Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.

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2020-034

Please cite this paper as:
Wang, Teng (2020). "Branching Networks and Geographic Contagion of Commodity Price Shocks," Finance and Economics Discussion Series 2020-034. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2020.034.

Branching Networks and Geographic Contagion of Commodity Price Shocks

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Abstract

This paper studies the role of banks' branching networks in propagating the oil shocks. Banks that were exposed to the oil shocks through their operations in oil-concentrated counties experienced a liquidity drainage in the form of a declining amount of demand deposit inflow as well as an increasing percentage of troubled loans. Banks were forced to sell liquid assets, and contracted lending to small businesses and mortgage borrowers in counties that were not directly affected by the oil shocks. The effect is magnified when banks do not have strong community ties, but is mitigated if banks' branching network is sufficiently dispersed. I also find the decline in local credit supply cannot be completely offset by healthy competing banks' increased lending, providing fresh evidence from the perspective of bank competition.

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1. Introduction

The collapse of oil prices could have devastating effects on the economy. The recent turmoil in global oil markets is again wreaking havoc in all corners of the U.S. oil industry, pushing shale drillers and oil-sand miners to desperate measures. With the U.S. oil prices plunge into negative territory for the first time ever on April 20, 2020, It is expected that a bankruptcy boom will hit the oil and gas industry should the trend persist. The vast majority of smaller shale oil and gas producers operate in the rural, western part of the U.S., where those producers rely heavily on loans from local banks that are in turn dependent on deposits from their employees and families. In the time of a sudden shock to the local industries, do these local banks face a liquidity shortage? What can the local bank do to cope with the shocks? In this paper, I study the effects of oil price shocks to the local banking sector. I also investigate how the effects of oil shocks were transmitted through the bank branching networks from one region to the broader economy.

To provide insights into the effects of oil shocks, I reviewed the 2014 crash in oil prices as a quasi-natural experiment of adverse shocks to the liquidity of banks that operate in areas with a high concentration of its workforce in the oil industry. The recent oil price collapse in 2014 to 2016 provides a unique opportunity to study the effects of oil shocks on banks and the geographic transmission of the shocks across regions in the post-crisis period. Similar to the Great Recession, the recent oil shock is featured by a sudden collapse in the asset price. With oil price dropping from over $100 a barrel to less than $50 within a few months of time, the shock was severe enough to hit all U.S. shale producers unexpectedly. Unlike the Great Recession, which was a systemic shock that affected the whole economy, the oil shock was an idiosyncratic shock that affected mainly the oil and gas production sectors. The effects were thus mostly concentrated in certain regions of the country while the economies in the unaffected areas continued trending up. The large contrasts among different geographic regions provide a perfect setting to isolate a supply shock from banks with a higher exposure to the oil production regions that were adversely affected by the oil shocks. By exploiting the large geographic variation in the exposure to the oil shocks, I compare the banks with and without significant branching exposures to the oil-concentrated areas and their resulting changes in liquidity management and lending practice.

Using data on banks' deposit-taking branch locations, I identify banks with significant exposures to regions where oil industry concentrates. Relative to banks operating in other non-affected regions, I conjecture that exposed banks experience a decline in local deposit inflow from employees, residents, and oil firms, as well as an increase in the delinquency and default of oil loans, both leading to a drainage of the banks' liquidity. Next, I investigate whether firms sell their securities holdings to replenish liquidity. In the overall bullish financial market, are banks more willing to sell less-liquid assets given the relative lower liquidity discount? Or did they sell the most liquid assets to gain access to immediate liquidity? Such questions help us gain fresh insights into the liquidity-management practices of banks in different economic cycles.

Second, I focus on the transmission channel of adverse regional economic shocks through the banks' branching networks. Over the past three decades, the banking sector in the U.S. has experienced dramatic changes, including geographic expansion of its branch networks and a higher level of financial integration. Studies show that these changes have been beneficial (Jayaratne and Strahan, 1996; Guiso, Sapienza, and Zingales, 2004; Huang, 2008). However, papers have also documented that the expansion of the banking sector is associated with the banks' risk taking (Dick, 2006; Jiang, Levine, and Lin, 2018). The recent crisis has highlighted a potential issue related to the ubiquity of the financial system. In particular, large economic shocks that could have been contained within part of the country spilled over to otherwise unaffected regions through the highly integrated financial system. Can having a geographically dispersed branching network help bank mitigate the effects of adverse shocks and thus limit the shock transmission? Or does it propagate a regional economic downturn to other unaffected areas of the economy? A dispersed branching network is more likely to transmit negative shocks than a unit bank, but the transmission is mitigated if the network is sufficiently dispersed.

The main results reveal that banks exposed to the oil shock through their operations in oil-concentrated counties experienced a liquidity drainage in the form of a declining amount of demand deposit inflow as well as an increasing percentage of troubled loans. I also find that these banks sold a significant amount of assets to replenish liquidity shortfalls following the liquidity drainage, and that the decrease is most significant for securities that are most liquid. Furthermore, I find these exposed banks substantially contracted their lending in counties that did not experience the negative shocks from the oil price collapse. In particular, exposed banks propagate the drop in liquidity to unaffected counties and cut their lending to local small businesses by 8.4 percentage points (or 1.05 million) per county each year from 2014 to 2016. A similar decline in the mortgage-lending space is recorded in unaffected areas, both in terms of the total amount of loans originated as well as the approval rates of mortgage applicants. Further analyses show that exposed banks cut more lending in communities where they either do not have a link or face higher levels of information asymmetries. The lending cut is less significant if the bank's branching network is sufficiently dispersed across different regions.

Next, I look at whether healthy, competing banks of similar profiles are able to step in and provide the necessary credit to borrowers who dropped by the troubled banks. In particular, I look at the healthy, competing banks' lending in the same market where the exposed banks contracted lending. In addition to providing insights into credit market competition during crisis times, this test also serves as a robustness check that increases confidence in the identification of the main finding. The results show that healthy banks were not able to completely fill the credit gap caused by troubled banks' decrease in lending, especially in the area of small business lending, possibly due to information asymmetries in the market. Overall, the evidence highlights the negative impacts of the energy market shock, and also suggests that competing banks are limited in their ability to quickly step in and substitute credit supply to borrowers.

This project is related to a few strands of literature. First, this paper contributes to the literature on the role of banks' geographic networks in transmitting economic shocks. On the one hand, a well-expanded geographic branching network allows banks to acquire stable funding across different areas (Becker, 2007) and transmit excessive funds across geographic areas (Gilje, Loutskina, and Strahan, 2016). On the other hand, banks' geographic networks could also transmit negative shocks across the system (e.g., Peek and Rosengren, 1997, 2000; Acharya and Schnabl, 2010; Chava and Purnanandam, 2011; Schnabl, 2012). For example, Landier, Sraer, and Thesmar (2013) show that increased banking integration due to large banks explains one-third of the increase in housing price co-movement across different geographies. Recent studies show that banks severely hit by the financial crisis also propagated economic shocks across the U.S. economy. Chava and Purnanandam (2011) find that financial market integration can allow shocks to propagate from one economy to another. Bord, Ivashina, and Taliaferro (2017) and Berrospide, Black, and Keeton (2016) show that large banks operating in U.S. counties most affected by the drop in real estate prices contracted their credit to small businesses in counties that were not affected by falling real estate prices. Instead of looking at the transmission channel of economic shocks to certain banks, this paper focuses on the banks' different exposures to regional shocks and investigates how the banking industry transmits these economic shocks to certain geographical areas and to other credit markets.

