NBER WORKING PAPER SERIES

BANK LIQUIDITY, CREDIT SUPPLY, AND THE ENVIRONMENT

Ross Levine
Chen Lin
Zigan Wang
Wensi Xie

Working Paper 24375
http://www.nber.org/papers/w24375

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2018

Chen Lin acknowledges financial support from the Center of Financial Innovation and Development and the Seed Funding for Strategic Interdisciplinary Research at Hong Kong University. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Bank Liquidity, Credit Supply, and the Environment
Ross Levine, Chen Lin, Zigan Wang, and Wensi Xie
NBER Working Paper No. 24375
March 2018
JEL No. G21,O16,Q40,Q52,Q53

ABSTRACT

We evaluate the impact of the credit conditions facing corporations on their emissions of toxic air pollutants. Exploiting cross-county, cross-time shale discoveries that generated liquidity windfalls at local bank branches, we construct measures of (1) the degree to which banks in non-shale counties, i.e., counties where shale was not discovered, receive liquidity shocks through their branches in shale counties and (2) the degree to which a corporation in a non-shale county has a relationship lender that receives liquidity shocks through its branches. From both the county- and firm-level analyses, we discover that positive shocks to credit conditions reduce corporate pollution.

Ross Levine
Haas School of Business
University of California at Berkeley
545 Student Services Building, #1900 (F685)
Berkeley, CA 94720-1900
and NBER
Ross_levine@haas.berkeley.edu

Chen Lin
Faculty of Business and Economics
The University of Hong Kong
Hong Kong
chenlin1@hku.hk

Zigan Wang
Faculty of Business and Economics
The University of Hong Kong
Hong Kong
wangzigan@gmail.com

Wensi Xie
Department of Finance
Chinese University of Hong Kong
Hong Kong
wensixie@baf.cuhk.edu.hk

1. Introduction

Air pollution increases the incidence of respiratory and cardiovascular diseases, cancer, asthma and allergies, reproductive and neurodevelopmental disorders, and premature death.[1] The World Health Organization (WHO) estimates that in 2012 around 1 in 8 deaths were attributable to air pollution. According to *Ambient Air Pollution 2016* released by the WHO, 92% of the world's people breathe air with pollution concentrations that exceed WHO Air Quality Guidelines (AQG) limits. Even in developed countries, environmental pollution is the biggest threat to human health and well-being. For example, the *Air Quality Report 2016* by the European Environment Agency estimates that approximately 50% of the EU's urban population was exposed to concentrations of small particulate matter exceeding WHO AQG limits. As another example, the *State of the Air 2017* report by the American Lung Association shows that more than 40% of the people in the U.S. live in counties that have unhealthful levels of air pollution.

In this paper, we examine how bank liquidity and credit supply affect the environment. More specifically, we evaluate the impact of shocks to the supply of credit on corporate emissions of toxic air pollutants.[2] Although the literature shows that credit conditions shape economic growth (e.g., King and Levine 1993, Jayaratne and Strahan 1996, Levine and Zervos 1998), firm and industry dynamics (Cetorelli and Strahan, 2006), business cycle fluctuations (e.g., Bernanke and Gertler, 1989, Morgan, Rime, and Strahan, 2004), innovation (e.g., Brown, Fazzari, and Petersen 2009), and the distribution of income and economic opportunities (e.g., Black and Strahan 2001, Beck, Levine, and Levkov 2012), the literature has not focused on how credit conditions influence corporate emissions of toxic pollutants, and as a result, the quality of the environment. In this study, we identify shocks to the supply of bank credit and examine the impacts on corporate pollution and environmental quality.

[1] In addition to harming public health (e.g., Chay and Greenstone 2003, Ebenstein et al. 2015, Schlenker and Walker 2016, IIsen, Rossin-Slater, and Walker 2017), pollution reduces housing prices (e.g., Currie, Davis, Greenstone and Walker 2015), lower labor productivity (e.g., Zivin and Neidell 2012), and influences industrial production (e.g., Greenstone 2002).

[2] U.S. Government Accountability Office estimates that industrial plants in the nation emit a total of about 4 billion pounds of toxic chemicals every year (Currie, Davis, Greenstone, and Walker, 2015).

A simple cost-benefit framework suggests how access to credit can shape toxic emissions by corporations. The costs of reducing pollution involve sizeable upfront investments, as shown by Walker (2013).[3] The benefits, however, largely accrue over time, as pollution abatement reduces expected fines and penalties from violating regulatory and legal limits on toxic emissions, augments the health and productivity of its workers, and boosts the firm's reputation.[4] Therefore, a boost in the supply of bank credit can improve access to credit, allowing firms to finance large pollution abatement investments, and lower interest rates, increasing the net present value of projects that reduce pollution. Similarly, if credit conditions tighten, firms will be less likely to invest in pollution abatement and might cut expenditures on existing environmental protection activities, increasing their emissions of toxic air pollutants. Although we do not have corporate-level data on investment in pollution abatement, we can evaluate how the supply of credit influences the emissions of toxic pollutants by corporations.

To assess the impact of credit conditions on corporate pollution, we must address two standard identification challenges: (1) unobserved factors might simultaneously drive both the corporation's credit conditions and its emissions of toxic air pollutants and (2) reverse causality might drive the credit-pollution relationship, i.e., corporation's environmental policies might shape the credit conditions offered by its lenders. To address these challenges, we develop and implement two complimentary empirical strategies for identifying shocks to the credit conditions facing firms. The first strategy identifies shocks to the credit conditions facing firms in a county and the second strategy identifies shocks to the credit conditions facing individual firms.

Both of our empirical strategies start with the same building block: identifying liquidity shocks to individual banks. In particular, we start with Gilje, Loutskina, and Strahan (2016). They show that (1) unexpected technological breakthroughs in fracking made shale gas production economically viable; (2) following these technological breakthroughs, the

[3] The EPA estimates that in 2016 companies spent more than $13.7 billion on actions and equipment to control pollution. See, https://www.epa.gov/enforcement/enforcement-annual-results-fiscal-year-2016.
[4] According to the EPA, fees and penalties from for violating environmental laws and regulations reached $6 billion in 2016.

energy industry began rapidly purchasing shale mineral leases from landowners in promising areas, i.e., in "shale counties;" (3) the landowners then deposited a portion of these mineral-lease payments in local banks, boosting bank liquidity; and (4) banks receiving shale liquidity shocks from their branch networks in shale counties increased their residential mortgage lending in non-shale counties, i.e., counties that did not receive shale liquidity shocks. Thus, we first confirm that shale discoveries increased local bank deposits in shale counties. We then demonstrate that these banks improved the credit conditions offered to their corporate clients in non-shale counties, i.e., the "treated" corporations.[5] Based on this building block, we then develop two novel strategies for evaluating the impact of shocks to the credit conditions facing treated firms on their toxic emissions and the quality of the environment.

For our first empirical strategy, we use shale liquidity shocks to individual banks to identify shocks to the credit conditions facing firms in a county. Specifically, we construct measures of the degree to which banks in non-shale counties receive liquidity shocks through their branch networks in shale counties. In this way, we identify county-specific shocks to the supply of bank credit available to corporations in non-shale counties and then evaluate how these shocks to credit conditions influence pollution in those counties. Importantly, we focus on changes in credit conditions and environmental outcomes in counties without any shale discoveries or drilling activities. This mitigates concerns that our results are driven by changes in local economic conditions resulting from shale discoveries or development. We use data on hazardous pollutants collected by Environmental Protection Agency (EPA) monitoring stations across the country. Thus, conceptually, our first empirical strategy compares the environment outcomes in two otherwise similar non-shale counties, except that banks in one county receive greater liquidity shocks through their branch networks than banks in the other county.

We discover that a positive shock to the supply of bank credit in a county lowers toxic air pollution in the county. That is, when a non-shale county's banks are more exposed to positive liquidity shocks through their branches in counties experiencing shale discoveries,

[5] Consistent with this finding, Peek and Rosengren (2000), and Strahan (2009) show that declines in bank liquidity translate into reductions in the supply of bank credit. In addition, Gatev and Strahan (2009) find that bank liquidity positions affect syndicated loan structure.

we observe sharp reductions in air pollution in those treated, non-shale counties. These results hold when (a) controlling for time-varying county traits along with county and year fixed effects, (b) using several different measures of shocks to the credit conditions facing corporations within non-shale counties, (c) analyzing each of the five major toxic air pollutants, and (d) employing different measures of the intensity of air pollution in counties. In terms of economic magnitudes, consider Benzene, the most monitored hazardous air pollutant by the EPA in our sample. We find that in counties where banks received a shale-liquidity shock equal to one standard deviation of the cross-county distribution of such shocks, Benzene concentration levels fell by 26% of the standard deviation of Benzene concentration levels across counties.

Our second strategy identifies shocks to the credit conditions facing individual firms. To link shale liquidity shocks to a bank with its lending to specific firms, we use syndicated loan deals because Dealscan provides information on each firm's lenders in each deal. This strategy relies on two testable conditions. First, bank-firm relationships endure, so that if a bank was the lead arranger for a syndicated loan to a firm in the past, the bank is likely to be a lead arranger for the firm in the future. We call such a bank the firm's relationship lender, where firms can have more than one such lender. Second, banks receiving shale liquidity shocks through their branches in non-shale localities offer better credit terms to their relationship firms in non-shale counties. We first verify that these two conditions hold. We then use shale liquidity shocks to a firm's relationship lenders to construct time-varying measures of the credit conditions facing each firm. Conceptually, therefore, our second empirical strategy compares the environment outcomes in two otherwise similar corporations located in non-shale counties, except that the relationship lenders for one of these corporations receives greater liquidity shocks through their branch networks in shale counties than the relationship lenders for the other corporation.

Using this strategy, we evaluate the impact of shocks to the credit conditions facing individual firms on (a) their emissions of toxic pollutants, (b) expert assessments of their environmental policies, and (c) their expressions of concern in 10-K filings about the environment. To measure the release of toxic pollutants by individuals firms, we use data from the EPA's Toxic Release Inventory (TRI) program on toxic emissions from the individual plants of firms. We obtain assessments of each firm's environmental performance from MSCI, which provides independent evaluations of corporations for institutional investors. To gauge a company's concerns about its environmental policies, we conduct textual analyses of corporate 10-K filings with the Securities and Exchange Commission (SEC). The sample size varies depending on whether we are examining toxic emissions using TRI data, expert assessments using the MSCI, or 10-K filings. Our TRI sample, for instance, contains 66,819 plant-year observations involving 8839 plants over the period from 2000 through 2014.

We find that positive shocks to the credit conditions facing firms (a) reduce their emissions of toxic air pollutants, (b) boost their overall environmental performance, as measured by MSCI ratings, and (c) increase their focus on environmental considerations, as expressed in SEC 10-K filings. These results are robust to controlling for firm, industry-year, and state-year fixed effects, as well as time-varying firm characteristics. Furthermore these results hold when using different measures of the shale liquidity shocks and across different measures of toxic air pollution. Critically, as emphasized above, we examine firms and plants located in counties in which there have been no shale discoveries or development. This limits concerns that the findings are driven by changes in local conditions triggered by shale activities. The estimated economic magnitudes are material. For example, if one firm receives a positive liquidity shock equal to the sample mean value, while an otherwise identical firm does not, our estimates indicate that toxic air emissions from the firm receiving the shock would fall by 7%.

The rest of the paper proceeds as follows. Section 2 describes the data and variables. Section 3 introduces the technological breakthroughs in "fracking" and demonstrates that shale discoveries boosted bank liquidity. Section 4 describes the county- and firm-specific shocks to credit conditions. Sections 5 and 6 provide the county-level and firm-level results respectively, while Section 7 concludes.

2. Data and Variables

2.1 Toxic air pollutants concentration from EPA monitoring stations

To evaluate the impact of an increase in the supply of bank credit on the local environment, we use the U.S. Environmental Protection Agency (EPA) data on the concentration of hazardous airborne pollutants collected at outdoor monitors across the nation. The EPA (2017) defines hazardous airborne pollutants as "those pollutants that are known or suspected to cause cancer or other serious health effects (including reproductive effects or birth defects), or adverse environmental effects." For each monitor, the EPA annual summary files contain pollutant-by-pollutant summary statistics on the arithmetic mean, 50^{th}, 75^{th}, and 90^{th} percentile of the readings from each monitor over each year. This provides annual quantitative and objective measures of hazardous pollutant concentrations across geographic locations. We focus on the five toxic air pollutants with the most comprehensive data: Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene.

We use these data on toxic air pollutants in two ways. First, we use the monitor level data to investigate whether changes in the credit conditions facing corporations lead to changes in toxic pollutants as detected by monitoring sites close to the company's plants. Second, we examine whether improvements in the supply of credit to firms in a county influences air pollution in that county. To calculate the concentration of each hazardous air pollutant at the county-year level, we compute the average of each summary statistic—mean, median, 75^{th} percentile, etc.—across monitors within the county and year. The average number of monitoring sites in a county equals 1.76, and the median value equals to one. Table 1 Panel A presents cross-county summary statistics on the annual mean, median, 75^{th}, and 90^{th} percentile values of each of the five hazardous pollutant concentrations in our sample. We provide detailed variable definition in Appendix Table A1.

2.2 Firm-specific toxic emissions and environmental activities

We examine three firm-specific measures of toxic emissions and environmental policies: (1) The Toxic Release Inventory (TRI) dataset contains information on the toxic emissions by individual plants; (2) MSCI provides independent assessments by professional analysts of each parent company's environmental performance; and (3) we construct a text-based measure of the parent company's environmental protection activities from SEC 10-K filings. We now describe each of these datasets in greater detail.

2.2.1 Toxic Release Inventory

We obtain pollutant emissions information at the plant-level from the Toxic Release Inventory (TRI) basic dataset, which is maintained by the U.S. Environmental Protection Agency (EPA). TRI collects information on the production, storage, and release of toxic chemicals from over 40,000 plants in the U.S. Starting in 1987, the TRI program tracks the release of more than 650 chemicals that cause significant adverse effects on human health or the environment. Industrial plants that (a) are involved in manufacturing, metal mining, electric power generation, chemical manufacturing and hazardous waste treatment, (b) have more than 10 full-time employees, and (c) use or produce more than threshold levels of TRI-listed toxic substances must report their releases of toxins to the TRI. The TRI provides self-reported toxic emissions data at the plant-level, where a unique ID, along with information on the plant's name, physical location, and parent company's name, identifies each plant. For each plant in a year, we construct two measures of its emissions of pollutants. *Toxic Air Releases* is the total amount of toxic airborne chemicals released from a plant in a year; and *Total Toxic Releases* is the total amount of toxic chemicals released (including air emissions, water discharges, underground injection, etc.) from each plant in a year. We then aggregate the toxic release data at the plant level to the parent and link the parent companies to their data files in *Compustat*.

To obtain parent companies' financial and other information, we match the TRI parent company names to those in Compustat. As there is no common identifier between the two databases, we apply a "fuzzy match" based on a string matching similarity score of parent company names as reported in each dataset. We then perform a manual check on all the matches to ensure accuracy. Our final TRI pollutant emission sample includes 75,555 plant-year observations over the 2000 – 2014 sample period, involving toxic release records from 9281 plants belong to 1050 companies that are successfully matched with corresponding Compustat firms.

To address the concern that our analyses might be driven by changes in local economic conditions resulting from the shale development activities, we use a sample of TRI plants that are located in counties where there has been no shale development since 2003. This reduces the number of plant-year observations from 75,555 to 66,819, and the number of plants from 9281 to 8839.

2.2.2 MSCI environmental ratings

MSCI provides the Kinder, Lydenberg and Domini (KLD) ratings on corporate environmental activities. The MSCI database includes a variety of binary indicators on corporate social performance for Russell 3000 companies since 2003, and has been used in research on corporate environmental policies (e.g., Krüger, 2015). The MSCI rating scores are constructed from numerous sources including companies' regulatory filings and news reports. The indicators are designed to assess a company's overall environment performance along both positive (*strengths*) and negative (*concerns*) dimensions. The indicators cover topics including toxic emissions and waste management, end-of-life recycling or disposal of packaging materials, investment in low-carbon technologies, the operation of an environmental management system, etc.

