are not implicating the collateral channel as the main causal mechanism behind these correlations. To establish causality, we turn to our regression framework (4) with the estimates summarized in Table 12.

We begin with the estimation of the effects of the collateral channel on the market-level credit growth as an outcome variable. The first result in column (1) and (2) indicates that after conditioning on credit supply and demand, the collateral channel terms are not statistically significant determinants of credit allocations for all firms in the market and for firms that a categorized as low bank dependent. However, consistent with the micro-level estimates, market-level bank credit to high bank-dependent borrowers is very sensitive to real estate values and the share of firms that pledge real estate collateral. In particular, the coefficient estimates reported in column (3) imply that for the median market with 20 percent share of firms pledging real estate as collateral, a 1 percentage point increase in commercial real estate prices leads to about an 82 basis points higher growth in bank credit to high bank-dependent borrowers. Second, there is evidence that a higher share of firms pledging real estate collateral has positive effects on overall credit growth and credit growth to low bank-dependent borrowers regardless of real estate values. An increase of this share by 10 percentage points leads to about 9 and 6 basis points increase in overall credit and credit to low bank-dependent borrowers, respectively.

The remainder of the variation in market credit growth can be attributed to credit supply and demand conditions. The credit supply factor impacts market-level credit to both groups of borrowers but has higher impact on overall credit and credit to low-bank-dependent borrowers. For every percentage point increase in the credit supply factor, credit growth to all firms increases by about 65 basis points and 40 basis points for high-bank dependent firms. Market-level bank credit responds differently to credit demand conditions of the two

groups of firms. Overall bank credit is more sensitive to the demand conditions of low bank-dependent borrowers, which tend to be larger firms. A 1 percentage point increase in credit demand conditions of those borrowers raises credit growth by about 3 percentage points. In contrast, total credit growth increases by 30 basis points in response to a one percentage point increase in the credit demand conditions of high bank-dependent borrowers. Second, columns two and three also show that there is no significant crowding-out or crowding-in effects of credit demand of low bank-dependent borrowers on high bank-dependent borrowers and vice versa. These results are consistent with the fact that high bank-dependent borrowers are more likely to be constrained and their credit demand conditions are less likely to be satisfied with higher credit growth.

Insert Table 12.

We next evaluate the effect of the collateral channel on market-level economic activity. The results of this analysis are summarized in Table 13. Although the relaxation of borrowing constraints had statistically significant effects on bank credit to the relatively small high bank-dependent borrowers, small firms have disproportionately larger shares in employment as documented by Neumark et al. (2011). As a result, changes in borrowing constraints for those borrowers are expected to drive employment growth and the unemployment rate in areas with high concentration of high bank-dependent borrowers.

The coefficient estimates of the collateral channel term for the unemployment rate and the growth in employment capture both the disproportionately higher shares of employment in small businesses as well as any agglomeration effects of the collateral channel. The estimates imply that a 1 percentage point increase in collateral values in the median market, which has 20 percent of borrowers pledging real estate collateral, leads to about a 0.8 basis point decrease in unemployment rate and about a 14 basis point increase in the growth of total employment. Consistent with the fact that the nontradable sectors concentrate a higher share of high bank-dependent borrowers, the collateral channel has large and statistically significant impact on employment in the nontradable sector of about 20 basis points for the median market and has an overall impact one employment of about 14 basis points. In contrast, we do not find evidence that the collateral channel affects employment growth in the tradable sector.

Insert Table 13.

We next examine the effect of the collateral channel on net business creation using annual data from the Census Bureau's CBP. These data allow us to measure net growth in establishments by industry sector and employment size. We group establishments into tradable and nontradable sectors and in four size groups: very small establishments with employment sizes up to 9 employees, which constitute more than 70 percent of all establishments; medium-sized establishments with total employees between 10 and 99, which represent about one-fourth of all establishments; medium-to-large establishments with total employees between 100 and 499, which represent about 2 percent of all establishments; and the very large establishments with total employees exceeding 500, which represent less than 1 percent of all establishments. We use the annual growth in establishments for each market and group as an outcome variable.

The results from this estimation are summarized in Table 14. The coefficient estimates imply that for the median market a 1 percent increase in commercial real estate values boosts overall establishment growth about 4 basis points. The effect is concentrated in the nontradable sector in the smallest size group of establishments with up to 9 employees. This evidence is consistent with smaller firms in the nontradable sector being more credit constrained and more dependent on bank credit. In contrast, we do not find evidence for an effect of the collateral channel on the overall growth in the smallest size establishments in tradable sector establishments. However, we find a statistically significant and economically large effect of the collateral channel in the 100 to 499 employee size category. The coefficient estimates imply that a 1 percent increase in commercial real estate prices leads to a 74 basis point growth in tradable sector establishments in this size category for the median market. While this size category is both less likely to be credit constrained than the smaller establishment sizes and more likely to have access to some form of nonbank financing, we cannot completely rule out the workings of the collateral channel either directly or through agglomeration effects. The publicly available CBP data do not allow us to distinguish between gross establishment creation and destruction, nor can we record transitions between size categories due to employment growth at the establishment level. Nevertheless, the results on establishment growth are in line with the overall effects of the collateral channel on the unemployment rate and the growth in employment.

Insert Table 14.

6 Conclusion

We provide direct evidence that the collateral channel is most relevant for non-publicly traded and high bank-dependent firms. Furthermore, we show that the firm-level relaxation of borrowing constraints due to the appreciation of the value of pledged real estate collateral lead to aggregate market-level effects with significant amplification of the micro-level elasticities in markets with higher shares of firms pledging real estate as collateral. Unlike the existing literature that has relied on associations between housing prices and firm-level investment providing indirect evidence for the workings of the collateral channel, the key to our identification is that we observe the pledging of real estate collateral and we can appropriately control for lender-specific credit supply and firm-specific credit demand factors when quantifying the effects of borrowing constraints. Thus, our work provides direct evidence for the workings of the collateral channel for private bank-dependent borrowers.

Our data and methodology allow us to aggregate the micro-level effects of collateral constraints and examine their aggregate effects controlling for other credit allocation mechanisms and the endogenous substitutions among a menu of available asset-based and earnings-based types of collateral. While our estimates are reduced-form, they could be useful in calibrating a more structural approach to assess the general equilibrium and welfare effects of the collateral channel in the presence of heterogeneous firms with different access to market-based finance. The economically significant credit multiplier and its agglomeration effects on firm investment and employment outcomes also has a potential implications for the business cycle and firm dynamics. Our sample involves an economic expansion during which credit constraints were relaxed. In a downturn, markets that experience significant decreases in commercial real estate values would also experience disproportionately larger contraction in bank credit due to tightening of credit constraints. Furthermore, the entry and exit of firms and the average firm growth will also differ across markets with different real estate supply elasticities and use of collateral, with divergent effects on firm dynamics and firm-size distributions. We leave these implications of our findings for future research.

7 Tables and Figures

7.1 Tables

Table 1: Descriptive statistics of corporate borrowers and bank lenders

Statistic	mean	sd	p5	p25	p50	p75	p95
				A. Borrower characteristics			
Total assets ($mln)	601.19	3198.77	2.05	6.35	17.27	70.18	2078.52
Total bank credit ($mln)	32.83	175.52	1.13	1.85	4.05	14	122.2
Credit lines ($mln)	39.02	171.3	1.23	2.18	5.47	19.06	160
Utilization rate (pct)	49.32	40.21	0	0	51.87	93.32	100
Term loans ($mln)	17.14	104.37	1.08	1.52	2.86	8.31	62.64
Share of bank credit (pct)	49.2	32.2	2.1	21.7	46.5	75.4	100
Growth in bank credit (pct)	15.2	41.7	-41.9	-2.7	0	31.7	101
Cash-to-assets (pct)	11.69	16.18	0	1.42	5.72	15.14	44.58
Capital expenditure (pct)	1.57	8.3	-7.62	0	0.03	2.61	13.91
Credit rating	BB	D	CCC	BB	BB	BBB	A
Expected default prob.	2.81	10.25	0.06	0.27	0.7	1.7	9.06
Expected LGD	32.62	18.22	5	20.7	34	42	60
Expected utilization at default	73.82	75.98	18.11	50	75.9	100	102.57
Debt-to-assets (pct)	60	23	17	44	63	78	93
				B. Bank characteristics			
Total assets ($mln)	488,788	674,996	65,951	122,034	176,900	381,451	2,191,626
CET1 ratio (pct)	12.7	3.5	9.5	10.7	11.9	13.6	17.8
HQLA-assets (pct)	17.1	11.4	4.8	9.8	14.5	19.9	47.9
Number of borrowers	3391.9	3463	117.6	1441	2291	3598	12687.2
Committed credit ($mln)	88,389	115,338	6,830	22,719	42,150	85,143	399,007
Number of markets	59.1	11.5	35	57	62	66	68
Market concentration [HHI] (0,100)	7	4	4	4	6	8	13
Largest market share [0,1]	0.21	0.1	0.11	0.13	0.21	0.25	0.37
Share of largest 3 markets [0,1]	0.34	0.1	0.22	0.25	0.35	0.41	0.53
Credit to low-elasticity markets [0,1]	0.4	0.13	0.2	0.29	0.4	0.48	0.6
Credit to high-elasticity markets [0,1]	0.16	0.08	0.06	0.1	0.16	0.21	0.32

NOTE: Panel A contains summary statistics of 92,069 nonfinancial corporate borrowers headquartered in one of 68 MSA areas over the period from 2013:Q1 through 2019:Q4. The sample includes both publicly traded and private companies that borrow from at least one of the 34 large multi-market banks reporting in FR Y-14. Capital expenditures are net of depreciation and are shown as percent of the lag of total assets. Total bank credit measures the sum of committed amounts on credit lines and term loans. Expected utilization at default is based on the bank reported expected exposures at default. Share of bank credit is the ratio of bank term loans and credit lines to total liabilities and unused credit lines of obligors. Panel B summarizes the average characteristics of the multi-market banks in the FR Y-14 dataset. Balance sheet and income statement information for those banks is obtained from FR Y-9C. SOURCE: Federal Reserve Board, Forms FR Y-14 and FR Y-9C, Call Reports, and authors' calculations.