Second, this paper is related to the literature on banks' management of liquidity shocks. Many recent papers on mutual funds investigate how mutual fund managers deal with liquidity shortfalls and the decision of mutual funds to hold liquid assets (e.g., Yan, 2006; Simutin, 2014; Huang, 2015; Hanouna, Novak, Riley, and Stahel, 2015). Shek, Shim, and Shin (2015) and Morris, Shim, and Shin (2017) find that fund managers tend to hoard cash and sell illiquid assets to increase their cash positions to meet investor redemptions, whereas other studies find that fund managers prefer to sell more-liquid securities when market liquidity is drying up (e.g., Jiang, Li, and Wang, 2017). Research on banks' liquidity management mostly focuses on the relationship between banks' lending and holding of assets with various levels of liquidity (Acharya, Gromb, and Yorulmazer, 2009; Cornett, McNutt, Strahan, and Tehranian, 2011). Studies have also focused on the liquidity-hoarding activities during a liquidity shortfall (e.g., Ramos, 1996; Caballero and Krishnamurthy, 2008; Diamond and Rajan, 2011; Gale and Yorulmazer, 2012; Acharya and Merrouche, 2010). In this paper, instead of looking at systemic shocks, I use the oil price collapse as a regional shock that drains the liquidity in certain banks and investigate their liquidity-management behavior. The combination of regional liquidity shocks and an overall bullish security market provides a unique testing ground to investigate banks' choice of selling securities with different liquidity. Selling more-liquid securities provides a swift replenishment of liquidity, whereas selling less-liquid assets during economic booms allows banks to avoid the heavy discount of selling illiquid assets during an economic downturn. This paper contributes to the discussion by providing new evidence showing that banks mostly sell liquid assets when facing liquidity pressure.

This paper is related to the research on the impact of oil price shocks. Gilje, Loutskina, and Strahan (2016) show that when facing positive liquidity windfall from shale gas booms, banks export the liquidity to other unaffected areas in the form of credit provisioning. This paper differs from Gilje et al. (2016) by examining banks' exposure to negative liquidity shocks, which are arguably more constraining than positive windfalls, and investigates how they manage the shortfalls. Bidder et al. (2019) also look at declining oil prices as a shock to the 30 largest banks with oil loan portfolios on their balance sheets and investigate how it affects the loans of other borrowers in different industries. Instead of looking at loan portfolios at large banks, I focus on the changes in liquidity of small regional banks and look at the liquidity-management and geographic transmission of banks with higher deposit exposure to oil-concentrated regions.

Last, this paper provides novel evidence on bank competition and financial integration. Many papers find that increased local bank competition and financial integration contributes to local economic growth (Jayaratne and Strahan 1996, Guiso et al. 2004, Huang 2008). Notably, many studies use U.S. interstate banking reforms to identify the causality between bank competition and economic growth. In particular, credit competition improves bank services (Dick 2006), expands credit availability, and lowers interest rates (Zarutskie 2006, Rice and Strahan 2010), while limiting access to credit for underperforming firms (Bertrand et al. 2007). Using comprehensive micro dataset aggregated at the census tract level, a recent study by Wang (2019) finds that amid the increased competition after out-of-state banks either acquire a local bank or establish a new branch, incumbent banks increased the supply of local small business loans. This paper adds to the existing literature by providing fresh evidence on the dynamics of banks competition under the unique setting of an idiosyncratic bank shock.

The rest of the paper is organized as follows. Section 2 describes the data sources. Section 3 reports the empirical strategy and key results, demonstrating the propagation of distant shocks through the banking networks. Section 4 concludes.

2. Data

2.1 Banks' exposure to oil price shocks

To measure banks' liquidity exposure to oil price shocks, I collect the location information of banks' deposit-taking branches as well as the industry mix in each location. Census County Business Patterns database shows the local mix of industries across all counties in the U.S., and includes information on the payroll income, number of business establishment, and size of workforce. Clearly, as the main source of banks' funding liquidity, local payroll income is the most relevant variable to look at. The distribution of payroll income across local industries thus reflects banks' funding dependency on various industries. Consistent with the definition used in Bidder et al. (2019), I identify local exposures to oil and gas industry if the reported North America Industry Classification System (NAICS) code is either 211, 213111, or 213112 (oil and gas extraction, drilling oil and gas wells, and support activities for oil and gas operations). I calculate the percentage of a county's payroll income that is from the oil industry as shown in Figure 1. I define a county as sensitive to oil price shocks if a significant proportion of the local payrolls come from the oil industry.[2] It is clear that vast majority of oil-concentrated counties locate in the rural, western part of the U.S., where smaller shale oil and gas producers operate in. Those producers rely heavily on loans from local banks that are in turn dependent on deposits from their employees and families.

[Please insert Figure 1 here]

Next, I construct banks' liquidity exposure to each county using data from the Summary of Deposit (SOD) of the Federal Deposit Insurance Company (FDIC). The FDIC SOD collects information on each bank branch in the U.S., covering the universe of U.S. bank branches since 1994. The FDIC provides annual updates on detailed branch characteristics such as the address, geographic coordinates, deposit quantities, date of establishment, and ownership changes following

[2] In particular, I define an oil-concentrated counties as the ones that the percentile of the local payroll income from the oil industry is among the top 5 percentile among all counties across the U.S.. The reason is that most areas are recovering during the sample period. In order to identify counties that were "truly affected" by the oil shocks, it is advised to concentrate on the ones that are heavily relying on the oil and gas industries. Furthermore, using alternative threshold of 10 percent does not alter the results.

M&A. I calculate the deposit-weighted liquidity exposure to oil-concentrated regions faced by each bank at each branch location based on the unique identifier of each branch, its amount of deposits, its parent bank, and the physical location provided by SOD. In this study, I use county as a proxy for the local market. One advantage of using the more disaggregated data is that it further minimizes endogeneity concerns. A small geographical region is often the preferred proxy for the local market in the study of banking (e.g., Huang, 2008), as valuable bank-firm relationships in small business lending can only be preserved at a short distance, as suggested by Petersen and Rajan (2002).

2.3. Bank characteristics and credit provisioning

To capture the characteristics of entrant and incumbent banks, I collect FDIC Call Report data on bank characteristics from the Federal Reserve Bank of Chicago. The Call Report data contain quarterly balance sheet and income statement data, including bank age, size, liquidity, profitability, and capital ratio, for all U.S. commercial banks.

I collect data on small business loans to capture the changes in exposed banks' lending behavior in the local market. Banks with significant exposures to oil shocks are often smaller banks active in small business lending, operating in the rural, western part of the U.S. Because of the opaqueness of their business conditions, small business borrowers are often credit constrained and tend to depend on local relationship lenders for financing. Large firms, on the other hand, are less likely to be affected by the changes in small local banks' lending. Not only do they have operations in multiple locations, but they are also more likely to arrange financing through bond issuance or large loans that are often syndicated through a large number of financial institutions. Focusing on small business loans ensures that the actual shifts in credit supply by exposed banks will be captured.

I calculate the yearly aggregated amount of small- and medium-sized enterprise (SME) loans originated in a county by a bank using data from the Community Reinvestment Act (CRA) from the Federal Financial Institutions Examination Council (FFIEC). The FFIEC is an interagency body that, among other duties, collects periodic financial information filed by depository institutions on behalf of the Federal Reserve System (FRS), the Federal Deposit Insurance Corporation (FDIC), and the Office of the Comptroller of the Currency (OCC). The CRA was passed into law in 1977 by Congress (12 U.S.C. 2901) and has been implemented by bank regulators (see 12 CFR parts 25, 228, 345, and 195). Congress intended that CRA would encourage each financial institution to take steps to meet the credit needs of borrowers in the localities in which the institution does business. The CRA database covers loans with commitment amounts less than $1 million originated by financial institutions with more than $1 billion in assets. Under the CRA, banks report small business loans at a granular, community level. It covers approximately 75 percent of small-business originations to over 30,000 neighborhoods. The CRA data provide a complete record of new lending quantities at the bank, county, and year levels. Next, because supplying mortgage loans is also an important part of local banks' lending business, I supplement the dataset with data on banks' lending in the retail mortgage market. The FFIEC's Home Mortgage Disclosure Act (HMDA) database provides not only the amount of yearly aggregated amount of mortgage loans granted in the target county, but also the approval rates of mortgage loans from specific banks in that county.

2.4. Controls for target market conditions

I construct variables that reflect the local economic situation—such as market size, growth perspective, overall level of bank entries, and expansion rate of a local credit market—based on data from various sources, such as the U.S. Census Bureau, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the National Establishment Time-Series database. In addition, I manually collect archival data from the House of Representatives website and calculate the percentage of each state's House of Representatives members who are Democrats to proxy for the political climate in that state in that year. An overview of the main variables and the summary statistics are shown in Table 1.

