Bank Branching Networks and Geographic Contagion of Oil Price Shocks

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Abstract

This paper studies the role of branching networks of U.S. regional banks as a transmission channel that propagates commodity price shocks across the country. The recent oil price collapse adversely affected regions with a high concentration of its workforce in the oil and gas industry, contributing to a higher rate of loan defaults and lower deposit inflow into local bank branches. I show that smaller banks that operate in counties most affected by the oil price collapse were forced to sell their liquid asset holdings and contracted their credit to small businesses and mortgage borrowers in counties that were not affected by falling oil prices, relative to healthy banks. The negative contagion effect is stronger for smaller banks with less-liquid asset reserves. I further show that exposed banks contracted lending more in counties with the presence of a higher percentage of small businesses, indicating that those borrowers could be disproportionally affected in times of liquidity scarcity.

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1. Introduction

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, resulting in a more integrated credit market with increased local bank competition and a greater level of service, contributing to local economic growth (Jayaratne and Strahan, 1996; Guiso, Sapienza, and Zingales, 2004; Huang, 2008). However, the recent crisis also alarmingly revealed 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. On the one hand, the presence of a geographically dispersed branching network mitigates adverse shocks and economic downturn being concentrated in one region. On the other hand, a dispersed branch network allows a negative economic downturn to be transmitted to other unaffected areas of the economy, thus decreasing the credit supply to borrowers in those areas. In this paper, I study the role of the bank branch network in propagating commodity price changes in one region of the U.S. to the entire economy.

The recent oil price collapse in 2014 to 2016 provides a unique opportunity to study the geographic transmission of financial shocks across regions in the post-crisis period. Unlike the Global Financial Crisis that originated in the domestic financial sector with a detrimental effect, the recent oil price collapse was largely an exogenous shock that first affected the real economy. Instead of a systemic shock that affected the whole sector through banks' cross-holdings of mortgage-backed securities, the oil shock was an idiosyncratic shock that originated from the oil and gas (O&G) production sectors that were mostly concentrated in certain areas of the country while the economies in the rest of the country were 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 hit by the commodity price shocks. In this paper, I use the 2014 drop 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 O&G industry, or O&G-concentrated areas. Exploiting the large geographic variation in the exposure to the oil shock, I look at counties that were not affected by the oil price drop, and I compare changes in lending behavior by diversified banks with and without significant branches located in the O&G-concentrated areas.

First, I investigate the impact of regional economic downturns on banks that operate in those areas. Based on data on banks' deposit-taking branch locations, I identify banks that collect deposits and potentially lend to regions exposed to adverse oil shocks. The oil price shock hit an O&G-concentrated region's economy, leading to a decline in local deposit inflow from residents and oil firms, an increasing probability of delinquency and default in O&G loans, and the drainage of banks' liquidity. I further investigate whether firms change the mix of securities holdings to replenish liquidity and meet the demand from depositors and firms in withdrawing deposits and borrowing loans. Under liquidity pressure, do banks first sell more-liquid assets, or do they hoard such assets and only sell illiquid assets? Are banks more willing to sell less-liquid assets given that they will probably be sold at a lower discount rate given the overall bullish financial market? 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 banks' branching networks. Studies show that a deposit windfall to banks due to shale gas discovery was transmitted through the branching networks (Gilje et al., 2016). This study focuses on whether adverse regional economic shocks are transmitted to other geographical areas through banks' branch networks. I conjecture negative liquidity contagion effects from areas directly affected by oil industry downturns to areas not hit by the downturn. In addition, I test whether certain bank and market characteristics exacerbate the cross-geographic transmission of negative shocks.

The main results reveal that banks that were exposed to the oil shock through their operations in O&G-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 banks exposed to the oil price shock sold a significant amount of assets to replenish liquidity shortfalls following the liquidity drainage, and that the decrease in holding is most significant for securities that are most liquid. Furthermore, I find banks that were exposed to the oil shock substantially contracted their lending in counties that did not experience the negative shocks from oil price decline. In particular, exposed banks propagate the drop in liquidity to unaffected counties and cut their lending to local small businesses by $0.9 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 in the approval rates of mortgage applicants. Further analyses show that exposed smaller banks with less-liquid assets cut lending the most compared to larger banks with more-liquid assets.