Table 2: Descriptive statistics of geographic markets

Statistic	mean	sd	p5	p25	p50	p75	p95
			A. Credit growth				
Annualized growth in credit	6.95	32.91	-32.5	-6.36	5.18	17.49	49.13
—high bank-dependent	8.93	56.95	-40.88	-8.55	4.87	21.37	68.93
—low bank-dependent	6.96	36.61	-38.02	-7.83	4.68	18.91	55.57
Credit supply factor	1.36	3.42	-2.46	-0.45	0.7	2.62	6.8
Credit demand factor high-bank dependent	3.29	9.24	-7.12	-1.22	2.15	6.05	17.12
Credit demand factor low-bank dependent	1.7	7.1	-8.01	-1.68	1.29	4.62	12.68
Share of credit to low-bank dependent borrowers	0.8	0.08	0.66	0.75	0.81	0.85	0.89
—nontradable sector	0.3	0.13	0.12	0.21	0.28	0.39	0.52
—tradable sector	0.49	0.15	0.23	0.39	0.51	0.6	0.73
Share of credit to high-bank dependent borrowers	0.2	0.08	0.11	0.15	0.19	0.25	0.34
—nontradable sector	0.11	0.06	0.05	0.08	0.1	0.14	0.2
—tradable sector	0.09	0.05	0.04	0.06	0.08	0.11	0.2
			B. Market characteristics				
Credit (multi-market)	31,034	35,326	3,559	9,516	21,509	38,638	86,869
Credit (regional)	2,960	9,059	42	292	772	1,954	10,322
C&I share of multi-market banks	0.86	0.15	0.6	0.81	0.92	0.96	0.99
Multi-market HHI (0,100)	10.52	3.33	7.54	8.44	9.49	11.11	17.66
Number of multi-market banks	27.86	5.98	11	27	29	31	34
Supply elasticity	1.74	0.86	0.66	1	1.61	2.35	3.29
Commercial real estate price growth	6.39	5.61	-2.69	3.22	6.34	9.59	15.18
			C. Use of collateral				
Share of real estate collateral	21	8	9	15	20	26	35
Share of accounts receivable	21	6	12	16	2	26	31
Share of cash and securities	8	5	3	5	7	10	16
Share of other fixed assets	10	3	6	8	10	12	16
Share of blanket lien	20	6	10	16	20	23	29
Share of unsecured	18	6	9	14	19	23	28
Share of other	9	3	5	6	8	11	14
			D. Economic activity				
Unemployment rate	4.87	1.69	2.8	3.7	4.5	5.6	8.1
Growth in employment: all	2.34	8.66	-9.6	-2.89	1.21	6.95	16.57
Growth in employment: nontradable sector	2.03	9.58	-13.12	-3.51	1.31	7.18	18.3
Growth in employment: tradable sector	1.72	22.13	-22.85	-4.62	0.98	7.15	25.8
Share of nontradable sector employment	72	5	65	69	71	75	80
Growth in establishments: all	1.99	5.03	-6.3	-0.19	2.44	4.72	8.07
Growth in establishments: nontradable	2.18	5.24	-5.6	-0.05	2.47	4.61	8.74
Growth in establishments: tradable	1.76	12	-14.69	-3.29	1.34	6.14	19.57
Share of nontradable establishments	77	3	72	74	76	79	82
Share establishments 1-9 employees	71.57	2.13	68.15	70.31	71.43	72.62	75.36
Share establishments 10-99 employees	25.88	1.94	22.33	24.86	26	27.07	28.89
Share establishments 100-499 employees	2.3	0.32	1.79	2.08	2.29	2.52	2.85
Share establishments 500+ employees	0.25	0.06	0.14	0.21	0.25	0.3	0.35

NOTE: The sample covers 68 geographic markets and over the period from 2013:Q1 to 2019:Q4. The credit supply and demand factors are aggregated to the market level using bank-level and firm-level lagged loan volume weights, respectively. SOURCE: Federal Reserve Board, Forms FR Y-14 and FR Y-9C; Bureau of Labor Statistics; Call Reports; Federal Deposit Insurance Corporation, Summary of Deposits; Census Bureau, Country Business Patterns; real estate supply elasticities Saiz (2010), and authors' calculations.

Table 3: Asset-based collateral types and borrower characteristics

Statistic	mean	sd	p25	p50	p75	N
			A. Real estate			
Total assets ($mln)	52	485	2	4	14	41263
Share fixed assets (pct)	44	33	13	40	74	41263
Cash-to-assets (pct)	14	19	2	7	18	41263
Share accounts receivable (pct)	13	17	0	4	20	41263
Committed amount ($mln)	4	9	1	2	3	41263
Debt-to-assets (pct)	61	24	45	65	80	41263
Share bank credit (pct)	49	30	21	48	76	41263
Investment grade	0.16	0.36	0	0	0	41263
Expected prob. of default (pct)	3.46	10.4	0.67	1.26	2.22	41263
Expected loss given default (pct)	30.6	11.63	23.88	31	38.29	41263
			B. Accounts receivable			
Total assets ($mln)	179	1034	5	11	34	16672
Share fixed assets (pct)	16	20	3	8	22	16672
Cash-to-assets (pct)	11	14	2	6	14	16672
Share accounts receivable (pct)	23	22	4	17	37	16672
Committed amount ($mln)	13	57	2	3	10	16672
Debt-to-assets (pct)	64	22	50	68	81	16672
Share bank credit (pct)	46	27	25	46	66	16672
Investment grade	0.18	0.38	0	0	0	16672
Expected prob. of default (pct)	3.49	8.5	0.64	1.37	2.98	16672
Expected loss given default (pct)	28.97	15.72	17.9	27	37.44	16672
			C. Fixed assets other than real estate			
Total assets ($mln)	331	1521	6	22	91	10609
Share fixed assets (pct)	27	30	2	13	46	10609
Cash-to-assets (pct)	25	27	3	14	39	10609
Share accounts receivable (pct)	12	16	0	3	18	10609
Committed amount ($mln)	5	16	1	2	4	10609
Debt-to-assets (pct)	52	27	28	53	75	10609
Share bank credit (pct)	37	34	6	27	63	10609
Investment grade	0.53	0.49	0	1	1	10609
Expected prob. of default (pct)	1.11	3.04	0.09	0.32	0.93	10609
Expected loss given default (pct)	53.94	41.87	12.75	40	100	10609
			D. Cash and securities			
Total assets ($mln)	922	3262	8	26	152	8607
Share fixed assets (pct)	40	26	17	37	61	8607
Cash-to-assets (pct)	12	16	2	6	15	8607
Share accounts receivable (pct)	17	16	5	13	26	8607
Committed amount ($mln)	7	19	1	2	6	8607
Debt-to-assets (pct)	61	21	47	63	76	8607
Share bank credit (pct)	25	27	2	14	43	8607
Investment grade	0.31	0.46	0	0	1	8607
Expected prob. of default (pct)	2.59	8.02	0.39	1.01	2.18	8607
Expected loss given default (pct)	32.4	14.68	23.14	31.44	39.6	8607

NOTE: The sample period covers 2013:Q1 through 2019:Q4. The number of unique borrowers that use a particular collateral is reported in the last column. SOURCE: Federal Reserve Form FR Y-14 and authors' calculations.