[Please insert Table 1 here]

3. Empirical Results

3.1 Banks' exposure to oil price collapse

This section investigates the effects of an oil price drop on the liquidity of exposed banks with significant operation in oil concentrated counties. I identify the exposure of banks' liquidity to oil price collapse by looking at their deposit-taking branch location and counties' exposure to the oil industry, measured by the percentage of the workforce in that sector as mentioned in section 2. In recent years, the shale gas boom contributed to regional job growth and an increase in deposits taken by banks with branch locations close to shale gas producers in various areas of the U.S. due to the development in fracking technology. During a precipitous drop in the energy price, I conjecture that banks in geographic areas with a large share of oil producers will experience a severe drop in deposit inflows. A sharp decline in oil prices reduces revenue and profitability for firms that are involved in oil extraction activities, as well as for firms that supply equipment to oil producers, forcing firms to cut production or slash employment, leading to a reduction in deposit flow to banks located nearby. Having a large percentage of deposits from oil-concentrated counties leads to a more severe drainage of liquidity sources. I calculate the weighted exposure of banks' exposure to oil industries as

$$oil\ and\ gas\ exposure_{b,t} = \sum_{c=1}^{n} \frac{deposit\ obtained\ from\ oil\&gas\ concentrated\ county_{b,c,t}}{total\ deposit\ obtained\ from\ all\ branches_{b,t}} \quad (1)$$

This measure captures the relative importance of banks' aggregated demand deposit inflow that comes from the oil and gas concentrated counties. Banks that have a high exposure to oil-concentrated areas that are hit by an oil price collapse are likely to see a decrease in short-term deposit inflows and higher default and delinquency on the existing loans, both of which add pressure to banks' liquidity management. I use a difference-in-differences (DD) approach to study the effects of an oil price drop on deposits taken and loan losses by banks that have significant exposure to the oil-concentrated counties. The model specification is:

$$Demand\ deposits_{b,t} = \alpha + \beta_1 exposed\ bank_{b,t} \times Post\ oil\ price\ collapse_t +$$

$$\beta_2 Controls_{b,t-1} + \omega_b + \mu_t + \varepsilon_{b,t} \quad (2)$$

In Equation (2), the dependent variable *Demand deposits* is the ratio between the total amount of deposit inflow to all branches of the bank and the total assets of the bank in year *t*. In addition to deposit inflow, I also include *bank loan charge-offs* as dependent variable that measures the percentage of loans that marked by the bank as unlikely to be collected in year *t*. Based on the oil exposure index shown above, I set the value of the DD treatment indicator variable *Exposed banks* equal to one if the bank is among top 20 percentile of all banks in terms of its exposure to oil counties and zero otherwise, and I interact it with the oil shock variable *Post oil price collapse*.[3]

I try different specifications by excluding and including lagged control variables such as bank size, bank loan loss provision, and bank tier-1 common equity ratios. Bank fixed effects are included to absorb the potential influence of any time-invariant bank heterogeneity. Year fixed

[3] I also tried alternative threshold defining whether a bank is exposed to the oil shocks and the results are consistent with the ones with definition used in the main test.

effects are included to absorb the potential influence of any macro trends in banking activity across the nation. Robust standard errors are clustered at the bank level.

[Please insert Table 2 here]

Table 2 reports the within-bank level response of various key indicators to the liquidity drainage from the oil shock. It is clear that the collapse in oil prices has a significant dampening effect on exposed banks' deposit inflow and loan charge-offs, as the regression coefficient of the DD term, *Exposed banks* × *Post oil price collapse,* is negative and statistically significant at the 1% level across all regressions, both with and without control variables. The magnitude of the reduction is also economically sizable. Compared to control firms, treated firms on average experience a reduction of 58.8 percentage points in the total amount of deposits that go into the local banking sector in each county every year from 2014 to 2016, which is 3.85 times of the average ratio of demand deposit in the sample. Similarly, treated firms on average experience an increase in the ratio of bank loan charge-offs by 5.9 percentage points, which is huge compared to the mean charge-off ratio of 0.3 percentage points across firms in the sample, indicating that banks with branches in oil-concentrated areas have been writing off a higher amount of problematic loans after the oil price collapse. Combining the results shows that exposed banks experienced liquidity shortfalls and incurred higher deposit expenses and higher amounts of troubled loans.

I further employ the following dynamic DD regression framework similar to the one used in Beck, Levine, and Levkov (2010) to identify the exact timing of the treatment effect. To examine whether the documented treatment effect of oil price collapse on banks' deposit inflow and loan default is driven by potential nonparallel trends between the treated banks and control banks prior to the oil shock occurs:

$$Bank\ characteristics_{b,t} = \beta_0 + \beta_1 Exposed\ bank_b * D_{-2,t} + \beta_2 Exposed\ bank_b * D_{-1,t} + \beta_3 Exposed\ bank_b * D_{0,t} + \beta_4 Exposed\ bank_b * D_{1,t} + \beta_5 Exposed\ bank_b * D_{2,t} + \beta_7 Controls_{b,t-1} + \omega_b + \mu_t + \varepsilon_{b,t\ .}\ (4)$$

In Equation (4), $D_{x,t}$ is an indicator that equals 1 if year *t* is the *x*th year relative to the price collapse (with the reference quarter being the third year prior to the oil price collapse year) of the focal price collapse year; other notations follow previously given definitions. Such a dynamic DD model enables us to examine both the existence and timing of the treatment effect. If the reduction in deposit inflow and increase in charge-offs are indeed caused by exposure to the oil industries, then we should expect zero difference-in-differences between the treatment firms and control firms prior to the oil price collapses, that is, β_1 and β_2 should be insignificant. Moreover, we expect the event-year DD estimate, β_3, to be either 0 or negative for the demand deposit, and 0 or positive for the charge-offs, as it may take some time for the downturn to hit banks. We expect the post-event DD estimates, β_4 to β_5, to be significant. The results are reported in column (3) and (6) of Table 2.

In conjecture with the hypothesis, I find no difference between the changes in deposit inflow and loan charge-offs of the treatment banks and the changes in activity of control banks before the collapse of oil price. The treatment effect is observed only at and after the test release quarter across all specifications and is statistically significant mostly at the 1% level. This finding suggests the treatment effect on bank’s demand deposit inflow and loan charge-offs only exists from the year of the oil price collapse and onwards, but does not exist in prior quarters. In addition, I start to see the effects on banks’ loan charge-offs earlier than deposit inflow, likely due to the effects of local oil industry’s defaulting on the loans/delinquent on their payment first hit the bank before the effects from job loss kicks in.

In addition to the deposit amount, I further look at the ratio of interest expense on the deposit. Facing a decline in the inflow of the demand deposit, exposed banks may have attempted to increase the interest rate in order to attract more deposits. Results shown in Table 3 confirm this prediction. Exposed banks relying on funding from oil-concentrated areas increased interest costs to maintain/attract deposit inflows. Furthermore, exposed banks also provisioned much higher loan losses in addition to charging off loans at a higher rate, indicating that banks with branches in oil-concentrated areas viewed the shock as non-transitory and were preparing to write off a higher amount of problematic loans in the future.

[Please insert Table 3 here]

The result shows that exposed banks experienced liquidity shortfalls and incurred higher deposit expenses and higher amounts of troubled loans. Next, I look at whether firms manage liquidity shortfalls by selling securities they hold. Facing a dramatic drop in liquidity, banks are likely to sell their assets to replenish liquidity, so that they can satisfy normal withdrawals from depositors and demands for loans from borrowers. Literature suggests that financial firms sold the most liquid assets during the crisis in order to replenish the liquidity during the crisis It is useful to see how banks handle liquidity shortfalls during a period of general economic recovery. Columns 3-5 of Table 3 show how banks change their security holding mix after being hit by oil shocks. Interestingly, I find that banks are more likely to sell their most liquid assets first, such as cash and Treasury bonds, to meet the drop in liquidity, and the economic magnitudes decrease monotonically as the assets become less liquid. In particular, after the oil price collapse, exposed banks are expected to lower their holdings of cash and Treasury bonds, as the cash and Treasury bond to asset ratio declined by 64 and 35 percentage points, respectively. The decline is economically significant—with the mean cash to assets ratio of only 11.6 percentage points, an average bank will exhaust their cash reserve within two years. In contrast, the decrease in banks' holding of mortgage-backed securities (MBS) is less significant with a much lower magnitude. This result shows that instead of hoarding liquidity or opting for vertical skimming, there is a clear order of how banks sell their assets—the more liquid the asset, the more likely that banks will sell it first. The finding is consistent with prior studies in the mutual fund literature showing that fund managers tend to get rid of liquid assets when they face liquidity problems. It is worth noting that when the oil price shock hit the market in 2014, only part of the economy was affected; the U.S. economy as a whole was in a booming period, meaning that less-liquid assets will not be sold at a discount in general. Therefore, the finding of a pecking order in banks' asset selling is sheds new lights on financial intermediaries' liquidity management practices in time of crisis.