Next, I conduct various placebo tests with factitious oil shocks in neighboring counties that are adjacent to the counties that were hit by the oil shock, and the results substantiate the validity of the empirical results and increase confidence in the interpretation of the main finding. In addition, I find some evidence that healthy banks operating in neighboring counties were able to increase their lending to small businesses as well as to mortgage borrowers. Overall, the evidence highlights the role of banks' branching networks as the transmission channel that propagates negative liquidity shocks across different geographic areas, especially to markets with greater opaqueness.

This project is related to two 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 that were 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 investigates how the banking industry transmits economic shocks to certain geographic areas to other credit markets by focusing on banks' different exposure to regional shocks.

Second, this paper is also 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 I investigate their liquidity-management behavior. The combination of regional liquidity shocks and an overall bullish security market provides a unique test 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 therefore provides new evidence to the discussion by showing that when facing liquidity pressure, banks mostly sell liquid assets.

Last but not the least, this paper is related to the research on the impact of commodity 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. Different from Gilje et al. (2016), this paper looks at banks' exposure to negative liquidity shocks, which are arguably more constraining than positive windfalls, and investigates how they manage the shortfalls. Bidder et al. (2017) also look at oil price collapse as a shock to the 30 largest banks with O&G loan portfolios on their balance sheets and investigate how it affects loans of other borrowers of 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 behavior of banks with higher deposit exposure to O&G-concentrated regions. To be specific, do banks exposed to adverse liquidity shocks end up selling more-liquid securities or do they hoard liquidity and sell the less-liquid assets?

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

2. Data

2.1 Banks' exposure to O&G price shocks

To measure banks' liquidity exposure to O&G price shocks, I collect the location information of banks' deposit-taking branches as well as the concentration O&G industry workforce concentration in each location. I calculate the percentage of a county's workforce that is in the O&G industry and define a county as sensitive to O&G price shocks if a significant proportion of the local labor force in the county works in the O&G industry. Next, I constructed banks' exposure of liquidity risk to each county using data collected 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. It provides annual updates on detailed branch characteristics such as the address, geographic coordinates, deposit quantities, date of establishment, and ownership changes following M&A. I calculate the deposit-weighted liquidity exposure to O&G-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 from 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 considered a 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.

To capture the changes in exposed banks' provisions of loans in markets that were not affected by the oil shock, I collect data on small business loans originated by exposed banks. Focusing on small business loans therefore ensures that I capture the actual shifts in exposed banks' lending to the local market. Because of the opaqueness of their business conditions, small business borrowers tend to rely on local relationship lenders. Large firms, on the other hand, suffered less from the information opaqueness and were more likely to arrange financing through bond issuance or large loans that are often syndicated through a large number of financial institutions. 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 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. The CRA data provide a complete record of new lending quantities at the bank, county, and year levels. Next, 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.

3. Empirical Results

3.1. The effects of oil price collapse on O&G-concentrated counties

First, I look at the effects of oil price collapse on counties with significant exposure to O&G production. A sharp decline in oil prices reduces revenue and profitability for firms that are involved in O&G extraction activities, as well as for firms that supply equipment to oil producers, forcing firms to cut production or slash employment, both of which are likely to lead to a reduction of deposit flow to banks located nearby. 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 development in the fracking technology. In time of a large drop in the energy price, I conjecture that banks in geographic areas with a large share of O&G producers will experience a severe drop in deposit inflows.

