

Risk Hedging and Loan Covenants*

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ABSTRACT

We study lending agreements and derivative positions of U.S. oil and gas producers and show that loan covenants are important determinants of hedging outcomes. Hedging covenants appear in more than 85% of sample loan agreements, with explicit minimum hedging requirements delineated in 54%, and are more prevalent for firms with higher expected costs of default. Firms with contractual hedging commitments have lower borrowing costs and perform better during the COVID-19 pandemic, even after controlling for the magnitude of hedges. The results imply that understanding firms' hedging outcomes requires explicit consideration of the lending covenants employed to mitigate agency conflicts.

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“Our credit agreement requires that we hedge at least 75% but not more than 80% of projected oil production from our existing proved producing mineral interests for not less than 30 months.”

Exco Resources Inc.

In recent decades academics, including [Stulz \(1984\)](#), [Smith and Stulz \(1985\)](#), [Bessembinder \(1991\)](#), [Froot, Scharfstein, and Stein \(1993\)](#), [Morellec and Smith \(2007\)](#), [Rampini and Viswanathan \(2010\)](#), and [Bolton, Chen, and Wang \(2011\)](#), have developed plausible theories of corporate risk management that prescribe optimal hedge ratios for value-maximizing firms or utility-maximizing managers. Yet, these theories may fail to explain why firms with similar characteristics pursue notably different risk management policies, and the empirical evidence provides mixed support for model predictions (e.g., [Mian \(1996\)](#), [Nance, Smith, and Smithson \(1993\)](#), [Geczy, Minton, and Schrand \(1997\)](#), and [Tufano \(1996\)](#)). In this paper, we contribute to the understanding of firms’ observed hedging outcomes by showing that lenders often play a central role, as covenants that delineate specific hedging requirements such as minimum hedge ratios and allowed counterparties appear in the large majority of the loan agreements in our sample of loans to oil and gas firms.

Since borrowers could presumably negotiate financing agreements that exclude hedging-related covenants, it can be inferred that their presence benefits both lenders and borrowers at the time these agreements are negotiated. We provide evidence indicating that hedging-related covenants benefit lenders by effectively mitigating agency costs and benefit borrowers because they are associated with lower interest costs. Of course, as [Smith and Warner \(1979\)](#) emphasize in their classic analysis of debt contracts, covenants are costly because they reduce borrowers’ flexibility. Indeed, we find that hedging covenants tend to be used more often in those cases where the benefits of hedging, as measured by empirical proxies for expected bankruptcy costs, are largest.

Like most empirical studies that study firm-specific hedging in detail, e.g., [Tufano \(1996\)](#) and [Adam and Fernando \(2006\)](#) who study gold producers, [Ellul and Yerramilli \(2013\)](#) who study bank holding companies, [Rampini, Sufi, and Viswanathan \(2014\)](#) and [Giambona and Wang \(2020\)](#) who study airlines, [Cornaggia \(2013\)](#) who studies agricultural producers, and [Haushalter \(2000\)](#) and [Jin and Jorion \(2006\)](#) who study oil and gas firms, we study risk management practices by firms

in a single industry. Specifically, our sample includes 2,591 firm-years for 308 U.S. oil and gas producers during the period 1999-2019. Oil and gas firms provide an excellent setting to study risk management practices and the role of lenders in shaping hedging outcomes. First, oil and gas firms disclose detailed data on their derivative positions. Second, they are strongly exposed to energy commodity prices. Third, there exist well-developed and liquid energy derivative markets. Fourth, the emergence of hydraulic fracturing and horizontal drilling techniques during this period resulted in oil and gas firms dramatically expanding their capital spending programs and financing this expansion almost dollar-for-dollar with new debt. Average inflation-adjusted annual capital expenditures in the oil and gas industry grew from \$143 million in 1999 to \$1 billion in 2019, while long-term debt issuance increased from \$150 million to \$1.1 billion per firm/year. These large increases in capital expenditures and borrowing provide increased statistical power to detect relations between borrowing, covenants, and hedging.¹

We show that the credit agreements used in oil and gas loans include covenants requiring borrowers to commit to certain hedging policies. These covenants commonly specify minimum hedge ratios and minimum hedge maturities, place limits on magnitudes of derivative positions, contain non-speculation clauses, require that firms hedge with lender-approved counterparties and periodically report to lenders of derivatives positions, and contain provisions that reduce the borrowing base should hedges be unwound. We find that hedging covenants became more prevalent over time and are present in more than 85% of all credit and loan agreements in the sample, with 54% of agreements containing explicit minimum hedging requirements.

The literature, e.g. [Campello, Lin, Ma, and Zou \(2011\)](#), has noted that firms borrowing and hedging outcomes are positively related, with the interpretation that firms endogenously choose to hedge, in part to negotiate better loan terms. We study outcomes when firms borrow with and without covenants that commit them to contractually-specified minimum hedging constraints. The results indicate relations between borrowing amounts and firm hedge ratios are much stronger in those cases where loan covenants commit firms to hedging, and indeed are not statistically sig-

¹Indeed, oil and gas firms comprise a large segment of overall credit market transactions; according to the Bank for International Settlements oil and gas firms accounted for around 40% of both syndicated loans and debt securities outstanding as of 2014 (see, e.g., [Domanski, Kearns, Lombardi, and Shin \(2015\)](#)).

nificant when such covenants are absent. These results support the interpretation the positive empirical relation between borrowing and hedging is much stronger when there is a formal commitment to ongoing hedging. In combination with the observation that new capital expenditures were financed almost dollar-for-dollar by increased debt, these results support the reasoning that financial contracting technology in the form of hedging covenants played an important role in enabling the U.S. fracking revolution.

We also consider the possibility discussed by [Roe \(2011\)](#) and [Bolton and Oehmke \(2015\)](#) that derivative contracts might be used opportunistically to expropriate wealth from existing creditors. Our results are not at odds with this reasoning, but support the interpretation that lenders take proactive steps to mitigate this danger. First, close to 50% of lending agreements explicitly disallow the use of derivatives for speculative purposes. Second, in many cases covenants prevent oil and gas firms from offering collateral to derivative counterparties, which strips derivatives of their effective seniority over debt claims. Third, financing and risk management are often bundled, as over half of lending agreements explicitly allow, and about 10% require, firms to use the original lender as a counterparty to any derivative transactions. Such bundling effectively internalizes any potential transfers from lenders to hedge counterparties, and we find that the positive relation between debt issuance and hedge outcomes is greater in those cases when financing and hedging are bundled.

In addition, we provide evidence regarding the effectiveness of covenant-specified hedging commitments during the emergence of the COVID-19 pandemic in early 2020, when oil prices declined from more than \$60 per barrel to less than \$20 and industry market valuations were reduced by more than 50%. We find that firms with minimum hedging covenants in their loan agreements had a significantly lower sensitivity to the daily crude oil price and the worldwide COVID-19 case count, even after allowing for the effects of hedge ratios themselves. For example, during the month of March, firms with minimum hedging requirements posted an average return 14.7% higher than firms without such requirements. For highly levered firms the return differential was 30.0%. These results may be attributable to firms without contractual commitments to ongoing hedges choosing to unwind their in-the-money hedges to raise cash, thereby becoming more exposed to the rapidly

evolving economic conditions.

[Griffin, Nini, and Smith \(2019\)](#) study lenders' use of covenants more broadly, documenting a 50% decline in the number of covenants per loan and a 70% decline in the number of covenant violations between 1997 and 2016, as lenders sought to reduce excessive covenant-related costs. Our results showing increased reliance on hedging-related covenants over roughly the same period are therefore all the more striking, and indicate increased recognition by lenders of the importance and desirability of hedging, at least in the oil and gas industry.

The evidence reported here supports the conclusion that oil and gas firms increased their hedge ratios even as they sharply increased their borrowing in the wake of the fracking boom because both they and their lenders benefited from the inclusion of binding hedging commitments in their loan agreements. On balance, these results highlight the importance of creditors' interests in explaining observed hedge outcomes and their use of covenants to protect such interests, while also supporting the reasoning that the firms that benefit most from controlling agency conflicts are more likely to consent to the inclusion of hedge covenants in their lending contracts.² While, as noted, the marked increase in capital investment and borrowing occasioned by the fracking boom increase statistical power, the economic motivations for the inclusion of hedging-related covenants in loan contracts are not unique to oil and gas firms. A preliminary search verifies that lender covenants of the type we observe for oil and gas firms, including requirements to hedge, non-speculation clauses, hedge reporting requirements, and identification of approved hedge counterparties, are also observed in other industries.³ It will be of interest for future research to assess if such covenants are as ubiquitous and serve similar economic roles in industries other than the economically-important oil and gas industry studied here.