3.2 Transmission of liquidity shocks through banks' branching networks

There are three approaches banks may take to replenish their liquidity: increase the interest rate on deposits to retain existing/attract additional deposits, sell assets to generate extra short-term liquidity, or cut the amount of liquidity outflows through reducing either business or retail lending. Looking at the third channel helps us understand how exposed banks transmit shocks by constraining loan supply to the real economy.

Next, we focus on exposed banks' loan supply and examine banks' role in transmitting liquidity shocks from oil-dependent areas to other geographic areas through lending. I look at exposed banks' lending activities in counties that were *not* exposed to the oil industry after negative commodity prices hit the exposed banks. I look at banks' lending to both small business borrowers and retail mortgage borrowers. As a result of the opaqueness of their business conditions, small business borrowers tend to rely on local relationship lenders. Focusing on small business loans therefore ensures that I capture the actual shifts in banks' branch loan supply to the *local* market. Looking at the mortgage market allows me to further identify shifts in loan supply as information on the loan approval rate is available. I conjecture that banks transmit the liquidity shocks to non-oil-concentrated areas that were not hit by the oil price collapse. The model specification is:

$$loan\ provision_{b,c,t} = \alpha + \beta_1 exposed\ bank_b \times oil\ price\ collapse_t + \beta_2 Controls_{b,c,t-1} + \omega_{b,c} + \mu_t + \varepsilon_{b,c,t} \quad (3)$$

I evaluate changes in exposed banks' originations of CRA and mortgage loans to borrowers outside the oil-concentrated areas, where *c* represents the county, *b* represents the bank, and *t* represents the year. In order to properly control for any shifts in the local demand for bank credit, I try different specifications including various controls and fixed effects in place. For instance, I include variables that control for the local economic, political, and market characteristics, including variables that capture the wealth level and business conditions of the local market, variables on local bank competition using the Herfindahl-Hirschman index (HHI) of banks' deposit size, and variables on the business structure using the average number of employees hired in local firms. I control the state political climate using the fraction of each state's U.S. House of Representatives members who are Democrats. I also include the total population and the personal income growth rate to capture the size and growth perspectives of the local economy. Including those variables mitigates the concern that local business conditions and political climate could affect the local banking sector and the business demands in the area. In addition, I include county fixed effect ω_i and year fixed effect μ_t to control for both time-invariant unobservable county factors and nationwide shocks that happened during a particular year that could possibly affect both the local legal/political/economic situation as well as local deposits. I cluster the standard error at the county level to address the concern that the residuals might be correlated within a state and any serial correlation induced by the small variation in the DD indicator (Bertrand et al., 2004). In one specification, I include the county year $\omega_i \times \mu_t$ fixed effects in the regression so that any demand-related factors that arise from the local market across various periods are properly captured. Table 4 reports the regression results.

[Please insert Table 4 here]

It is clear that exposed bank branches decreased the amount of small business loans and mortgage loans originated in non-oil-concentrated counties after the oil price collapse, as the regression coefficient of the DD term, $exposed\ bank \times post\ oil\ price\ collapse$, is negative and statistically significant at least at the 1% level across all regressions, both with and without control variables. On average, exposed banks decreased small business lending by 8.4 percentage points. The magnitude of the reduction is also economically sizable – considering the mean in the sample, an 8% decrease in the lending amount is equivalent to a reduction of $1.05 million in banks' lending to small businesses in a local county, during each year after they are affected by oil price collapse.

The decrease in lending could be driven by a decreased credit supply from exposed banks in response to the downfall of liquidity back home, but it could also be the result of a decrease in local demand unrelated to the bank entries. Looking at the changes in the mortgage lending market helps us understand the extent to which the shift in local credit market is supply driven. If the decline in banks' lending to local community is driven by credit supply, we should expect the approval rate of mortgage loans to decline too. Following the model specification similar to equation (3), I test the impact of the oil price collapse on exposed banks' total amount of mortgage loans and the approval rate of the mortgage loans. Results are reported in Table 5.

[Please insert Table 5 here]

Consistent with the expectation, I document a significant, negative treatment effect of the oil price collapse on exposed banks' provisioning of mortgage loans in subsequent years. Compared to control firms, treated firms on average decrease their mortgage loans granted to local community by 1.1 percentage points per year, while the approval rate decreases by 0.9 percentage points. This result is consistent with exposed banks cutting small business credit supply in areas that were not affected by the oil price collapse, although the decline is smaller for the mortgage market, possibly due to the lower risks in these market.

Combining the empirical evidence, I conclude that exposed banks transmitted the negative liquidity shocks to other geographic areas that were not affected by the oil price decline, in both the wholesale credit lending and the retail lending market.

3.3 Variations in the decline of banks' credit supply to local communities

It is known that information asymmetries in the market are one of the key reasons for the existence of relationship lending, which is a popular lending technology often used by local banks in lending to small businesses (e.g. Petersen and Rajan 1994, Berger and Udell, 1994). In this section, I investigate whether banks facing liquidity constraints cut lending more in communities where they do not have a strong link or face higher levels of information asymmetries.

To measure banks' community linkages, I look at whether a bank has a branch in the local market as the level of information asymmetries the bank face in the market. Having branches located in a market helps banks collect necessary information for conducting relationship lending. I compare banks' transmission of liquidity shocks in markets in which they have branches versus in markets in which they do not have branches. To measure the level of information asymmetry in the local market, I create a novel measurement of information asymmetries in a market combining the industry composition of firms in a local market with the average asset intangibility of firms in each industry. I measure the composition of firms across various industries in one market in a given year using the Census's Statistics of U.S. Businesses. Next, I calculate the industry-average asset intangibility using accounting data of all U.S. firms in each industry of that year from the Compustat database. I then combine the industry composition of the local market with the average ratios of asset intangibility in each industry and calculate a market-specific asset intangibility index.[4] This industry composition-based measure reflects the overall asset tangibility of firms in one market and incorporates the dynamics in the industry distribution in that market over time. As a second measure of information asymmetries in the market, I look at the percentage of small-sized firms, defined as firms with fewer than 250 employees in the local market, from the Census database. Based on the two measures on information asymmetries, I create dummy variables indicating whether a market is high in opacity relative to the national average in that year.

I interact the three dummies with the treatment dummy of exposed banks as well as the post oil shock time dummy, and test whether the coefficient of the interaction term is significantly negative, meaning that liquidity-constrained banks cut more lending to borrowers in markets with higher information asymmetries. The results are shown in Table 6.

[Please insert Table 6 here]

I find that the transmitted drop in exposed banks' small business lending is more severe in unaffected markets where banks do not have branches, as well as markets with a higher percentage of opaque firms with higher asset intangibility and smaller sizes. The coefficient estimates are significantly negative for the interactions using all three dummy variables, meaning that banks cut small business lending more in places of a weak community linkage and of a higher level of information asymmetries. The economic significance is sizable considering the relative size of the coefficients on the interaction terms to the base effects. This result indicates that the information asymmetries faced by banks help propagate the negative liquidity shocks, as banks cut risky and costly lending more to borrowers in markets with a higher level of information asymmetry.

[4] Although the absolute level of asset intangibility could vary across firms of different sizes, the relative rank order/variation in asset intangibility across different industries should be largely consistent. As we are only focusing on the cross-sectional comparison in the asset intangibility across markets in each year, it is proper to use the industry-level asset intangibility from Compustat to extrapolate to the local market level based on the distribution of industry.