Table 4: Earnings-based collateral types and borrower characteristics

Statistic	mean	sd	p25	p50	p75	N
			A. Blanket lien			
Total assets ($mln)	167	1233	3	8	24	19018
Share fixed assets (pct)	24	25	4	14	37	19018
Cash-to-assets (pct)	16	19	3	9	21	19018
Share accounts receivable (pct)	23	22	3	17	37	19018
Committed amount ($mln)	9	46	1	2	6	19018
Debt-to-assets (pct)	58	23	41	60	76	19018
Share bank credit (pct)	44	26	23	43	64	19018
Investment grade	0.16	0.36	0	0	0	19018
Expected prob. of default (pct)	3.29	9.48	0.64	1.08	2.17	19018
Expected loss given default (pct)	39.12	15.1	32.8	37.74	43.33	19018
			B. Other collateral			
Total assets ($mln)	595	2318	5	20	132	6310
Share fixed assets (pct)	33	31	5	22	56	6310
Cash-to-assets (pct)	13	18	2	6	17	6310
Share accounts receivable (pct)	11	16	0	3	15	6310
Committed amount ($mln)	19	72	2	4	13	6310
Debt-to-assets (pct)	62	24	45	65	80	6310
Share bank credit (pct)	37	32	7	30	63	6310
Investment grade	0.29	0.45	0	0	1	6310
Expected prob. of default (pct)	3.9	10.82	0.43	1.2	3.57	6310
Expected loss given default (pct)	32.05	19.8	17.86	30	45	6310
			C. Unsecured			
Total assets ($mln)	1566	4040	8	66	675	10536
Share fixed assets (pct)	29	29	5	18	48	10536
Cash-to-assets (pct)	14	18	2	7	19	10536
Share accounts receivable (pct)	14	17	1	8	21	10536
Committed amount ($mln)	38	188	2	4	17	10536
Debt-to-assets (pct)	55	24	37	57	73	10536
Share bank credit (pct)	26	30	1	12	42	10536
Investment grade	0.44	0.49	0	0	1	10536
Expected prob. of default (pct)	1.97	8.29	0.17	0.48	1.16	10536
Expected loss given default (pct)	44.02	17.68	37	45	49.79	10536

NOTE: The sample period covers 2013:Q1 through 2019:Q4. The number of unique borrowers that use a particular collateral is reported in the last column. SOURCE: Federal Reserve Form FR Y-14 and authors' calculations.

Table 5: Supply elasticities and real estate prices

	Dependent variable: Real estate prices			
	Commercial		Residential	
	(1)	(2)	(3)	(4)
Elasticity × Mortgage rate 30yr, t	−0.050***		−0.035***	
	(0.004)		(0.003)	
Elasticity × {Elasticity < $Q1$}× Mortgage rate 30yr, t		−0.179***		−0.116***
		(0.014)		(0.018)
Elasticity × {Elasticity ∈ $(Q1, Q3)$}× Mortgage rate 30yr, t		−0.058***		−0.044***
		(0.006)		(0.004)
Elasticity × {Elasticity > $Q3$}× Mortgage rate 30yr, t		−0.036***		−0.026***
		(0.003)		(0.004)
Observations	5,606	5,606	5,341	5,341
R^2	0.303	0.390	0.293	0.322
F-test	33.85	48.53	32.59	36.28

NOTE: The regression sample includes 68 MSA areas and covers 2000:Q1 through 2019:Q4. Regressions in columns (2) and (4) fit linear splines that allow for different slope coefficients for markets with supply elasticities in the first quartile, the interquartile range, and the fourth quartile. All regressions include market fixed-effects. Heteroscedasticity consistent standard errors are clustered at the market level and are shown in parenthesis. Significant at *p<0.1; **p<0.05; ***p<0.01. SOURCE: The commercial real estate prices in columns (1) and (2) are from CBRE Econometric Advisors, residential real estate prices are from the Federal Housing Finance Agency, and real estate supply elasticities are from Saiz (2010).

Table 6: Determinants of real estate collateral use

	Dependent variable: Use of real estate collateral $\{0,1\}$			
	(1)	(2)	(3)	(4)
Mortgage rate 30yr, t	-0.13^{***}			
	(0.01)			
Elasticity$_m$ $\times$ Mortgage rate 30yr, t	0.02^{***}			
	(0.005)			
Elasticity$_m$	-0.21^{***}	-0.14^{***}	-0.14^{***}	-0.13^{***}
	(0.02)	(0.002)	(0.002)	(0.002)
$\widehat{P_{m,t}}$		-0.29^{***}	-0.56^{***}	-0.44^{***}
		(0.02)	(0.03)	(0.03)
$\widehat{P_{m,t}}\times$ Share of fixed assets$_{f,t-1}$			0.59^{***}	0.60^{***}
			(0.07)	(0.07)
Share of fixed assets$_{f,t-1}$			0.96^{***}	0.94^{***}
			(0.01)	(0.01)
High bank-dependence$_{f,t-1}$			0.28^{***}	0.29^{***}
			(0.004)	(0.004)
Share of bank credit$_{f,t-1}$			0.31^{***}	0.32^{***}
			(0.01)	(0.01)
log(Total assets)$_{f,t-1}$			-0.20^{***}	-0.20^{***}
			(0.001)	(0.001)
Debt-to-assets$_{f,t-1}$			0.002^{***}	0.002^{***}
			(0.0001)	(0.0001)
Return on assets$_{f,t-1}$			-0.005^{***}	-0.004^{***}
			(0.0001)	(0.0001)
CET1 buffer$_{b,t-1}$				0.07^{***}
				(0.001)
HQLA-to-assets$_{f,t-1}$				-0.001^{***}
				(0.0002)
LTV$_{b,m,t-1}$				0.07^{***}
				(0.01)
Constant	-0.18^{***}	-0.65^{***}	-0.48^{***}	-0.76^{***}
	(0.03)	(0.004)	(0.01)	(0.01)
Observations	1,341,757	1,341,757	1,341,757	1,341,757
Log Likelihood	−635,434.80	−635,658.50	−492,515.80	−489,032.60
Akaike Inf. Crit.	1,270,878.00	1,271,323.00	985,051.60	978,091.20

NOTE: The regression is a probit on the indicator function for whether the predominant form of collateral is real estate. The share of fixed assets is the firm-level share of fixed assets (property, plant, and equipment) in total assets of the firm and is a proxy for the ownership of real estate. Commercial real estate prices are instrumented based on column (2) of Table 5. Significant at *p<0.1; **p<0.05; ***p<0.01.

Table 7: The collateral channel effects on firm-level bank credit

	Dependent variable:					
	Growth in bank credit $\Delta L_{f,b,m,t}$					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
$P_{m,t} \times \mathbb{I}\{\text{Real estate}_{f,b,t}\}$	13.80***		13.37***	7.40**		7.75**
	(1.45)		(1.53)	(3.56)		(3.65)
$\mathbb{I}\{\text{Real estate}_{f,b,t}\}$	−2.78***		−2.68***	−0.30		−0.35
	(0.56)		(0.57)	(0.63)		(0.65)
$P_{m,t} \times$ Share of fixed assets$_{f,t-1}$		6.37**	3.39		−3.03	−4.29
		(2.57)	(2.56)		(6.31)	(6.40)
Share of fixed assets$_{f,t-1}$		−0.19	0.55		1.94*	2.11*
		(1.00)	(0.99)		(1.09)	(1.11)
log(Total assets)$_{f,t-1}$	−0.64***	−0.59***	−0.62***	−0.59***	−0.59***	−0.58***
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
Return on assets$_{f,t-1}$	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Debt-to-assets$_{f,t-1}$	−0.08***	−0.08***	−0.08***	−0.08***	−0.08***	−0.08***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$\mathbb{I}\{\text{Investment grade}_{f,t-1}\}$	1.45***	1.46***	1.44***	1.47***	1.46***	1.46***
	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)
Credit demand factor $\alpha_{f,t}$	0.11***	0.11***	0.11***	0.11***	0.11***	0.11***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	726,328	726,328	726,328	726,328	726,328	726,328
R^2	0.27	0.27	0.27	0.27	0.27	0.27
Adjusted R^2	0.14	0.14	0.14	0.14	0.14	0.14

NOTE: The regression analysis is based on an unbalanced panel of 32 banks, 68 MSA markets, and 73,760 borrowers, for which we observe all control variables and, out of which, 27,124 borrowers pledge real estate as collateral. The left-hand side variable is the year-over-year growth rate in lending of bank b to firm f in market m. The growth in lending is expressed in percentage points, whereas commercial real estate prices are expressed in decimals. Therefore, the magnitudes of the θ_1 estimates are in basis points. That is, in column (1), a 1 percentage point increase in commercial real estate prices leads to a 13.8 basis point increase in borrowing. All regressions include firm and bank-market-time fixed effects. Market level commercial real estate prices are instrumented based on first-stage regression reported in column (2) of Table 5. The standard errors in columns (4) though (6) are constructed based on a bootstrap with clustering at the borrower and market level. Significant at *p<0.1; **p<0.05; ***p<0.01.