²Further, hedge covenants introduce a degree of standardization to loan contracts that may facilitate the inclusion of energy industry bank loans in Collateralized Loan Obligations (CLOs). Borrowing firms ultimately benefit from entering contracts that effectively commit them to hedging programs, as we document that borrowers with hedging covenants pay lower interest on their loans.

³Examples include [Cincinnati Bell](#) and [Lumen Technologies, Inc.](#), where credit agreements include non-speculation clauses, [Consol Coal Resources](#), where a lending agreement contains both hedge reporting requirements and non-speculation clauses, as well as [Air Transport Services Group](#), for which hedging is required and [Airtran Holdings](#), for which acceptable swap counterparties are specified.

I. Literature Review

A substantive literature focuses on the benefits of corporate risk management to shareholders and managers. The literature has shown that hedging can increase firm value (see, e.g., [Allayannis and Weston \(2001\)](#), [Graham and Rogers \(2002\)](#), [Adam and Fernando \(2006\)](#), [Mackay and Moeller \(2007\)](#), [Bartram, Brown, and Conrad \(2011\)](#), [Ellul and Yerramilli \(2013\)](#), [Cornaggia \(2013\)](#), and [Pérez-González and Yun \(2013\)](#)).⁴ Mechanisms for value creation include that by reducing the variability of cash flows hedging can decrease the expected costs of financial distress, increase debt capacity, minimize the corporate tax bill, decrease the expected costs of external financing, and increase productive investment (see, e.g., [Smith and Stulz \(1985\)](#), [Bessembinder \(1991\)](#), [Froot, Scharfstein, and Stein \(1993\)](#), [Leland \(1998\)](#), [Graham and Smith \(1999\)](#), [Graham and Rogers \(2002\)](#), [Fehle and Tsyplakov \(2005\)](#), and [Purnanandam \(2008\)](#)). In addition, hedging can reduce information asymmetries and allow managers to better signal their ability to the labor market ([DeMarzo and Duffie \(1995\)](#)). Risk-averse corporate executives may also engage in hedging to increase their personal utility, for example, by decreasing compensation risk ([Stulz \(1984\)](#) and [Smith and Stulz \(1985\)](#)). Consistent with this view, [Tufano \(1996\)](#) finds that hedging in the gold mining industry is related to executive compensation structure and [Knopf, Nam, and Thornton \(2002\)](#) find that firms hedge more when the sensitivity of managers' stock and stock option portfolios to stock price increases.⁵ However, hedging can also have costs. For example, [Acharya, Lochstoer, and Ramadorai \(2013\)](#) find that a higher hedging demand from oil and gas producers tends to increase their hedging costs via price-pressure on futures.

However, the literature has also shown that derivative contracts can aggravate debt-related agency problems. Most obviously, derivative contracts can be used to speculate rather than hedge. As [Jensen and Meckling \(1976\)](#) emphasized, increases in risk can effectively transfer value from creditors to equity holders. More recently, [Bolton and Oehmke \(2015\)](#) show that because derivative

⁴Exceptions are [Jin and Jorion \(2006\)](#), who find no relation between hedging and market value, and [Guay and Kothari \(2003\)](#), who argue that the magnitude of risk exposures that can be effectively hedged are too small to have a meaningful effect on firm value.

⁵The model presented by [Rampini and Viswanathan \(2010\)](#) focuses on hedging by financially constrained firms. [Rampini, Sufi, and Viswanathan \(2014\)](#) test the predictions of their theory using a sample of U.S. commercial airlines, finding that more financially constrained airlines are less likely to hedge fuel costs.

claims are effectively senior to other claims in case of bankruptcy, firms may have incentives to enter hedge positions that effectively reduce the value of existing debt claims.

We contribute to the literature by focusing attention on the role of creditors in affecting risk management outcomes. [Beatty, Petacchi, and Zhang \(2012\)](#) document that approximately ten percent of the lending agreements in their sample of 2,388 bank loans include “interest rate protection” covenants, which require borrowers who rely on floating interest rate loans to hedge the resulting interest rate exposure. We document the existence of a substantially broader range of hedging-related covenants that mainly focus on commodity price exposures and that appear in over 85% of sample lending agreements. Our study is further related to studies linking hedging policies and leverage. [Haushalter \(2000\)](#) shows that hedging is related to leverage as risk management alleviates financial contracting costs. [Pérez-González and Yun \(2013\)](#) show that the introduction of weather-related derivatives enabled both hedging and greater borrowing by weather-sensitive firms. [Campello, Lin, Ma, and Zou \(2011\)](#) use a tax-based instrument to show that hedgers pay lower interest spreads and are less likely to face capital expenditure restrictions in their loan agreements. Our results are consistent with these papers in that we document a positive empirical relation between hedging and quantities borrowed and a negative relation between hedging and borrowing costs. We expand on their analyses by emphasizing the role of potentially binding hedging covenants in enabling these benefits, particularly for firms with high ex-ante default costs, by demonstrating that hedging covenants improve outcomes during the COVID crisis and are related to lower borrowing costs, even after allowing for the magnitudes of hedge positions.

We also contribute to the literature that studies the determinants and structure of loan covenants. [Bradley and Roberts \(2015\)](#) report that covenant use decreases with firm size, leverage, and growth opportunities. [Prilmeier \(2017\)](#) argues that covenants typically bind when loans are first issued, but that restrictions are relaxed as the duration of a borrower-lender relationship increases, implying that it is to the borrower’s benefit to continue to contract with the same lender. [Matvos \(2013\)](#) argues that a few boilerplate covenants have the most impact in terms of improving loan contract terms, while the marginal benefits from additional or more specific are minimal. In particular,

he reports an 84 basis-point interest rate reduction with just two loan covenants. [Simpson and Grossmann \(2017\)](#) find that certain covenants lost effectiveness after the 2007-09 financial crisis, which may help to explain the introduction of new covenants, including those that require hedging with derivative contracts, thereafter. [Nini, Smith, and Sufi \(2012\)](#) investigate the consequences of covenant violations, showing creditor reactions to violations improve firm’s operational and stock-price performance. [Griffin, Nini, and Smith \(2019\)](#) document decreased reliance on loan covenants overall in recent decades, a result that sharpens the importance of the increased usage of hedging-related covenants shown here. Our analysis shows how hedging related covenants can effectively control incentives to engage in risk shifting or to enter new hedge contracts that reduce the value of existing loans.

II. Capital Investment and Debt Financing During the Fracking Boom

We rely on data from the oil and gas industry during the period when hydraulic fracturing (“fracking”) was widely adopted. Fracking is a stimulation technique in which rock is fractured by a highly pressurized liquid. The first experiments involving fracking date to the late 1950s, but the high initial cost and relatively low efficiency prevented widespread early adoption. In years after 2000 hydraulic fracturing was successfully combined with horizontal drilling techniques, resulting in a commercially viable application to shale rock formations. The new technology was put to use in gas fields around 2005-2006 and to crude oil shortly thereafter.⁶ The new technology was capital intensive, requiring significant investment by firms in land, mineral rights, equipment, and labor.⁷ Figure 1 provides information regarding the evolution of fracking technology adoption by U.S. oil and gas companies during 1999-2019 period. Specifically, the frequency of mentions of ‘horizontal drilling’ increased from approximately 0.2 mentions per annual report before 2005 to more than 3 mentions post-2011. Similarly, the term ‘hydraulic fracturing’ was almost never used prior to 2005,

⁶See “The Texas well that started fracking revolution,” *Wall Street Journal*, June 29, 2018.

⁷The energy report by [Maugeri \(2012\)](#) indicates that fracking is more capital intensive than conventional technology in part because hydraulically fractured wells are depleted more rapidly, requiring more frequent drilling of new wells to maintain a constant level of production.

but appeared, an average, of approximately 30 times post-2011. The next two panels of Figure 1 provide data showing that exploration and extraction of oil and gas increased substantially in mid- and late-2000s. For comparison, in the bottom two panels of Figure 1, we show the total number of horizontal wells and dry shale gas production in the United States based on the data from the U.S. Energy Information Administration (EIA). Consistent with the increase in horizontal drilling documented in our sample, the total number of horizontal oil and gas wells in the United States increased dramatically after 2005.