Evidence is consistent with the findings from DeYoung et al. (2008) who examined a sample of SBA loans, and found that distance increases the likelihood of borrower default. In this paper, I find that banks' lending to community through local branches still play an important role in local banks' lending to small businesses, especially during the economic downturn. Credit demands of local communities are better served by a bank when the banks' actual branch is located close by (e.g. Berger and Udell, 1994).

3.4 Can geographic dispersion hedge against economic shocks?

The oil price collapse causes a liquidity shortfall at the exposed banks, forcing them to cut lending to communities. On one hand, banks' dispersed branching network transmits the oil shocks, causing lending declines in areas that were not directly affected by the crisis. On the other hand, a dispersed branching network allows banks to get deposit funding from diversified sources, which help mitigate the liquidity shortfall, and limits the credit declines in unaffected areas. Do we observe more or less lending reduction among more geographically diversified banks? To test whether having a dispersed branching network will propagate or mitigate the effects of oil price collapse, I include a variable that indicates if a bank' branching network is sufficiently dispersed across different geographic regions. In particular, I define the dummy variable equals to one if the bank has deposit-taking branches operating in more than 10 counties, and interact it with the treatment dummy of exposed banks as well as the post oil shock time dummy. [5]

The result is shown in Column 4 of Table 6. Clearly, banks affected by the oil price collapse with a sufficient, geographically-dispersed branching network are able to hedge against the negative shocks and therefore mitigate the negative transmissions of credit supply to other

[5] I also tried alternative threshold defining whether a bank has dispersed branching networks and the results are consistent with the definition used in the main test.

unaffected areas. In fact, the size of the coefficient of the interaction term is large enough to cancel out the baseline effects. This finding is interesting because it suggests that the relationship between the size of banks' branching networks and the shock transmission is probably non-linear. While shocks get transmitted more often once a bank starts operations in more than one location, the ones with sufficiently diversified branching network seem to be able to digest shocks and barely transmit shocks across different regions.

3.5 How do healthy banks respond in a competitive market?

The oil price collapse in 2014-16 forced exposed banks to reduce credit supply to areas that were not affected. This period is featured as economic recovery with growing credit demand from firms. One interesting question is: what do healthy competing banks do in markets where the affected banks have decreased lending? Do they step in and satisfy the credit needs from local borrowers? Or worried about "winning over" bad-quality borrowers left out by the troubled banks (e.g. Rajan, 1992; Shaffer, 1998), did the healthy banks shy away from lending to these firms outright? To answer this question, I look at the lending behavior of banks that were not exposed to the oil crisis, but extended loans to borrowers in the same market as exposed banks.

In this section, I look at the healthy competing banks' lending in the same market where the exposed banks contracted lending. Although serving similar types of customers, these healthy banks do not have significant deposit funding exposures to oil regions, but instead are exposed to non-oil-concentrated counties that are contiguous to the shocked ones. Also, as neighboring counties are geographically closely located, they are likely subject to the *same* time-varying local market dynamics such as trends in economic development and shocks to the local economy.[6] This analysis could therefore be seen as a cross-sectional placebo test to address the concern that the effects of an oil price related deposit drop on exposed banks' lending may not be fully exogenous.[7]

[Please insert Table 7 here]

The results in Table 7 indicate that competing banks that operated in the same market as the exposed banks did not step in and increase the lending to communities that were affected by the decline in lending from exposed banks. This result also suggests that competing banks might be cautious in extending more credit to local small businesses even though the declining credit availability to these firms is clearly supply-driven. This finding of little effect on banks operating in neighboring counties also confirms that our main findings shown in Table 4 are most likely driven by the oil price shocks rather than by uncontrolled time-varying local market factors.

Next, I look at the mortgage market. It is interesting that competing banks increased the total amount of mortgage loans granted, but the overall approval rate decreased. This set of results suggests that although competing banks have been trying to beef up their mortgage lending capacity to local communities, it is challenging for them to meet all the needs from local mortgage borrowers. The contrast between the small business lending and mortgage lending is probably driven by information asymmetry which makes banks more hesitant to engage in costly monitoring of the local small businesses. Given that the competing banks is increasing mortgage lending, could their increased lending offset the cut by the exposed banks? At first glance, we see that the increase

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[6] The idea is that those counties/banks have similar observable/unobservable characteristics (e.g., growth trends, culture, etc.) to the ones exposed to the oil price shocks and can serve as a close placebo treatment group that mimics the behavior of the exposed banks in affected counties, except that they were not affected by the oil price shock.

[7] Although it is less of an issue since I look at banks' transmission of liquidity shocks to other markets, concerns remain about whether time-varying local market characteristics other than oil price shocks might affect liquidity inflows into banks' branches in the affected area, and banks' lending in unaffected areas. In all tests shown in the previous section, I have controlled for a wide range of local political and economic conditions as well as local market expansion rates and conducted the analyses using disaggregated county-level data, which all help minimize the endogeneity concerns.

in the mortgage loan provision is smaller than the decline in mortgage lending by exposed banks, suggesting that it is not sufficient for the banking sector to fully internalize the negative oil shock through competition, even in the event of idiosyncratic bank shock during a period of the economic expansion.

4. Conclusion

The 2014–16 oil shock featured a significant, sudden collapse in commodity prices that in many ways resembles the recent oil price collapse at the beginning of 2020. With the huge, unexpected swings in the global oil market becoming the new normal, it is important to understand its impact on local communities, and in this case, how the banking sector helps transmit negative shocks across regions. This shock provides a unique setting for researchers to study the interconnectivity of the banks and their liquidity management in the post-crisis period. While its impact is smaller in scale, the nature of the commodity price shock shares certain similarities with the devastating 2007–10 crisis. As many recent papers show, these adverse outcomes of the Great Recession were broadly felt across the economy. In the case of the oil shock, the drop in asset prices had significant adverse effects on certain oil-concentrated regions of the U.S., with a large number of smaller shale gas producers, who emerged from the shale gas boom in recent years, running into trouble. This paper looks at how the local banking sector was affected, and also studies one mechanism that propagated these local shocks into the broader economy—namely, the reduction in lending in many markets by banks that had unusually high exposure to the specific markets in which the adverse effects of the oil price collapse were most felt.

I first find that banks that have a high exposure to oil-concentrated areas that are hit by an oil price collapse experienced a significant decrease in short-term deposit inflows along with higher default and delinquency on existing loans. These exposed banks also incurred higher interest costs and booked a higher level of loan losses. Furthermore, facing severe liquidity pressure, banks tended to sell their most-liquid securities to replenish liquidity and satisfy the demand from depositors' withdrawals and lending.

Looking at the transmission channel, I find that "exposed" banks reduced their lending in local markets that had *not* experienced the adverse effects of the oil shock in counties with a minimum exposure to oil industries, as compared to less-exposed banks lending in the same markets. These results are both statistically and economically significant. I find that banks cut more in markets with higher levels of information asymmetries. I also investigate the role of geographic dispersion in hedging banks' liquidity risk, and find that exposed banks with a sufficiently geographically-dispersed branching network are able to hedge against the negative shocks, and therefore did not cut credit supply to other unaffected communities.

I further conduct a series of additional checks with the aim of addressing the competitive dynamics of the banks in time of the large oil shock. I look at whether competing banks that were not directly exposed to the oil shock will be able to pick up the business left out by the affected banks. I find that competing banks were hesitant to expand lending to local small businesses, only fulfilling part of the credit gap in the mortgage lending space. The contrast between the null result in small business lending and partial substitution in mortgage lending market suggests that competing banks might be more cautious in extending credit to local small businesses given the worry for the information asymmetries issues and, in particular, the effect of the "winner's curse" in this case. Not only does the result inform us on the competition among local banks, but it also strengthens the main results as it shows that similar banks operating in neighboring non-affected areas did not transmit the negative shocks.