We construct the index of *Environmental rating* by summing all of the *strength* indicators and subtracting all of the *concerns* indicators. Specifically, *Environmental rating* = $\sum_{i=1}^{s} strengths_i - \sum_{j=1}^{c} concerns_j$, where s and c denote, respectively, the number of items on corporate environmental strengths and concerns. *Environmental rating* is designed to provide a quantitative measure on a firm's environmental management policies, programs and initiatives, as well as the severity of controversies related to the firm's environmental impact. *Environmental rating* ranges from -5 to 5, with higher value indicating greater environmental goodness.

2.2.3 A text-based measure of environmental protection activities from SEC 10-Ks

We also construct a text-based measure of corporate environmental protection activities from SEC 10-K filings. For each 10-K file, we search for phrases that indicate the nature of the corporation's environmental activities. We define *Environmental activities* as a dummy variable that equals one if a firm's 10-K filing contains one of the phrases, including "environmental compliance", "environmental remediation", "environmental control", "pollution control", "emission control", "contamination remediation", but not "environmental liability." About 20% of 10-Ks filed by 4941 sample firms over the period of 2000 – 2014 contain these expressions.

2.3 Shale wells data and bank liquidity shocks

To create bank-specific measures of their exposure to shale discoveries, we begin with *IHS Markit Energy*, which is a comprehensive database that provides detailed information on the date, location, and well orientation for more than 100,000 shale wells drilled across the U.S over the period of 2001 – 2014. A 14-digit API number developed by American Petroleum Institute (API) uniquely identifies each well. For each county in each year, we calculate the number of shale wells drilled since 2003, which is when technological innovations made large-scale "fracking" commercially viable.[6] $Wells_{jt}$ denotes the number of shale wells drilled in county j as of year t. Figure 1 shows the intensity of shale drilling activities across U.S. counties, represented by the total number of shale wells drilled across U.S. counties from 2003 to 2014, with darker colors indicating a larger amount of shale discoveries.

To measure a bank's liquidity gains from shale discoveries, we combine U.S. counties' shale drilling activities with the bank's local branch networks. We retrieve information on each bank's branch structure, location of its branches, and deposit balances in those branches

[6] Following existing research, as horizontal drilling is one of the key elements in the technologies of drilling shale wells, we treat horizontal wells as the measure of shale-related activities. According to Gilje, Loutskina, and Strahan (2016), almost all horizontal wells in the U.S. are drilled to extract shale or other unconventional resources after 2002.

from the Federal Deposit Insurance Corporation's (FDIC) Summary of Deposits (SOD) database.

Based on (a) the geographic distribution of a bank's branches across counties and (b) the number of shale wells drilled in each county, we construct our two core measures of each bank's exposure to shale-induced liquidity shock in each year.[7] The first measure, *Bank liquidity gain1*, equals the natural logarithm of one plus the number of shale wells drilled across counties in which a bank has at least one branch divided by the total number of branches owned by the banking institution. Formally, it equals

$$Bank\ liquidity\ gain1_{b,t} = Ln\left[1 + \sum_j \left(Wells_{jt} * 1\left(Branches_{bjt} > 0\right)\right) / \ Branches_{bt}\right], \quad \text{(1a)}$$

where b represents bank, j denotes county, and t denotes time. $Wells_{jt}$ denotes the number of shale wells drilled in county j from 2003 as of year t; $1(Branches_{bjt} > 0)$ denotes an indicator that equals one if bank b has branches in county j at year t and zero otherwise; $Branches_{bt}$ equals the total number of branches owned by bank b in year t. Note that *Bank liquidity gain1* equals zero for (a) banks without branches in shale development counties, and (b) all banks before 2003, which is before the technological breakthrough that fostered fracking. *Bank liquidity gain1* has a sample average of 0.286, with a higher value indicating greater liquidity shocks. And, among banks that are exposed to shale liquidity shocks, the sample average of *Bank liquidity gain1* equals 1.2.

The second bank-year liquidity shock measure, *Bank liquidity gain2*, equals the logarithm of one plus the number of shale wells across counties in which a bank has at least one branch, where the number of wells in each county is weighted by the bank market share in each county, divided by the total number of branches owned by the bank. Formally, the second measure is defined as follows.

---

[7] Note, our measure is a bit different from that used in Gilje, Loutskina, and Strahan (2016) because we account for the intensity of shale development in each county.

$$Bank\ liquidity\ gain2_{b,t} = Ln[1 + \sum_j (Wells_{jt} * 1(Branches_{bjt} > 0) * MktShr_{bjt}) / Branches_{bt}], \quad (1b)$$

where b represents bank, j denotes county, and t denotes year. $MktShr_{bjt}$ equals the proportion of all deposits held within county j in year t that are held at bank b's branches within county j. Other components, $Wells_{jt}$, $1(Branches_{bjt} > 0)$, and $Branches_{bt}$ are defined the same as above. By weighting the number of wells in a county by a bank's market share in that county, this measure assumes that a bank's liquidity inflows in a shale-development county is proportional to its market share in that county.[8]

2.4 Syndicated loan database

To link shale liquidity shocks to a bank with its lending to specific firms, we use syndicated loans. Syndicated loans provide U.S. nonfinancial businesses with about one trillion dollars of new credit each year and account for 58% of the commercial & industrial loans made by U.S. domestic banks, and 68% of C&I loans with maturities longer than 365 days.[9] In a typical syndicated loan deal, the lead arranger negotiates the specific contract terms, conducts due diligence and monitoring, and invites other participant lenders to share part of the loan. The lead arranger also tends to retain a larger share of the loan than other participants. A syndicated deal can include more than one tranche, also called a facility. The identity of the lead arranger or lead arrangers, the composition and number of other lenders,

---

[8] In robustness tests that confirm the findings based on *Bank liquidity gain1* and *Bank liquidity gain2*, we use a third measure, *Bank liquidity gain3*, that takes the second measure and further weights by whether each branch is in a shale-boom county or not. We define a shale-boom county as a county in which the number of wells is above the top quartile for all county-years in our sample. Once a county is categorized as a shale-boom county, it retains that categorization in all subsequent years. Formally, the second measure is defined as follows.

$$Bank\ liquidity\ gain3_{b,t} = Ln[1 + \sum_j (Wells_{jt} * 1(Branches_{bjt} > 0) * MktShr_{bjt} * 1(Boom_{jt})) / Branches_{bt}], \quad (1c)$$

where subscript b, j, and t, and component $Wells_{jt}$, $1(Branches_{bjt} > 0)$, and $Branches_{bt}$ denote the same as above. $Boom_{jt}$ is a dummy variable that equals one if the number of shale wells drilled in county j during year t is above the top quartile of county-years with shale development activities, and zero otherwise. Thus, this third measure captures each bank's exposure to the shale liquidity shock through its branch networks across shale-boom counties only.

[9] See, https://www.federalreserve.gov/releases/e2/201412/default.htm.

and the terms of the syndicated loan typically vary at the deal level. The vast majority of the syndicated deals in our sample have only one lead lender, which is consistent with the overview of this market in Standard & Poor's (2011) report. Almost 50% of the deals in our sample use at least five participant lenders.

We obtain syndicated loan data from *Thomson Reuters Dealscan* database. *Dealscan* collects information on syndicated loans from a variety of sources including SEC filings, public documents (10Ks, 10Qs, 8Ks and registration statements), loan syndicators and other internal sources. The database provides data at the loan-level, for which it reports the identity of the borrowers, lead lenders, loan amount, loan purposes, loan terms, etc. Lenders in *Dealscan* are reported at the BHC level. We therefore link lenders in *Dealscan* to the U.S. banks at the holding company level. We keep all the loans made to non-financial U.S. firms (excluding borrowers with U.S. SIC codes between 6000 and 6999), with the primary deal purposes classified as corporate purposes, working capital, capital expenditure, debt repayment, and takeover. We identify the lead arranger(s) for each loan package based on whether it is the *Administrative agent*. The rest of the lenders in the syndicate are treated as participants. For about 20% of syndicates without a specified administrative agent, lenders that serve as one of the significant titles mentioned in Standard & Poor (2011), namely Agent, Co-Agent, Lead Arranger, or Lead managers, or received Lead Arranger League Table credit, are identified as the lead arrangers.

The lenders and borrowers in *Dealscan* do not share a common identifier with BHCs in the *Summary of Deposits* (SOD) or firms in the toxic emission databases (e.g., *TRI*) or *Compustat*. To link the *Dealscan* lenders with banks from SOD, we manually merge the lenders at the parent holding company level with the BHC in the *SOD* database.[10] To obtain financial information for lenders, we further merge with the Federal Reserve FR Y-9C, which provides consolidated balance sheets and income statements for each BHC in the U.S.

To link *Dealscan* borrowers with firms in the TRI for pollutant emission data, we first merge *Dealscan* with *Compustat*, and use the identifier in *Compustat* to link *Dealscan* with

[10] To make the manual merge manageable, we remove loans in which the lead lenders make a small number of deals (less than ten). This restriction reduces the loan sample by only about 4%. This is consistent with the fact that the syndicated loan market is highly concentrated among top lead arrangers.

TRI (already linked with *Compustat*). Specifically, to merge *Dealscan* borrowers with the *Compustat* firms, we use the linking table between *Dealscan* and *Compustat* provided by Chava and Roberts (2008) for deals before 2012. This helps match more than 90% of the sample. For deals after 2012, we conduct a similar "fuzzy match" based on firm names as reported in each dataset, followed by a manual check of all matches. Out of 2087 firms with both toxic emission data and *Compustat* information, we are able to match 1050 with *Dealscan* borrowers. Our merged dataset contains 75,555 plant-year observations with 1050 nonfinancial firms over the period from 2000 to 2014, which (a) are reported with pollutant emission data in TRI, (b) appeared as *Dealscan* borrowers at least once, and (c) have *Compustat* financial information. We further remove TRI plants that are located in counties where there have been shale development since 2003 (shale counties), reducing the number of observations from 75,555 to 66,819, and the number of plants from 9281 to 8839.

3. Shale Discoveries and Bank Liquidity Gains

3.1 "Fracking" and shale discoveries

In the early 2000s, a technological breakthrough, known as "fracking," combined horizontal drilling with hydraulic fracturing to make shale gas production economically viable. It changed the U.S. energy landscape. According to the most recent *Annual Energy Outlook* (AEO 2016) released by the Energy Information Administration (EIA), shale gas went from accounting for less than 1% of U.S. natural gas production in the late 1990s to nearly 50% of total U.S. natural gas production by the end of 2015. Due to fracking, useable shale gas reserves can fulfill the entire estimated volume of U.S. natural gas consumption for at least 30 years.[11]

Mitchell Energy discovered how to produce vast quantities of shale gas in an economically profitable way in the Barnett Shale Play, Texas. Fracking breaks apart the highly non-porous rock of shale formations, freeing natural gas trapped inside the rock. When Devon bought Mitchell Energy and combined slick-water fracking with the drilling of horizontal wells in late 2002, this created the modern, highly profitable fracking method.

[11] See, https://www.eia.gov/energyexplained/index.cfm?page=natural_gas_where.

Therefore, we use 2003 as the first year when oil and gas industry started large-scale investment in shale development.

3.2 Shale development and bank liquidity windfalls

Given the technological improvements in fracking, oil and gas companies increased their purchase of mineral leases from landowners in promising areas. With mineral leases, local property owners typically receive payments, including a large upfront bonus, based on the number of leased acres, plus a royalty percentage on the extracted resources from the lease. Consequently, these purchases significantly boost deposits in local banks.

In terms of mineral leases increasing deposits in local banks, both anecdotal evidence and existing research suggest that the effects were large. As described in Plosser (2015), leasing contracts typically involve a bonus that varies between $10 and $30,000 per acre, and a royalty percentage ranging from 10% to 25%. Accordingly, if an individual owns one square mile of land (equivalent to 640 acres) and leases out his minerals at an average value of $15,005 per acre, he would receive an upfront payment of $9.6 million plus future monthly royalties. Gilje, Loutskina, and Strahan (2016) show that deposits grow faster among banks exposed to shale boom counties compared to unexposed banks.

We also confirm this finding in our context using the sample period from 2000 – 2014. The model specification to test this channel is as follows.

$$Deposit\ growth_{b,t} = \varphi_1 Bank\ liquidity\ gain_{b,t} + \varphi_3{}'\Pi_{b,t-1} + \alpha_b + \alpha_t + \varepsilon_{b,t}, \quad (2)$$

where *b* and *t* denote BHC and time, respectively. $Deposit\ growth_{b,t}$ is the growth rate of domestic deposits for BHC *b* during year *t*. $Bank\ liquidity\ gain_{b,t}$ represents one of the three measures on a BHC's exposure to shale drilling activities described above (i.e., *Bank liquidity gain1* or *Bank liquidity gain2*). The coefficient of interest is φ_1, which captures the extent to which a BHC's deposits grow in response to the shale development activities in its branching networks. If shale-well drilling indeed brings a large liquidity windfall to local branch offices, we expect φ_1 to be positive and statistically significant. We also control for an array of time-varying BHC specific characteristics measured at the beginning of each period ($\Pi_{b,t-1}$), namely *Total asset*, *Deposit/Total assets*, *Liquid assets/Total assets*, *Mortgages/Total assets*, *C&I loans/Total assets*, *Loan commitments/Total assets*, and *Letters of credits/Total assets*. We also include BHC and year fixed effects, α_b and α_t, throughout the analyses. Standard errors are clustered at the BHC level.

The results reported in Table 2 indicate that shale-well drilling activities within a BHC's branch networks lead to a significant increase in that BHC's deposit growth. As shown, both measures on BHC liquidity gains enter the regressions positively and significantly. The economic magnitudes are meaningful. The coefficient estimates from column 1 indicate that deposits in BHCs that are exposed to the shale development activities with an average value of *Bank liquidity gain1* (= 1.2) would grow 1.7 percentage points (=1.2*0.0138) faster than BHCs without such exposure. This is equivalent to about 20% of the sample mean of deposit growth.

Several factors suggest treating shale-drilling activities as exogenous liquidity windfalls for local bank branches. First, the technological breakthroughs in fracking were unexpected. Second, the economic viability of shale wells is often driven by broader macroeconomic factors, such as demand for natural gas and prices of natural gas (Lake et al., 2013), that are unlikely to be correlated with local economic conditions (Gilje, Loutskina, and Strahan, 2016). Third, at least two facts suggest that banks cannot strategically adjust branch networks to gain greater exposure to shale windfalls: (a) the discoveries of shale formations in different geographies are uncertain, as it is difficult even for the oil and gas companies to predict how many wells an area needs to drill before producing shale gas; and (b) mineral leasing by the oil and gas companies usually occurs at a very rapid pace. As reported by *Times-Picayune* in 2008, several years after the technological breakthroughs, the signing bonuses for buying mineral rights in the Louisiana's Haynesville Shale area increased from about $100 per acre to between $10,000 and $30,000 per acre within one year.

4. Measuring: County- and Firm-Level Liquidity Shocks

Having established that shale oil discoveries influence bank liquidity through their branches in areas exposed to these discoveries, we now employ two complimentary empirical strategies for evaluating the impact of an increase in bank liquidity on environmental quality. First, we examine only non-shale counties—counties in which shale was not discovered—and construct county-specific measures of the degree to which banks in these non-shale counties receive liquidity shocks through their branch networks in shale counties. We then evaluate the impact of these liquidity shocks on environment in these counties. Second, we examine how shocks to a firm's supply of credit influences its environmental actions. To do this, we construct firm-specific measures of the extent to which the firm's main relationship lenders receive shale liquidity shocks and then observe how this changes the firm's loan terms and the firm's environment actions. We now describe the county-level and firm-level liquidity shock measures in detail and examine the impact of these shocks on the environment in the next sections.