During the same period, sample firm annual capital expenditures (adjusted for inflation to year 2019) grew from less than \$265 million before 2005 to more than \$1 billion post-2011 (see Figure 2). These large investments were primarily financed by bank debt. Syndicated bank loans and revolving lines of credit have historically represented the marginal source of funds for oil and gas firms, and this remained the case as financing needs increased during the sample period, for at least two reasons. First, this period was characterized by historically low interest rates. Second, the widespread industry practice of Reserve Base Lending (RBL), whereby a loan is secured by a firm’s proved oil and gas reserves, made it easier for banks to extend credit during the period of high energy prices ([Azar \(2017\)](#)). Indeed, by increasing the quantity and unit value of oil and gas reserve collateral, the shale boom directly facilitated borrowing (see, e.g., [Kiyotaki and Moore \(1997\)](#) and [Brunnermeier and Oehmke \(2013\)](#)).

As Figure 2 shows, annual long-term debt issuance by sample firms increased from less than \$300 million before 2005 to approximately \$800 million post-2011. Equity issuance in contrast remained fairly steady, except for a temporary spike in 2016 when low energy prices made debt issuance secured by firms’ reserves more difficult. The next panel of Figure 2 illustrates the dynamics of LIBOR rates, which are often the basis for loan interest rates. While LIBOR rates were relatively high at the beginning of the sample period, they dramatically declined after 2008. The last two panels of Figure 2 display average spot prices and realized volatilities of monthly spot prices for natural gas and crude oil during the same period. These figures do not reveal significant trends in volatility or prices that could have explained a surge in hedging activity.

The several-fold increase in debt issuance by sample firms was accompanied by advancements in contracting technology, whereby new credit agreements began to include covenants requiring borrowers to commit to certain hedging policies and also specifying how derivative portfolios would be treated upon covenant violations or firm bankruptcy. We provide examples of such hedging covenants in Appendix A. Covenants often specify both the minimum and the maximum portion of estimated production that must be covered by a derivative position. In addition to hedge ratios, some credit agreements place minimum and maximum restrictions on hedge contract maturities. A non-speculation clause is often present in credit agreements, stating for example that ‘the hedge agreement is for the principal purpose of protecting against fluctuations in commodity prices and not for purpose of speculation.’ In addition, it became common for banks to require that all derivative positions be reported to the lender in a timely fashion, including information on hedged volumes, the type of securities (e.g., forwards, options, swaps) used, maturities, and counterparties. We also observe that the credit agreements may specify that some or all hedge contracts are to be terminated upon default, with any proceeds from the settlement of outstanding derivatives being immediately payable to the lender. Moreover, lenders often restrict the borrower’s ability to enter into new hedging contracts, either by explicit limitations or requiring that the counterparty to any new hedge contract is the lender or one of its affiliates.

III. Sample and Descriptive Statistics

A. Oil and Gas Firms in the Sample

We study U.S. oil and gas producing firms (SIC Code 1311 ‘Crude Petroleum and Natural Gas Extraction’) that have non-missing accounting data in COMPUSTAT during the 1999 to 2019 period. For each firm, we download annual statements (10-K or 10-KSB) from SEC EDGAR. We delete observations with no reported production of oil or natural gas and firm-years for which no corresponding annual reports are available. The resulting sample consists of 308 unique firms and 2,591 firm-year observations.

We search the annual reports for the following keywords related to firms’ risk management

practices: “hedg,” “swap,” “derivative,” “collar,” “risk management,” “futures,” and “forward.” Firms typically report the type (e.g., futures, options, swaps) of outstanding derivatives positions, their average maturities, quantities, and relevant contract prices.⁸ To calculate hedge ratios, we first sum, separately for oil and natural gas, all reported notional derivative quantities pertaining to the fiscal year following the reporting year. We then divide the hedge volume for each commodity by the next year’s actual production of the commodity.⁹ While it is possible that some firms enter into commodity derivative positions to speculate rather than to hedge (and we do see instances where hedge ratios substantially exceed one), we treat all outstanding positions as representing hedges. We also obtain from the financial statements the stated maximum maturity of any individual hedge contract, separately for oil and gas.

In Figure 3 we report data that illustrates changes in sample firms’ risk management policies during the 1999 to 2019 period. The fraction of firms engaging in at least some hedging of oil price exposure increased notably over the sample period, from approximately 39% before 2005 to more than 66% after 2011. The average fraction of the next year’s oil and gas production that is hedged increased from less than 20% prior to 2005 to more than 30% after 2011. On the bottom two panels of Figure 3 we present data regarding the average maturity of oil and gas hedging contracts. The maximum maturities of oil and gas hedging contracts increased from about 5-10 months at the beginning of the sample to 14-20 months in the second half of the sample. Appendix B compiles definitions for the main variables employed in this study.

B. Sample Descriptive Statistics

We report descriptive statistics for our sample in Tables 1, 2, and 3. Table 1 reports on derivative usage and hedge ratios for the full sample, while Table 2 breaks out results separately for firms that do and do not enter hedge contracts, and Table 3 describes aspects of the hedging covenants

⁸A number of firms also report the additional positions they take in contracts that refer to differences in related prices, in particular basis, spread, or differential swaps. To avoid double counting, we exclude these additional derivatives for the purposes of calculating the hedged volume.

⁹If production data for the following year are unavailable, we divide the derivative volume by the current year’s production. The results are robust to alternatively calculating the hedge ratios as the future hedged volume divided by the current year’s production for all firm-years.

observed in sample loan agreements.

Panel A of Table 1 indicates that 67.0% of sample firms report using derivatives, with 64.0% of firms using derivatives to hedge commodity price exposure in particular. The fraction of firms hedging crude oil prices is 54.1%, almost identical to the fraction of hedging natural gas prices, which is 53.9%.¹⁰ In addition, 20.3% of firms enter interest rate derivatives, such as floating-for-fixed interest rate swaps, and 8.3% firms report using foreign exchange derivatives.

Panel B of Table 1 reports on annual oil and gas production and on the characteristics of firms' outstanding hedging portfolios. The average hedge ratio is 30.1% for crude oil production and 26.5% for natural gas production. The average derivative maturity is 13.5 months for oil contracts and 14.3 months for natural gas contracts.

Finally, the last panel of Table 1 reports on firm-level characteristics. The oil and gas firms that comprise our sample have high leverage (mean book leverage of 35.9%) and low profitability. Specifically, the mean (median) return on assets is -17% (1%). Notably, sample firms issue on average long-term debt in an amount equal to 18.4% of the book value of their assets each year. Reflecting the large reliance on debt financing, firms are in default (most commonly in Chapter 11) at year end for 1.3% of firm-year observations. Firms in the sample pay annual interest on their loans equal to 10.3% of the outstanding value of debt. Also reflecting low profitability, both the mean and median amounts of tax-loss carryforwards are positive.

In Table 2 we compare firm characteristics for firms that report entering commodity hedges versus those that do not. Consistent with the reasoning that economies of scale apply to risk management activities, firms that hedge are on average much larger (\$4.92 billion vs \$0.61 billion in assets) and have substantially greater annual production as compared to non-hedging firms. Firms that hedge have significantly lower average market-to-book ratios (1.22 vs. 3.04) as compared to non-hedging firms, indicating that investors perceive that their growth opportunities are less valuable. While both groups are unprofitable on average, non-hedging firms are considerably more so (return on assets of -39.3% vs. -5.1%).

¹⁰In general, more firms hedge natural gas price exposure in the early part of the sample, whereas oil price hedging is more prevalent in the late part of the sample. Firms are also more likely to hedge natural gas price exposure when it constitutes a greater portion of their overall energy production.

Financing policies also differ substantially for hedgers vs. non-hedgers. Firms that hedge their commodity exposure have, on average, book leverage of 39.0%, compared to 30.5% for non-hedgers. Despite having significantly more leverage, hedgers are significantly less likely to be in default, which is likely related to the difference in average size and profitability. Hedgers also pay a notably lower average interest rate on their debt than non-hedgers (8.0% vs. 16.1%). Also noteworthy are the differences in debt issuance for firms that manage their commodity risk versus those that do not. Specifically, the average annual long-term debt issuance is 23.1% of book value of assets for hedgers, compared to 10.1% for non-hedgers. The fact that hedgers issue more new debt as compared to non-hedgers could reflect at least three potential explanations: (i) hedges are used to obtain better loan contracting terms, (ii) firms that borrow enter hedges to expropriate wealth from lenders, or (iii) lenders include covenants that effectively commit the firm to hedging. Our empirical results reported below are intended to assess the extent to which each of these explanations contributes.