The findings of this paper highlight the negative impact of the shock from the energy market, as well as the potential costs and benefits related to having a dispersed branch system in the banking sector. A banking system consisting of larger banks with geographically diversified branch networks could better hedge against the “hot-spot” risks that arise from certain regions and potentially help reduce default probability. In contrast, a system that consists of smaller banks operating in a smaller region may prevent the fire from spreading to other areas, which was one major cause of the last financial crisis. In addition, the results show that it is unrealistic to only rely on the market mechanism to address the issue of credit supply shortage caused by the oil shock. Due to the higher level of information asymmetry in small business lending and the limited resources they could deploy, healthy banks’ ability to substitute credit to borrowers of failing banks is quite limited.

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Table 1. Descriptive statistics

This table reports descriptive statistics of our sample. The sample covers the period January 2010 to December 2016. All variables are described in Appendix A1. The continuous variables are winsorized at the 1st and 99th percentiles. We report the means, medians, standard deviations, 25th percentiles, 75th percentiles, and the number of observations.

Variable	Mean	Median	Std. Dev.	P25	P75	N
Local market characteristics						
Local market size	176809	118525	156377	69572	194052	595683
Local bank competition	0.095	0.080	0.076	0.057	0.098	595683
Local per capita income	42704	41940	6266	38006	46393	595683
Average firm employment size	20.163	20.374	2.681	18.847	21.858	595683
Political balance	0.344	0.306	0.232	0.222	0.467	595683
Personal income growth rate	0.038	0.036	0.047	0.017	0.055	585904
Total population	263229	53031	715061	20777	198758	585904
Dummy higher assets intangibility	0.196	0	0.397	0	0	595683
Dummy higher fraction of small firms	0.162	0	0.369	0	0	595683
non-local market	0.766	1	0.423	1	1	604031
Bank characteristics						
Bank size	2426.6	172.3	42417.7	84.3	398.1	142293
Bank liquidity	0.114	0.082	0.101	0.047	0.145	141971
Bank ROA	0.005	0.005	0.006	0.003	0.008	141971
Bank capital ratio	0.179	0.158	0.074	0.135	0.197	141785
Demand deposit	0.145	0.135	0.087	0.081	0.193	142292
Amount of SME loans originated	12.566	0.228	411.477	0.038	1.358	604031
Total amount of mortgage loans granted	0.016	0.001	0.131	0.000	0.006	281649
Approval rate of the mortgage loans	0.567	0.596	0.306	0.348	0.810	281649
Ratio interest expense on deposit	0.004	0.003	0.003	0.002	0.006	142275
Loan loss provision	0.002	0.001	0.004	0.000	0.002	141678
Bank loan charge-offs	0.003	0.001	0.005	0.000	0.003	141678
Cash	0.116	0.082	0.106	0.044	0.149	142275
Treasury bonds	0.068	0.037	0.084	0.007	0.095	142293
MBS	0.079	0.048	0.093	0.002	0.121	142293
geographically dispersed branching	0.048	0	0.499	0	0	138973

Table 2. Effects of the oil shock on banks' deposit inflow and loan default

The table presents coefficient estimates from difference-in-differences (DD) analyses of the changes in exposed banks with significant operation in affected counties after the oil shock hit. The dependent variables capture banks' deposit inflow, and loan charge-offs. The coefficients on the interaction term of Exposed banks× Post oil price collapse capture the DD estimate of the effect of the oil shock on banks. The analyses are conducted using quarterly data that cover the period from January 2010 to December 2016. All other control variables are lagged one year prior to the oil shock and defined in Table 1. Fixed effects are denoted at the bottom of the table, and robust standard errors are clustered at the county level and are shown in parentheses. *, **, and *** denote an estimate that is statistically significantly different from zero at the 10%, 5%, and 1% levels, respectively.

Panel A. bank deposit and loan quality

Dependent Variable:	**Demand deposits**			**Bank loan charge-offs**		
	(1)	(2)	(3)	(4)	(5)	(6)
Exposed banks	0.650***	0.707***	0.908***	-0.031	-0.049**	-0.054**
	(0.181)	(0.183)	(0.221)	(0.020)	(0.020)	(0.027)
***Exposed banks* × Post oil price collapse**	-0.681***	-0.588***		0.109***	0.059***	
	(0.171)	(0.172)		(0.014)	(0.013)	
Treated × D-2			-0.142			-0.001
			(0.116)			(0.019)
Treated × D-1			-0.308			0.009
			(0.170)			(0.021)
Treated × D			-0.121			0.043*
			(0.206)			(0.022)
Treated × D+1			-0.576**			0.054**
			(0.242)			(0.023)
Treated × D+2			-1.610***			0.093***
			(0.263)			(0.025)
Bank controls						
Bank size $_{t-1}$		-0.953***	-0.927***		0.385***	0.384***
		(0.322)	(0.322)		(0.039)	(0.039)
Bank ROA $_{t-1}$		36.930***	36.468***		-21.360***	-21.344***
		(7.690)	(7.697)		(1.045)	(1.046)
Bank capital ratio $_{t-1}$		0.704	0.669		-0.807***	-0.805***
		(1.973)	(1.971)		(0.183)	(0.183)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Within-sample R^2	0.888	0.888	0.888	141,672	141,168	141,168
Number of observations	142,287	141,779	141,779	0.480	0.509	0.509

Table 3. Effects of the oil shock on banks' liquidity management practices

The table presents coefficient estimates from difference-in-differences (DD) analyses of the changes in exposed banks with significant operation in affected counties after the oil shock hit. The dependent variables capture banks' interest expense, loss provisions, and security-holding positions. The coefficients on the interaction term of Exposed banks× Post oil price collapse capture the DD estimate of the effect of the oil shock on banks. The analyses are conducted using quarterly data that cover the period from January 2010 to December 2016. All other control variables are lagged one year prior to the oil shock and defined in Table 1. Fixed effects are denoted at the bottom of the table, and robust standard errors are clustered at the county level and are shown in parentheses. *, **, and *** denote an estimate that is statistically significantly different from zero at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Dependent Variable:	Ratio interest expense on deposit	Loan loss provision	Cash	Treasury bonds	MBS
Exposed banks	-0.030***	-0.041**	0.610*	0.274	-0.234
	(0.005)	(0.019)	(0.322)	(0.254)	(0.259)
***Exposed banks* × Post oil price collapse**	0.048***	0.090***	-0.640***	-0.350*	-0.225
	(0.004)	(0.011)	(0.228)	(0.182)	(0.239)
Bank controls					
Bank size $_{t-1}$	0.152***	0.365***	-3.131***	0.278	-0.283
	(0.009)	(0.036)	(0.387)	(0.197)	(0.281)
Bank ROA $_{t-1}$	-1.953***	-10.297***	-69.313***	7.953	-14.086*
	(0.261)	(0.910)	(10.588)	(6.440)	(7.635)
Bank capital ratio $_{t-1}$	-0.259***	-0.167	5.318**	12.795***	15.165***
	(0.050)	(0.165)	(2.422)	(1.604)	(1.937)
Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Within-sample R^2	0.860	0.417	0.811	0.869	0.886
Number of observations	141,760	141,168	141,760	141,780	141,780

Table 4. Exposed banks' small business lending to counties without significant oil industry presence

The table presents coefficient estimates from difference-in-differences (DD) analyses of the changes in lending in exposed banks with significant operation in affected counties after the oil shock hit. The dependent variables capture the amount of banks' small business-lending to local communities that were not affected directly by the oil shocks. The coefficients on the interaction term of Exposed banks × Post oil price collapse capture the DD estimate of the effect of the oil shock on banks' lending in counties that were not affected. The analyses are conducted using yearly data that cover the period from January 2010 to December 2016. All other control variables are lagged one year prior to the oil shock and defined in Table 1. FE are denoted at the bottom of the table, and robust standard errors are clustered at the county level and are shown in parentheses. *, **, and *** denote an estimate that is statistically significantly different from zero at the 10%, 5%, and 1% levels, respectively.