I use a difference-in-differences (DD) approach to study the effects of an oil price drop on deposits taken in the local market. The dependent variable *total amount of deposit* measures the amount of deposit inflow to all branches in a county in a year. Based on counties' exposure to the

O&G industry measured by the percentage of the workforce in that sector as identified in section 2, I set the value of the DD treatment indicator variable *O&G-concentrated counties* equal to one if the percentile of the O&G industry workforce is among the top 5 percentile among all counties across the U.S. and zero otherwise, and I interact it with the oil shock variable *oil price collapse*. I regress the total amount of deposits into local banks. The model specification is

$$total\ amount\ of\ deposit_{c,t} = \alpha + \beta_1 oil\ and\ gas\ concentrated\ counties_{c,t-1} \times oil\ price\ collapse_t$$
$$+\beta_2 Controls_{c,t-1} + \omega_c + \mu_t + \varepsilon_{ct} \quad (1)$$

Regression (1) tests the effect of the oil price collapse on deposit inflow into banks located within O&G-concentrated counties, where *c* represents county, and *t* represents year. The total amount of deposit inflow is the measure of the county and year level, the interaction term between O&G-concentrated counties and oil price collapse is the DD indicator, and β_1 is the DD estimate that captures the effects of oil price collapse on the deposit inflow into banks within the county. I include variables that control for the local economic, political, and market characteristics. For instance, I control for the wealth level and business condition of the local market using the local per capita income, local bank competition using the Herfindahl-Hirschman index (HHI) of banks' deposit size, and 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 amount of deposits 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).

Table 2 reports the DD regression results. It is clear that there is a significant negative treatment effect of the DD indicator on deposit inflow into banks within O&G-concentrated counties. The coefficient is statistically significant at the 1% level, and the baseline regression result indicates that the oil price collapse, on average, leads to a $0.15 million decrease in the total amount of deposits that go into the local banking sector in each county every year from 2014 to 2016. Considering the average total amount of deposits taken by banks in a county, the economic significance is sizable.

3.2 Banks' exposure to oil price collapse

I identify the exposure of banks' liquidity to oil price collapse by looking at their deposit-taking branch location. Having a large percentage of deposits from O&G-concentrated counties leads to a more severe drainage of liquidity sources. I calculate the weighted exposure of banks' exposure to O&G industries as

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

I use a DD approach to study the effects of an oil price drop on affected banks and investigate how they transmit liquidity shortfalls to other counties without exposures to O&G price shocks. Based on the O&G 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 O&G counties and zero otherwise, and I interact it with the oil shock variable *oil price collapse*. I first study the effects of oil price collapse on affected banks and focus on the changes to key characteristics of affected banks, such as deposits, loan loss provision, and holdings of different securities. Banks that have a high exposure to O&G-concentrated areas that are hit by an oil price collapse are likely to see a decrease in short-term deposit inflows and higher loan loss provisioning, both of which add pressure to banks' liquidity management. There are three approaches banks may take to replenish their liquidity: increase the interest rate on deposits to 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. First, I focus on the changes in key characteristics of exposed banks such as deposit amount, cost of deposits taken, loan loss provisioning, and charge-offs, as well as holdings of different types of securities. I regress the key variables on the treatment dummies, controlling for the other factors that might affect banks. The model specification is

$$Bank\ characteristics_{b,t} = \alpha + \beta_1 exposed\ bank_{b,t} \times oil\ price\ collapse_t + \beta_2 Controls_{b,c,t-1} + \omega_{b,c} + \mu_t + \varepsilon_{b,c,t} \qquad (2)$$

Table 3 reports the within-bank level response of various key indicators to the liquidity drainage from the oil shock. First, looking at the funding side, it is clear that the amount of short-term deposits has significantly declined, whereas the costs/interest payments on deposits has gone up at banks that are exposed to the O&G industry following the collapse of the O&G price. This observation is consistent with the results shown in Table 2, suggesting that banks relying on O&G-concentrated areas experienced significant decreases in liquidity and struggled to increase interest costs to maintain/attract deposit inflows. In the next two columns, we see that exposed banks also provisioned much higher loan losses and incurred a higher level of charge-off rates, indicating that banks with branches in O&G-concentrated areas have been preparing/writing off a higher amount of problematic loans after the O&G price collapse. Combining the results shows that exposed banks experienced liquidity shortfalls and incurred higher deposit expenses and higher amounts of troubled loans.