C. Hedging Covenants

Before we proceed to analyze relations between debt issuance, covenants, and risk management, we describe the hedging covenants present in sample firms' lending agreements. To obtain the sample of lending agreements, we search firms' annual reports for mentions of any outstanding credit agreement or loans, and then extract the full text of these agreements from prior SEC filings (most commonly contained in 8-K or 10-Q reports).¹¹ We are able to identify a credit or loan agreement for 1,996 firm-years, or 77.0% of the sample. In Panel A of Table 3 we report summary data regarding the covenants that appear in these lending agreements. The agreements contain hedging covenants in the large majority, 85.3%, of cases. Fifty four percent of agreements explicitly require a minimum amount of hedging by indicating a minimum hedge ratio, hedged volume, or maturity, and/or by specifying that the loan commitment will be reduced if the borrower unwinds existing hedges. Nearly half of lending agreements include clauses that prohibit the use of derivatives for speculative purposes. Notably, for 54.7% of the firm-years, the lending agreements explicitly state that the lending bank can be used as a counterparty to firm derivative transaction, and for

¹¹When multiple agreements are outstanding, we record the information on the most recent one.

8.8% of the firm-years the loan agreement requires the lender to be the counterparty for hedging transactions.

Interestingly, more than two thirds, specifically 69.9%, of the loan agreements place restrictions on the maximum allowed hedge ratios and/or maturities. Why limit the amount of hedging? One danger is that a firm will effectively engage in risk shifting by using derivatives to speculate rather than hedge once debt is in place. A limit on the size of the derivative position effectively controls this potential agency problem. Also, if a company hedges 100% of its anticipated future output but production unexpectedly declines (as occurred during the first quarter of 2020), the company will effectively be over-hedged and may have to pay derivative obligations out of its cash reserves to the detriment of lenders.

In Panel B of Table 3 we present statistics for all firm-years in the sample, including observations for firms that do not have any debt, or have indentures or notes rather than bank debt. For this broader sample, hedging covenants are present in 69.9% of firm-years and covenants that require hedging are observed for 44.0% of observations. In 26.1% of cases, there is an explicit covenant requiring the firm to hedge a minimum percentage of its future production. When such covenant is present, the minimum allowed hedge ratio is, on average, 54.2%. The requirement to maintain a minimum maturity of hedging contracts is less frequent (16.6% firm-years), and when present, it specifies the average allowed minimum maturity of approximately 26 months. In almost half of the cases, the lending agreements require the borrower to enter hedging contracts only with counterparties pre-approved by the lender or with counterparties that have a credit rating above a certain threshold. In 44.6% of firm-years, the lending agreements explicitly allow the lending bank to be a counterparty to firm hedging positions, and in 7.2% firm-years they require the lender to be a counterparty.

In 60.0% of firm-years, the agreements also require timely reports of all of the firm's derivative positions to the lender, including hedged volumes, involved counterparties, type of derivatives used, strike prices for option positions, and the relevant contract maturities.¹² Lenders seek to ensure

¹²The reporting requirements vary considerably across firms, with some agreements asking only for the initial report of outstanding hedging positions, others requiring quarterly updates, and some asking for a report each time there is a change in hedging position.

that existing hedges are maintained, as 30.7% of agreements either explicitly prohibit the unwinding of hedges or state that the borrowing base will be reduced conditional on hedge termination or entry into any offsetting derivative positions. Thirty five percent of observations place restrictions on the use of interest rate swaps or specify other hedging covenants, and a majority (53.4%) of observations contain restrictions on posting collateral for hedge contracts (thereby requiring hedges to be unsecured) entering into option positions, the strike prices on these contracts, and cross-default provisions.

In Panel C of Table 3 we report on the hedging covenants present in lending agreements for several prominent lending banks. These reveal significant differences in bank styles. Some banks, such as Well Fargo Bank and BNP Paribas, frequently require a minimum quantity of hedging (83.2% and 84.6% of observations, respectively). Others, such as Bank of America and Bank One, seldom (32.6% and 33.9%, respectively) specify a minimum quantity. However, all of these banks include hedging requirements in a majority of the lending agreements, ranging from 75% for the Bank of Oklahoma to 100% for BNP Paribas, Bank of Montreal, Union Bank, Citibank, and Royal Bank of Canada.

In Figure 4, we plot the fraction of oil and gas firms subject to hedging covenants over time. The presence of such covenants increased from 57.1% at the beginning of the sample to 78.9% by the end. The number of hedging covenants increased from an average of two per firm in 1999 to more than five in 2019. More dramatic was the increase in the number of covenants specifically requiring hedging, which we define as having a covenant that requires a minimum hedge ratio, specifies that the borrowing base of the loan will be reduced upon unwinding of existing hedges, or/and having a covenant that requires a minimum maturity of hedges, which increased from approximately 22% at the beginning of the sample to approximately 60% by the end of the sample period. The figure also shows an increased tendency of firms to add non-speculation clauses and hedging reporting requirements.

D. Rationale for Hedge Covenants

If hedge covenants are beneficial to both borrowers and lenders, why don't all lending agreements include such covenants? [Smith and Warner \(1979\)](#) discuss the restrictive covenants included in many lending agreements, and argue that while the benefits of their inclusion may be substantial, covenants also impose shadow costs to the extent that they constrain the firm from the flexibility to respond to unforeseen events in an efficient manner. They acknowledge that such costs cannot readily be measured, but they maintain that such costs are important as they develop their testable implications. We are also unable to directly measure the costs associated with a lack of flexibility, and we instead focus on the likelihood that the benefits of restrictive covenants will vary across firms. In particular, we hypothesize that hedging covenants will be used more frequently when expected default costs, attributable to either a higher likelihood of default or higher expected costs in case of default, and the related agency costs are larger.

In Table 4 we report results of empirical analyses that assess which firm characteristics are associated with the presence of hedging covenants. The first two columns report results where the dependent variable is an indicator variable equal to one if a firm has any hedging covenant in its lending agreement and zero otherwise, whereas the last two columns use as the dependent variable the number of different hedging covenants (0 through 11).¹³ We estimate the model by the OLS in specifications 1 and 3, and use the probit model and Tobit model in specifications 2 and 4, respectively, to account for the binary or truncated distribution of the dependent variables.

Somewhat surprising, in light of the widespread evidence that larger firms are more likely to hedge, this multivariate analysis does not reveal a significant relation between the presence or number of hedging covenants and the quantity of firm assets, and we detect only a weak relation between covenants and profitability. However, the results reported on Table 4 are generally supportive of the prediction that expected default costs are an important determinant of the choice to use hedging covenants. For example, based on specification 1, firms that are in default as of the

¹³Specifically, we use the covenants for minimum and maximum hedge ratios, minimum and maximum hedge maturities, reduction in borrowing base upon hedge unwinding, non-speculation clause, reporting clause, approved counterparties clause, restrictions on use of interest rate derivatives, requirement of hedging with the lender, and other restrictions.

end of the year have an approximately 11.2% higher probability of having any hedging covenant. The results also indicate that firms with lower cash reserves, higher leverage, and weaker credit ratings are more likely to have hedging covenants, and to have more of them. In contrast, firms with better investment opportunities, as indicated by their higher market-to-book ratios, have fewer covenants and are less likely to have covenants. Of course, expected default costs depend not only on the probability of default, but also on the expected costs of default should it occur. We observe that the presence of hedging covenants (though not the number of distinct covenants) is negatively related to asset tangibility, measured as proven (and marketable) reserves relative to total assets. On balance, these results are supportive of the reasoning that firms and lenders agree to the use of hedging covenants in those cases where expected default costs are relatively large.

IV. Debt Financing and Risk Management

A. Debt Issuance and Hedging

As noted, the literature has demonstrated positive empirical relations between borrowing and hedging. We first assess the extent to which firm debt issuance and risk management outcomes are related in our sample of oil and gas firms during the period of increased capital investment and borrowing associated with the fracking boom. After documenting a strong positive relation, we shed light on the relative importance of differing explanations by assessing the extent to which the positive relationship between borrowing and hedging is observed when hedging-related covenants are absent, and the strength of the relation as a function of specific covenants.

In specifications 1 to 3 of Table 5 we report results obtained when the dependent variable is the oil hedge ratio, while for those reported in specifications 4 to 6 the dependent variable is the natural gas hedge ratio.¹⁴ The corresponding results for hedge maturities are reported in the Internet Appendix. We are interested in the coefficient estimate on debt issuance. We control in the regression specifications for variables that are empirically known to affect risk management decisions, including firm size measured by the log of total assets, growth options measured by the

¹⁴Table IA.1 of the Internet Appendix shows that our results are robust to using a flow variable (newly entered hedges) instead of a stock variable (hedge ratio), as the dependent variable. Our results are also robust to alternatively clustering the standard errors by year or state of firm headquarters by year (see Table IA.2 of the Internet Appendix).

market-to-book ratio, tax function convexity as measured by tax-loss carry forwards relative to book asset value (following [Nance, Smith, and Smithson \(1993\)](#)), firm profitability measured by return on assets, incidence of firm default, as well as the average spot commodity prices during the fiscal year and the volatility of commodity prices. Specifications 1, 2, 4, and 5 do not include firm-fixed effects, while specifications 3 and 6 include firm fixed effects to control for potential omitted time-invariant firm-characteristics that could drive both debt issuance and risk management policies. In each specification we cluster the standard errors by firm to accommodate the likelihood that risk management policies are persistent over time within a given firm.