Table 8: The collateral channel and bank dependence

	Dependent variable:			
	Growth in bank credit $\Delta L_{f,b,m,t}$			
	OLS		IV	
Bank dependence	Low	High	Low	High
	(1)	(2)	(3)	(4)
$P_{m,t} \times \mathbb{I}\{\text{Real estate}_{f,b,m,t}\}$	11.61^{***}	18.41^{***}	7.37	10.43^{**}
	(1.89)	(2.63)	(5.01)	(4.24)
$\mathbb{I}\{\text{Real estate}_{f,b,m,t}\}$	-2.12^{**}	-3.59^{***}	-0.21	-0.40
	(0.81)	(0.82)	(0.95)	(0.75)
$\log(\text{Total assets})_{f,t-1}$	-0.77^{***}	-0.49^{**}	-0.75^{***}	-0.44^{**}
	(0.17)	(0.20)	(0.17)	(0.21)
$\text{Share of fixed asset}_{f,t-1}$	-0.29	1.93^{***}	-0.28	1.99^{***}
	(0.80)	(0.54)	(0.81)	(0.54)
$\text{Return-on-assets}_{f,t-1}$	0.09^{***}	0.02^{***}	0.09^{***}	0.02^{***}
	(0.01)	(0.01)	(0.01)	(0.01)
$\text{Debt-to-assets}_{f,t-1}$	-0.10^{***}	-0.07^{***}	-0.10^{***}	-0.07^{***}
	(0.01)	(0.01)	(0.01)	(0.01)
$\mathbb{I}\{\text{Investment grade}_{f,t-1}\}$	1.39^{***}	1.37^{***}	1.40^{***}	1.42^{***}
	(0.39)	(0.38)	(0.39)	(0.39)
Credit demand factor $\alpha_{f,t}$	0.16^{***}	0.05^{***}	0.16^{***}	0.05^{***}
	(0.01)	(0.01)	(0.01)	(0.01)
Observations	460,357	265,971	460,357	265,971
R^2	0.28	0.35	0.28	0.35
Adjusted R^2	0.13	0.18	0.13	0.18

NOTE: The left-hand side variable is the year-over-year growth rate in lending of bank b, to firm f in market m. Market level commercial real estate prices are instrumented based on first-stage regression (5) in columns (4). A borrower is categorized as highly bank-dependent, if it is a nonpublicly traded company that obtains at least 50 percent of total credit from banks in our sample. All regressions include firm and bank-market-time fixed effects. Heteroscedasticity consistent standard errors are clustered at the borrower and market level. Market level commercial real estate prices are instrumented based on first-stage regression reported in column (2) of Table 5. The standard errors for IV specifications in columns (4) though (6) are constructed based on a bootstrap with clustering at the market level in the first stage and clustering at the borrower and market level in the second stage. Significant at *p<0.1; **p<0.05; ***p<0.01.

Table 9: Collateral types, credit growth, and bank dependence

	Growth in					
Dependent variable:	*Credit commitments* $\Delta L_{f,b,t}$			Utilized amounts $\Delta L^{U}_{f,b,t}$		
Bank dependence	All	Low	High	All	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{P_{m,t}} \times \mathbb{I}\{\text{Real estate}_{f,b,t}\}$	7.10*	7.24	12.40**	22.99	16.50	57.87*
	(3.61)	(4.40)	(5.40)	(24.21)	(33.14)	(29.82)
$\mathbb{I}\{\text{Real estate}_{f,b,t}\}$	3.02***	2.95***	3.23***	3.62	3.37	0.36
	(0.70)	(0.90)	(1.07)	(5.50)	(7.08)	(7.66)
$\mathbb{I}\{\text{Cash and securities}_{f,b,t}\}$	6.17***	6.02***	6.66***	18.86***	20.16***	4.77
	(0.75)	(0.82)	(2.07)	(3.37)	(3.52)	(11.70)
$\mathbb{I}\{\text{Accounts receivable}_{f,b,t}\}$	6.47***	6.16***	8.44***	23.75***	24.20***	19.78***
	(0.40)	(0.43)	(0.96)	(2.38)	(2.72)	(5.72)
$\mathbb{I}\{\text{Non-RE fixed assets}_{f,b,t}\}$	1.28**	0.82	4.99***	7.29***	6.74***	9.47**
	(0.50)	(0.52)	(0.92)	(1.87)	(1.98)	(4.59)
$\mathbb{I}\{\text{Blanket lien}_{f,b,t}\}$	6.34***	6.35***	6.47***	23.25***	23.73***	20.56***
	(0.38)	(0.41)	(0.94)	(1.90)	(2.22)	(4.92)
$\mathbb{I}\{\text{Unsecured}_{f,b,t}\}$	10.88***	10.86***	11.67***	21.36***	22.49***	2.14
	(0.50)	(0.52)	(1.74)	(3.06)	(3.38)	(7.54)
$\mathbb{I}\{\text{Other}_{f,b,t}\}$	(omitted)					
Share of fixed assets$_{f,t-1}$	1.50***	−0.39	1.66***	19.53**	16.20	20.54***
	(0.47)	(0.73)	(0.52)	(7.41)	(10.29)	(5.58)
log(Total assets)$_{f,t-1}$	−0.62***	−0.88***	−0.43**	−3.95***	−3.07**	−9.22***
	(0.12)	(0.17)	(0.18)	(0.95)	(1.18)	(1.62)
Return on assets$_{f,t-1}$	0.04***	0.09***	0.01	0.26***	0.30***	0.15
	(0.01)	(0.01)	(0.01)	(0.07)	(0.09)	(0.12)
Debt-to-assets$_{f,t-1}$	−0.08***	−0.11***	−0.06***	−0.93***	−1.01***	−0.67***
	(0.01)	(0.01)	(0.01)	(0.07)	(0.10)	(0.08)
$\mathbb{I}\{\text{Investment grade}_{f,t-1}\}$	1.39***	1.45***	1.04***	4.03	4.67	−0.70
	(0.29)	(0.37)	(0.36)	(2.47)	(3.01)	(2.69)
Credit demand factor $\alpha_{f,t}$	0.12***	0.16***	0.04***	0.12***	0.16***	0.16***
	(0.002)	(0.003)	(0.002)	(0.01)	(0.01)	(0.01)
Observations	728,104	501,344	226,760	545,603	425,920	119,683
R^2	0.27	0.28	0.35	0.18	0.19	0.29
Adjusted R^2	0.14	0.14	0.16	0.05	0.05	0.06

NOTE: Growth in credit commitments is the year-over-year growth rate in total committed amounts of both credit lines and term loans. Growth in utilized amounts is the annualized growth rate in utilized amounts on existing credit lines. Market-level commercial real estate prices are instrumented based on first-stage regression (5). The different collateral types represent the dominant form of collateral used by the firm across all its credit facilities obtained from bank b. A borrower is categorized as high bank-dependent if it is a nonpublicly traded company that obtains at least 50 percent of total credit from banks in our sample. Market-level commercial real estate prices are instrumented based on first-stage regression reported in column (2) of Table 5. The standard errors are constructed based on a bootstrap with clustering at the borrower and market level in the second stage. Significant at *p<0.1; **p<0.05; ***p<0.01.

Table 10: The effect of the collateral channel on loan spreads, maturity, and expected losses

	Dependent variable:			
	Spread	Maturity	LGD	PD
	(1)	(2)	(3)	(4)
$\widehat{P_{m,t-1}} \times \mathbb{I}\{\text{Real estate}_{f,b,t}\}$	-0.46^{**}	13.65^{**}	4.86	0.55
	(0.22)	(6.65)	(3.92)	(1.44)
$\mathbb{I}\{\text{Real estate}_{f,b,t}\}$	0.11^{***}	0.08	-3.13^{***}	-0.02
	(0.04)	(1.16)	(0.74)	(0.38)
$\mathbb{I}\{\text{Cash and securities}_{f,b,t}\}$	0.12^{***}	-1.82^{***}	-2.07^{***}	0.09
	(0.03)	(0.61)	(0.55)	(0.28)
$\mathbb{I}\{\text{Accounts receivable}_{f,b,t}\}$	0.05^{***}	-1.44^{***}	-1.43^{***}	0.26
	(0.02)	(0.35)	(0.32)	(0.16)
$\mathbb{I}\{\text{Non-RE fixed assets}_{f,b,t}\}$	0.04^{**}	-1.57^{***}	-0.73^{**}	-0.22
	(0.02)	(0.37)	(0.29)	(0.18)
$\mathbb{I}\{\text{Blanket lien}_{f,b,t}\}$	0.005	-1.35^{***}	0.87^{***}	-0.22
	(0.02)	(0.39)	(0.31)	(0.19)
$\mathbb{I}\{\text{Unsecured}_{f,b,t}\}$	-0.05^{**}	-3.49^{***}	4.18^{***}	-0.12
	(0.02)	(0.35)	(0.33)	(0.13)
$\mathbb{I}\{\text{Other}_{f,b,t}\}$	(omitted)			
$\log(\text{Total assets})_{f,t-1}$	-0.0004	-0.09	0.22^{**}	0.02
	(0.01)	(0.15)	(0.11)	(0.09)
$\text{Return on assets}_{f,t-1}$	-0.003^{***}	0.04^{***}	0.005	-0.04^{***}
	(0.001)	(0.01)	(0.01)	(0.01)
$\text{Firm debt-to-assets}_{f,t-1}$	0.004^{***}	-0.06^{***}	-0.005	0.04^{***}
	(0.001)	(0.01)	(0.01)	(0.01)
$\mathbb{I}\{\text{Investment grade}_{f,t-1}\}$	-0.09^{***}	0.01	-0.34	-0.04
	(0.02)	(0.37)	(0.21)	(0.10)
Credit demand factor $\alpha_{f,t}$	-0.001^{***}	0.004	-0.0001	-0.004^{***}
	(0.0002)	(0.01)	(0.002)	(0.001)
Observations	50,206	50,206	50,206	50,206
R^2	0.78	0.80	0.77	0.70
Adjusted R^2	0.66	0.70	0.65	0.54

NOTE: Maturity of credit facilities are measured in months. LGD and PD stand for expected loss-given default and expected probability of default of the loan, respectively. Commercial real estate prices are instrumented based on specification (2) in Table 5. All regressions include firm, and bank-market-time fixed effects. Heteroscedasticity consistent standard errors are clustered at the bank level. Significant at *p<0.1; **p<0.05; ***p<0.01.