4.1 County-level liquidity shock measures

To evaluate the impact of county-level liquidity shocks on pollution in these counties, we construct county-specific liquidity shocks. For each non-shale county in each year, we aggregate shale liquidity shocks to banks operating in that county. We take the two core bank-specific shale liquidity shock measures defined above and weight them by the share of the county's deposits held by each bank.

We compute two county-level liquidity shock measures from these bank-specific shocks. Consider first the county-level shock based on *Bank liquidity gain1*:

$$County\ liquidity\ gain1_{j,t} = \sum \kappa_{b,j,t} * Bank\ liquidity\ gain1_{b,t}, \quad (3)$$

where *County liquidity gain1*$_{j,t}$ represents the extent to which banks in non-shale county j at time t received shale liquidity shocks via their branch networks in shale counties, *Bank liquidity gain1*$_{b,t}$ denotes the bank-specific shale liquidity shock measure for bank b in year t

(Equation 1a), and $\kappa_{b,j,t}$ is the share of county *j*'s total deposits in year *t* that are held in bank *b*'s branches that are located in county *j*. The second county-level liquidity shock, *County liquidity gain2,* is computed in a similar manner but is based on *Bank liquidity gain2*$_{b,t}$ (Equation 1b).

4.2 Firm-level liquidity shock measures

To evaluate the impact of a liquidity shock to a firm's relationship lenders on the firm's toxic emissions and other environmental actions, we need to both identify the firm's relationship lenders and construct a measure of the shale liquidity shock to that firm. To identify the firm's relationship lenders, we use the lead arrangers in the firm's syndicated loans over the previous five years. As noted above, syndicated loans account for about 60% of total domestic C&I loans and the lead arranger plays the primary role in screening and monitoring firms and organizing the financing of the loan with other banks. Furthermore, we show below that lending relationships endure: if a bank was a firm's lead arranger in a past syndicated loan, it is likely that the bank will be the firm's lead arranger in future syndicated loans.[12] In this way, we define the firm's relationship lenders as the lead arrangers in the borrowing firm's syndicated deals over the previous five years.

Thus, to compute two firm-level liquidity shock measures, we proceed as follows. For each firm that has borrowed in the syndicated loan market, we calculate its exposure to shale liquidity shocks as the weighted average of the liquidity shocks to each of its relationship lenders. The weight for each lender equals the proportion of the total amount of syndicated loans received by the borrower in which the lender was the lead arranger. Specifically,

$$Firm\ liquidity\ gain1_{i,t} = \sum_{b \in S[t-5,t-1]} \omega_{i,b,t} * Bank\ liquidity\ gain1_{b,t}, \quad (4)$$

where *Firm liquidity gain1*$_{i,t}$ represents the extent to which firm *i* at time *t* is exposed to liquidity shocks via syndicated relationship lenders and is based on *Bank liquidity gain1*$_{b,t}$

[12] Prior research emphasizes the value of enduring banking relationships, e.g., Williamson (1987), Sharp (1990) and Boot (2000).

(Equation 1a). *S[t – 5,t – 1]* represents the pool of all BHCs that have served as lead arrangers for borrower *i* during the last five years, and $\omega_{i,b,t}$ denotes the fraction of borrower *i*'s syndicated loans in which BHC *b* was the lead arranger over the previous five years, [*t* – 5, *t* – 1]. *Firm liquidity gain1*$_{i,t}$ is therefore constructed as the weighted average of the shale liquidity shock across borrower *i*'s relationship lenders at time *t*. *Firm liquidity gain2*$_{i,t}$ is defined similarly, but is based on *Bank liquidity gain2* (Equation 1b).

5. Empirical Findings: County-Level Liquidity Shocks and Environmental Quality

5.1 County liquidity shocks and county pollution

To evaluate the impact of county-level liquidity shocks on air pollution in these counties, we use the following regression specification.

$$Poll_{j,t} = \beta_1 County\ liquidity\ gain_{j,t} + \beta_2' \Pi_{j,t} + \alpha_j + \alpha_t + \varepsilon_{j,t}. \quad (5)$$

The dependent variable, *Poll*$_{j,t}$, is one of the pollution concentration measures, where there are 25 measures: for each of the five pollutants (Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene), there are statistics on the mean, 50th, 70th, and 90th percentile readings at the monitors within county *j* during year *t*. The explanatory variable of interest, *County liquidity gain*$_{j,t}$ represents one of the two county-level liquidity shock measures defined by Equation (3), where we focus on *County liquidity gain1*$_{j,t}$ and *County liquidity gain2*$_{j,t}$. We include a set of county characteristics, $\Pi_{j,t}$, namely *Ln(Per capita personal income)*, *Ln(Population)*, *Labor market participation*, and *Unemployment* to account for time-varying economic conditions, and county and year fixed effects, α_j and α_t to condition out time-invariant factors across counties and time specific effects. In this way, we are comparing toxic pollutant concentrations between otherwise similar non-shale counties in which banks receive different liquidity shocks through their branch networks in shale counties. It is worth emphasizing that we reduce the possibility that the results will be affected by changes in the demand side emanating from shale discoveries by examining only counties in which there are no shale discoveries. We estimate Equation (5) using OLS, with standard errors clustered at the county level, and report the results in Tables 3 and 4.

We find that county-level liquidity shocks materially reduce pollution. Table 3 reports the results for each of the five toxic air pollutants on the two measures of county-specific liquidity shocks. In Panel A, we provide the results on the mean values of the five pollutants collected by EPA monitoring stations during each year. In Panel B, we provide the results for the 50th percentile. We provide the results for the 75th and 90th percentiles of the values of the five pollutants collected by monitors during the year in Table 4.

As shown, the two county-level liquidity shock measures, *County liquidity gain1* in columns 1 – 5 and *County liquidity gain2* in columns 6 – 10, enter negatively and statistically significantly across all of the regressions reported in Panels A and B of Table 3. Positive liquidity shocks are associated with sharp decreases in both average and median toxic air pollution concentrations. The estimated economic magnitudes are large. For example, the coefficient estimates from Panel A column 1 indicate that the annual mean level of Benzene fell by 0.37 (= 0.555*0.659) in non-shale counties in which banks received a one standard deviation (0.659) boost in liquidity from shale oil discoveries in their branches in shale counties. This is equivalent to 26% (= 0.37/1.426) of the standard deviation of *Mean, Benzene* in our sample.

We next evaluate the impact of county-level liquidity shocks on extreme toxic pollutant concentrations. That is, rather than focusing on the mean or median pollutant readings and monitors during a year, we focus on very high readings (the 75th and 90th percentile) during the year in each county. To test this, we continue to use the same regression specification as in Table 3, except that we now examine pollution levels at the 75th and 90th percentiles of readings at each monitor during each year. Furthermore, to continue our focus on shocks to the supply of bank credit, we continue to examine only counties in which there are no shale discoveries. Banks in these non-shale counties may receive liquidity shocks through their branch networks in shale-counties. We report the results in Table 4, where Panels A and B provide the results on the 75th and 90thpercentiles respectively. We again examine each of the five pollutants and give the results for both county-specific liquidity shock measures.

As shown in Table 4, we find that positive liquidity shocks in non-shale counties materially reduce the level of extreme toxic air pollutant concentrations in those counties. That is, the county-level liquidity shock measures enter negatively and significantly in all regressions, suggesting that positive shocks to the supply of credit in a county significantly reduces the 75th (Panel A) and 90th (Panel B) values of EPA monitored toxic pollutant concentrations in a year. Moreover, As shown in Appendix Table A2 and A3, the results remain highly robust when using a third county-level liquidity shock measure, *County liquidity gain3*, which further differentiates shale counties by whether they experience a shale boom or not. With respect to the estimated impact, consider Benzene. The coefficients from column 6 of Panel A and B imply that one-standard deviation shock to county liquidity (0.121) would reduce the 75th and 90th monitored values of Benzene by 0.412 (= 3.408*0.121) and 0.795 (= 6.568*0.121) respectively. This is equivalent to 23.8% (= 0.412/1.729) and 24.8% (= 0.795/3.197) of their corresponding sample standard deviations. The results presented in Table 3 and 4 suggest that positive liquidity shocks to a county's banks reduce hazardous air pollution concentrations in the county.

5.2 County liquidity shocks and county pollution: heterogeneous effects

To provide additional evidence on whether county-level liquidity shocks affect pollution, we assess whether the drop in pollution associated with a given bank liquidity shock is greater in counties in which firms have paid more EPA fines. Specifically, we conjecture that (1) when firms believe that they face a more intense monitoring by the EPA regarding regulatory limits on toxic emissions, this increases the expected value of making pollution abatement investments and (2) when there are more EPA fines in a county, this tends to increase firms' assessments of EPA monitoring intensity.[13] Thus, we evaluate

[13] For example, when there are more fines, firms' perceptions of the likelihood of being fined might increase because of increases in the actual intensity with which regulators examine and penalize toxic emissions in that county or because of increases in the degree to which firms are aware that regulators are monitoring their emissions, i.e., the salience of the environment regulatory regime to the firms.

whether easing access to credit has an especially pronounced effect on pollution abatement in counties in which there have been more substantial EPA fines.

To conduct this evaluation, we use a county-level indicator of penalties for violating the Clean Air Act (CAA) based on EPA's compliance and enforcement data. For each county in each year, we calculate the total dollar amount of CAA penalties over the past five years across plants located in the county. We define *EPA Penalties* as equal to one if the total penalty amount in a county is above the median value of county-years in the EPA's compliance and enforcement dataset, and zero otherwise. To test our conjecture above, we interact *EPA Penalties* with the county-specific liquidity shock measure, include that interaction term in Equation (5), and report the regression results in Table 5.

We find that the pollution-reducing effects of liquidity shocks are greater in counties with a more intense regulatory focus, as measured by *EPA Penalties*. For brevity, we simply provide the results on the median and 90th percentile values for the five toxic air pollutants. In Appendix Table A4, we find similar results for mean and 75th percentile, as well as alternative measures of county-specific liquidity shocks. As can be seen from columns 1 – 5, the interaction of county-specific liquidity shocks and penalties for violating CAA, *County liquidity gain2*EPA Penalties*, enters the pollution regressions negatively and significantly across the annual 50th percentile values for each of the five pollutants. In addition, as shown in columns 6 – 10, the coefficient estimates on the interaction enters the regression of 90th percentile values for four out of the five toxic parameters. The estimated economic magnitudes are large: the coefficients from column 1 suggest that the Benzene-reducing effects of credit supply in counties with a higher amount of penalties for violating the CAA are about twice as large as those in counties with a relatively lower amount. Consistent with the previous tables, we include *Ln(Per capita personal income)*, *Ln(Population)*, *Labor market participation*, and *Unemployment* to account for time-varying economic conditions, and county and year fixed effects to condition out time-invariant factors across counties and time trends.

6. Empirical Findings: Firm-Level Liquidity Shocks and Firm-Level Environmental Activities

In this section, we evaluate the impact of shocks to the credit conditions facing firms on their environment activities. To identify the impact of BHC-specific liquidity shocks on the environment actions of related firms, we rely on two assumptions. First, BHC-firm relationships in the syndicated loan market endure over time, i.e., if a BHC was a lead arranger for a syndicated loan to a firm, that same BHC is likely to be a lead arranger for future syndicated loans to that firm. Second, BHCs that receive liquidity shocks—from their branches in localities in which shale oil is discovered—make credit available at better terms to their relationship firms, including firms in localities in which shale oil was not discovered. Based on these assumptions, we use shale-based liquidity shocks to a firm's relationship lender as a measure of an exogenous change in the credit conditions facing the firm and then assess the impact on the firm's environmental actions.

We first present evidence on these two key identifying assumptions and then evaluate the impact of firm-level liquidity shocks on their environmental activities. In particular, we analyze the impact of liquidity shocks to a firm's relationship lender on the firm's emissions of toxic air pollutants, the concentration of toxic air pollution at EPA monitors close to the firm's toxic emission plants, expert assessments of the firm's overall environmental-related performance, and the degree to which the firm is focused on environmental protection as detected in its 10-Ks.

6.1 Evidence on identifying assumptions

A key assumption underlying our identification strategy is that syndicated loan relationships endure. To test this assumption, we proceed as follows. First, in each year, we find the 20 most active lead arrangers of syndicated loans, i.e., those with the largest number of syndicated loans as the lead arranger. For each borrower in year *t*, who has previously accessed the syndicated loan market, we consider these 20 most active syndicated lenders as potential syndicated lenders in year *t*.[14] Third, we estimate the following regression:

[14] We find robustness results when defining potential lenders as top 5, top 10, and top 50 active lenders.

$$Lead\ arranger_{b,i,j,s} = \gamma_1 Previous\ lead_{b,i} + \alpha_{b,j} + \alpha_{b,s} + \alpha_{b,t} + \varepsilon_{b,i,j,s}, \quad (6)$$

where the dependent variable, $Lead\ arranger_{b,i}$ equals one if bank b acts as the lead arranger for borrower *i* in industry *j* operated in state *s* in the current deal and zero otherwise. $Previous\ lead_{b,i}$ equals one of two variables: (1) *Previous lead arranger* is an indicator variable of whether bank *b* has served as the lead arranger for borrower *i* in any deals over the previous five years or (2) *Previous lead arranger_lending ties* equals the fraction of loans for which bank *b* served as borrower *i*'s lead arranger over the previous five years. Thus, *Previous lead arranger_lending ties* differentiates lenders by the strength of their ties with a borrower. If lending relationships endure, then we expect that $\gamma_1 > 0$. Standard errors are clustered at the borrower level.

The results reported in Table 6 indicate that borrowers tend to repeatedly use their previous lead arrangers when accessing the syndicated loan market. As shown in columns 1 and 2, both measures of previous lending relationships enter the regressions positively at the 1% significance level. To further isolate the repeat-borrowing propensity, columns 3 and 4 include lender, borrower industry-by-lender, borrower state-by-lender, and year-by-lender fixed effects. As shown, the results hold. Given that a firm used a bank as the lead arranger, the probability that the firm uses the same lender the next time it accesses the syndicated loan market is estimated to be on average 0.5, and increases to 0.7 with strong lending ties.

A second key identifying assumption is that when BHCs receive positive liquidity shocks from their branches in localities experiencing shale discoveries, they provide more favorable loan terms to their borrowers. Using the loan facility information from Dealscan, we evaluate this by estimating the following regression at the loan level.

$$Loan\ Term_{l,b,i,j,s,t} = \theta_1 Bank\ liquidity\ gain_{b,t} + \theta_2' Z_{l,i,t} + \alpha_b + \alpha_{j,t} + \alpha_{s,t} + \varepsilon_{l,b,i,j,s,t}. \quad (7)$$

The dependent variable, $Loan\ Term_{l,b,i,j,s,t}$, is either (1) the log loan amount or (2) the all-in-drawn spread in the contract of loan facility *l* syndicated by lender *b* to borrower *i* in industry *j* operated in state *s* during year *t*. The key explanatory variable, *Bank liquidity gain*$_{b,t}$ represents one of the shale liquidity shock measures to BHC *b* in year *t* (i.e., either *Bank liquidity gain1* or *Bank liquidity gain2*).[15] Furthermore, we include a set of control variables: borrower sales at the time of loan origination, indicators of the loan type, and indicators of the deal purpose ($Z_{l,i,t}$), lender fixed effects (α_b), borrower industry-by-year ($\alpha_{j,t}$), and borrower state-by-year fixed effects ($\alpha_{s,t}$). Standard errors are clustered at the lender level.

As shown in Table 7, we discover that BHCs that are exposed to greater, positive shale liquidity shocks originate larger loans and loans with smaller spreads. The coefficients on our key explanatory variables, *Bank liquidity gain1* (columns 1 and 3) and *Bank liquidity gain2* (columns 2 and 4), enter the regressions in which *Loan amount* is the dependent variable positively and significantly, and the regressions in which *All-in-Drawn Spread* is the dependent variable negatively and significantly. These findings suggest that when BHCs receive positive liquidity shocks from their branches in localities experiencing shale oil discoveries, they offer more favor loan terms.