The coefficient estimates in Table 5 reveal a robust positive relation between new debt issuance and firms' hedge ratios.¹⁵ The coefficient estimates imply that the relation is economically important. For example, based on the first specification, a one standard deviation increase in debt issuance is associated with roughly 8.3% higher oil hedge ratios (t-statistic = 7.52), as compared to a mean hedge ratio of 30.1%. Inclusion of firm-fixed effects reduces the magnitude of the estimated positive relation, but the coefficient remains statistically significant (t-statistic = 2.47). Estimates are similar for the natural gas hedge ratio, where the coefficient estimate on debt issuances is statistically significant both without (t-statistic = 6.56) or with (t-statistic = 2.29) firm fixed effects.

Another notable result that emerges from Table 5 is that firms that are in default at the end of the fiscal year have lower hedge ratios. These results are stronger for both oil and gas hedge ratios when the regression specification includes firm fixed effects. In particular, the estimates obtained in specifications 3 and 6 indicate that firms in default have hedge ratios that are 27.1% lower for oil and 30.4% lower for natural gas. These results are consistent with the empirical findings by [Rampini, Sufi, and Viswanathan \(2014\)](#) for the airline industry, who attribute the result to the unwillingness of firms in default to post collateral.¹⁶

¹⁵While our conclusions regarding the relation between loan covenants and hedging outcomes do not rely on identifying exogenous shocks, we report in the Internet Appendix on the outcome of three sets of instrumental variable tests, showing that conclusions are robust when we focus on plausibly exogenous variation in debt issuance and covenant inclusion.

¹⁶However, the mechanism may differ for oil and gas producers, since they post as collateral their proven reserves rather than cash. An alternative explanation for the result is that counterparties may terminate and settle for cash derivative contracts upon firm default.

The results on Table 5 also indicate a positive relation between hedging and commodity price levels, though results are not fully consistent across specifications. Focusing first on crude oil hedge ratios, the spot price itself does not have significant explanatory power, but when the spot price is interacted with the amount of debt issuance (column 2) the estimated coefficient is strongly positive (t-statistic = 4.16). The corresponding results for natural gas hedge ratios show that both the spot price itself (column 1) and the product of the spot price and the quantity of debt issuance (column 5) enter with positive and significant coefficient estimates. The significant effect of the interaction term between firm leverage and spot prices supports the reasoning by [Azar \(2017\)](#) that firms with newly issued debt lock in high prices to maintain the minimum lending base. The positive coefficient on the level of the natural gas spot price is consistent with the selective hedging interpretation.¹⁷ The results in Table 5 also indicate a strong positive relation between hedge ratios and firm size, for both oil and natural gas. This result supports the economies of scale argument presented in the prior literature.

On balance, the results reported on Table 5 demonstrate strong evidence that debt issuance and risk management outcomes are strongly positively related for oil and gas firms during the fracking boom. However, these estimates do not clarify why this relation exists. We next turn to tests that can shed light on the importance of alternative explanations.

We posit that firms commit to entering hedge contracts that they may not have otherwise selected by consenting to the inclusion of hedging covenants whose terms potentially bind. The literature has identified two additional channels, not necessarily exclusive to each other or to the view that covenants play an important role, that may also imply a positive relation between borrowing and hedging outcomes. Firms may enter hedges in part to facilitate borrowing and to negotiate better loan terms. If so, firms will enter hedge contracts whether committed to by covenant or not. Alternatively, firms may, after securing debt contracts, enter derivatives that create speculative exposures or that are effectively senior to existing debt in bankruptcy, in either case expropriating wealth from lenders.

¹⁷Managers may have, or believe they have, informational advantage over other market participants. Several authors (see, e.g., [Brown, Crabb, and Haushalter \(2006\)](#), [Faulkender \(2005\)](#), and [Adam and Fernando \(2006\)](#)) document support for the hypothesis that managerial views affect their risk management policies.

B. The Catering Channel

To assess the possibility that firms hedge in order to cater to lenders, we form two subsamples. The first is comprised of firms that issue debt with either (i) a contractual minimum hedging commitment or a covenant that calls for automatic decreases in the firm's borrowing base if hedges are unwound or terminated, while the second is comprised of firms that issue debt without these commitments.

We report in Table 6 the results of the OLS regressions where the dependent variables are hedge ratios for oil (columns 1 to 3) and natural gas (columns 4 to 6). While each specification includes year fixed effects, the other results are distinguished by the inclusion of firm fixed effects (columns 2 and 4) and both firm and lender fixed effects (columns 3 and 6). The results indicate that the positive empirical relations between hedging outcomes and debt issuance are largely attributable to those transactions that include hedge covenants in the loan agreement. Coefficient estimates on debt issuance with hedging covenants are uniformly positive and significant in all six columns of Table 6, with t-statistics ranging from 2.58 (when explaining natural gas hedge ratios with year, firm, and lender fixed effects, column 6) to 8.44 (when explaining oil hedge ratios with year fixed effects, column 1). In contrast, coefficient estimates obtained for the quantity of debt issuance without hedge covenants are of mixed signs and are insignificant, with the exception of marginally significant coefficient (t-statistic = 1.74) in column 4.

In the last row of Table 6 we report t-statistics for the difference in coefficient estimates for debt issuances with and without covenants. The coefficient estimate for debt issuance with hedge covenants is always greater than the estimate for debt without hedge covenants, and the difference is statistically significant except in column 6. That is, the results of this analysis show that, for our sample of oil and gas firms, it is debt issuance in combination with the commitment to hedge in the form of contractual covenants that mainly drives the strong positive relation between borrowing and hedge outcomes observed in the full sample. These effects are economically strong. For example, based on specifications 1 and 4, a one standard deviation increase in debt issuance with such covenants is associated with 12.5% and 9.1% higher hedge ratios for oil and gas, respectively.

On balance, the results reported here are not at odds with the reasoning that firms may voluntarily hedge to cater to lenders, but support the reasoning that the relation between hedge ratios and debt issuance is considerably stronger in those cases where the lender and the borrower agree to the presence of hedging covenants.

C. The Expropriation Channel

Another potential explanation for the observation that firms that borrow more also enter a larger quantity of derivative contracts is that hedge contracts can effectively expropriate creditor wealth. Such expropriation can occur if derivatives are used for speculative rather than hedging purposes. Also, as [Bolton and Oehmke \(2015\)](#) emphasize, since derivatives are exempt from the automatic stay in bankruptcy, newly-entered hedges that are collateralized by firm assets can effectively transfer claims on firm assets from existing creditors to derivative counterparties. This type of agency problem is exacerbated when a firm is close to default and when it is more likely to owe rather than receive derivative payments in default.

To assess more formally the expropriation of debtholders as a potential explanation for the positive relation between debt issuance and the use of commodity derivatives, we conduct two additional tests. First, if derivatives are issued primarily because of their effective seniority over debt securities in case of default, we would anticipate stronger relations between borrowing and hedging outcomes for the less profitable firms that face a high probability of bankruptcy. Similarly, firm use of derivatives for risk shifting purposes would also predict a stronger relation between borrowing and hedging for the less profitable firms. To assess this possibility, we include in regressions that explain firm hedge ratios the product of the quantity of debt issued as a proportion of assets and the borrowing firm’s return on assets for the year. Second, in those cases where the original lender provides a bundle of financing and hedging to the firm any such effects should be internalized, at least in part.¹⁸ Absent incentives to expropriate, we would expect a smaller effect of debt

¹⁸Contract “bundling,” whereby the loan and hedging services are provided by the same party, can eliminate priority conflicts in default and improve oversight, but such provisions also expose the lenders to the risk that they will be required to make payment on the hedge contracts at the same time that the firm is in danger of default. Banks likely avoid this outcome by entering additional hedge contracts with a diversified third party.

issuance on hedging. To assess this possibility, we include in the regressions that explain firm hedge ratios products of the amount borrowed and two indicator variables, one that equals one for contracts where covenants specifically allow for hedging with the lender and zero otherwise, and one that equals one for contracts where covenants specifically require that hedging be with the lender and zero otherwise. Finally, to assess the possibility that firms with greater debt speculate with derivatives to expropriate their lenders, we include in the regressions product of the amount borrowed and an indicator variable that equals one for contracts where covenants explicitly disallow any speculation with derivatives and zero otherwise.