Dependent Variable:	**Total amount of small business loans originated**			
	(1)	(2)	(4)	(4)
Exposed banks	0.046***	0.023***	0.022***	0.022***
	(0.006)	(0.007)	(0.007)	(0.007)
Exposed banks × Post oil price collapse	-0.038***	-0.038***	-0.045***	-0.038***
	(0.004)	(0.004)	(0.005)	(0.004)
State controls				
Local market size $_{t-1}$				0.000
				(0.000)
Local bank competition $_{t-1}$				0.064
				(0.040)
Local per capita income $_{t-1}$				-0.000***
				(0.000)
Average firm employment size $_{t-1}$				-0.012***
				(0.004)
Political balance $_{t-1}$				0.025**
				(0.011)
County controls				
Personal income growth rate $_{t-1}$				-0.069***
				(0.014)
Total population $_{t-1}$				-0.000
				(0.000)
Bank controls				
Bank size $_{t-1}$		0.171***	0.180***	0.172***
		(0.007)	(0.007)	(0.007)
Bank liquidity $_{t-1}$		0.313*	0.828***	0.312*
		(0.180)	(0.189)	(0.184)
Bank ROA $_{t-1}$		-0.002	-0.002	-0.002
		(0.003)	(0.003)	(0.003)
Bank capital ratio $_{t-1}$		0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
County FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
County FE× Year FE	No	No	Yes	No
Within-sample R^2	0.368	0.357	0.341	0.355
Number of observations	599,458	548,165	535,757	535,772

Table 5. Exposed banks' retail mortgage lending to counties without significant oil industry presence

The table presents coefficient estimates from difference-in-differences (DD) analyses of the changes in lending in exposed banks with significant operation in affected counties after the oil shock hit. The dependent variables capture the amount of banks' mortgage-lending to local communities that were not affected directly by the oil shocks. The coefficients on the interaction term of Exposed banks × Post oil price collapse capture the DD estimate of the effect of the oil shock on banks' lending in counties that were not affected. The analyses are conducted using yearly data that cover the period from January 2010 to December 2016. All other control variables are lagged one year prior to the oil shock and defined in Table 1. FE are denoted at the bottom of the table, and robust standard errors are clustered at the county level and are shown in parentheses. *, **, and *** denote an estimate that is statistically significantly different from zero at the 10%, 5%, and 1% levels, respectively.

Dependent Variable:	**Total amount of mortgage loan granted**	**Approval rate of the mortgage loans**
	(1)	(2)
Exposed banks	0.005***	-0.001
	(0.000)	(0.003)
Exposed banks × Post oil price collapse	-0.005***	-0.009***
	(0.000)	(0.002)
State controls		
Local market size $_{t-1}$	-0.000**	0.000**
	(0.000)	(0.000)
Local bank competition $_{t-1}$	-0.006	-0.061**
	(0.004)	(0.027)
Local per capita income $_{t-1}$	-0.000***	0.000
	(0.000)	(0.000)
Average firm employment size $_{t-1}$	0.001	0.003*
	(0.000)	(0.002)
Political balance $_{t-1}$	-0.002**	0.016**
	(0.001)	(0.006)
County controls		
Personal income growth rate $_{t-1}$	-0.003	0.030**
	(0.002)	(0.014)
Total population $_{t-1}$	-0.000***	0.000
	(0.000)	(0.000)
Median applicant income $_{t-1}$	-0.000***	0.000***
	(0.000)	(0.000)
Bank controls		
Bank size $_{t-1}$	0.007***	-0.042***
	(0.001)	(0.004)
Bank liquidity $_{t-1}$	0.093***	-0.176
	(0.026)	(0.152)
Bank ROA $_{t-1}$	0.010***	0.094***
	(0.004)	(0.030)
Bank capital ratio $_{t-1}$	-0.022***	-0.273***
	(0.002)	(0.012)
County FE	Yes	Yes
Bank FE	Yes	Yes
Year FE	Yes	Yes
Within-sample R^2	0.223	0.264
Number of observations	245,834	245,988

Table 6. Variations in the decline of exposed banks' credit supply to local communities

The table presents coefficient estimates of differential spillover effects of the oil shock on banks' small business lending activities. The dependent variables capture the total amount of banks' small business lending to local communities that were not affected directly by the oil shocks. The coefficients on the triple interaction terms capture the differential effect of market information asymmetries and bank characteristics. The analyses are conducted using yearly data that cover the period from January 2010 to December 2016. All other control variables are lagged one year prior to the oil shock and defined in Table 1. Fixed effects are denoted at the bottom of the table, and robust standard errors are clustered at the county level and are shown in parentheses. *, **, and *** denote an estimate that is statistically significantly different from zero at the 10%, 5%, and 1% levels, respectively.

Dependent Variable:	**Total amount of small business loans originated**			
	(1)	**(2)**	**(3)**	**(4)**
Exposed banks	0.014*	0.008	-0.179***	-0.035*
	(0.007)	(0.007)	(0.020)	(0.019)
Exposed banks × After Shock	-0.033***	-0.030***	0.045***	-0.027**
	(0.005)	(0.005)	(0.009)	(0.013)
Exposed banks × After Shock × high assets intangibility	-0.036**			
	(0.017)			
Exposed banks × After Shock × high fraction of smaller firms		-0.047**		
		(0.021)		
Exposed banks × After Shock × non-local market			-0.077***	
			(0.011)	
Exposed banks × After Shock × geographically dispersed branching				0.038***
				(0.014)
State controls				
Local market size $_{t-1}$	0.000	0.000	0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Local bank competition $_{t-1}$	0.056	0.056	0.034	0.099**
	(0.040)	(0.040)	(0.036)	(0.039)
Local per capita income $_{t-1}$	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Average firm employment size $_{t-1}$	-0.015***	-0.013***	-0.010**	-0.009**
	(0.004)	(0.004)	(0.004)	(0.004)
Political balance $_{t-1}$	0.029***	0.028**	0.020**	0.019*
	(0.011)	(0.011)	(0.010)	(0.011)
County controls				
Personal income growth rate $_{t-1}$	-0.064***	-0.066***	-0.028**	-0.049***
	(0.014)	(0.014)	(0.012)	(0.014)
Total population $_{t-1}$	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Bank controls				
Bank size $_{t-1}$	0.171***	0.171***	0.192***	0.173***
	(0.007)	(0.007)	(0.009)	(0.008)
Bank ROA $_{t-1}$	0.301	0.292	1.667***	-0.027
	(0.184)	(0.183)	(0.187)	(0.208)
Bank capital ratio $_{t-1}$	-0.002	-0.002	-0.002	-0.002
	(0.003)	(0.003)	(0.003)	(0.002)
Bank liquidity $_{t-1}$	0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
County FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Within-sample R^2	0.355	0.355	0.595	0.345
Number of observations	535,772	535,772	535,772	479,590

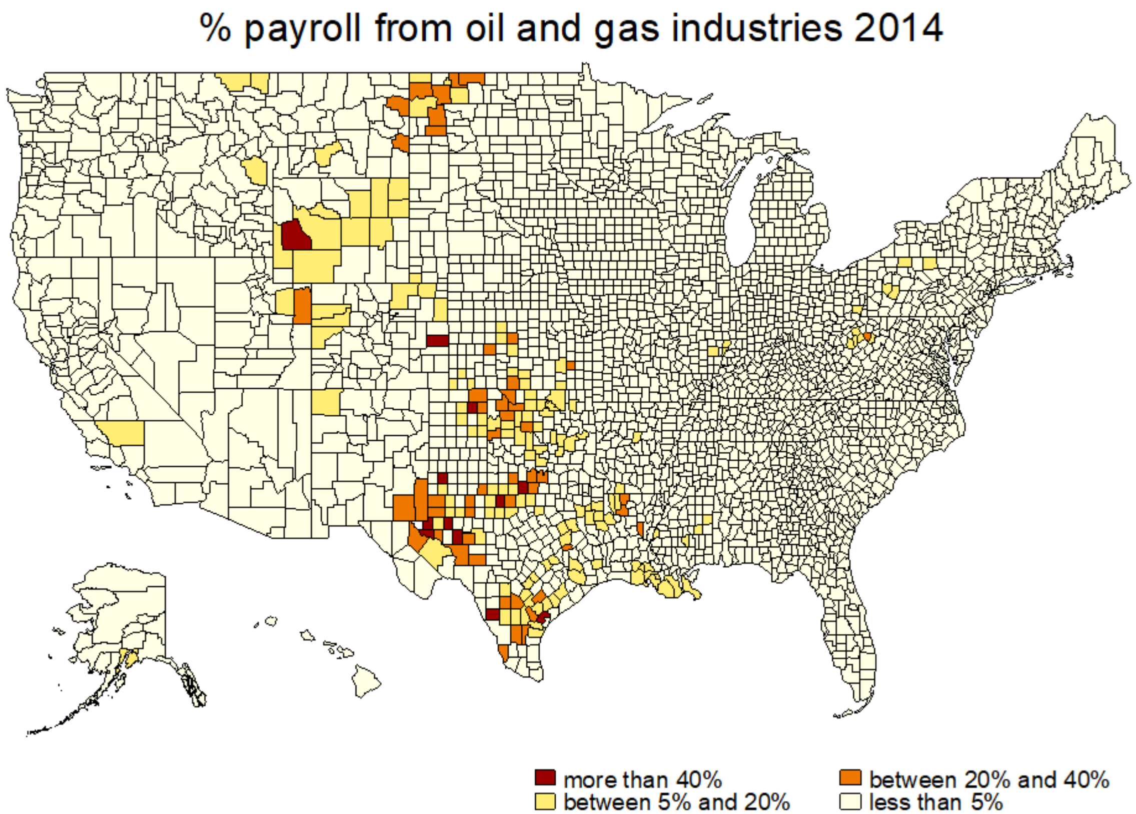
Table 7. Healthy competing banks' lending to counties without significant oil industry presence