Column 5-7 show how banks change security holdings after being hit by liquidity shocks. 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. 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. In particular, after the oil price collapse, exposed banks are expected to lower their holdings of cash and Treasury bonds by 0.575 percentage point and 0.448 percentage point, respectively. 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. This result 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 their liquidity management practices.

3.3 Transmission of liquidity shocks through banks' branching networks

Facing shortfalls, banks choose to sell more-liquid assets first to replenish liquidity. Next, we focus on exposed banks' loan supply and examine banks' role in transmitting liquidity shocks from O&G-dependent areas to other geographic areas through lending. I look at exposed banks' lending activities in counties that are not exposed to the O&G industry after negative commodity prices hit the exposed banks. I also look at banks' lending to both small business borrowers as well as 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-O&G-concentrated areas that were not hit by the oil price collapse. The model specification is

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

Where we evaluate changes in exposed banks' originations of CRA and mortgage loans to borrowers outside the O&G-concentrated areas, where *c* represents the county, *b* represents the bank, and *t* represents the year. Table 4 reports the regression results. Exposed bank branches decreased the amount of small business loans and mortgage loans originated in non-O&G-concentrated counties after the oil price collapse in the U.S. On average, exposed banks decreased small business lending, including \$0.9 million in small business loans and \$0.013 million in mortgage loans, after their liquidity was shocked 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. I further look at the approval rate of mortgage loans to identify whether the decrease in local lending activity mainly came from banks' liquidity shortfalls. Column 3 shows that the approval rate of mortgage loans by exposed banks also experienced a large drop (2.4%) following the oil price decline, and the result is also significant economically.

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

3.4 Liquidity shocks and information asymmetries in corporate lending

Information asymmetries in the market are one of the key reasons for the existence of banks as financial intermediaries, and it is both risky and costly for banks to lend in a market with a higher level of information asymmetries. In this section, I investigate whether banks facing liquidity constraints cut lending more in markets featuring higher information asymmetries. The level of information asymmetry is higher in markets with a higher percentage of small-sized firms or firms with higher asset intangibility, or markets where banks do not have a local branch that collects information.

First, 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.[2] 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. For the 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. For the third measure, 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

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[2] 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.

helps banks to collect information and mitigate information asymmetries. I compare banks' transmission of liquidity shocks to borrowers in markets in which they have branches versus in markets in which they do not have branches.

Based on the three measures, I create three dummy variables indicating whether a market is high in opacity relative to the national average in that year. I interact the three information asymmetry dummies with the treatment dummy of exposed banks as well as the post oil shock time dummy, and I 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 5.

I find that the transmitted drop in exposed banks' small business lending is more severe in unaffected markets with severe information asymmetries, characterized by a higher percentage of opaque firms with higher asset intangibility and smaller sizes, or markets where banks do not have branches. The coefficient estimates are significantly negative for the interactions using all three dummy variables. The economic significance is sizable considering the relative size of the coefficients on the interaction terms to the base effects. This result is consistent with my conjecture and indicates that the level of information asymmetries faced by banks helps propagate the negative liquidity shocks transmitted to borrowers through lending.

To decrease the liquidity drainage caused by the oil price shocks, exposed banks transmit negative liquidity shocks to areas that were not hit by oil price shocks, and they cut risky and costly lending more to borrowers in markets with a higher level of information asymmetry. I further test if smaller banks with lower levels of liquidity propagate the transmission of liquidity shocks to other areas, and the results are shown in Columns 4-5 of Table 5. It is clear that when facing liquidity shortfalls from oil price collapse, exposed banks with little cash as liquidity reserve or banks of smaller size transmit negative shocks through cutting a higher amount of lending to borrowers in unaffected regions.