6.2 Credit supply and both plant-level and parent company toxic emissions

We next evaluate how plants—located in non-shale counties—adjust their toxic emissions after their parent company's relationship lenders receive a positive liquidity shock through branch networks in shale counties. We estimate the following regressions at the plant-year level.

$$Toxic\ emission_{p,i,ind,st,t} = \beta_1 Firm\ liquidity\ gain_{i,t} + \beta_2' \Pi_{i,t-1} + \alpha_p + \alpha_{ind,t} + \alpha_{st,t} + \varepsilon_{p,i,ind,st,t}, \quad (8)$$

where the dependent variable, $Toxic\ emission_{p,i,ind,st,t}$, is either *Toxic Air Releases* or *Total Toxic Releases* from plant *p* affiliated with parent company *i* of industry *ind*, located in state *st*, in year *t*. *Firm liquidity gain*$_{i,t}$ measures the extent to which the relationship lenders of

[15] We focus on publicly listed non-financial borrowers, and use the types of loans classified as revolvers. Table 1 Panel B provides the summary statistics for the key variables in our syndicated loan sample.

parent company i receive positive liquidity shocks, and is defined above in Equation (4). We control for a set of parent company traits ($\Pi_{i,t-1}$): *Total assets*, *Profitability*, and *Leverage*, measured at the beginning of each period, and the contemporaneous value of parent company sales, *Sales*. We include plant, industry-year, and state-year fixed effects, α_p, $\alpha_{ind,t}$, and $\alpha_{st,t}$, to condition out any time-invariant differences across pollution plants and time-varying differences across industries and states. We estimate the model using OLS, with standard errors clustered at the firm level. To the extent that parent companies effectively devote more resources to limiting toxic emissions when they receive better credit conditions, we expect $\beta_1 < 0$.

As shown in Panel A of Table 8, we discover that when a parent company's relationship lenders receive a positive liquidity shock, the parent company's plants pollute less. Panel A reports the empirical results using Equation (8). Columns 1 – 2 report the regression results of *Toxic Air Releases*, and columns 3 – 4 report those of *Total Toxic Releases*. As shown, the key explanatory variables of the degree to which a parent company's relationship lenders receive positive liquidity shocks (i.e., *Firm liquidity gain1*, or *Firm liquidity gain2*) enter negatively and significantly at the 1% level in all specifications. These results suggest that improvements in firms' access to finance lead to less toxic emissions at the plant level. Importantly, these results are unlikely to be affected by shifts in local economic conditions as we exclude plants located in counties with shale development.

To interpret the economic magnitudes of the estimated coefficients, consider two otherwise similar firms, except that one receives a positive, sample mean liquidity shock (i.e., *Firm liquidity gain1* = 0.486 as shown in Table 1 Panel C) due to its lending relationships with BHCs exposed to shale liquidity windfalls, while the other does not receive the shock (i.e., *Firm liquidity gain1* = 0). The coefficient estimates from Panel A column 1 indicate that toxic air emissions from plants affiliated with the "shocked" firm would be 7.1% (= 0.486*0.146) lower than those of the other firm.

Turning from the plant to the company, we now aggregate the toxic releases of plants (in non-shale counties) and apply them to the parent company and assess whether a positive liquidity shock to a parent company's relationship lenders reduce its toxic emissions using the following:

$$Toxic\ emission_{i,ind,st,t} = \beta_1 Firm\ liquidity\ gain_{i,t} + \beta_2' \Pi_{i,t-1} + \alpha_i + \alpha_{ind,t} + \alpha_{st,t} + \varepsilon_{i,ind,st,t}, \quad (9)$$

where the dependent variable, $Toxic\ emission_{i,ind,t}$, is either the log amount of toxic air releases or all chemical releases by plants affiliated with firm *i* in industry *ind* headquartered in state st in year t. The other variables and estimation procedure are the same as those in Equation (8).

As reported in Panel B of Table 8, the parent company level analyses confirm the plant-level results: When a parent company's relationship lenders receive a positive liquidity shock, the company emits less air pollutants. These results are unlikely to be driven by changes in local economic conditions resulting from shale development as we exclude plants in shale counties and firms headquartered in counties with shale development from our sample.[16] The estimated economic effects are large. For example, if a parent company's relationship lenders receive an average liquidity shock (i.e., *Firm liquidity gain1* = 0.486), the coefficient estimates from Panel B column 1 indicate that its toxic air emissions would be 20% (= 0.486*0.420) lower than a similar company whose relationship lenders did not receive any liquidity shock.

6.3 Credit supply, TRI plants, and nearby pollutants concentration from EPA monitors

We further examine whether less toxic plant emissions resulting from enhanced accessibility to finance leads to detectable reductions in toxic pollutants concentration, using data records from EPA monitoring sites located "near" those pollution plants. Thus, rather than using toxic emissions data from TRI plants, we now use data from individual monitors to test whether there is a measurable reduction in environmental quality. To do this, we first

[16] As shown in the Appendix Table A5 columns 1 – 4, Table 8 results are robust to using another liquidity shock measure, *Firm liquidity gain3*.

compile a sample of EPA monitors that collect toxic air pollutants concentration data and have toxic emission plants located within a certain distance (two, three, or five miles). To identify toxic emission plants, we use those covered in the TRI dataset. We determine each plant's active operating years using the National Establishment Time-Series (NETS) database. NETS follows over 58.8 million establishments from 1990 to 2014, covering essentially the universe of establishments in the U.S. For each establishment, NETS contains information on the first and last year of operation for which we use to determine the active operating year for each toxic emission plant. For each EPA monitoring site in a year, we then match it to all the active toxic emission plants located within two, three, or five miles, where we calculate the geographic distance between each monitor and TRI plant using their latitude and longitude.

We then construct a time-varying, monitor-specific measure by taking the average liquidity shocks received by its neighboring plants. The liquidity shock measure of a plant equals the extent to which its affiliated firm is exposed to liquidity shocks through its relationship lenders, and is defined above in Equation (4). Appendix Table A1 provides detailed variable definitions. We employ the following specification to evaluate whether changes in the accessibility of bank credit across firm of nearby plants lead to detectable shifts in ambient toxic air pollutants concentrations.

$$Poll_{m,j,t} = \pi_1 Liquidity\ gain(within\ \tau\ miles\ of\ a\ monitor)_{m,t} + \alpha_m + \alpha_{j,t} + \varepsilon_{m,j,t}, \quad (10)$$

where the dependent variable $Poll_{m,j,t}$ is the pollutant-by-pollutant median level of concentration from monitor *m* located in county *j* in year *t*. The key explanatory variable, *Liquidity gain (within τ miles of a monitor)*$_{m,t}$, denotes the extent to which toxic emission plants located within τ miles of monitor *m* receive liquidity shocks in year *t* (i.e., *Liquidity gain1 (within τ miles of a monitor)* or *Liquidity gain2 (within τ miles of a monitor)*), where τ equals 2, 3, or 5. Appendix Table A1 describes variable definition in greater detail. We include monitor and county-year fixed effects (α_m and $\alpha_{j,t}$) to condition out any time-invariant differences across monitors, and time-varying differences across counties. In this way, we isolate the credit supply effects from changes in local economic conditions.

Furthermore, consistent with previous analyses, we exclude monitors located in counties with shale development to mitigate the concern of changes in local economic conditions due to shale development. We estimate the model using OLS, with standard errors clustered at the monitor level. Given that Table 8 results suggest that an easing access to finance of their parent companies leads plants to reduce toxic emissions, we expect $\pi_1 < 0$.

The estimation results reported in Table 9 are consistent with our conjecture. The dependent variable is the median values of annual observations on each of the five most-monitored hazardous air pollutants (namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene) concentration collected from EPA outdoor monitoring stations. Panel A calculates liquidity shocks at the monitor level using toxic emission plants within three miles around each monitor. As shown, both *Liquidity gain1 (within 3 miles of a monitor)* and *Liquidity gain2 (within 3 miles of a monitor)* enter the regressions negatively and significantly across columns, suggesting that the level of toxic pollutants concentration declines when nearby plants experience an easing access to bank credit. We include monitor and county-by-year fixed effects in all specifications to account for time-invariant factors across monitor, time-varying factors across counties. Our results remain robust when altering the distance range of toxic emission plants around each monitor. As reported in Panel B and C, our results are robust to calculating monitor-specific liquidity shocks using toxic emission plants within two or five miles of each monitor. Moreover, the results are robust to using a different liquidity shock measure, *Liquidity gain3 (within τ miles of a monitor)*, as shown in Appendix Table A6.

Taken together, the results in Tables 8 and 9 are consistent with the credit view: enhanced accessibility to finance leads to a reduction in borrowing firms' pollutant emissions with positive repercussions on environmental quality.

6.4 Credit supply and corporate focus on the environment

We next assess whether positive liquidity shocks to a corporation's relationship lenders augment the firm's focus on environment protection. Specifically, we use (1) the MSCI ratings on each corporation's overall environmental performance, *Environmental* *rating*, and (2) our textual analysis of SEC 10-K filings of the degree to which the corporation discusses actions it is taking to protect the environment, *Environmental activities*. Section 2.2 above provides detailed definitions of these two indicators. Methodologically, we use the Equation (9) regression specification.

As reported in Table 10 columns 1 and 2, we find a strong and robust impact of the degree to which a corporation's relationship lenders receive a positive liquidity shock and the MSCI environmental ratings of the firm. The coefficient estimates on the firm liquidity shock measures, *Firm liquidity gain1* and *Firm liquidity gain2*, are positive and significant at the 1% statistical level in all specifications, suggesting that an improvement in the credit conditions increases the extent to which firms adopt policies, programs, and initiatives that improve the environment.

Furthermore, Table 10 columns 3 and 4 show that after relationship lenders receive positive liquidity shocks, their firms produce 10-K filings that focus more on environmental protection. As shown, both measures on firm liquidity shocks enter the regressions positively and significantly. The results in Table 10 hold when including firm controls (*Total assets*, *Profitability*, *Leverage*, and *Sales growth*), firm fixed effects, industry-by-year fixed effects, and state-by-year fixed effects. As shown in Appendix Table A5 columns 5 and 6, the results also obtain when using the third liquidity shock measure, *Firm liquidity gain3*. These results are unlikely to be driven by changes in local economic conditions resulting from shale development as we exclude firms headquartered in—and plants operating in—counties with shale development from our sample.

7. Conclusion

In this study, we evaluated the impact of changes in the credit conditions facing corporations on their emissions of toxic air pollutants in particular and their environmental policies more generally. To make this assessment, we developed and implemented two identification strategies. For both strategies, we exploit shale discoveries that created exogenous liquidity windfalls for local bank branches and show that banks receiving these liquidity shocks from their branch networks in counties with shale discoveries improved the credit conditions that they offered to their clients in non-shale counties, i.e., counties where shale was not discovered. The first strategy is implemented at the county-level. We construct measures of the degree to which banks in non-shale counties receive liquidity shocks through their branch networks in shale counties and evaluate how these shocks to county credit conditions influence the emissions of toxic air pollutants in those counties. The second strategy is implemented at the firm-level. Using syndicated loan data, we examine firms located in non-shale counties. We then measure the degree to which a firm's relationship lender in the syndicated loan market received a liquidity shock through its branches in shale counties and evaluate how these shocks influenced the firm's pollution activities.

We discover that an easing of credit conditions reduces corporate pollution. From the county-level analyses, we find that when banks in non-shale counties receive positive liquidity shocks through their branches in shale counties, there is a sharp reduction in toxic air pollution in those non-shale counties. From the firm-level analyses, we find that when a firm's relationship lender receives positive liquidity shocks through their branches in shale counties, the firm (a) reduces its emissions of toxic air pollutants, (b) gets higher ratings on its overall environmental performance by MSCI analyses, and (c) increases the frequency with which it mentions environmental concerns in its SEC 10-K filings. Our analyses only include firms and plants located in non-shale counties to reduce concerns that the findings are driven by local shale activities.

References

Beck, T., Levine, R., Levkov, A., 2010. Big bad banks? The winners and losers from bank deregulation in the United States. *Journal of Finance* 65, 1637-1667.

Bernanke, B., Gertler, M., 1989. Agency costs, net worth, and business fluctuations. *American Economic Review* 79, 14-31.

Black, S.E., Strahan, P.E., 2001. The division of spoils: rent-sharing and discrimination in a regulated industry. *American Economic Review* 91, 814-831.

Brown, J.R., Fazzari, S.M., Petersen, B.C., 2009. Financing innovation and growth: cash flow, external equity, and the 1990s R&D boom. *Journal of Finance* 64, 151-185.

Cetorelli, N., Strahan, P.E., 2006. Finance as a barrier to entry: bank competition and industry structure in local U.S. markets. *Journal of Finance* 61, 437-461.

Chay, K.Y. and Greenstone, M., 2003. The impact of air pollution on infant mortality: evidence from geographic variation in pollution shocks induced by a recession. *Quarterly Journal of Economics* 118, 1121-1167.

Currie, J., Davis, L., Greenstone, M., Walker, R., 2015. Environmental health risks and housing values: evidence from 1,600 toxic plant openings and closings. *American Economic Review* 105, 678-709.

Demirgüç-Kunt, A. and Maksimovic, V., 1998. Law, finance, and firm growth. *Journal of Finance* 53, 2107-2137.

Ebenstein, A., Fan, M., Greenstone, M., He, G., Yin, P., Zhou, M., 2015. Growth, pollution, and life expectancy: China from 1991-2012. *American Economic Review Papers & Proceedings* 105, 226-31.

Gatev, E., Strahan, P.E., 2009. Liquidity risk and syndicate structure. *Journal of Financial Economics* 93, 490-504.

Gilje, E.P., Loutskina, E., Strahan, P.E., 2016. Exporting liquidity: Branch banking and financial integration. *Journal of Finance* 71, 1159-1184.

Greenstone, M., 2002. The impacts of environmental regulations on industrial activity: evidence from the 1970 and 1977 clean air act amendments and the census of manufactures. *Journal of Political Economy* 110, 1175-1219.

IIsen, A., Rossin-Slater, M., and Walker, W.R., 2017. Every breath you take—every dollar you'll make: the long-term consequences of the Clean Air Act of 1970. *Journal of Political Economy* 125, 848-902.

Jayaratne, J., Strahan, P.E., 1996. The finance-growth nexus: evidence from bank branch deregulation. *Quarterly Journal of Economics* 111, 639-670.

King, R.G., Levine, R., 1993. Finance and growth: Schumpeter might be right. *Quarterly Journal of Economics* 108, 717–738.

Kashyap, A.K., Lamont, O.A., Stein, J.C., 1994. Credit conditions and the cyclical behavior of inventories. *Quarterly Journal of Economics* 109, 565-592.

Krüger, P., 2015. Corporate goodness and shareholder wealth, *Journal of Financial Economics* 115, 304-329.

Lake, L.W., Martin, J., Ramsey, J.D., Titman, S., 2013. A Primer on the economics of shale gas production just how cheap is shale gas? *Journal of Applied Corporate Finance* 25, 87-96.

Morgan, D.P., Rime, B., Strahan, P.E., 2004. Bank integration and state business cycles. *Quarterly Journal of Economics* 119, 1555-1584.

Peek, J., Rosengren, E.S., 2000. Collateral damage: effects of the Japanese bank crisis on real activity in the United States. *American Economic Review* 90, 30-45.

Plosser, M.C., 2015. Bank heterogeneity and capital allocation: evidence from "Fracking" shocks. *Working Paper*.

Rice, T., Strahan, P.E., 2010. Does credit competition affect small-firm finance? *Journal of Finance* 65, 861-889.

Schlenker, W., Walker, W.R., 2016. Airports, air pollution, and contemporaneous health. *Review of Economic Studies* 83, 768-809.