Table 11: The effect of the collateral channel on capital expenditures and asset growth

	Dependent variable:					
	Firm capital expenditures$_{f,t}$			Growth in firm assets$_{f,t}$		
Bank dependence	All	Low	High	All	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{P_{m,t}} \times \mathbb{I}\{\text{Real estate}_{f,b,t}\}$	3.48**	2.37	6.85*	5.62***	4.15**	8.75***
	(1.70)	(1.95)	(3.67)	(1.49)	(1.93)	(2.27)
$\mathbb{I}\{\text{Real estate}_{f,b,t}\}$	−0.20	−0.01	−0.37	−0.72***	−0.55*	−1.01**
	(0.30)	(0.33)	(0.74)	(0.27)	(0.33)	(0.48)
$\mathbb{I}\{\text{Cash and securities}_{f,b,t}\}$	0.002	−0.03	0.43	0.16	0.17	0.16
	(0.12)	(0.12)	(0.80)	(0.19)	(0.20)	(0.73)
$\mathbb{I}\{\text{Accounts receivable}_{f,b,t}\}$	0.21***	0.11	1.28***	0.29***	0.26**	0.64**
	(0.08)	(0.08)	(0.33)	(0.11)	(0.12)	(0.32)
$\mathbb{I}\{\text{Non-RE fixed assets}_{f,b,t}\}$	0.44***	0.36***	1.34***	0.37***	0.31***	0.89**
	(0.09)	(0.09)	(0.42)	(0.11)	(0.12)	(0.39)
$\mathbb{I}\{\text{Blanket lien}_{f,b,t}\}$	0.16*	0.09	0.87**	0.44***	0.43***	0.59*
	(0.08)	(0.09)	(0.36)	(0.12)	(0.13)	(0.33)
$\mathbb{I}\{\text{Unsecured}_{f,b,t}\}$	0.23***	0.19**	0.82*	0.01	0.05	−0.43
	(0.08)	(0.08)	(0.48)	(0.13)	(0.14)	(0.43)
$\mathbb{I}\{\text{Other}_{f,b,t}\}$	(omitted)					
$\log(\text{Total assets})_{f,t-1}$	−0.53***	−0.43***	−1.78***	−2.80***	−3.14***	−1.70***
	(0.09)	(0.09)	(0.39)	(0.12)	(0.15)	(0.15)
$\text{Return on assets}_{f,t-1}$	0.04***	0.04***	0.04***	0.04***	0.05***	0.02***
	(0.005)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$\text{Debt-to-assets}_{f,t-1}$	−0.01	−0.003	−0.03**	−0.08***	−0.09***	−0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$\mathbb{I}\{\text{Investment grade}_{f,t-1}\}$	0.29***	0.31***	0.17	0.0003	−0.06	0.14
	(0.09)	(0.10)	(0.24)	(0.16)	(0.19)	(0.20)
Credit demand factor $\alpha_{f,t}$	−0.002	−0.002	−0.0003	0.003	0.003	0.002
	(0.001)	(0.001)	(0.003)	(0.002)	(0.003)	(0.003)
Credit supply factor $\beta_{b,t}$	0.01***	0.01***	0.03***	0.002	−0.001	0.02*
	(0.002)	(0.002)	(0.01)	(0.003)	(0.004)	(0.01)
$\text{Lagged dependent variable}_{f,t-1}$	0.50***	0.50***	0.50***	−0.09***	−0.08***	−0.13***
	(0.005)	(0.01)	(0.01)	(0.003)	(0.003)	(0.003)
Observations	642,288	551,746	90,542	948,256	747,043	201,213
R^2	0.76	0.76	0.79	0.15	0.14	0.17
Adjusted R^2	0.74	0.74	0.75	0.07	0.07	0.04

NOTE: Firm capital expenditures are expressed as the annualized percent of lagged total assets. Firm asset growth is the year-over-year growth of firms' total assets. Commercial real estate prices are instrumented based on specification (2) in Table 5. All regressions include firm, bank, and market-time fixed effects. Heteroscedasticity consistent standard errors are clustered at the firm level. Significant at *p<0.1; **p<0.05; ***p<0.01.

Table 12: The effect of the collateral channel on market-level bank credit

Dependent variable: Market-level bank credit growth			
Bank dependence	All	Low	High
	(1)	(2)	(3)
$\widehat{P_{m,t-1}} \times$ Share real estate pledged$_{m,t-1}$	131.68	55.88	414.14*
	(136.87)	(181.46)	(233.29)
Share real estate pledged$_{m,t-1}$	91.49**	63.70*	82.12
	(36.73)	(32.15)	(75.03)
Share accounts receivable pledged$_{m,t-1}$	11.28	27.87	64.02
	(37.97)	(40.71)	(68.29)
Share cash and securities pledged$_{m,t-1}$	−61.26*	−19.12	17.27
	(33.88)	(36.48)	(55.76)
Share non-RE fixed assets pledged$_{m,t-1}$	−20.72	−20.64	42.73
	(40.65)	(32.33)	(76.20)
Share blanket lien pledged$_{m,t-1}$	24.74	59.32	10.28
	(38.26)	(38.32)	(71.07)
Share unsecured pledged$_{m,t-1}$	−12.69	−35.18	−23.73
	(24.07)	(30.32)	(53.40)
$\widehat{P_{m,t-1}}$	−41.50	35.57	−14.09
	(27.87)	(51.45)	(54.62)
Credit supply factor, $\beta_{m,t}$	0.65***	0.60*	0.40**
	(0.15)	(0.34)	(0.20)
Credit demand low bank-dependent$_{m,t}$	2.98***	3.51***	0.38
	(0.09)	(0.09)	(0.23)
Credit demand high bank-dependent$_{m,t}$	0.30***	−0.03	2.17***
	(0.07)	(0.07)	(0.17)
Lagged dependent variable$_{m,t-1}$	−0.08***	−0.05***	−0.19***
	(0.02)	(0.02)	(0.03)
Observations	1,768	1,768	1,768
R^2	0.55	0.58	0.36
Adjusted R^2	0.53	0.56	0.33

NOTE: Bank credit growth is the year-over-year growth in market-level committed amounts of bank credit lines and term loans. The different types of collateral pledged are aggregated as shares of loans pledging a particular form of collateral of the total market-level bank credit. The regressions are based on a panel of 68 MSA areas from 2013:Q1 to 2019:Q4. Commercial real estate prices are instrumented based on specification (2) in Table 5. The regressions are weighted by the lagged market-level bank credit. All regressions include market and time fixed effects. Heteroscedasticity and autocorrelation robust standard errors are clustered at the market level. Significant at *p<0.1; **p<0.05; ***p<0.01.

Table 13: The effect of the collateral channel on market-level employment

	Dependent variable:			
	Unemployment	Growth in employment		
	rate	Total	Non-tradable	Tradable
	(1)	(2)	(3)	(4)
$\widehat{P_{m,t-1}} \times$ Share real estate pledged$_{m,t-1}$	-3.81^{*}	68.51^{**}	98.27^{***}	-16.68
	(2.16)	(31.85)	(24.23)	(125.90)
Share real estate pledged$_{m,t-1}$	0.50	1.07	0.38	-32.94
	(0.97)	(7.17)	(6.99)	(29.43)
Share accounts receivable pledged$_{m,t-1}$	-2.16^{*}	-2.39	0.78	-40.19^{*}
	(1.09)	(5.52)	(7.07)	(20.90)
Share cash and securities pledged$_{m,t-1}$	-2.60^{*}	9.14	21.34^{***}	-64.59^{*}
	(1.35)	(6.68)	(6.61)	(33.26)
Share non-RE fixed assets pledged$_{m,t-1}$	0.28	10.14	11.78	-39.90
	(1.15)	(7.00)	(7.30)	(28.39)
Share blanket lien pledged$_{m,t-1}$	-1.43	9.29	17.50^{***}	-19.29
	(0.99)	(5.63)	(6.48)	(20.50)
Share unsecured$_{m,t-1}$	0.23	4.79	8.23	-15.86
	(0.80)	(4.93)	(4.97)	(20.82)
$\widehat{P_{m,t-1}}$	1.80^{*}	-25.27^{**}	-31.22^{***}	-12.25
	(0.92)	(10.32)	(7.40)	(32.96)
Credit supply factor, $\beta_{m,t}$	-0.003	0.20^{***}	0.14^{**}	-0.06
	(0.004)	(0.04)	(0.06)	(0.30)
Credit demand low bank-dependent$_{m,t}$	0.001	-0.002	0.02	-0.05
	(0.001)	(0.02)	(0.03)	(0.05)
Credit demand high bank-dependent$_{m,t}$	-0.002^{*}	0.03	0.03^{*}	0.04
	(0.001)	(0.02)	(0.02)	(0.07)
Lagged dependent variable$_{m,t-1}$	0.77^{***}	-0.29^{***}	-0.31^{***}	-0.32^{***}
	(0.03)	(0.06)	(0.05)	(0.04)
Observations	1,674	1,768	1,768	1,768
R^2	0.97	0.63	0.74	0.20
Adjusted R^2	0.97	0.61	0.72	0.15

NOTE: The regression is based on a panel of 68 MSA areas from 2013:Q1 to 2019:Q4. Commercial real estate prices are instrumented based on specification (2) in Table 5. All regressions include market, time fixed effects, and are weighted by the lagged bank credit. Heteroscedasticity and autocorrelation robust standard errors are clustered at the market level. Significant at *p<0.1; **p<0.05; ***p<0.01.