3.5 Robustness tests with unaffected counties without exposure to the O&G industry

A potential concern is that the effects of an oil price related deposit drop on exposed banks may not be fully exogenous. Although it is less of an issue since we 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.

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 this section, we include an additional falsification test to further address this concern. I examine banks with branches located in non-O&G-concentrated counties that are contiguous to the actual O&G-concentrated counties used in the analyses. This test can be viewed as a cross-sectional placebo test; 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. If unobserved/uncontrolled time-varying local dynamics drive the deposit inflow, we should expect the deposit inflow and bank transmission of liquidity shocks to move in a similar fashion as that observed in Table 4 when the bank branches in neighboring counties were hit by the decline in oil prices. In contrast, if it is the actual oil price shock that shifted deposit inflow into bank branches in the exposed counties, we should not expect a negative impact on banks' deposits taken and liquidity transmission in counties that were not hit by the oil price collapse. Next, I look at the transmission of placebo liquidity shocks by banks located in neighboring counties. I conjecture that banks operating in neighboring counties did not face a liquidity shortage caused by the oil shock and therefore did not decrease lending in other counties.

The results in Table 6 fail to reveal a statistically significant negative impact of placebo shocks, and deposit and lending in neighboring counties were not negatively affected similarly as they were in the focal county. Similarly, results in Table 7 show that banks operating in counties neighboring those affected by the placebo shock did not decrease loan supply to other markets given that their liquidity was not negatively affected by O&G price collapse. Quite the contrary, there is some evidence that healthy banks operating in neighboring counties were able to increase their lending to small businesses as well as to mortgage borrowers. This finding of little effect on banks operating in neighboring counties further confirms that our main findings are most likely driven by the O&G price shocks rather than by uncontrolled time-varying local market factors.

4. Conclusion

The 2014–16 oil price collapse featured a significant, sudden drop in commodity prices. The drop in asset prices had significant adverse effects on certain O&G-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. The 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, while these adverse outcomes of the Great Recession were broadly felt across the economy, their causes were more localized, with real estate prices collapsing in certain local markets. This paper 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 particular markets in which the adverse effects of the O&G price collapse were mostly felt.

I first find that O&G-concentrated counties had a significant decrease in deposit inflow into local bank branches. Banks with higher exposure to the shock areas incurred lower deposit inflows, raised interest costs, and booked a higher level of loan losses. Facing severe liquidity pressure, banks tend 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 O&G 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 a higher level of information asymmetries. I also find that exposed smaller banks with less-assets cut lending the most, as compared to larger banks with more-liquid assets. Results also show that healthy banks use their stronger balance sheets to enter new markets and gain market share in both deposits and small business lending.

I further conduct a series of robustness checks that look at banks with a significant presence in neighboring counties that were not adversely affected by the oil price drop. 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. The null result confirmed that the oil price drop has been the cause of the liquidity drought in local markets, and that banks transmit the shocks to wider geographic areas through lending, suggesting that a bank-lending channel served as the transmission channel that propagated the liquidity shocks through the broader economy.

The findings of this paper highlight the potential costs related to having a large branch system in the banking sector. The banking system consists of larger banks with geographically diversified branch networks mitigating their exposure to “hot-spot” risks that arise from certain regions and potentially helping 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.

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Table 1. Definitions of the main variables

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)
Exposure to liquidity shock measures *(source: FDIC Summary of Deposit)*		
	Oil shock	The number of out-of-state bank entries through establishing new branches as a percentage of total number of out-of-state bank entries (branching plus M&A) in a census tract
Bank characteristics and loan provisioning *(source: FDIC Call report, HMDA database, FDIC Summary of Deposit, FFIEC Community Reinvestment Act database)*		
	Bank size	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
	Total amount of deposits	Yearly aggregated amount of deposit of all bank branches in the target county (in billions $)
	Amount of SME loans originated	Yearly 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" (in billions $)
	Total amount of mortgage loan granted	Yearly aggregated amount of mortgage loans granted in the target county (in billions $)
	Approval rate of the mortgage loans	Yearly 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)