We report the results in Table 7. The coefficient estimate on the product of the quantity of debt issued and return on assets is positive and significant when explaining crude oil hedge ratios (column 3 of Panel A) and is positive and insignificant when explaining natural gas hedge ratios (column 3 of Panel B), rather than negative as would be anticipated if expropriation were the main motivator for the use of derivative contracts. Also, coefficient estimates on the amount borrowed are larger when interacted with the indicator variables that identify cases where hedging with the lender is allowed and cases where hedging with the lender is required, for both oil and gas hedges. That is, the relation between borrowing and hedge quantities is stronger rather than weaker when the firm hedges with its lender. We also do not find support for greater use of derivatives for risk shifting purposes, as the relation between borrowing and hedge quantities is stronger in cases when any speculation with derivatives is explicitly prohibited.

On balance, these results support the hypothesis that the relation between borrowing and hedging outcomes arises in our sample because firms use hedging covenants to explicitly commit to certain hedging policies. The results do not imply that the economic channels posited by catering to lenders and/or the expropriation of lenders are unimportant. Rather, they suggest that (i) catering is more effective in combination with a credible commitment to ongoing hedging policies and (ii) the agency problems that give rise to expropriation incentives can be effectively mitigated by credible commitments to ongoing hedging. The fact that borrowers are willing to enter lending contracts with such commitments implies that borrowers also benefit from them.

V. Efficiency of Hedging Covenants

A. Stock Price Performance during the COVID-19 Pandemic

To this point, we have focused on hedging commitments as determinants of risk management policies. We now assess the effectiveness of such committed hedging as compared to voluntary hedging programs when the oil and gas industry was subject to a large negative demand shock. We focus in particular on the emergence during early 2020 of the COVID-19 coronavirus, which disrupted firm operations, reduced global demand for oil and gas, and decreased energy prices. While it is somewhat self-evident that effective hedges will provide benefits to oil and gas producing firms at a time when prices for these commodities were subject to a large negative shock, we are interested in the subtler hypothesis that contractual commitments to maintain ongoing hedges provided benefits beyond those attributable to the quantity of hedges in place.

We obtain daily stock returns for all U.S. oil and gas firms between January 1, 2020 and March 20, 2020. We end the sample at this date because by this time the U.S. stock market had likely incorporated most of the negative news associated with the pandemic. Further, the Senate voted on the CARES Act on March 23 and 25, and the Act was signed into law on March 27 (H.R. 748 “Coronavirus Aid, Relief, and Economic Security Act”). We measure the evolution of the economic shock by two variables: the daily WTI crude oil spot price as reported by Bloomberg and the global count of COVID-19 cases.¹⁹ Summary statistics for this sample are reported in Panel A of Table 8. Not surprisingly, oil and gas stocks performed poorly during this period, with daily returns that averaged -1.61%.

Panel B of Table 8 reports results of regressions where the dependent variable is the daily stock return. The key coefficients of interest are those estimated on the interaction between covenant-based hedging commitments and the shock variables, oil return and case count. As would be anticipated, stock returns are strongly positively related to changes in the crude oil price, and are negatively related to the number of confirmed virus cases. Firms that have hedging commitments in their loan contracts have higher average returns, other things equal, as indicated by the positive

¹⁹The results are very similar if instead of case count, we use the number of deaths attributed to COVID-19.

coefficient estimates on the first row of Table 8, Panel B.

A key outcome is that firms with hedging commitments in their loan contracts were less exposed to crude oil price shocks, as indicated by the negative and significant coefficient estimates on the product of the hedging requirement indicator and the crude oil price variable. While this result might seem to simply quantify the intuition that hedges are effective in reducing exposures to commodity prices, the correct interpretation is subtle. When the regression specification includes both the product of the hedging requirement indicator and the crude oil price variable as well as the product of hedge ratio (measured at December 2019) and the crude oil price variable (column 3), only the former is significant. That is, the results imply that it is the presence of a *hedging commitment* rather than the magnitude of the hedge ratio that is associated with reduced exposure to the commodity price. Similar results are obtained when we include products of these indicator variables with the number of COVID cases. That is, the presence of hedging covenants provided benefits even after allowing for any effects of the size of hedging positions. A likely channel for this effect is that firms without ongoing contractual commitments to maintain hedges were free to unwind in-the-money hedges early in 2020 when their cash flow declined, while those with contractual commitments could not.²⁰

Figure 5 provides further information regarding cumulative returns in March 2020. For reference, the red vertical lines denote the dates when the first U.S. death was attributed to COVID-19, when the WHO declared the coronavirus outbreak to be a global pandemic, and when the U.S. declared a national emergency. The cumulative returns of firms with contractual hedging commitments are approximately 14.7% higher by the end of the period as compared to oil and gas firms not subject to contractual hedging commitments. The return differential was larger for more highly levered firms, as shown on the next panel of Figure 5, which focuses on firms with above-median leverage. In this subsample firms with hedging commitments experienced approximately 30.0%

²⁰For example, Noble Energy reported that it “cash-settled certain 2020 crude oil hedges, generating \$160 million in realized gains.” <http://investors.nbleenergy.com/news-releases/news-release-details/noble-energy-announces-first-quarter-results>. Similarly, California Resources reported that it had monetized all of its crude oil hedge positions; the company filed for Chapter 11 later in the year. <https://news.crc.com/press-release-details/2020/California-Resources-Corporation-Reduces-Capital-to-Mechanical-Integrity-Level/default.aspx>. In unreported results, we also find that firms with hedging covenants were less likely to engage in cost-cutting measures or reduce their capital budgets during the pandemic of early 2020.

higher cumulative returns. Overall, the results show that covenant based hedging commitments were effective in mitigating the exposure of oil and gas firms to the negative shocks associated with the emergence of COVID-19 even after allowing for levels of hedging activity.

B. Borrowing Costs

Finally, we examine whether firms that enter loan agreements containing hedging covenants are able to secure more favorable loan terms. [Campello, Lin, Ma, and Zou \(2011\)](#) previously documented lower borrowing costs for firms that hedge more and [Beatty, Petacchi, and Zhang \(2012\)](#) documented lower borrowing costs for firms that consented to interest rate protection agreements. Our hypothesis goes a step further, positing that borrowing costs are negatively related to loan covenants that require commodity price hedging, even after allowing for hedging quantities. Because covenants commit the firms to ongoing hedging policies that are appealing to the lenders, we expect competition in lending to lead to lower borrowing costs for those loans that include such covenants, *ceteris paribus*. This is indeed what we find.

While we do not observe interest rates for individual loans, Compustat reports firms' total annual borrowing costs (interest and related fees paid). We compare these costs to the average (of beginning- and end-of-year) total debt and assess how this measure varies with the number of hedging covenants in the credit agreement, the inclusion of a covenant requiring a minimum amount of hedging and observed hedge ratios. Columns 1 to 3 of Table 9 report the results of OLS regressions with annual borrowing costs as the dependent variable. Consistent with evidence reported by [Campello, Lin, Ma, and Zou \(2011\)](#), we find that hedging is associated with lower borrowing costs, in that the estimated coefficient on the hedge ratio is negative and significant.

Here too, however, our results indicate that hedging-related covenants have an effect that goes beyond the quantify of hedging, as the number of hedging covenants is also significantly and negatively related to borrowing costs. Based on specification 1, the inclusion of one additional hedging covenant in the loan agreement is associated with approximately 0.7% lower annual interest and fee expense. By comparison, the average annual interest and fee expense is 8.0% for firms that hedge and 16.1% for firms that do not hedge (Table 2). These results also support our interpretation that

hedging-related loan covenants effectively mitigate the agency problems highlighted by [Bolton and Oehmke \(2015\)](#), who predicted that (page 2355) “creditors demand higher promised repayments to compensate for the higher credit risk” (resulting from the subordination of their claims to derivative counterparties).