Sharpe, S.A., 1990. Asymmetric information, bank lending, and implicit contracts: A stylized model of customer relationships. *Journal of Finance* 45, 1069-1087.

Standard & Poor's, 2011. A Guide to the Loan Market. The McGraw-Hill Companies, Inc., NewYork, NY. https://www.lcdcomps.com/d/pdf/LoanMarketguide.pdf

Strahan, P.E., 2009. Liquidity production in 21st century banks. *Oxford Handbook on Banking* Allen N. Berger, and John Wilson eds., Oxford University Press, New York, NY.

Times-Picayune, 2008. Drilling rush in North Louisiana creates new millionaires. September 16.http://www.nola.com/news/index.ssf/2008/09/northwest_la_oil_rush_creating.html

Walker, W.R., 2013. The transitional costs of sectoral reallocation: evidence from the Clean Air Act and the workforce. *Quarterly Journal of Economics* 128, 1787-1835.

Williamson, S.D., 1987. Costly monitoring, loan contracts, and equilibrium credit rationing. *Quarterly Journal of Economics* 102, 135-145.

Zivin, J.G. and Neidell, M., 2012. The impact of pollution on worker productivity. *American Economic Review* 102, 3652-3673.

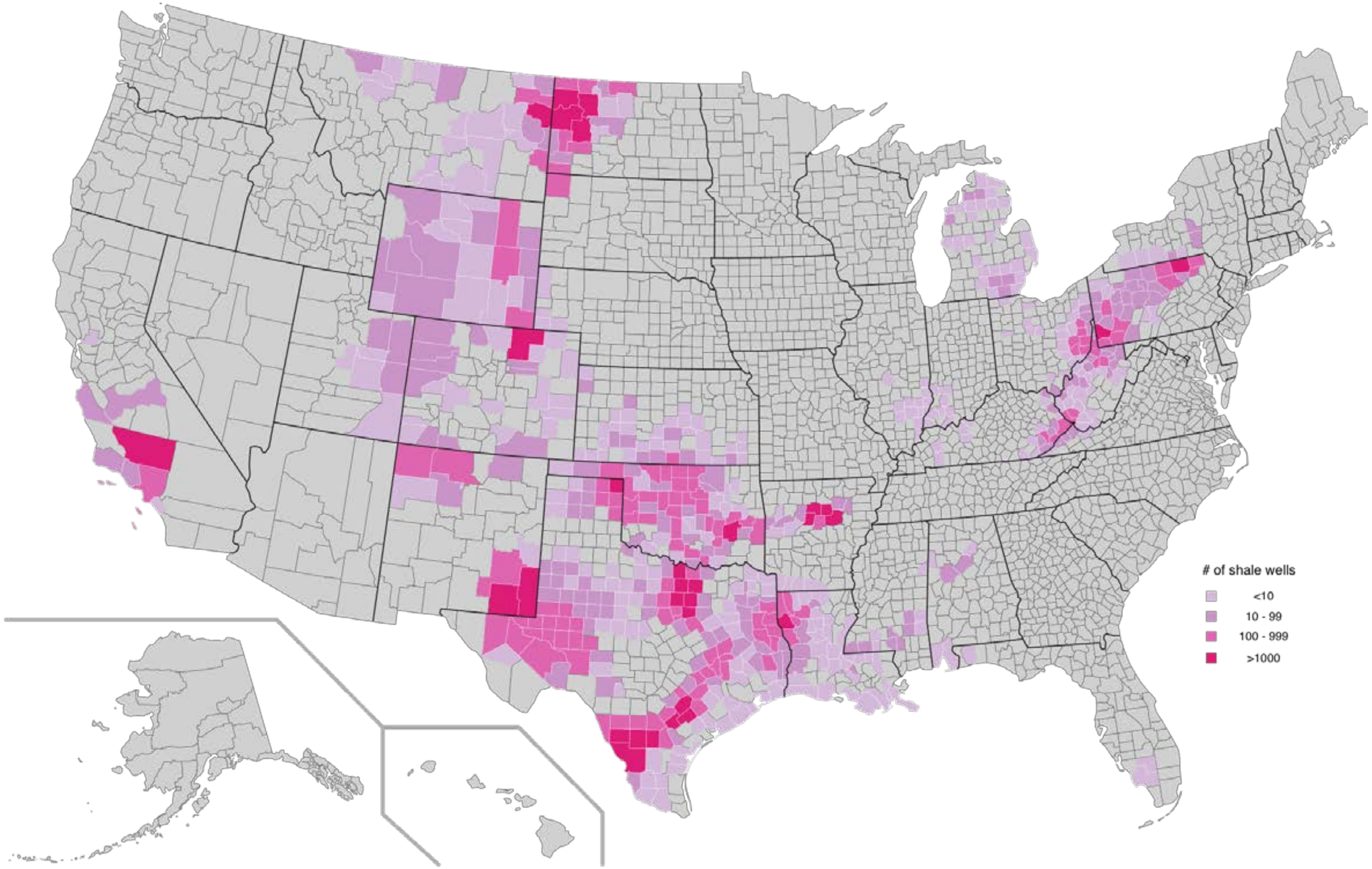

Figure 1. The Number of Shale Wells Drilled from 2003 to 2014 by U.S. County

Note: Based on IHS North America Performance Evaluator 2014. This figure represents the number of shale wells drilled in each county over the period of 2003 – 2014, with darker colors indicating higher values.

Table 1 Summary Statistics

Panel A: County Sample

Variable	N	Mean	SD	P25	P50	P75
Hazardous Pollutant Concentration						
Benzene						
Mean, Benzene	2327	1.816	1.426	0.996	1.470	2.139
50th percentile, Benzene	2327	1.434	1.002	0.840	1.200	1.750
75th percentile, Benzene	2327	2.220	1.729	1.236	1.800	2.604
90th percentile, Benzene	2327	3.393	3.197	1.700	2.598	3.800
Toluene						
Mean, Toluene	2267	4.347	4.091	1.852	3.152	5.377
50th percentile, Toluene	2267	3.195	2.982	1.400	2.300	4.000
75th percentile, Toluene	2267	5.232	4.852	2.200	3.833	6.580
90th percentile, Toluene	2267	8.471	8.292	3.490	6.100	10.500
Ethylbenzene						
Mean, Ethylbenzene	2241	0.666	0.675	0.267	0.485	0.857
50th percentile, Ethylbenzene	2241	0.501	0.535	0.175	0.390	0.678
75th percentile, Ethylbenzene	2241	0.820	0.830	0.320	0.600	1.023
90th percentile, Ethylbenzene	2241	1.306	1.358	0.520	0.960	1.625
o-Xylene						
Mean, o-Xylene	2213	0.770	0.826	0.277	0.555	0.971
50th percentile, o-Xylene	2213	0.578	0.665	0.200	0.400	0.747
75th percentile, o-Xylene	2213	0.962	1.018	0.353	0.690	1.235
90th percentile, o-Xylene	2213	1.566	1.746	0.567	1.100	1.920
m/p Xylene						
Mean, m/p Xylene	2148	2.011	2.237	0.698	1.378	2.520
50th percentile, m/p Xylene	2148	1.492	1.743	0.489	0.983	1.919
75th percentile, m/p Xylene	2148	2.515	2.798	0.880	1.700	3.200
90th percentile, m/p Xylene	2148	4.091	4.652	1.400	2.800	5.100

County-Specific Liquidity Shock						
County liquidity gain1	2327	0.518	0.659	0.001	0.208	0.864
County liquidity gain2	2327	0.078	0.121	0.000	0.017	0.111
County liquidity gain3	2327	0.070	0.114	0.000	0.012	0.096
County Characteristics						
EPA Penalties, (in thousand dollar)	2327	1295	3802	15	139	746
Ln(Per capita personal income)	2327	10.495	0.294	10.304	10.472	10.665
Ln(Population)	2327	12.629	1.280	11.875	12.751	13.577
Labor market participation	2327	0.505	0.049	0.479	0.511	0.537
Unemployment	2327	0.064	0.027	0.045	0.057	0.077

Panel B: Syndicated Loans

Variable	N	Mean	SD	P25	P50	P75
Syndicated Loan Terms						
Loan amount	8584	19.203	1.533	18.358	19.337	20.253
All-in-drawn spread	8015	1.530	1.057	0.700	1.275	2.150
Lead Arrangers' Liquidity Shock						
Bank liquidity gain1	8584	0.540	0.676	0	0.196	1.072
Bank liquidity gain2	8584	0.089	0.140	0	0.021	0.130

Panel C: Non-financial Firm

Variable	N	Mean	SD	P25	P50	P75
Toxic Emissions						
Toxic Air Releases, plant-level	66819	6.8516	5.356	0.833	7.314	11.115
Total Toxic Releases, plant-level	66819	8.3294	5.120	4.279	9.047	11.991
Toxic Air Releases, firm-level	8626	10.116	5.370	7.031	11.072	14.072
Total Toxic Releases, firm-level	8626	11.461	4.995	8.838	12.010	15.007
Corporate Focus on the Environment						
Environmental rating	20407	0.000	0.849	0	0	0

Environmental activities	42483	0.205	0.404	0	0	0
Firm-Specific Liquidity Shock						
Firm liquidity gain1	8626	0.486	0.648	0	0.044	1.022
Firm liquidity gain2	8626	0.072	0.106	0	0.002	0.130
Firm liquidity gain3	8626	0.067	0.102	0	0.000	0.121
Firm Characteristics						
Total assets	8626	7.429	1.766	6.238	7.390	8.615
Return on assets	8626	0.032	0.092	0.009	0.040	0.075
Leverage	8626	0.608	0.238	0.460	0.596	0.731
Sales	8626	7.419	1.639	6.358	7.409	8.514

Panel D: Monitor Sample

Variable	N	Mean	SD	P25	P50	P75
Hazardous Pollutant Concentration						
50^{th} percentile, Benzene	3650	1.756	1.343	1.000	1.400	2.100
50^{th} percentile, Toluene	3545	3.865	3.674	1.700	2.730	4.780
50^{th} percentile, Ethylbenzene	3483	0.612	0.655	0.210	0.420	0.800
50^{th} percentile, o-Xylene	3460	0.684	0.781	0.240	0.460	0.843
50^{th} percentile, m/p Xylene	3342	1.813	2.108	0.640	1.200	2.200
Monitor-Specific Liquidity Shock						
Liquidity gain1 (within 3 miles of a monitor)	3650	0.464	0.57	0	0.166	0.860
Liquidity gain2 (within 3 miles of a monitor)	3650	0.054	0.08	0	0.013	0.085
Liquidity gain3 (within 3 miles of a monitor)	3650	0.050	0.07	0	0.010	0.079
Liquidity gain1 (within 2 miles of a monitor)	3650	0.358	0.55	0	0.000	0.614
Liquidity gain2 (within 2 miles of a monitor)	3650	0.044	0.08	0	0.000	0.053
Liquidity gain3 (within 2 miles of a monitor)	3650	0.041	0.07	0	0.000	0.048
Liquidity gain1 (within 5 miles of a monitor)	3650	0.550	0.56	0	0.361	1.014
Liquidity gain2 (within 5 miles of a monitor)	3650	0.061	0.07	0	0.027	0.108
Liquidity gain3 (within 5 miles of a monitor)	3650	0.057	0.07	0	0.021	0.100

Table 2 Bank Shale Liquidity Shocks and Deposit Growth

This table presents the bank-year regressions of bank deposit growth on liquidity shock from the shale-drilling activities from 2000 – 2014. The dependent variable is the growth rate of domestic deposits across columns. For each bank holding company in a year, we construct two measures of shale liquidity shocks, *Bank liquidity gain1* and *Bank liquidity gain2*. Both measures capture the extent to which each bank receives liquidity gains resulting from shale development through its branch networks across counties. *Bank liquidity gain1* measures the number of shale wells drilled across counties in which a bank has at least one branch. Similar to *Bank liquidity gain1*, *Bank liquidity gain2* further considers a bank's market share in each shale county. Equations (1a) and (1b), and Appendix Table A1 provide detailed variable definitions. Bank specific controls include *Total asset*, *Deposit/Total assets*, *Liquid assets/Total assets*, *Mortgages/Total assets*, *C&I loans/Total assets*, *Loan commitments/Total assets*, and *Letters of credits/Total assets*, all measured at the beginning of each year. We include BHC and Year fixed effects throughout the table. P-values are calculated using heteroscedasticity robust standard errors clustered at the BHC level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

	Deposit growth	
	(1)	(2)
Bank liquidity gain1	0.0138***	
	(0.001)	
Bank liquidity gain2		0.0709***
		(0.000)
Total assets, lag	-0.180***	-0.180***
	(0.000)	(0.000)
Deposit/Total assets, lag	-0.676***	-0.680***
	(0.000)	(0.000)
Liquid assets/Total assets, lag	-0.467***	-0.461***
	(0.000)	(0.000)
Mortgages/Total assets, lag	0.0901*	0.0907*
	(0.0689)	(0.0678)
C&I loans/Total assets, lag	0.271***	0.272***
	(0.0006)	(0.001)
Loan commitments/Total assets, lag	0.0517	0.0507
	(0.256)	(0.265)
Letters of credits/Total assets, lag	0.374	0.317
	(0.359)	(0.433)
BHC fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	6,447	6,447
R-squared	0.420	0.421
# of banks	759	759

Table 3 Bank Liquidity and Hazardous Air Pollution, County-Level Analyses Using Data from EPA Pollution Monitoring Stations

This table reports the regression results of the effects of county-level liquidity shocks on the concentration of hazardous airborne pollutants based on EPA monitoring stations. Our county-year sample includes only non-shale counties, i.e., those counties with no local shale development. We take the five most monitored hazardous pollutants, namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene. The dependent variable in Panel A and B is the arithmetic mean and median values of each of the five air pollutants collected by EPA monitoring stations during each year. The key explanatory variable is one of the county-specific, time-varying measures on the extent to which banks in a county are exposed to shale development via its branch located in shale-boom counties, i.e., *County liquidity gain1* or *County liquidity gain2*. For each county in a year, we calculate its banks' shale liquidity shock by taking the average of bank-specific shale liquidity shock (i.e., *Bank liquidity gain1* or *Bank liquidity gain2*), weighted each bank by its local market share in that particular county. We provide detailed definitions for *County liquidity gain1*(*2*), and *Bank liquidity gain1*(*2*) in Equations (3), (1a), and (1b), and Appendix Table A1. County controls include *Ln(Per capita personal income)*, *Ln(Population)*, *Labor market participation*, and *Unemployment*. We include county and year fixed effects across columns. P-values are calculated using heteroscedasticity robust standard errors clustered at the county level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

Panel A: Mean

	Arithmetic mean									
	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain1	-0.555***	-1.083***	-0.115**	-0.158**	-0.610***					
	(0.000)	(0.000)	(0.033)	(0.015)	(0.001)					
County liquidity gain2						-3.018***	-5.523***	-0.639**	-0.833**	-2.761***
						(0.000)	(0.000)	(0.027)	(0.019)	(0.003)
Ln(Per capita personal income)	0.148	1.419	0.175	0.296	0.315	0.284	1.583	0.200	0.320	0.336
	(0.851)	(0.521)	(0.552)	(0.377)	(0.746)	(0.709)	(0.476)	(0.494)	(0.341)	(0.732)
Ln(Population)	1.997***	3.621*	0.447	0.463	1.707	2.398***	4.144**	0.530	0.550	1.823
	(0.007)	(0.065)	(0.353)	(0.484)	(0.196)	(0.002)	(0.023)	(0.272)	(0.413)	(0.173)
Labor market participation	-2.377	-1.744	-0.551	-1.822	-2.019	-1.947	-1.019	-0.485	-1.737	-1.650
	(0.365)	(0.785)	(0.641)	(0.174)	(0.592)	(0.431)	(0.874)	(0.681)	(0.190)	(0.663)
Unemployment	-3.074	-12.12	-1.131	-1.312	-9.155*	-1.946	-9.759	-0.901	-0.991	-7.698
	(0.533)	(0.153)	(0.492)	(0.534)	(0.098)	(0.673)	(0.242)	(0.566)	(0.625)	(0.151)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.660	0.669	0.657	0.662	0.674	0.662	0.669	0.657	0.662	0.674
# of counties	303	291	290	289	277	303	291	290	289	277