Table 2. The effect of shock on counties with a high concentration of its workforce in the oil and gas industry

The table presents coefficient estimates from difference-in-differences (DD) analyses of the changes in the total amount of deposits in a county after the oil shock hit. The dependent variable is the total amount of deposit inflow into branches within a county. The coefficients on the interaction term of *Oil & gas concentrated counties*× Post oil price collapse capture the DD estimate of the effect of the oil shock on local deposit inflow. 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)**
Dependent Variable:	Total amount of deposits	Total amount of small business loans originated
Oil & gas concentrated counties	0.063***	1.320
	(0.017)	(1.361)
***Oil & gas concentrated counties* × Post oil price collapse**	-0.145***	-5.310***
	(0.032)	(1.540)
State controls		
Local market size $_{t-1}$	-0.000	0.000***
	(0.000)	(0.000)
Local bank competition $_{t-1}$	-0.491	-29.605***
	(0.439)	(10.068)
Local per capita income $_{t-1}$	0.000***	0.001
	(0.000)	(0.000)
Average firm employment size $_{t-1}$	-0.051	-5.183***
	(0.038)	(1.188)
Political balance $_{t-1}$	0.013	4.264
	(0.087)	(3.367)
County controls		
Personal income growth rate $_{t-1}$	0.238***	12.287***
	(0.061)	(2.640)
Total population $_{t-1}$	0.000***	0.003***
	(0.000)	(0.000)
Median applicant income $_{t-1}$		
County fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Within-sample R^2	0.986	0.993
Number of observations	18,340	18,512

Table 3. Effects of the oil shock on banks with significant operation in affected counties

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, loan quality, 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.

Panel A. bank deposit and loan quality

	(1)	**(2)**	**(3)**	**(4)**
Dependent Variable:	Demand deposit	Ratio interest expense on deposit	Loan loss provision	Bank loan charge-offs
Exposed banks	0.671***	-0.030***	-0.048**	-0.054***
	(0.182)	(0.005)	(0.020)	(0.019)
***Exposed banks* × Post oil price collapse**	-0.581***	0.047***	0.089***	0.059***
	(0.172)	(0.004)	(0.011)	(0.013)
Bank controls				
Bank size $_{t-1}$	-1.003***	0.157***	0.368***	0.388***
	(0.327)	(0.009)	(0.036)	(0.039)
Bank ROA $_{t-1}$	36.375***	-1.993***	-10.341***	-21.311***
	(7.597)	(0.260)	(0.903)	(1.049)
Bank capital ratio $_{t-1}$	0.976	-0.267***	-0.175	-0.803***
	(1.954)	(0.050)	(0.166)	(0.184)
Bank fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Within-sample R^2	0.888	0.861	0.417	0.509
Number of observations	141,364	141,345	140,757	140,757

Panel B. bank security holding

	(5)	**(6)**	**(7)**
Dependent Variable:	Cash	Treasury bonds	MBS
Exposed banks	0.570*	0.300	-0.234
	(0.322)	(0.261)	(0.259)
***Exposed banks* × Post oil price collapse**	-0.664***	-0.337*	-0.236
	(0.227)	(0.181)	(0.238)
Bank controls			
Bank size $_{t-1}$	-3.125***	0.226	-0.240
	(0.390)	(0.198)	(0.285)
Bank ROA $_{t-1}$	-67.205***	7.038	-13.062*
	(10.449)	(6.332)	(7.575)
Bank capital ratio $_{t-1}$	5.236**	12.897***	14.910***
	(2.414)	(1.583)	(1.933)
Bank fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Within-sample R^2	0.811	0.869	0.886
Number of observations	141,345	141,365	141,365