Table 14: The effect of the collateral channel on the growth in establishments

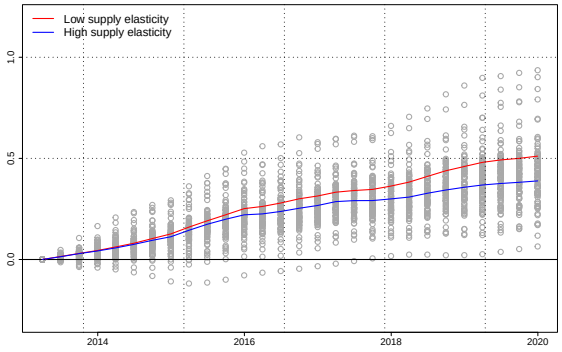
	Dependent variable: Growth in establishments								
	Aggregate	Nontradable				Tradable			
	All	1-9	10-99	100-499	500+	1-9	10-99	100-499	500+
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\widehat{P_{m,t-1}} \times$ Share real estate pledged$_{m,t-1}$	21.26**	24.71*	19.25	−34.50	396.98	13.79	21.40	374.52***	142.39
	(10.42)	(13.86)	(20.51)	(54.86)	(276.88)	(30.87)	(36.80)	(132.09)	(460.83)
$\widehat{P_{m,t-1}}$	−1.96	0.34	−10.79	−3.23	−39.09	−9.05	−15.29	−89.68**	154.31
	(5.04)	(8.42)	(7.31)	(18.07)	(125.56)	(10.40)	(13.28)	(42.29)	(166.33)
Share real estate pledged$_{m,t-1}$	−9.88**	−12.74*	−3.40	−9.79	−128.78*	−16.96*	6.01	−79.63**	163.43
	(4.39)	(7.50)	(7.29)	(19.90)	(65.05)	(8.91)	(9.76)	(39.25)	(137.43)
Share accounts receivable pledged$_{m,t-1}$	−1.67	−5.05	7.40	−13.55	6.58	−14.29	18.46**	−24.14	227.39*
	(4.54)	(7.09)	(4.57)	(18.82)	(83.81)	(9.33)	(8.60)	(29.65)	(123.34)
Share cash and securities pledged$_{m,t-1}$	−9.61**	−13.84	−5.03	−9.24	−78.38	−20.40**	8.75	−23.11	258.85**
	(4.45)	(8.38)	(6.90)	(19.15)	(69.11)	(9.12)	(9.13)	(40.33)	(129.10)
Share non-RE fixed assets pledged$_{m,t-1}$	−4.06	−6.07	3.55	−3.74	−85.26	−16.95**	7.65	−29.30	157.14
	(4.39)	(8.26)	(5.80)	(21.01)	(69.31)	(7.49)	(7.97)	(40.39)	(96.42)
Share blanket lien pledged$_{m,t-1}$	0.26	−1.33	5.53	−2.26	−54.62	−5.80	8.93	−5.27	106.86
	(3.64)	(6.18)	(4.58)	(13.90)	(56.27)	(8.21)	(7.73)	(29.07)	(81.89)
Share unsecured$_{m,t-1}$	−6.04	−12.68	2.02	9.31	−56.85	−7.36	13.71*	1.08	43.33
	(4.51)	(8.50)	(5.12)	(17.52)	(71.47)	(6.83)	(7.83)	(30.39)	(117.40)
Credit supply factor, $\beta_{m,t}$	0.003	−0.03	−0.02	0.27*	0.83	0.03	0.06	0.19	−0.28
	(0.03)	(0.05)	(0.04)	(0.15)	(1.48)	(0.06)	(0.10)	(0.28)	(0.91)
Credit demand low bank-dependent$_{m,t}$	0.02	0.04	0.01	−0.02	0.40	0.02	0.07**	0.05	−0.18
	(0.01)	(0.03)	(0.01)	(0.05)	(0.27)	(0.02)	(0.03)	(0.08)	(0.30)
Credit demand high bank-dependent$_{m,t}$	−0.06*	−0.10	−0.03***	0.03	−0.19	−0.02	−0.03	−0.31***	−0.25
	(0.04)	(0.07)	(0.01)	(0.08)	(0.20)	(0.02)	(0.04)	(0.05)	(0.36)
Lagged dependent variable$_{m,t-1}$	−0.14***	−0.20***	−0.28***	−0.32***	−0.38***	−0.27***	−0.35***	−0.23***	−0.35***
	(0.04)	(0.02)	(0.05)	(0.04)	(0.11)	(0.06)	(0.05)	(0.05)	(0.06)
Observations	372	372	372	372	372	372	372	372	361
R^2	0.69	0.44	0.64	0.57	0.48	0.49	0.41	0.41	0.53
Adjusted R^2	0.60	0.30	0.54	0.45	0.34	0.36	0.25	0.25	0.40

NOTE: The regressions are based on a panel of 68 MSA areas from 2013 to 2019. Commercial real estate prices are instrumented based on specification (2) in Table 5. All regressions include market and year fixed effects. Heteroscedasticity and autocorrelation robust standard errors are clustered at the market level. Significant at *p<0.1; **p<0.05; ***p<0.01.

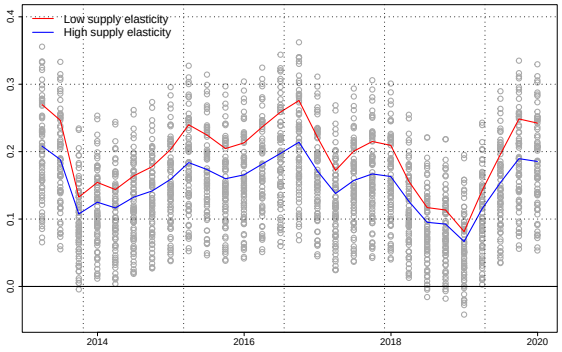
7.2 Figures

Figure 1: Commercial real estate prices

A. Commercial real estate prices

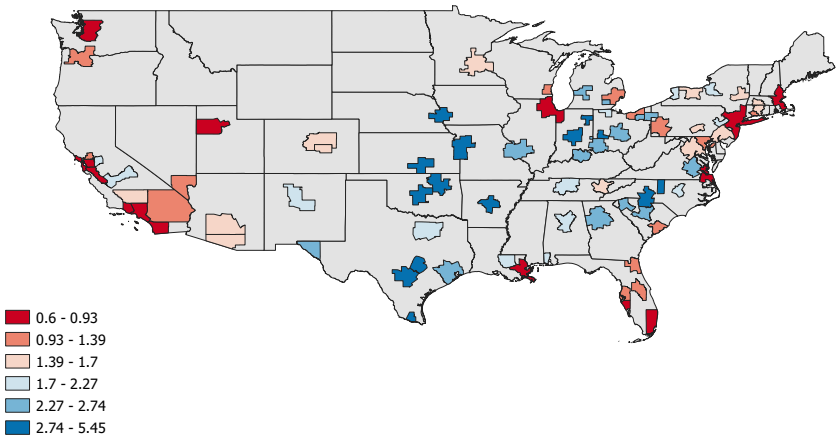


B. Instrumented commercial real estate prices



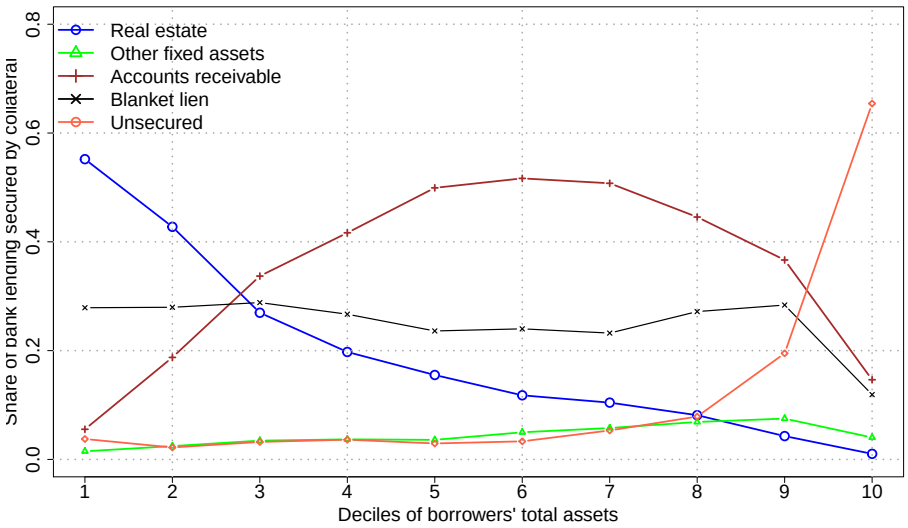
NOTE: The commercial real estate index is a composite price index of office, retail, industrial, and hotel properties. Each gray circle represents a market-level price. Low supply elasticity markets are markets with supply elasticities in the first quartile, whereas high supply elasticity markets are those with supply elasticities in the third quartile. The instrumented commercial real estate prices are the fitted values of regression specification (2) in Table 5. SOURCE: CBRE Econometric Advisors, Saiz (2010), and authors' calculations.