Panel B: Median

	50th Percentile									
	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain1	-0.345***	-0.831***	-0.0902**	-0.137***	-0.444***					
	(0.000)	(0.000)	(0.042)	(0.008)	(0.002)					
County liquidity gain2						-1.916***	-3.825***	-0.446*	-0.721**	-2.041***
						(0.000)	(0.001)	(0.054)	(0.012)	(0.005)
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.721	0.735	0.656	0.664	0.665	0.723	0.734	0.656	0.664	0.665
# of counties	303	291	290	289	277	303	291	290	289	277

Table 4 Bank Liquidity and Extreme Hazardous Air Pollution, County-Level Analyses Using Data from EPA Pollution Monitoring Stations

This table reports the regression results of the effects of county-level liquidity shocks on the extreme concentration of hazardous airborne pollutants from EPA monitoring stations. Our county-year sample includes only non-shale counties, i.e., counties with no local shale development. We take the five most monitored hazardous pollutants, namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene. The dependent variable in Panel A and B is the 75th, and 90th values of each of the five air pollutants concentration collected by EPA monitoring stations during each year. The key explanatory variable is one of the county-specific, time-varying measures on the extent to which banks in a county are exposed to shale development via its branch located in shale-boom counties, i.e., *County liquidity gain1* or *County liquidity gain2*. For each county in a year, we calculate its banks' shale liquidity shock by taking the average of bank-specific shale liquidity shock (i.e., *Bank liquidity gain1* or *Bank liquidity gain2*), weighted each bank by its local market share in that particular county. We provide detailed definition for *County liquidity gain1*(*2*), and *Bank liquidity gain1*(*2*) in Equations (3), (1a), and (1b), and Appendix Table A1. County controls include *Ln(Per capita personal income)*, *Ln(Population)*, *Labor market participation*, and *Unemployment*. We include county and year fixed effects across columns. P-values are calculated using heteroscedasticity robust standard errors clustered at the county level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

Panel A: 75th Percentile

	75th Percentile									
	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain1	-0.673***	-1.309***	-0.178***	-0.263***	-0.857***					
	(0.000)	(0.000)	(0.004)	(0.001)	(0.001)					
County liquidity gain2						-3.408***	-5.951***	-0.934***	-1.304***	-3.891***
						(0.000)	(0.001)	(0.008)	(0.004)	(0.002)
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.696	0.727	0.662	0.685	0.683	0.696	0.726	0.662	0.685	0.682
# of counties	303	291	290	289	277	303	291	290	289	277

Panel B: 90th Percentile

	90th Percentile									
	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain1	-1.249***	-2.020***	-0.184*	-0.314**	-1.249***					
	(0.000)	(0.000)	(0.062)	(0.016)	(0.001)					
County liquidity gain2						-6.568***	-10.14***	-1.295**	-1.578**	-5.770***
						(0.000)	(0.001)	(0.018)	(0.026)	(0.002)
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.605	0.683	0.628	0.639	0.659	0.606	0.683	0.629	0.639	0.658
# of counties	303	291	290	289	277	303	291	290	289	277

Table 5 Bank Liquidity and County-Level Hazardous Air Pollution, Heterogeneity across EPA Penalties for CAA Enforcement

This table reports the regression results of the heterogeneous effects of county-level liquidity shocks on hazardous air pollutants concentration from EPA monitoring stations, while differentiating counties by the intensity of EPA penalties. Consistent with the previous tables, our county-year sample includes only non-shale counties, i.e., counties with no local shale development. We take the five most monitored hazardous pollutants, namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene. The dependent variable is the 50th or 90th values of each of the five air pollutants concentration collected by EPA monitoring stations during each year. *EPA Penalties* is an indicator that equals one if the dollar amount of penalties imposed on a county's establishments for violating Clean Air Act over the past five years are greater than the sample median value, and zero otherwise. The key explanatory variable, *County liquidity gain2*, is a county-specific, time-varying measure on the extent to which banks in a county are exposed to shale development via its branch networks. For each county in a year, we calculate its banks' shale liquidity shock by taking the average of bank-specific shale liquidity shock (i.e., *Bank liquidity gain2*), weighted each bank by its local market share in that particular county. We provide detailed definition for *County liquidity gain2*, and *Bank liquidity gain2* in Equations (3) and (1b), and Appendix Table A1. We define a bank's market share in a county as the share of total deposits in the county that is held by the bank. County controls include *Ln(Per capita personal income)*, *Ln(Population)*, *Labor market participation*, and *Unemployment*. We include county and year fixed effects across columns. P-values are calculated using heteroscedasticity robust standard errors clustered at the county level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

	50th Percentile					90th Percentile				
	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain2 * EPA Penalties	-1.021***	-2.355*	-0.690***	-0.690**	-1.922***	-2.038*	-6.476**	-1.229**	-1.121	-4.732***
	(0.002)	(0.053)	(0.001)	(0.012)	(0.004)	(0.058)	(0.035)	(0.015)	(0.104)	(0.004)
County liquidity gain2	-1.161***	-2.077	0.0796	-0.202	-0.639	-5.059***	-5.327	-0.355	-0.750	-2.211
	(0.001)	(0.111)	(0.676)	(0.428)	(0.301)	(0.000)	(0.116)	(0.434)	(0.221)	(0.180)
EPA Penalties	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.725	0.735	0.659	0.667	0.668	0.606	0.684	0.630	0.640	0.660
# of counties	303	291	290	289	277	303	291	290	289	277

Table 6 Lending Relationship Stickiness in the Syndicated Market

This table reports the regression results of the likelihood of using a borrower's previous lenders when accessing the syndicated market for a new loan. For each loan contract in which the borrower has previously accessed the market, they are matched to a set of potential lenders, where potential lenders are the top 20 active lenders in the market in the same year of the loan contract. The dependent variable, *Lead arranger*, is an indicator that equals one if the lender serves as the actual lead arranger for that deal, and zero otherwise. The key explanatory variable in columns 1 and 2, *Previous lead arranger*, is an indicator for whether the lender served as the lead arranger on the borrower's loan deals over the previous five years. The explanatory variable in columns 3 and 4, *Previous lead arranger_lending ties*, equals the fraction of loans for which the lender served as the borrower's lead arranger over the previous five years. Appendix Table A1 provides detailed variable definitions. The specific fixed effects are indicated in the table, namely, Lender, Borrower industry (2-digit SIC)-by-Lender, Borrower State-by-Lender, Year-by-Lender fixed effects. P-values are calculated using heteroscedasticity robust standard errors clustered at the borrower level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

	Lead arranger			
	(1)	(2)	(3)	(4)
Previous lead arranger	0.475***		0.432***	
	(0.000)		(0.000)	
Previous lead arranger_lending ties		0.706***		0.658***
		(0.000)		(0.000)
Lender fixed effects	Yes	Yes	Yes	Yes
Borrower Industry-by-Lender fixed effects	No	No	Yes	Yes
Borrower State-by-Lender fixed effects	No	No	Yes	Yes
Year-by-Lender fixed effects	No	No	Yes	Yes
Observations	595,626	595,626	588,777	588,777
R-squared	0.383	0.432	0.474	0.519
# of borrowers	5987	5987	5898	5898

Table 7 Bank Liquidity and Loan Terms

This table reports the regression results of syndicated loan terms on lenders' exposure to shale liquidity shocks. The unit of analysis is the loan facility level. The dependent variable is the logarithm of the loan amount of each deal in columns 1 – 2, and the all-in-drawn loan spread in columns 3 – 4. Columns 3 and 4 report the coefficient estimates divided by 100 for expository purposes. We focus on public borrowers, and facilities of revolvers. For each bank in a year, we measure its exposure to the shale-drilling activities using two variables, *Bank liquidity gain1* and *Bank liquidity gain2*. Both measure the extent to which each bank receives liquidity gains resulting from shale development through its branch networks across counties. *Bank liquidity gain1* measures the number of shale wells drilled across counties in which a bank has at least one branch. Similar to *Bank liquidity gain1*, *Bank liquidity gain2* further considers a bank's market share in each shale county. Equations (1a) and (1b), and Appendix Table A1 provide detailed variable definitions. We control for Lender fixed effects, together with borrower sales at close, industry-by-year, and state-by-year fixed effects. P-values are calculated using heteroscedasticity robust standard errors clustered at the lender level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

	Loan Amount		All-in-Drawn Spread	
	(1)	(2)	(3)	(4)
Bank liquidity gain1	0.158***		-0.119**	
	(0.001)		(0.049)	
Bank liquidity gain2		0.578*		-1.039***
		(0.097)		(0.001)
Lender fixed effects	Yes	Yes	Yes	Yes
Borrower Size	Yes	Yes	Yes	Yes
Borrower Industry-by-Year fixed effects	Yes	Yes	Yes	Yes
Borrower State-by-Year fixed effects	Yes	Yes	Yes	Yes
Observations	8,584	8,584	8,015	8,015
R-squared	0.839	0.839	0.711	0.713

Table 8 Liquidity Shocks and Plant and Parent Company Toxic Releases

This table presents the effects of liquidity shocks to a firms' relationship lenders on the firm's (or its plants') releases of toxic chemicals. The unit of analyses is the plant-year level in Panel A where we exclude plants located in counties with shale development activities, and the firm-year level in Panel B where we further exclude firms headquartered in counties with shale development activities. The dependent variable is logarithm of the volume of air emissions in columns 1 – 2 and the logarithm of the total volume of toxic chemicals released in columns 3 – 4, measured for each plant in a given year. The key explanatory variable is, *Firm liquidity gain1* in columns 1 and 3, and *Firm liquidity gain2* in columns 2 and 4. For each firm in a year, we construct its shale liquidity shock as the weighted average of its relationship lenders' liquidity shock (i.e., *Bank liquidity gain1* or *Bank liquidity gain2*), where each relationship lender is weighted by the loan amount it acted as the lead arranger in deals during the previous five years. We provide detailed definition for *Firm liquidity gain1*(*2*), and *Bank liquidity gain1*(*2*) in Equations (4), (1a), and (1b), and Appendix Table A1. Firm controls include *Total assets (lag)*, *Profitability (lag)*, *Leverage (lag)*, and *Sales*. Panel A includes Plant, Industry (SIC 3-digit)-by-Year fixed effects, and State-by-Year fixed effects, and Panel B includes Firm, and Industry-by-Year fixed effects. P-values are calculated using heteroscedasticity robust standard errors clustered at the firm level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

Panel A: Plant-Level Toxic Releases

	Toxic Air Releases		Total Toxic Releases	
	Excl. plants located in counties w/ shale development			
	(1)	(2)	(3)	(4)
Firm liquidity gain1	-0.146***		-0.133***	
	(0.005)		(0.010)	
Firm liquidity gain2		-1.079***		-0.878***
		(0.000)		(0.002)
Total assets, lag	-0.00800	-0.00719	-0.0354	-0.0346
	(0.910)	(0.920)	(0.639)	(0.648)
Return on assets, lag	0.743***	0.753***	0.791***	0.797***
	(0.002)	(0.00204)	(0.002)	(0.001)
Leverage, lag	0.471***	0.474***	0.189	0.190
	(0.010)	(0.010)	(0.301)	(0.300)
Sales	0.130	0.134	0.0585	0.0629
	(0.189)	(0.183)	(0.511)	(0.485)
Plant fixed effects	Yes	Yes	Yes	Yes
Industry-by-year fixed effects	Yes	Yes	Yes	Yes
State-by-year fixed effects	Yes	Yes	Yes	Yes
Observations	66,819	66,819	66,819	66,819
R-squared	0.912	0.912	0.904	0.904
# of firms	1040	1040	1040	1040
# of plants	8839	8839	8839	8839

Panel B: Firm-Level Toxic Releases

	Toxic Air Releases		Total Toxic Releases	
	Excl. plants in shale counties and firms headquartered in shale counties			
	(1)	(2)	(3)	(4)
Firm liquidity gain1	-0.420***		-0.400***	
	(0.009)		(0.008)	
Firm liquidity gain2		-2.630***		-2.340***
		(0.005)		(0.010)
Firm Controls	Yes	Yes	Yes	Yes
Firm Fixed effects	Yes	Yes	Yes	Yes
Industry-by-year Fixed effects	Yes	Yes	Yes	Yes
State-by-year Fixed effects	Yes	Yes	Yes	Yes
Observations	8,626	8,626	8,626	8,626
R-squared	0.936	0.936	0.930	0.930
# of firms	1004	1004	1004	1004

Table 9 Liquidity Shocks and Hazardous Pollutant Concentration near Toxic Emission Plants, Monitor-Level Analyses

This table reports the effects of liquidity shocks received by toxic emission plants on hazardous air pollutants concentration collected by their neighboring EPA monitors within three (Panel A), two (Panel B), or five miles (Panel C). We exclude monitors located in counties with shale development from our monitor-year regressions. The dependent variable is the median values of each of the five most-monitored hazardous air pollutants (namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene) concentration in each year. The key explanatory variable, *Liquidity gain1 (within τ miles of a monitor)* or *Liquidity gain2 (within τ miles of a monitor)*, is a monitor-specific, time-varying measure on the extent to which a monitor's neighboring toxic-pollutant-emission plants receive positive liquidity shocks. For each monitor in a year, we calculate its nearby plants' shale liquidity shock by averaging the shale liquidity shock of their parent companies (i.e., *Firm liquidity gain1* or *Firm liquidity gain2*). Appendix Table A1 and Equation (4) provide detailed variable definitions. We include monitor and county-year fixed effects in all specifications. P-values are calculated using heteroscedasticity robust standard errors clustered at the monitor level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

Panel A: Hazardous pollutant emission plants within *three* miles of each monitor

	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Liquidity gain1 (within 3 miles of a monitor)	-0.248***	-0.450**	-0.182***	-0.185***	-0.423***					
	(0.005)	(0.030)	(0.001)	(0.001)	(0.002)					
Liquidity gain2 (within 3 miles of a monitor)						-1.671**	-3.507**	-1.209***	-1.332***	-2.998***
						(0.013)	(0.018)	(0.001)	(0.001)	(0.002)
Monitor FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,650	3,545	3,483	3,460	3,342	3,650	3,545	3,483	3,460	3,342
R-squared	0.863	0.853	0.827	0.826	0.837	0.863	0.853	0.826	0.826	0.837
# of monitors	611	587	578	574	542	611	587	578	574	542

Panel B: Hazardous pollutant emission plants within *two* miles of each monitor

	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Liquidity gain1 (within 2 miles of a monitor)	-0.226***	-0.345	-0.163***	-0.170***	-0.433***					
	(0.004)	(0.117)	(0.001)	(0.001)	(0.001)					
Liquidity gain2 (within 2 miles of a monitor)						-1.244**	-2.108	-0.852***	-0.946***	-2.648***
						(0.031)	(0.121)	(0.005)	(0.006)	(0.001)
Monitor FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,650	3,545	3,483	3,460	3,342	3,650	3,545	3,483	3,460	3,342
R-squared	0.863	0.853	0.827	0.826	0.838	0.862	0.853	0.826	0.825	0.837
# of monitors	611	587	578	574	542	611	587	578	574	542