Table 4. Spillover of negative liquidity shocks 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 banks' small business and mortgage-lending activities. 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. 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)**
Dependent Variable:	Total amount of small business loans originated	Total amount of mortgage loan granted	Approval rate of the mortgage loans
Exposed banks	2.803***	0.024***	-0.003
	(0.318)	(0.003)	(0.002)
***Exposed banks* × Post oil price collapse**	-0.903***	-0.013***	-0.024***
	(0.152)	(0.002)	(0.002)
State controls			
Local market size $_{t-1}$	-0.000	-0.000**	0.000
	(0.000)	(0.000)	(0.000)
Local bank competition $_{t-1}$	-0.312	-0.007	-0.027
	(0.663)	(0.005)	(0.028)
Local per capita income $_{t-1}$	-0.000***	-0.000***	-0.000
	(0.000)	(0.000)	(0.000)
Average firm employment size $_{t-1}$	-0.267***	0.000	-0.001
	(0.094)	(0.001)	(0.002)
Political balance $_{t-1}$	0.957***	-0.002	0.013**
	(0.265)	(0.002)	(0.006)
County controls			
Personal income growth rate $_{t-1}$	-0.961***	-0.003	0.000
	(0.311)	(0.004)	(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 $_{t-1}$	0.824***	0.003***	-0.044***
	(0.101)	(0.000)	(0.000)
Bank liquidity $_{t-1}$	-0.996	0.469***	-4.767***
	(7.809)	(0.055)	(0.185)
Bank ROA $_{t-1}$	-0.176	-0.056***	-0.102***
	(0.172)	(0.011)	(0.023)
Bank capital ratio $_{t-1}$	-0.024***	-0.001	-0.163***
	(0.009)	(0.001)	(0.006)
County fixed effects	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Within-sample R^2	0.071	s	0.265
Number of observations	536,301	246,406	246,406

Table 5. Differential spillover effects of the oil shock through branch networks

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 loan. 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)**	**(5)**
Exposed banks	1.322***	1.341***	-0.261	2.925***	4.095***
	(0.296)	(0.303)	(0.256)	(0.320)	(0.448)
Exposed banks × After Shock	-0.192	-0.088	3.837***	-0.780***	-1.541***
	(0.147)	(0.155)	(0.599)	(0.126)	(0.227)
Exposed banks × After Shock × high assets intangibility	-4.433***				
	(1.106)				
Exposed banks × After Shock × high fraction of smaller firms		-3.962***			
		(0.920)			
Exposed banks × After Shock × non-local market			-4.558***		
			(0.879)		
Exposed banks × After Shock × low cash reserve				-1.119***	
				(0.392)	
Exposed banks × After Shock × smaller-size banks					-1.557***
					(0.510)
State controls					
Local market size $_{t-1}$	0.000	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Local bank competition $_{t-1}$	-0.845	-0.888	-0.615	-0.325	-0.152
	(0.695)	(0.671)	(0.665)	(0.658)	(0.658)
Local per capita income $_{t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Average firm employment size $_{t-1}$	-0.294***	-0.208**	-0.248***	-0.262***	-0.266***
	(0.095)	(0.086)	(0.094)	(0.095)	(0.093)
Political balance $_{t-1}$	1.107***	1.035***	0.842***	0.947***	0.923***
	(0.275)	(0.263)	(0.260)	(0.265)	(0.261)
County controls					
Personal income growth rate $_{t-1}$	-0.829***	-0.793***	-0.121	-0.942***	-0.954***
	(0.313)	(0.306)	(0.314)	(0.312)	(0.310)
Total population $_{t-1}$	-0.000***	-0.000***	-0.000***	-0.000***	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Bank controls					
Bank size $_{t-1}$	0.811***	0.818***	1.802***	0.833***	
	(0.099)	(0.100)	(0.152)	(0.101)	
Bank ROA $_{t-1}$	-3.559	-3.744	127.249***	0.202	-13.413**
	(7.183)	(7.173)	(13.709)	(7.756)	(6.784)
Bank capital ratio $_{t-1}$	-0.178	-0.178	-0.248	-0.212	-0.215
	(0.173)	(0.172)	(0.226)	(0.184)	(0.205)