Figure 2: Real estate supply elasticities by MSA



NOTE: The housing supply elasticities are plotted for the 68 MSA areas in our data. Red color indicates markets with relatively low real estate supply elasticities (less then 1.7), whereas blue color indicates markets with high real estate supply elasticities (more then 1.7). SOURCE: Saiz (2010).

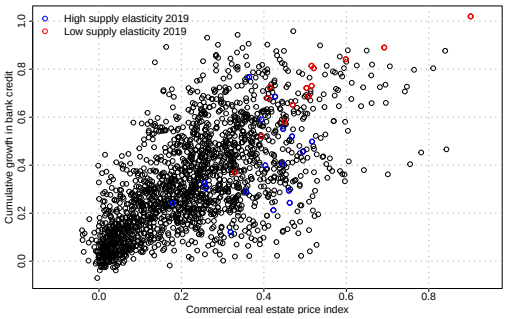
Figure 3: Collateral use in bank credit by firm size



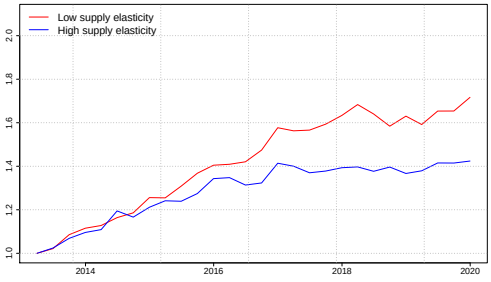
NOTE: For each decile of the firm size distribution, we compute the loan-volume share of loans secured by the particular type of collateral. FR Y-14 collect information on collateral at the credit facility level into seven mutually exclusive categories: real estate, cash and marketable securities, accounts receivable and inventories, fixed assets excluding real estate, blanket lien, other, and unsecured. SOURCE: Federal Reserve Form Y-14Q H1 Schedule and authors' calculations.

Figure 4: Commercial real estate prices, bank credit, and employment growth

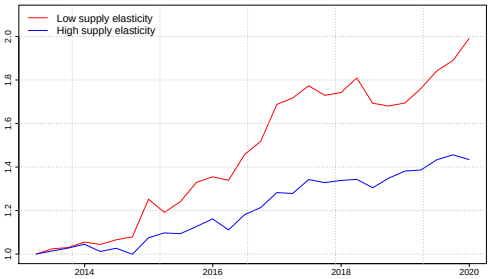
A. Commercial real estate prices and bank credit



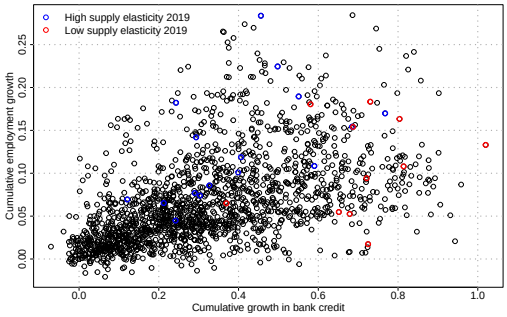
B. Credit to all borrowers



C. Credit to high bank-dependent borrowers



D. Bank credit and employment growth



NOTE: Panel A examines the cumulative growth in bank credit and commercial real estate prices across the different geographic areas over the sample period from 2013:Q1 to 2019:Q4. Panel B examines the cumulative growth in bank credit in low- and high-supply-elasticity markets over the sample period. Panel C examines the cumulative growth in bank credit in low- and high-supply-elasticity markets for high bank-dependent borrowers. Panel D examines the cumulative employment growth across the different geographic areas over the sample period 2013:Q1 to 2019:Q4 against commercial real estate prices. Red dots indicate low-supply-elasticity markets, whereas blue dots indicate high-supply-elasticity markets. SOURCE: CBRE Econometric Advisors, Federal Reserve Form Y-14Q H1 Schedule, and Saiz (2010).

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Online appendix not for publication
"The Collateral Channel and Bank Credit"

Arun Gupta Horacio Sapriza Vladimir Yankov[11]

A Data construction

Our main dataset is based on the FR Y-14Q schedule. The data are submitted by banks quarterly and contain the quarter-end loan balances of all commercial and industrial (C&I) loans with total committed amounts exceeding $1 million. We restrict the sample to U.S. domiciled nonfinancial borrowers containing consistent balance sheet and income statement information. We conduct a number of screens of the data to filter out outliers and inconsistent or stale information. For example, we verify that all balance sheet quantities are non-negative and satisfy the balance sheet identities. We also drop extreme observations that are in the 2.5 and 97.5 percentiles of the distribution for each variable.

We collapse the loan-level data to a bank-firm-market panel dataset by aggregating all outstanding credit facilities between a bank and a borrower. When we collapse the data, we make distinctions between term loans, credit lines, and the utilization on credit lines. If there are multiple credit facilities with different collateral types, we select the predominant form of collateral used based on the loan amounts. For most loan and borrowers, there is a single collateral pledged. We use the location of the headquarters of the borrower defined by a zip code to assign a borrower to a particular MSA area. We assume that the real estate collateral pledged is in the same location as the reported headquarters of the borrower. This assumption is very likely to be correct for the bulk of very small borrowers in our sample. We merge the FR Y-14 data with data on commercial real estate prices constructed by CBRE Econometric Advisors. We also restrict our sample to borrowers located in one of 68 major metropolitan statistical areas (MSAs) for which we have commercial real estate prices as well as real estate supply elasticities (Saiz, 2010).

We start with a sample of over 250,000 borrowers and after applying our different filters and validity checks, we are left with our final analysis sample that spans the period from 2013:Q1 to 2019:Q4 and consists of 32 bank holding companies that lend to 92,069 borrowing firms across 68 MSA-level markets. Below we describe the construction of each variable used in the regression analyses:

- $\Delta L_{f,b,m,t}$ is the year-over-year growth rate in total commitments (CLCOG074) of bank b to firm f in market m at time t. The year-over-year growth rate removes

[11]The Board of Governors of the Federal Reserve System, 20th Street and Constitution Avenue N.W., Washington, D.C. 20551. Views expressed in this paper do not reflect the official position of the Federal Reserve System.

seasonality in bank credit. The distribution of this variable is a mixture of a discrete distribution of firms that do not experience any changes in their borrowing and firms that experience changes, and a continuous distribution of growth rates for firms that obtain new loans or refinance existing loans. Around 40 percent of our data records no changes in committed amounts. In our analysis, we exclude firms with no growth in commitments, and to account for potential sample selection bias due to the exclusion of these observations, we implement a Tobit model in which we use the remaining maturity of a loan as a predictor for whether a firm would obtain a new loan or not. Adding the inverse Mills ratio to our baseline regression does not change our results. Results from this analysis are available upon request. Source: FR Y-14Q H1 schedule and authors' calculations.

- $\mathbb{I}\{\text{Real estate}_{f,b,m,t}\}$ is a {0,1} dummy variable equal to 1 if the firm f in market m at time t uses real estate collateral as the dominant form of collateral for loans obtained from bank b. The dominant form of collateral is based on the loan amount. We do the same construction for all the other collateral types. Source: FR Y-14Q H1 schedule and authors' calculations.

- $P_{m,t}$ is the average commercial real estate price in market m at time t. We take the average of the MSA-level price indices across retail, office, hotels, and industrial properties and normalize this index to 0 at the beginning of our sample. Source: CBRE Econometric Advisors.

- Capital expenditures$_{f,t}$ represents the capital expenditures (CLCEM324) divided by total assets (CLCEM316) of f at time t. FR Y-14 reports capital expenditures net of depreciation. We exclude depreciation from our analysis and use gross capital expenditures. Source: FR Y-14Q H1 schedule and authors' calculations.

- Share of fixed assets$_{f,t}$ is the total amount of fixed assets composed of real estate properties and other fixed assets (CLCEM316) divided by total firm assets (CLCE2170). Source: FR Y-14Q H1 schedule and authors' calculations.

- Total assets$_{f,t}$ is the firm's total assets (CLCE2170). Source: FR Y-14Q H1 schedule.

- Return no assets$_{f,t}$ is the firm's net income (CLCEM306) divided by the lag of total assets (CLCE2170). Source: FR Y-14Q H1 schedule and authors' calculations.

- Debt-to-assets$_{f,t}$ is the firm's total liabilities (CLCE2950) divided by its total assets (CLCE2170). Source: FR Y-14Q H1 schedule and authors' calculations.

- $\mathbb{I}\{\text{Investment grade}_{b,f,t}\}$ is a {0,1} dummy variable equal to 1 if the lender has assessed the borrower with a credit rating (CLCOG080) equivalent to BBB or higher. These credit ratings are assigned as part of the bank's reporting of risk-weighted assets to regulators. Source: FR Y-14Q H1 schedule and authors' calculations.

- $\mathbb{I}\{\text{Highly bank dependent}_{f,t}\}$ is a {0,1} dummy variable equal to 1 if the borrower is a non-publicly traded firm with bank credit of more than 50 percent of reported liabilities. We also classify borrowers with missing information on total liabilities as highly bank-dependent. Source: FR Y-14Q H1 schedule and authors' calculations.

- Unemployment rate$_{m,t}$ is the quarterly unemployment rate in an MSA. Source: Bureau of Labor Statistics (BLS).