Panel C: Hazardous pollutant emission plants within *five* miles of each monitor

	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Liquidity gain1 (within 5 miles of a monitor)	-0.259**	-0.775**	-0.182***	-0.157**	-0.388**					
	(0.014)	(0.012)	(0.002)	(0.036)	(0.047)					
Liquidity gain2 (within 5 miles of a monitor)						-1.463*	-3.865*	-1.315***	-1.022*	-2.435*
						(0.060)	(0.079)	(0.005)	(0.070)	(0.077)
Monitor FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,650	3,545	3,483	3,460	3,342	3,650	3,545	3,483	3,460	3,342
R-squared	0.862	0.854	0.825	0.825	0.836	0.862	0.853	0.825	0.824	0.836
# of monitors	611	587	578	574	542	611	587	578	574	542

Table 10 Liquidity Shocks and Corporate Focus on the Environment

This table presents the effects of liquidity shocks to a firms' relationship lenders on (a) MSCI ratings on its overall environmental performance, *Environmental rating*, and (b) the degree to which the corporation discusses actions it is taking to protect the environment in its SEC 10-K filings, *Environmental activities*. The dependent variable is *Environmental rating* in columns 1 and 2, and *Environmental activities* in columns 3 and 4. The key explanatory variable is *Firm liquidity gain1* in columns 1 and 3, and *Firm liquidity gain2* in columns 2 and 4. For each firm in a year, we construct its shale liquidity shock as the weighted average of its relationship lenders' shale liquidity shock (i.e., *Bank liquidity gain1* or *Bank liquidity gain2*), where each relationship lender is weighted by the loan amount it acted as the lead arranger in deals during the previous five years. We provide detailed definition for *Firm liquidity gain1*(*2*), and *Bank liquidity gain1*(*2*) in Equations (4), (1a), and (1b), and Appendix Table A1. Firm controls include *Total assets (lag)*, *Profitability (lag)*, *Leverage (lag)*, and *Sales growth*. We also include Firm, Industry (SIC 3-digit)-by-Year, and State-by-Year fixed effects. P-values are calculated using heteroscedasticity robust standard errors clustered at the firm level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

	Environmental rating		Environmental activities	
	MSCI Analyses		Textual Analysis of SEC 10-K Filings	
	(1)	(2)	(3)	(4)
Firm liquidity gain1	0.124***		0.0190***	
	(0.000)		(0.006)	
Firm liquidity gain2		0.366***		0.159***
		(0.000)		(0.000)
Firm Controls	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Industry-by-year fixed effects	Yes	Yes	Yes	Yes
State-by-year fixed effects	Yes	Yes	Yes	Yes
Observations	20,120	20,120	42,483	42,483
R-squared	0.709	0.708	0.652	0.652
# of firms	2582	2582	4941	4941

Appendix

Table A1 Variable Definition

Variable	Definition	Source
Liquidity Shock Measures		
Bank-specific liquidity shock measures		
Bank liquidity gain1	The log of one plus the number of shale wells drilled across counties in which a bank has at least one branch divided by the total number of branches owned by the banking institution. $Bank\ liquidity\ gain1_{b,t} = Ln\left[1 + \sum_j \left(Wells_{jt} * 1\left(Branches_{bjt} > 0\right)\right) / \ Branches_{bt}\right]$ (1a), where *b* represents bank, *j* denotes county, and *t* denotes time. $Wells_{jt}$ denotes the number of shale wells drilled in county *j* from 2003 as of year *t*; $1(Branches_{bjt} > 0)$ denotes an indicator that equals one if bank *b* has branches in county *j* at year *t* and zero otherwise; $Branches_{bt}$ equals the total number of branches owned by bank *b* in year *t*.	IHS Markit Energy; Summary of Deposits (SOD)
Bank liquidity gain2	The log of one plus the number of shale wells across counties in which a bank has at least one branch, where the number of wells in each county is weighted by the bank market share in each county, divided by the total number of branches owned by the bank. $Bank\ liquidity\ gain2_{b,t} = Ln[1 + \sum_j (Wells_{jt} * 1\left(Branches_{bjt} > 0\right) * MktShr_{bjt})/Branches_{bt}]$ (1b), where *b* represents bank, *j* denotes county, and *t* denotes year. $MktShr_{bjt}$ equals the proportion of all deposits held within county *j* in year *t* that are held at bank *b*'s branches within county *j*. Other components, $Wells_{jt}$, $1\left(Branches_{bjt} > 0\right)$, and $Branches_{bt}$ are defined the same as above.	
Bank liquidity gain3	The log of one plus the number of shale wells across counties in which a bank has at least one branch, where the number of wells in each county is weighted by (a) the bank market share in each county and (b) whether each branch is in a shale-boom county or not, divided by the total number of branches owned by the bank. We define a shale-boom county as a county in which the number of wells is above the top quartile for all county-years in our sample. Once a county is categorized as a shale-boom county, it retains that categorization in all subsequent years. $Bank\ liquidity\ gain3_{b,t} = Ln[1 + \sum_j \left(Wells_{jt} * 1\left(Branches_{bjt} > 0\right) * MktShr_{bjt} * 1\left(Boom_{jt}\right)\right)/Branches_{bt}]$ (1c),	

	where subscript b, j, and t, and component $Wells_{jt}$, $1(Branches_{bjt} > 0)$, and $Branches_{bt}$ denote the same as above. $Boom_{jt}$ is a dummy variable that equals one if the number of shale wells drilled in county j during year t is above the top quartile of county-years with shale development activities, and zero otherwise.	
County-specific liquidity shock measures		
County liquidity gain1	For each county in a year, it equals the weighted average of *Bank liquidity gain1* across banks operating in the county, weighted by the share of total deposits in the county held by each bank. $County\ liquidity\ gain1_{j,t} = \sum \kappa_{b,j,t} * Bank\ liquidity\ gain1_{b,t}$, where j denotes county, b represents bank, and t denotes time. *Bank liquidity gain1*$_{b,t}$ denotes the bank-specific shale liquidity shock measure for bank b in year t, as defined above in Equation (1a). $\kappa_{b,j,t}$ is the share of county j's total deposits in year t that are held in bank b's branches that are located in county j.	IHS Markit Energy; Summary of Deposits
County liquidity gain2	For each county in a year, it equals the weighted average of *Bank liquidity gain2* across banks operating in the county, weighted by the share of total deposits in the county held by each bank. $County\ liquidity\ gain2_{j,t} = \sum \kappa_{b,j,t} * Bank\ liquidity\ gain2_{b,t}$, where j denotes county, b represents bank, and t denotes time. *Bank liquidity gain2*$_{b,t}$ denotes the bank-specific shale liquidity shock measure for bank b in year t, as defined above in Equation (1b). $\kappa_{b,j,t}$ is the share of county j's total deposits in year t that are held in bank b's branches that are located in county j.	
County liquidity gain3	For each county in a year, it equals the weighted average of *Bank liquidity gain3* across banks operating in the county, weighted by the share of total deposits in the county held by each bank. $County\ liquidity\ gain3_{j,t} = \sum \kappa_{b,j,t} * Bank\ liquidity\ gain3_{b,t}$, where j denotes county, b represents bank, and t denotes time. *Bank liquidity gain3*$_{b,t}$ denotes the bank-specific shale liquidity shock measure for bank b in year t, as defined above in Equation (1c). $\kappa_{b,j,t}$ is the share of county j's total deposits in year t that are held in bank b's branches that are located in county j.	
Firm-specific liquidity shock measures		

Firm liquidity gain1	For each firm that has borrowed in the syndicated loan market, it equals the weighted average of *Bank liquidity gain1* across its relationship lenders. The weight for each lender equals the fraction of the syndicated loan amount received by the firm in which the lender acted as the lead arranger. $Firm\ liquidity\ gain1_{i,t} = \sum_{b \in S[t-5,t-1]} \omega_{i,b,t} * Bank\ liquidity\ gain1_{b,t}$, where *i* denotes firm, *b* represents bank, and *t* denotes time. $Bank\ liquidity\ gain1_{b,t}$ denotes the shale liquidity shock for relationship lender *b* at time *t*, which is defined in Equation (1a) above. As lenders in Dealscan are reported at the holding company level, we use *Bank liquidity gain1* at the bank holding company level. *S[t – 5,t – 1]* represents the pool of all BHCs that have served as lead arrangers for borrower *i* during the last five years, and $\omega_{i,b,t}$ denotes the fraction of borrower *i*'s syndicated loans in which BHC *b* was the lead arranger over the previous five years, [*t* – 5, *t* – 1].	IHS Markit Energy; Summary of Deposits; Dealscan
Firm liquidity gain2	For each firm that has borrowed in the syndicated loan market, it equals the weighted average of *Bank liquidity gain2* across its relationship lenders. The weight for each lender equals the fraction of the syndicated loan amount received by the firm in which the lender was the lead arranger. $Firm\ liquidity\ gain2_{i,t} = \sum_{b \in S[t-5,t-1]} \omega_{i,b,t} * Bank\ liquidity\ gain2_{b,t}$, where *i*, *b*, *t*, *S[t – 5,t – 1]* and $\omega_{i,b,t}$ are the same as above. $Bank\ liquidity\ gain2_{b,t}$ denotes the shale liquidity shock for relationship lender *b* at time *t*, which is defined in Equation (1b) above. As lenders in Dealscan are reported at the holding company level, we use *Bank liquidity gain2* at the bank holding company level.	
Firm liquidity gain3	For each firm that has borrowed in the syndicated loan market, it equals the weighted average of *Bank liquidity gain3* across its relationship lenders. The weight for each lender equals the fraction of the syndicated loan amount received by the firm in which the lender was the lead arranger. $Firm\ liquidity\ gain3_{i,t} = \sum_{b \in S[t-5,t-1]} \omega_{i,b,t} * Bank\ liquidity\ gain3_{b,t}$, where *i*, *b*, *t*, *S[t – 5,t – 1]* and $\omega_{i,b,t}$ are the same as above. $Bank\ liquidity\ gain3_{b,t}$ denotes the shale liquidity shock for relationship lender *b* at time *t*, which is defined in Equation (1c) above. As lenders in Dealscan are reported at the holding company level, we use *Bank liquidity gain3* at the bank holding company level.	
Monitor-specific liquidity shock measures		
Liquidity gain1 (within τ miles of a monitor)	For each monitor in a year, it equals the average liquidity shocks received by its neighbouring plants within two, three, or five miles of the monitor. The liquidity shock measure of a plant equals the extent to which its affiliated firm is exposed to liquidity shocks through its relationship lenders, and equals *Firm liquidity gain1*.	IHS Markit Energy; Summary of Deposits; Dealscan; National

Liquidity gain2 (within τ miles of a monitor)	For each monitor in a year, it equals the average liquidity shocks received by its neighbouring plants within two, three, or five miles of the monitor. The liquidity shock measure of a plant equals the extent to which its affiliated firm is exposed to liquidity shocks through its relationship lenders, and equals *Firm liquidity gain2*.	Establishment Time-Series (NETS); Toxic Release Inventory (TRI)
Liquidity gain3 (within τ miles of a monitor)	For each monitor in a year, it equals the average liquidity shocks received by its neighbouring plants within two, three, or five miles of the monitor. The liquidity shock measure of a plant equals the extent to which its affiliated firm is exposed to liquidity shocks through its relationship lenders, and equals *Firm liquidity gain3*.	
County-Level Variables		
Hazardous Pollutant Concentration		
Mean, Benzene/Toluene/Ethylbenzene/o-Xylene/m/p Xylene	For each county in a year, we take the average of the arithmetic mean readings across monitors within the county and year. We focus on the five toxic air pollutants with the most comprehensive data: Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene	Environmental Protection Agency (EPA)
50^{th} percentile, Benzene/Toluene/Ethylbenzene/o-Xylene/m/p Xylene	For each county in a year, we take the average of the 50^{th} percentile readings across monitors within the county and year. We focus on the five toxic air pollutants with the most comprehensive data: Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene	
75^{th} percentile, Benzene/Toluene/Ethylbenzene/o-Xylene/m/p Xylene	For each county in a year, we take the average of the 75^{th} percentile readings across monitors within the county and year. We focus on the five toxic air pollutants with the most comprehensive data: Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene	
90^{th} percentile, Benzene/Toluene/Ethylbenzene/o-Xylene/m/p Xylene	For each county in a year, we take the average of the 90^{th} percentile readings across monitors within the county and year. We focus on the five toxic air pollutants with the most comprehensive data: Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene	
County Characteristics		
EPA Penalties	For each county in each year, we first calculate the total dollar amount of CAA penalties over the past five years across plants located in the county. We then define *EPA Penalties* as equal to one if the total penalty amount in a county is above the sample median value, and zero otherwise	EPA Enforcement and Compliance History Online (ECHO)
Ln(Per capita personal income)	Natural log of the personal income of a county divided by the resident population of the county	Bureau of Economic Analyses (BEA)
Ln(Population)	Natural log of the number of individuals (both civilian and military) who reside in in a county	

Labor market participation	The ratio of the number of persons aged 16 and older to the total population	Bureau of Labor Statistics (BLS)
Unemployment	The ratio of the unemployed persons to the number to the labor force	
Firm-Level Variables		
Toxic Emissions		
Toxic Air Releases, plant-level	The total amount of toxic airborne chemicals released from a plant in a year	Toxic Release Inventory
Total Toxic Releases, plant-level	The total amount of toxic chemicals released (including air emissions, water discharges, underground injection, etc.) from each plant in a year	
Toxic Air Releases, firm-level	The total amount of toxic airborne chemicals released from a firm's plants in non-shale counties	
Total Toxic Releases, firm-level	The total amount of toxic chemicals released from a firm's plants in non-shale counties	
Corporate Focus on the Environment		
Environmental rating	The number of items on corporate environmental strengths minus the number of items on corporate environmental concerns. The index ranges from -5 to 5, with higher value indicating greater environmental goodness	MSCI ESG KLD STATS
Environmental activities	A dummy variable that equals one if a firm's 10-K filing contains one of the phrases, including "environmental compliance", "environmental remediation", "environmental control", "pollution control", "emission control", "contamination remediation", but not "environmental liability"	SEC Analytics
Firm Characteristics		
Total assets	Log total assets	Compustat
Return on assets	Net income to total assets	
Leverage	Total debt divided by total assets	
Sales	Log total sales	
Monitor-Level Variables		
Hazardous Pollutant Concentration from EPA Monitors		
50^{th} percentile, Benzene/Toluene/Ethylbenzene/o-Xylene/m/p Xylene	For each monitor in a year, we use the 50^{th} percentile of the monitor readings within the year. We focus on the five toxic air pollutants with the most comprehensive data: Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene	Environmental Protection Agency (EPA)

Syndicated Loan-Related Variables		
Lead arranger	A dummy variable that equals one if a bank acts as the lead arranger in the syndicated deal and zero otherwise. We identify the lead arranger(s) for each loan based on whether it is the administrative agent. The rest of the lenders in the syndicate are treated as participants. For about 20% of syndicates without a specified administrative agent, lenders that serve as one of the significant titles mentioned in Standard & Poor (2011), namely Agent, Co-Agent, Lead Arranger, or Lead managers, or received Lead Arranger League Table credit, are identified as the lead arrangers	Dealscan
Previous lead arranger	A dummy variable that equals one if a bank has served as the lead arranger for the borrower in any deals over the previous five years, and zero otherwise	
Previous lead arranger_lending ties	It equals the fraction of loans for which the bank served as the borrower's lead arranger over the previous five years. Thus, *Previous lead arranger_lending ties* differentiates lenders by the strength of their ties with a borrower	
Loan amount	Natural log dollar amount of the facility	
All-in-drawn spread	The annual spread (fees and interest) the borrower pays in basis points over LIBOR for each dollar drawn down from the loan.	