Bank liquidity $_{t-1}$	-0.023**	-0.023***	-0.047***		-0.022**
	(0.009)	(0.009)	(0.010)		(0.009)
County fixed effects	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Within-sample R^2	0.073	0.073	0.122	0.071	0.068
Number of observations	536,301	536,301	536,301	536,301	536,301

Table 6. Effects of oil price collapse in non-oil and gas concentrated neighboring counties

The table presents coefficient estimates from placebo difference-in-differences (DD) analyses of the changes in the total amount of deposits in the neighboring county after the oil shock hit the focal counties. The dependent variable is the total amount of deposit inflow into branches within a neighboring county. 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 deposit inflow into local bank branches. 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)
Dependent Variable:	Total amount of deposit
Exposed banks	-0.089**
	(0.039)
***Exposed banks* × Post oil price collapse**	0.007
	(0.041)
State controls	
Local market size $_{t-1}$	-0.000
	(0.000)
Local bank competition $_{t-1}$	-0.493
	(0.442)
Local per capita income $_{t-1}$	0.000***
	(0.000)
Average firm employment size $_{t-1}$	-0.052
	(0.037)
Political balance $_{t-1}$	0.026
	(0.087)
County controls	
Personal income growth rate $_{t-1}$	0.276***
	(0.063)
Total population $_{t-1}$	0.000***
	(0.000)
Median applicant income $_{t-1}$	
County fixed effects	Yes
Year fixed effects	Yes
Within-sample R^2	0.986
Number of observations	18,340

Table 7. Placebo oil shocks on banks operating in non-oil shock neighboring counties

The table presents coefficient estimates from difference-in-differences (DD) analyses of the placebo changes in lending in banks with significant operation in unaffected neighboring counties after the oil shock hit. The dependent variables capture banks' small business and mortgage-lending activities. 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)**	**(3)**
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	-0.197	-0.003***	0.026***
	(0.161)	(0.001)	(0.002)
***Placebo-oil shock hit banks* × Post oil price collapse**	0.408*	0.003***	0.048***
	(0.215)	(0.001)	(0.002)
State controls			
Local market size $_{t-1}$	-0.000*	-0.000**	0.000
	(0.000)	(0.000)	(0.000)
Local bank competition $_{t-1}$	0.148	-0.001	-0.003
	(0.801)	(0.005)	(0.029)
Local per capita income $_{t-1}$	-0.000***	-0.000***	-0.000
	(0.000)	(0.000)	(0.000)
Average firm employment size $_{t-1}$	-0.211**	0.000	0.004
	(0.100)	(0.001)	(0.002)
Political balance $_{t-1}$	0.558**	-0.002	0.011
	(0.272)	(0.002)	(0.007)
County controls			
Personal income growth rate $_{t-1}$	-0.715**	-0.001	-0.004
	(0.323)	(0.004)	(0.015)
Total population $_{t-1}$	-0.000***	-0.000***	0.000
	(0.000)	(0.000)	(0.000)
		-0.000***	0.000***
		(0.000)	(0.000)
Bank controls			
Bank size $_{t-1}$	0.864***	0.004***	-0.046***
	(0.113)	(0.001)	(0.000)
Bank liquidity $_{t-1}$	-5.888	0.469***	-4.644***
	(7.260)	(0.060)	(0.191)
Bank ROA $_{t-1}$	-0.162	-0.065***	-0.107***
	(0.162)	(0.012)	(0.025)
Bank capital ratio $_{t-1}$	-0.025**	-0.009***	-0.146***
	(0.013)	(0.001)	(0.005)
County fixed effects	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Within-sample R^2	0.068	0.076	0.268
Number of observations	516,411	230,305	230,305

Figure 1. Counties with significant exposure to the oil and gas industry

This figure shows the percentage of the total workforce that is employed in the oil and gas industry in each county of the United States before the oil price collapse in 2014 using Census database. Lighter shades correspond to a lower concentration of the workforce in the oil and gas industry in the county, and darker shades correspond to a higher concentration of the workforce in the oil and gas industry.