- Employment growth$_{m,t}$ is the annualized quarterly growth rate in employment by industry NAICs code and MSA area. Source: Bureau of Labor Statistics Quarterly Census of Employment and Wages (BLS QCEW).

- Establishment growth$_{m,n,t}$ is the annualized quarterly growth rate in establishments by industry NAICs code and MSA area. Source: Bureau of Labor Statistics Quarterly Census of Employment and Wages (BLS QCEW).

- Establishment growth by firm size$_{m,n,t}$ is the annual growth rate in establishments by industry NAICs code, MSA area, and firm size distribution. Source: Census Bureau, County Business Patterns datasets.

B Controls for credit supply and demand

Our second approach to address the endogeneity problem of our baseline regression framework is to control for firm-specific loan demand and bank-specific credit supply conditions. We adopt the methodology of Amiti and Weinstein (2018), which generalizes the fixed effects approach of Khwaja and Mian (2008), and decomposes growth in bank credit into idiosyncratic credit demand and credit supply factors that satisfy firm-level and bank-level moment conditions. To make this decomposition operational, we need to modify the original framework to our data. Unlike the Japanese firm-bank dataset used by Amiti and Weinstein (2018), most bank-dependent firms in FR Y-14 have a single bank relationship.

As a result, we cannot identify the demand factors for the majority of borrowers in our data. To incorporate those borrowers in the analysis, we assign borrowers into groups based on geographic location, 2-digit NAICs industry code, investment-grade status, and high or low bank-dependence.[12] We assume that all firms within a group have a common credit demand process. The characteristics of the groups are chosen with the purpose of isolating credit demand that is driven by the location of the firm and its industry, which allows us to pick up differences in the marginal product of capital across geographic areas and industries. The last two characteristics are related to the degree to which the firms are credit constrained either because of their elevated credit risk, or lack of access to nonbank credit, or both.

To see how the decomposition works, suppose that firm f belongs to group i, then we assume that the growth in lending for that firm can be be decomposed into group i common demand factor $\alpha_{i,t}$ and bank supply factor $\beta_{b,t}$

$$\Delta L_{f,b,m,t} = \alpha_{i,t} + \beta_{b,t} + \xi_{f,b,m,t}, \tag{7}$$

such that for all firms $\{f_1, ..f_k\} \in i : \alpha_{f_1} = \alpha_{f_2} = .. = \alpha_{f_k} = \alpha_{i,t}$. The residual $\xi_{f,b,m,t}$ contains all the remaining bank-firm-market specific variation in bank credit including the effects of collateral use, collateral values, and bank credit policies across markets. For example, the decomposition does not model how a bank would allocate its extra lending capacity to the existing borrowers or to new lending relationships. If there are no frictions, all markets and firms the bank lends to in period $t-1$ will experience the same growth in lending equal to the bank's supply shock $\beta_{b,t}$. However, if bank's credit allocations are driven by additional variables such as the price of collateral, those factors would be captured by the residual term $\xi_{f,b,m,t}$ and our baseline regressions. Similarly, if a firm or groups of firms experience a positive demand shock, those firms will increase their borrowing from all banks in proportion to the demand shock. Therefore, any substitutions of borrowing across the different lenders including due to borrowing constraints would remain in the residual and be captured by our empirical framework. Furthermore, the grouping of firms based on the degree to which a firm is bank-dependent or whether it has an investment-grade status allows us to distinguish between more credit constrained firms for which substitutions across different lenders are harder and less constrained firms for which such substitutions are easier. The empirical results reveal that bank credit has different sensitivities to credit

[12]This is similar to the approach taken by Degryse et al. (2019), who apply the Amiti and Weinstein (2018) decomposition to credit registry data from Belgium. To generate a time-invariant groups, we use the average credit rating and the average bank-dependence for a firm throughout the sample. The online Appendix of Amiti and Weinstein (2018) provides a discussion on how this framework incorporates Khwaja and Mian (2008) procedure and other methodologies as special cases. See our online Appendix A for more details on the construction.

demand across the two groups of borrowers validating the choice of these groupings.

The firm loan demand factor $\alpha_{i,t}$ and the bank supply factor $\beta_{b,t}$ are constructed following Amiti and Weinstein (2018) and Degryse et al. (2019). To implement the decomposition, suppose there are N_B banks and N_F firm groups. Then define the total credit growth of firms in group i as $\Delta L_{i,t}$ and, similarly, the total lending growth of bank b as $\Delta L_{b,t}$. Let $D_{b,t-1}$ denote the set of borrowers of bank b and $B_{i,t-1}$ denote the set of banks that i firms borrow from. Then supply and demand factors are identified as a solution to the system of equations

$$\begin{aligned} \Delta L_{b,t} &= \beta_{b,t} + \sum_{j \in D_{b,t-1}} \omega_{b,j,t-1} \alpha_{j,t}, \text{for } b = 1, .., N_B \\ \Delta L_{i,t} &= \alpha_{i,t} + \sum_{l \in B_{i,t-1}} \tilde{\omega}_{i,l,t-1} \beta_{b,t}, \text{for } i = 1, .., N_F, \end{aligned} \tag{8}$$

where $\omega_{b,j,t-1} = \frac{L_{j,b,t-1}}{\sum_k L_{k,b,t-1}}$ and $\tilde{\omega}_{i,l,t-1} = \frac{L_{i,l,t-1}}{\sum_k L_{i,k,t-1}}$ are the lagged shares of credit from the respective counterparty j for bank b and bank l for firms i.[13] A desirable feature of the Amiti-Weinstein decomposition is that it allows for easy aggregation by using the lagged loan volumes as weights. Source: FR Y-14Q H1 schedule and authors' calculations.

C Solution of the stylized model

The solution of the problem in section 4

$$\begin{aligned} max_{K_{f,t+1}, L_{f,b,t+1}} \Big\{ A_{f,m,t+1} K_{f,t+1}^{\eta} - R_{f,b,t} L_{f,b,t+1} + P_{m,t+1} K_{f,t+1} \Big\}, \\ \text{subject to:} \\ K_{f,t+1} =& (1-\delta) K_{f,t} + I_{f,t} \\ L_{f,b,t+1} =& L_{f,b,t} + I_{f,t} \\ L_{b,f,t+1} \leq& \psi_{b,m,t} \quad \times \quad \underbrace{P_{m,t+1} \times K_{f,t+1}}_{\text{Market value of collateral}} , \end{aligned}$$

where $\eta, \delta, \psi_{b,m,t} \in (0,1)$.

[13] Because the system of equations contains $N_B + N_F$ unknowns but is only rank $N_B + N_F - 2$, the demand and supply factors are identified relative to a reference bank and reference group of borrowers. We select the largest bank and borrower based on loan volume. Following Amiti and Weinstein (2018), we re-normalize the demand factors relative to median firm demand factor and median bank supply factor, which removes the dependence on the choice of reference entity.

can be expressed as the optimization of the following Lagrangian problem

$$\begin{aligned}\mathcal{L}(K_{f,t+1},\lambda_{f,t}) = \quad & A_{f,m,t+1}K_{f,t+1}^{\eta} - R_{f,b,t}L_{f,b,t+1} + P_{m,t+1}K_{f,t+1} \\ & +\lambda_{f,t}(L_{b,f,t+1} - \psi_{b,m,t}P_{m,t+1}K_{f,t+1}) \\ & \rightarrow max_{\{K_{f,t+1},L_{f,b,t+1},\}}min_{\lambda_{f,t}}\end{aligned} \tag{9}$$

After substituting the expressions for the law of motion for capital and bank debt, we arrive at the following first-order condition for optimal capital

$$\eta A_{f,m,t+1}K_{f,t+1}^{\eta-1} - R_{f,b,t} + P_{m,t+1} + \lambda_{f,t}(1 - \psi_{b,m,t}P_{m,t+1}) = 0$$

The optimal capital level is

$$K_{f,t+1}^{*} = \begin{cases} \left(\frac{\eta A_{f,m,t+1}}{R_{f,b,t}-(1+\lambda_{f,t}(1-\psi_{b,m,t}))P_{m,t+1}}\right)^{\frac{1}{1-\eta}} & \text{constrained } \lambda_{f,t} > 0 \\ \left(\frac{\eta A_{f,m,t+1}}{R_{f,b,t}-P_{m,t+1}}\right)^{\frac{1}{1-\eta}} & \text{unconstrained } \lambda_{f,t} = 0 \end{cases}$$

Using the law of motion for firm debt and capital, we can express the optimal change in firm i's bank debt as

$$\Delta L_{f,b,t+1} = \begin{cases} \left(\frac{\eta A_{f,m,t+1}}{R_{f,b,t}-(1+\lambda_{f,t}(1-\psi_{b,m,t}))P_{m,t+1}}\right)^{\frac{1}{1-\eta}} - (1-\delta)K_{f,t}, & \text{constrained } \lambda_{f,t} > 0 \\ \left(\frac{\eta A_{f,m,t+1}}{R_{f,b,t}-P_{m,t+1}}\right)^{\frac{1}{1-\eta}} - (1-\delta)K_{f,t}, & \text{unconstrained } \lambda_{f,t} = 0. \end{cases}$$

The complementary slackness condition requires that $\lambda_{f,t}(L_{b,f,t+1} - \psi_{b,m,t}P_{m,t+1}K_{f,t+1}) = 0$.