Table A2 Bank Liquidity and Hazardous Air Pollution, County-Level Analyses: Robustness

This table reports the robustness tests that are the same as those in Table 3, except that we use a third measure of shocks to the credit conditions facing corporations within non-shale counties. Specifically, we examine the effects of county-level liquidity shocks on the concentration of hazardous airborne pollutants based on EPA monitoring stations. Our county-year sample includes only non-shale counties, i.e., those counties with no local shale development. We take the five most monitored hazardous pollutants, namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene. The dependent variable is the arithmetic mean (columns 1 – 5) and median values (columns 6 – 10) of each of the five air pollutants collected by EPA monitoring stations during each year. The key explanatory variable, *County liquidity gain3*, is a third county-specific, time-varying measure on the extent to which banks in a county are exposed to shale development via its branch located in shale-boom counties. For each county in a year, we calculate its banks' shale liquidity shock by taking the average of bank-specific shale liquidity shock (i.e., *Bank liquidity gain3*), weighted each bank by its local market share in that particular county. *Bank liquidity gain3* are defined in a similar way to *Bank liquidity gain2*, except that we focus on counties having a shale boom (the number of shale wells drilled during a year is above the sample top quartile value). We provide detailed definitions for *County liquidity gain3* and *Bank liquidity gain3* in Equations (3) and (1c), and Appendix Table A1. County controls include *Ln(Per capita personal income)*, *Ln(Population)*, *Labor market participation*, and *Unemployment*. We include county and year fixed effects across columns. P-values are calculated using heteroscedasticity robust standard errors clustered at the county level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

	Arithmetic mean					Median				
	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain3	-3.019***	-5.506***	-0.611**	-0.744**	-2.597***	-1.937***	-3.905***	-0.409*	-0.665**	-1.954**
	(0.000)	(0.000)	(0.042)	(0.041)	(0.007)	(0.000)	(0.001)	(0.083)	(0.023)	(0.011)
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.661	0.668	0.657	0.662	0.673	0.722	0.734	0.656	0.664	0.664
# of counties	303	291	290	289	277	303	291	290	289	277

Table A3 Bank Liquidity and Extreme Hazardous Air Pollution, County-Level Analyses: Robustness

This table reports the robustness tests that are the same as those in Table 4, except that we use a third measure of shocks to the credit conditions facing corporations within non-shale counties. Specifically, we examine the effects of county-level liquidity shocks on the extreme concentration of hazardous airborne pollutants from EPA monitoring stations. Our county-year sample includes only non-shale counties, i.e., those counties with no local shale development. We take the five most monitored hazardous pollutants, namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene. The dependent variable is the 75^{th} (columns 1 – 5) and 90^{th} (columns 6 – 10) values of each of the five air pollutants concentration collected by EPA monitoring stations during each year. The key explanatory variable, *County liquidity gain3*, is a third county-specific, time-varying measure on the extent to which banks in a county are exposed to shale development via its branch located in shale-boom counties. For each county in a year, we calculate its banks' shale liquidity shock by taking the average of bank-specific shale liquidity shock (i.e., *Bank liquidity gain3*), weighted each bank by its local market share in that particular county. *Bank liquidity gain3* are defined in a similar way to *Bank liquidity gain2*, except that we focus on counties having a shale boom (the number of shale wells drilled during a year is above the sample top quartile value). We provide detailed definitions for *County liquidity gain3* and *Bank liquidity gain3* in Equations (3) and (1c), and Appendix Table A1. County controls include *Ln(Per capita personal income)*, *Ln(Population)*, *Labor market participation*, and *Unemployment*. We include county and year fixed effects across columns. P-values are calculated using heteroscedasticity robust standard errors clustered at the county level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

	75th Percentile					90th Percentile				
	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain3	-3.391***	-5.969***	-0.878**	-1.196**	-3.643***	-6.579***	-9.853***	-1.251**	-1.393*	-5.414***
	(0.000)	(0.002)	(0.017)	(0.010)	(0.005)	(0.000)	(0.002)	(0.029)	(0.054)	(0.005)
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.695	0.726	0.661	0.684	0.681	0.605	0.682	0.628	0.638	0.658
# of counties	303	291	290	289	277	303	291	290	289	277

Table A4 Bank Liquidity and County-Level Hazardous Air Pollution, Heterogeneity across EPA Penalties: Robustness

This table reports the robustness tests that are the same as those in Table 5, except for using (a) different measures of shocks to the credit conditions facing corporations within non-shale counties (Panel A and B), and/or alternative measures of the intensity of air pollution in non-shale counties (Panel C and D). Specifically, we evaluate the heterogeneous effects of county-level liquidity shocks on hazardous air pollutants concentration, while differentiating counties by the intensity of EPA penalties. We take the five most monitored hazardous pollutants, namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene. The dependent variable is the 50^{th}, 90^{th} percentile, mean and 75^{th} percentile values of each of the five air pollutants concentration in Panel A, B, C, and D, respectively. *EPA Penalties* is an indicator that equals one if the dollar amount of penalties imposed on a county's establishments for violating Clean Air Act over the past five years are greater than the sample median value, and zero otherwise. The key explanatory variable is *County liquidity gain1* and *County liquidity gain3* in Panel A and B, and *County liquidity gain2* in Panel C and D. For each county in a year, we calculate its banks' shale liquidity shock by taking the average of bank-specific shale liquidity shock (i.e., *Bank liquidity gain1*, *Bank liquidity gain2*, or *Bank liquidity gain3*), weighted each bank by its local market share in that particular county. Appendix Table A1 provides detailed variable definitions. County controls include *Ln(Per capita personal income)*, *Ln(Population)*, *Labor market participation*, and *Unemployment*. We include county and year fixed effects across columns. P-values are calculated using heteroscedasticity robust standard errors clustered at the county level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

Panel A: 50th Percentile

	50th Percentile									
	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain1 * EPA Penalties	-0.201**	-0.401*	-0.119***	-0.112**	-0.343**					
	(0.014)	(0.080)	(0.003)	(0.033)	(0.013)					
County liquidity gain1	-0.197**	-0.536**	0.0004	-0.0527	-0.193					
	(0.031)	(0.023)	(0.992)	(0.307)	(0.144)					
County liquidity gain3 * EPA Penalties						-1.080***	-2.588**	-0.727***	-0.724**	-2.039***
						(0.003)	(0.048)	(0.001)	(0.012)	(0.005)
County liquidity gain3						-1.143***	-2.021	0.138	-0.130	-0.499
						(0.001)	(0.132)	(0.466)	(0.616)	(0.430)
EPA Penalties	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.723	0.736	0.659	0.666	0.669	0.724	0.735	0.658	0.666	0.668
# of counties	303	291	290	289	277	303	291	290	289	277

Panel B: 90th Percentile

	90th Percentile									
	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
County liquidity gain1 * EPA Penalties	-0.305	-1.209**	-0.197**	-0.193	-0.905***					
	(0.110)	(0.039)	(0.034)	(0.142)	(0.008)					
County liquidity gain1	-1.024***	-1.130*	-0.0326	-0.170	-0.566*					
	(0.000)	(0.064)	(0.736)	(0.164)	(0.099)					
County liquidity gain3 * EPA Penalties						-2.117*	-6.826**	-1.296**	-1.135	-4.879***
						(0.072)	(0.039)	(0.018)	(0.122)	(0.006)
County liquidity gain3						-5.023***	-4.878	-0.271	-0.579	-1.796
						(0.000)	(0.166)	(0.557)	(0.347)	(0.290)
EPA Penalties	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.605	0.684	0.629	0.640	0.661	0.606	0.684	0.630	0.640	0.659
# of counties	303	291	290	289	277	303	291	290	289	277

Panel C: Mean

	Arithmetic mean														
	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
County liquidity gain1 * EPA Penalties	-0.163*	-0.357	-0.122**	-0.123*	-0.440***										
	(0.090)	(0.237)	(0.013)	(0.052)	(0.008)										
County liquidity gain1	-0.435***	-0.823***	-0.0219	-0.0661	-0.282*										
	(0.000)	(0.009)	(0.682)	(0.281)	(0.096)										
County liquidity gain2 * EPA Penalties						-1.026**	-1.855	-0.742***	-0.716**	-2.331***					
						(0.038)	(0.245)	(0.004)	(0.031)	(0.004)					
County liquidity gain2						-2.256***	-4.173**	-0.0716	-0.297	-1.030					
						(0.000)	(0.016)	(0.773)	(0.335)	(0.206)					
County liquidity gain3 * EPA Penalties											-1.070**	-2.040	-0.790***	-0.740**	-2.439***
											(0.049)	(0.231)	(0.004)	(0.037)	(0.005)
County liquidity gain3											-2.230***	-4.061**	-0.0141	-0.202	-0.817
											(0.000)	(0.025)	(0.955)	(0.517)	(0.330)
EPA Penalties	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.661	0.670	0.658	0.664	0.677	0.663	0.670	0.659	0.664	0.676	0.662	0.669	0.659	0.664	0.675
# of counties	303	291	290	289	277	303	291	290	289	277	303	291	290	289	277

Panel D: 75th Percentile

	75th Percentile														
	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene	Benzene	Toluene	Ethyl benzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
County liquidity gain1 * EPA Penalties	-0.242*	-0.654*	-0.121**	-0.148*	-0.520**										
	(0.059)	(0.072)	(0.049)	(0.065)	(0.020)										
County liquidity gain1	-0.494***	-0.828**	-0.0851	-0.151*	-0.470**										
	(0.000)	(0.029)	(0.196)	(0.059)	(0.046)										
County liquidity gain2 * EPA Penalties						-1.347**	-3.608*	-0.769**	-0.855**	-2.770**					
						(0.026)	(0.062)	(0.016)	(0.049)	(0.013)					
County liquidity gain2						-2.412***	-3.274	-0.345	-0.662	-1.839					
						(0.000)	(0.118)	(0.290)	(0.113)	(0.108)					
County liquidity gain3 * EPA Penalties											-1.398**	-3.906*	-0.808**	-0.879*	-2.867**
											(0.035)	(0.060)	(0.018)	(0.058)	(0.016)
County liquidity gain3											-2.366***	-3.129	-0.266	-0.550	-1.561
											(0.001)	(0.150)	(0.422)	(0.198)	(0.186)
EPA Penalties	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148	2,327	2,267	2,241	2,213	2,148
R-squared	0.697	0.729	0.662	0.687	0.685	0.697	0.728	0.663	0.687	0.684	0.696	0.728	0.662	0.686	0.683
# of counties	303	291	290	289	277	303	291	290	289	277	303	291	290	289	277

Table A5 Liquidity Shocks, Toxic Releases, and Corporate Focus on the Environment: Robustness

This table presents the robustness tests that are the same as those in Table 8 and 10, except that we use a third measure of the extent to which a firm's relationship lenders receive a positive liquidity shock. Specifically, we examine the effects of liquidity shocks to a corporation's relationship lenders on the firm's (a) toxic releases, and (b) focus on environment protection. The unit of analyses is plant-year in columns 1 and 2 where we exclude plants located in counties with shale development activities, and firm-year columns 3 – 6 where we exclude firms headquartered in counties with shale development activities. The dependent variable is logarithm of the volume of air emissions in column 1 and 3 the logarithm of the total volume of toxic chemicals released in columns 2 and 4, *Environmental rating* from MSCI analyses in column 5 and *Environmental activities* from SEC 10-K filings. The key explanatory variable is *Firm liquidity gain3*. For each firm in a year, we construct its shale liquidity shock as the weighted average of its relationship lenders' liquidity shock (i.e., *Bank liquidity gain3*), where each relationship lender is weighted by the loan amount it acted as the lead arranger in deals during the previous five years. *Bank liquidity gain3* are defined in a similar way to *Bank liquidity gain2*, except that we focus on counties having a shale boom (the number of shale wells drilled during a year is above the sample top quartile value). We provide detailed definition for *Firm liquidity gain3*, and *Bank liquidity gain3* in Equations (4) and (1c), and Appendix Table A1. Firm controls include *Total assets (lag)*, *Profitability (lag)*, *Leverage (lag)*, and *Sales*. Columns 1 and 2 include Plant, Industry (SIC 3-digit)-by-Year fixed effects, and State-by-Year fixed effects, and Columns 3 – 6 include Firm, and Industry-by-Year fixed effects. P-values are calculated using heteroscedasticity robust standard errors clustered at the firm level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

	Plant-Year Level		Firm-Year Level			
	Toxic Air Releases	Total Toxic Releases	Toxic Air Releases	Total Toxic Releases	Environmental rating	Environmental activities
	Excl. plants located in shale counties		Excl. plants in shale counties and firms headquartered in shale counties		Excl. firms headquartered in shale counties	
	(1)	(2)	(3)	(4)	(5)	(6)
Firm liquidity gain3	-1.150***	-0.934***	-2.761***	-2.432***	0.130***	0.169***
	(0.000)	(0.002)	(0.005)	(0.009)	(0.000)	(0.000)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Plant Fixed effects	Yes	Yes	No	No	No	No
Firm Fixed effects	No	No	Yes	Yes	Yes	Yes
Industry-by-year Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
State-by-year Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	66,819	66,819	8,626	8,626	20,120	42,483
R-squared	0.912	0.904	0.936	0.930	0.709	0.652
# of firms	1040	1040	1004	1004	2582	4941
# of plants	8839	8839	-	-	-	-

Table A6 Liquidity Shocks and Hazardous Pollutant Concentration near Toxic Emission Plants: Robustness

This table reports the robustness tests that are the same as those in Table 9, except that we use a third measure of the extent to which a monitor's neighboring pollution plants receive a positive liquidity shock. Specifically, we evaluate the effects of liquidity shocks received by toxic emission plants on hazardous air pollutants concentration collected by their neighboring EPA monitors within three (Panel A), two (Panel B), or five miles (Panel C). We exclude monitors located in counties with local shale development from our monitor-year regressions. The dependent variable is the median values of each of the five most-monitored hazardous air pollutants (namely, Benzene, Toluene, Ethylbenzene, o-Xylene, and m/p Xylene) concentration in each year. The key explanatory variable, *Liquidity gain3 (within τ miles of a monitor)*, is a monitor-specific, time-varying measure on the extent to which a monitor's neighboring toxic-pollutant-emission plants receive positive liquidity shocks. For each monitor in a year, we calculate its nearby plants' shale liquidity shock by averaging the shale liquidity shock of their parent companies (i.e., *Firm liquidity gain3*). Appendix Table A1 and Equation (4) provide detailed variable definitions. We include monitor and county-year fixed effects in all specifications. P-values are calculated using heteroscedasticity robust standard errors clustered at the monitor level, and reported in parentheses. *,**, and *** indicate significance at 10%, 5%, and 1%.

Panel A: Hazardous pollutant emission plants within *three* miles of each monitor

	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)
Liquidity gain3 (within 3 miles of a monitor)	-1.718**	-3.633**	-1.239***	-1.373***	-3.070***
	(0.013)	(0.016)	(0.001)	(0.001)	(0.003)
Monitor FE	Yes	Yes	Yes	Yes	Yes
County-by-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	3,650	3,545	3,483	3,460	3,342
R-squared	0.863	0.853	0.826	0.826	0.837
# of monitors	611	587	578	574	542

Panel B: Hazardous pollutant emission plants within *two* miles of each monitor

	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)
Liquidity gain3 (within 2 miles of a monitor)	-1.336**	-2.268*	-0.881***	-0.983***	-2.758***
	(0.023)	(0.099)	(0.005)	(0.005)	(0.001)
Monitor FE	Yes	Yes	Yes	Yes	Yes
County-by-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	3,650	3,545	3,483	3,460	3,342
R-squared	0.862	0.853	0.826	0.825	0.837
# of monitors	611	587	578	574	542

Panel C: Hazardous pollutant emission plants within *five* miles of each monitor

	Benzene	Toluene	Ethylbenzene	o-Xylene	m/p Xylene
	(1)	(2)	(3)	(4)	(5)
Liquidity gain3 (within 5 miles of a monitor)	-1.548*	-4.015*	-1.360***	-1.062*	-2.511*
	(0.053)	(0.077)	(0.004)	(0.068)	(0.077)
Monitor FE	Yes	Yes	Yes	Yes	Yes
County-by-Year FE	Yes	Yes	Yes	Yes	Yes
Observations	3,650	3,545	3,483	3,460	3,342
R-squared	0.862	0.853	0.825	0.824	0.836
# of monitors	611	587	578	574	542