To shed further light on the mechanisms by which hedging covenants are associated with lower borrowing costs, we report in columns 4 to 6 of Table 9 results that are obtained when we include in the regression the product of the number of covenants and an indicator variable for small firm size (column 4), an indicator variable for firms with negative return on assets (column 5), and the firm’s S&P credit rating (column 6). The results indicate that the negative relation between borrowing costs and the number of hedging covenants is stronger for small firms, for firms with negative earnings, and for firms with weaker credit ratings. Since these are firms for which the probability of default and expected default costs are likely to be greater, the results are supportive of the reasoning that hedging covenants are most beneficial to lenders, and due to the forces of competition, result in lower interest rates to borrowers, when expected default related costs are high. The results here extend the evidence presented by [Campello, Lin, Ma, and Zou \(2011\)](#) by showing that the credible commitment attributable to hedging covenants can comprise a key channel by which hedging is related to lower borrowing costs.

VI. Conclusion

The literature on corporate hedging focuses on reasons why the use of derivatives to reduce risk can benefit managers and/or shareholders. We present evidence that observed risk management outcomes are shaped in part by *lender* requirements, in the form of covenants included in borrowing agreements. In particular, we document that the majority of lending agreements in the sample of oil and gas producing firms over the 1999 to 2019 period include covenants that variously specify minimum and maximum hedge ratios and hedge contract maturities, restrict speculation and the posting of collateral for derivative contracts, link the borrowing base to the maintenance of hedge positions, require the reporting of hedge positions to lenders, and allow or require that hedge

contracts be entered with the same bank that provides financing. Of course, firms enter borrowing contracts voluntarily, and could presumably negotiate loan contracts that do not include hedging covenants. We show that these covenants are most likely to be employed, and that the resulting benefits to borrowing firms in the form of lower interest costs are greater, when empirical proxies for expected bankruptcy costs are higher.

Consistent with prior evidence showing that borrowing and hedging are related, we document a strong positive relation between quantities of bank borrowing and of hedge contracts. We assess the relative importance of three channels that can contribute to this relation. In addition to the possibility that this relation arises due to lender's inclusion of hedge-related covenants, firms may voluntarily hedge, and this may lead to improved borrowing terms, or firms could expropriate prior lenders by entering new derivative contracts with higher effective seniority in case of default. The results we report indicate that the lower interest rates associated with hedging as implied by the catering hypothesis are strongest when the firm also makes a credible commitment, in the form of loan covenants, to implement and maintain certain hedging policies. Similarly, the results do not refute that derivative contracts may be entered to expropriate lender wealth, but show that hedging covenants can serve to mitigate the agency problems that gave rise to these incentives. Overall, the results for our sample of oil and gas firms indicate that banks' inclusion of hedging-related covenants in loan agreements is the main driver of the positive relation between borrowing and hedging. While the oil and gas industry is of inherent interest because of its economic prominence, and the economic rationales for the results obtained here are not industry-specific, it will nevertheless be of interest for future research to assess the relative importance of hedge covenants in other industries.

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Appendix A. Examples of Hedging Covenants

Below we provide several examples of language used in credit agreements to specify various hedging covenants, as well as examples of their treatment in default.

Minimum and Maximum Hedge Ratio Requirements

1. *“The notional quantity of gaseous and liquid hydrocarbons subject to Commodity Hedging Agreements by the Borrower or its Subsidiaries, at the time of entering into such Commodity Hedging Agreements, shall not be, without the prior written approval of the Required Lenders, greater than 80% or less than 60% of the monthly production of hydrocarbons from the Proved Developed Producing Oil and Gas Properties of the Borrower and its Subsidiaries as determined by the Administrative Agent for the nearest 36 month period.”* (Saratoga Resources, credit agreement, 2008)
2. *“We are required to maintain commodity price hedges with a term of not greater than 3 years and with notional amounts greater than 25% of projected production.”* (GMX Resources, 10-K, 2007)

Non-speculation Clause and Borrowing Base Redetermination

1. *“The Hydrocarbon Hedge Agreement is a Hedge Agreement entered into in the ordinary course of business for the principal purpose of protecting against fluctuations in commodity prices or commodity basis risk and not for purpose of speculation.”* (Red Mountain Resources, credit agreement, 2013)
2. *“Upon completion of (i) any early termination of any Hedge Transaction used in determining the Borrowing Base on the immediately preceding Determination Date..., the effect of which termination or Disposition would be a reduction in the Borrowing Base then in effect of 7.5% or more on a pro forma basis, the Borrowing Base shall immediately and automatically upon consummation of such transaction be reduced by the Borrowing Base contribution of such Hedge Transaction or assets, and all Net Cash Proceeds from the termination of such Hedge Transaction or the Disposition of such assets shall be applied to reduce or eliminate any Borrowing Base Deficiency resulting from such reduction.”* (Sandridge Energy, credit agreement, 2010)

Reporting Requirement and Lender Counterparty

1. *“...report required to be delivered by the Borrower pursuant to Section 8.01(e), as of the date of (or as of the date(s) otherwise set forth in) such report, sets forth, a true and complete list*

of all Swap Agreements of the Borrower and each other Credit Party, the material terms thereof (including the type, term, effective date, termination date and notional amounts or volumes), the estimated net mark-to-market value thereof, all credit support agreements relating thereto other than Loan Documents (including any margin required or supplied) and the counterparty to each such agreement.” (Rice Energy, credit agreement, 2016)

2. *“The Credit Facility requires that counterparties in derivative transactions be limited to the Lenders, including affiliates of the Lenders.” (Meridian Resource, 10-K, 2010)*

Appendix B. Variable Definitions

<i>Variable</i>	<i>Definition</i>
Firm size	The logarithm of the book value of assets.
Market-to-book ratio	The sum of long-term and short-term debt and the market value of equity, divided by the book value of assets.
Return on assets	The income before extraordinary items, divided by the book value of assets.
Leverage	The sum of long- and short-term debt, divided by the book value of assets.
Tax-loss carryforwards	Tax-loss carryforwards (TLCF), divided by the book value of assets.
Cash	Cash reserves, divided by the book value of assets.
Capex	Capital expenditures, divided by the book value of assets.
Asset tangibility	Total value of gas and oil reserves, divided by the book value of assets.
S&P credit rating	S&P long term issuer credit rating score (0 to 29); 0 is for unrated debt, one point is added for each credit rating category, 29 is for AAA-rated debt.
Debt issuance	The annual issuance of long-term debt (DLTIS), divided by the end-of-year book value of assets.
Oil hedge ratio, %	The sum of the outstanding notional amounts of oil derivatives for the next fiscal year, divided by the next year oil production.
Gas hedge ratio, %	The sum of the outstanding notional amounts of natural gas derivatives for the next fiscal year, divided by the next year natural gas production.
Oil hedge maturity	The maturity of outstanding oil hedging contracts (months).
Gas hedge maturity	The maturity of outstanding natural gas hedging contracts (months).
Crude oil spot price	The average WTI crude oil spot price per Bbl during the fiscal year.
Volatility of oil price	The standard deviation of monthly WTI crude oil price.
Natural gas spot price	The average Henry Hub natural gas spot price per Mcf during the fiscal year.
Volatility of gas price	The standard deviation of monthly Henry Hub natural gas price.
Technological shock	$\sum_j w_{ij2006} \times \log(1 + Horizontal\ wells_{jt})$, where w_{ij2006} is the number of state j mentions by firm i in 10-K in 2006 divided by all state mentions, and $Horizontal\ wells_{jt}$ is the number of horizontal wells in state j in year t .
Bank covenant adoption for other O&G loans	The proportion of the lending bank's <i>other</i> agreements originated during the same year that require hedging.
Firm default	An indicator equal to one if the firm is in default on its loan or in bankruptcy (Chapter 7 or Chapter 11) as of the end of the fiscal year; zero otherwise.
Debt issuance, no requirements	Long-term debt issuance divided by the book value of assets, multiplied by one if there are no covenants requiring hedging; zero otherwise.
Debt issuance, hedging requirements	Long-term debt issuance divided by the book value assets, multiplied by one if there are covenants requiring hedging; zero otherwise.
Interest paid, %	The total amount of interest and debt-related fees (XINT), divided by the average of the beginning-of-year and end-of-year value of total debt, %.

Appendix C. Figures and Tables

Figure 1. Revolution in Oil and Gas Industry

This figure illustrates the evolution of the oil and gas industry during the period 1999-2019. The top panels show the average number of times a firm in our sample mentions new technologies in its 10-K or 10-KSB filings, i.e., *horizontal drilling* and *hydraulic fracturing*. The middle panels show the average annual production of oil and gas for the firms in our sample, measured in thousands of barrels and millions of cubic feet, respectively. The bottom two panels give the aggregate statistics based on data from the U.S. Energy Information Administration (EIA). The left panel shows the total number of horizontal oil and gas wells in the United States. The right panel shows the monthly dry shale gas production, by the field.