The table presents coefficient estimates from difference-in-differences (DD) analyses of the changes in lending in healthy competing banks with significant operation in unaffected neighboring counties after the oil shock hit. The dependent variables capture the amount of banks' small business and mortgage-lending to local communities that were not affected directly by the oil shocks. The coefficients on the interaction term of capture the DD estimate of the effect of the oil shock on banks' lending in counties that were not affected. The analyses are conducted using yearly data that cover the period from January 2010 to December 2016. All other control variables are lagged one year prior to the oil shock and defined in Table 1. Fixed effects are denoted at the bottom of the table, and robust standard errors are clustered at the county level and are shown in parentheses. *, **, and *** denote an estimate that is statistically significantly different from zero at the 10%, 5%, and 1% levels, respectively.

	(1)	**(2)**	**(4)**
Dependent Variable:	Total amount of small business loans originated by competing banks in unaffected neighboring counties	Total amount of mortgage loan granted by competing banks in unaffected neighboring counties	Approval rate of the mortgage loans by competing banks in unaffected neighboring counties
Placebo-oil shock hit banks	-0.012***	-0.000***	0.011***
	(0.003)	(0.000)	(0.002)
Placebo-oil shock hit banks × Post oil price collapse	0.002	0.003***	-0.007***
	(0.004)	(0.000)	(0.002)
State controls			
Local market size $_{t-1}$	-0.000	-0.000**	0.000*
	(0.000)	(0.000)	(0.000)
Local bank competition $_{t-1}$	0.066*	-0.004	-0.059**
	(0.040)	(0.003)	(0.027)
Local per capita income $_{t-1}$	-0.000***	-0.000***	0.000
	(0.000)	(0.000)	(0.000)
Average firm employment size $_{t-1}$	-0.012***	0.001*	0.004*
	(0.004)	(0.000)	(0.002)
Political balance $_{t-1}$	0.027**	-0.002*	0.017***
	(0.011)	(0.001)	(0.006)
County controls			
Personal income growth rate $_{t-1}$	-0.066***	-0.002	0.031**
	(0.013)	(0.002)	(0.014)
Total population $_{t-1}$	-0.000	-0.000***	0.000
	(0.000)	(0.000)	(0.000)
Median applicant income $_{t-1}$		-0.000***	0.000***
		(0.000)	(0.000)
Bank controls			
Bank size $_{t-1}$	0.171***	0.007***	-0.042***
	(0.007)	(0.001)	(0.004)
Bank liquidity $_{t-1}$	0.164	0.092***	-0.209
	(0.188)	(0.026)	(0.152)
Bank ROA $_{t-1}$	-0.002	0.009**	0.097***
	(0.003)	(0.004)	(0.030)
Bank capital ratio $_{t-1}$	0.000	-0.030***	-0.299***
	(0.000)	(0.002)	(0.011)
County FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Within-sample R^2	0.355	0.223	0.471

Number of observations	535,772	245,834	245,834

Figure 1. Oil-concentrated counties measured by the percentage of a county's payroll income that is from the oil industry



Note: This figure identifies the oil-concentrated counties based on the percentage of a county's payroll income that is from the oil industry using the FDIC summary of deposit database and the Census County Business Patterns database. Lighter yellow color indicates lower percent of payroll income from the oil and gas industry in the county, and darker orange and red indicates a higher percentage of local payroll income from the oil and gas industry.

Appendix A1. Definitions of the main variables

This table provides an overview of variables used in the paper, as well as the definition and corresponding data sources.

TYPE	Variable	Definition
Local market characteristics *(source: U.S. Bureau of Economic Analysis, Bureau of Labor Statistics, Census's Statistics of U.S. Businesses, County Business Patterns database, Compustat, FDIC Summary of Deposit, House of Representatives, National Establishment Time-Series database)*		
	Local market size	Total number of establishment of the target state (in millions)
	Local bank competition	Herfindahl-Hirschman Index (HHI) calculated based on the deposit size of the local banks of the target state
	Local per capita income	Per capita income of the target state (in thousands $)
	Average firm employment size	Average number of employees a firm has in the target state
	Political balance	Percentage of U.S. House of Representatives members who are Democrats in the target state
	Personal income growth rate	Percentage change in the personal income of the target county
	Total population	Total population of the target county (in millions)
	Dummy higher assets intangibility	Dummy variable equals one if the local market asset intangibility index is higher than the average assets intangibility index across all market in that year; it equals zero otherwise
	Dummy higher fraction of small firms	Dummy variable equals one if the percentage of small businesses in local market is higher than the average percentage of small businesses across all areas in that year; it equals zero otherwise
	Non-local market	Dummy variable equals to one if the bank does not have a branch in the county
Exposure to liquidity shock measures *(source: FDIC Summary of Deposit, County Business Patterns database)*		
	Exposed bank	Dummy variable that equal to one if the bank is among top 20 percentile of all banks in terms of the relative importance of banks' aggregated demand deposit inflow coming from the oil and gas concentrated counties and zero otherwise
Bank characteristics and loan provisioning *(source: FDIC Call report, HMDA database, FDIC Summary of Deposit, FFIEC Community Reinvestment Act database)*		
	Bank size	Logarithm of bank total assets (in billions $) (the actual variable used in the analyses are log transferred)
	Bank liquidity	Percentage of cash to bank total deposit
	Bank ROA	Percentage of annualized net income to total assets
	Bank capital ratio	Percentage of the sum of bank tier 1and tier 2 capital to total assets
	Demand deposit	Percentage of the sum of demand deposit of all bank branches to total assets
	Amount of SME loans originated	Logarithm of annual aggregated amount of newly originated SME loans by an incumbent bank in one tract with original amounts of $1 million or less that were reported on the institution's Call Report or TFR as either "Loans secured by nonfarm or nonresidential real estate" or "Commercial and industrial loans"
	Total amount of mortgage loan granted	Logarithm of annual aggregated amount of mortgage loans granted by a bank in the target county

Total amount of mortgage loan applied	Logarithm of annual aggregated amount of mortgage loans applications a bank received in the target county
Approval rate of the mortgage loans	Annual aggregated amount of mortgage loans granted in the target county as a percentage of the yearly aggregated amount of mortgage loans application filed within the county (in percentage points)
Ratio interest expense on deposit	Ratio of interest expense to total size of deposit
Loan loss provision	Ratio of allowance for loan and lease loss to loans and leases held for sale of banks
Bank loan charge-offs	Ratio of total amount of loan charge offs to loans and leases held for sale of banks
Cash	Ratio of total amount of cash to deposit
Treasury bonds	Ratio of treasury and agency debt to bank total assets
MBS	Ratio of mortgage backed securities to bank total assets
Geographically dispersed branching	A dummy variable that takes value of one if the bank has dispersed branches operated at least in ten different counties