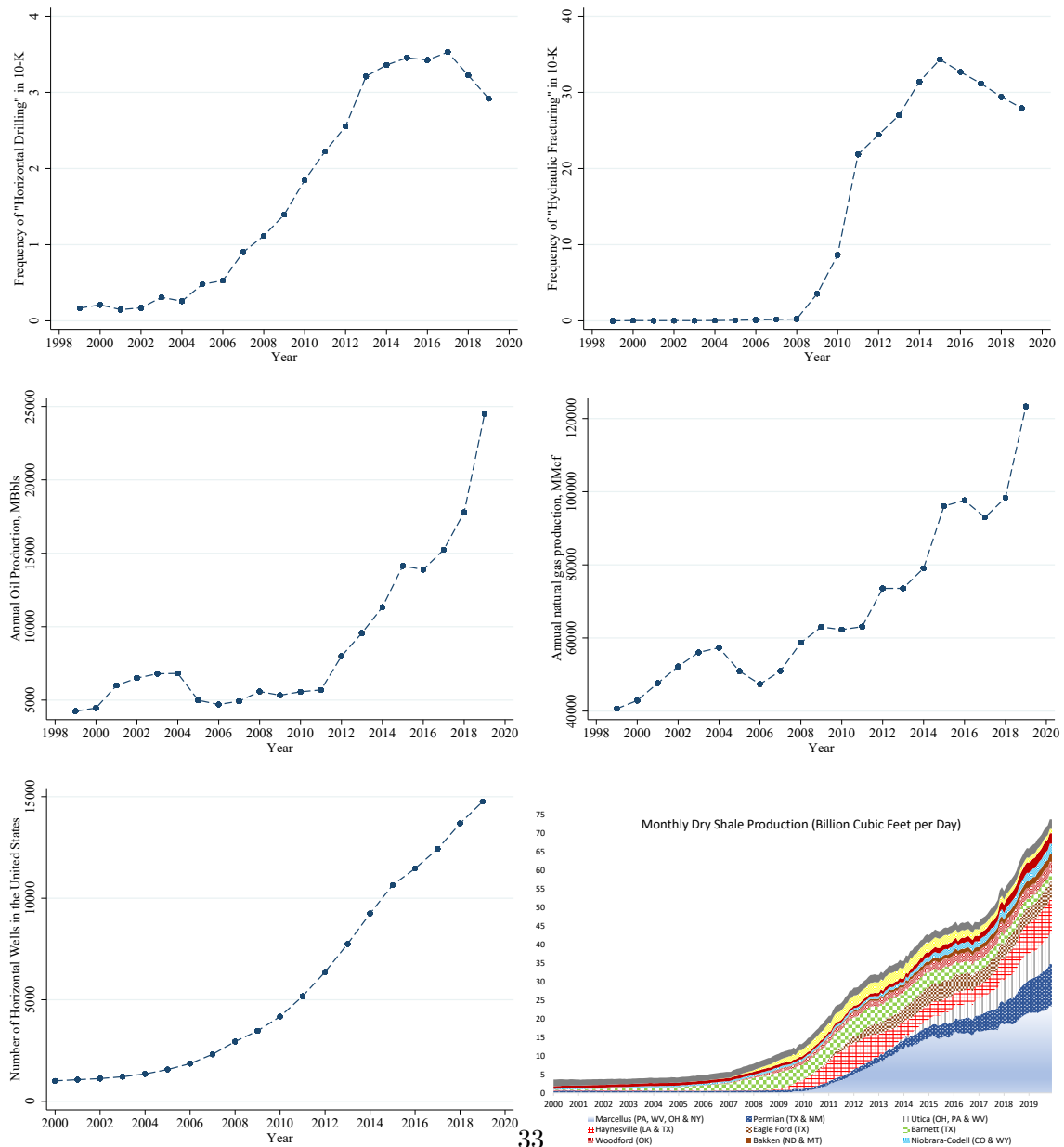


Figure 2. Oil and Gas Firms' Leverage and Commodity Prices

This figure illustrates external financing dynamics in oil and gas industry during the period 1999-2019. The top panels show the average annual capital expenditures and total new financing (in \$ million), adjusted for inflation to the base year of 2019. The middle panels illustrate the dynamics of inflation-adjusted debt and equity issuance (in \$ million) and LIBOR interest rates. For reference, we provide the dynamics of the oil price and volatility (WTI crude oil spot price) and the gas price and volatility (Henry Hub natural gas spot price) in the bottom panels.

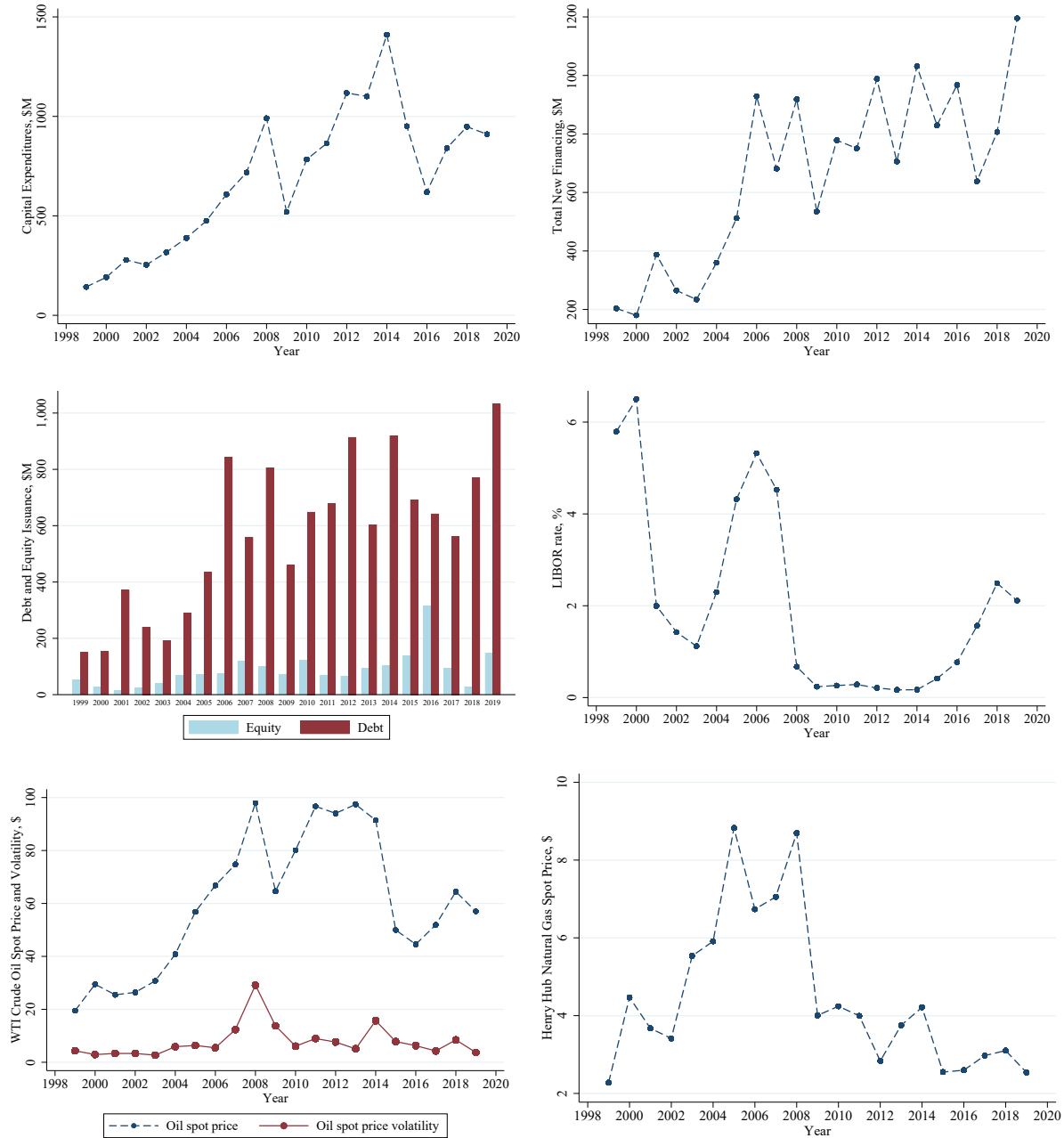


Figure 3. Evolution of Oil and Gas Firms' Risk Management Policies

This figure illustrates the evolution of risk management policies of oil and gas industry during the period 1999-2019. The top panels show the fraction of oil and gas producers that hedge oil price and natural gas price exposure. The middle panels show the average hedge ratios for oil and gas production. The bottom panels show the average maturity of oil and natural gas hedging contracts (in months).

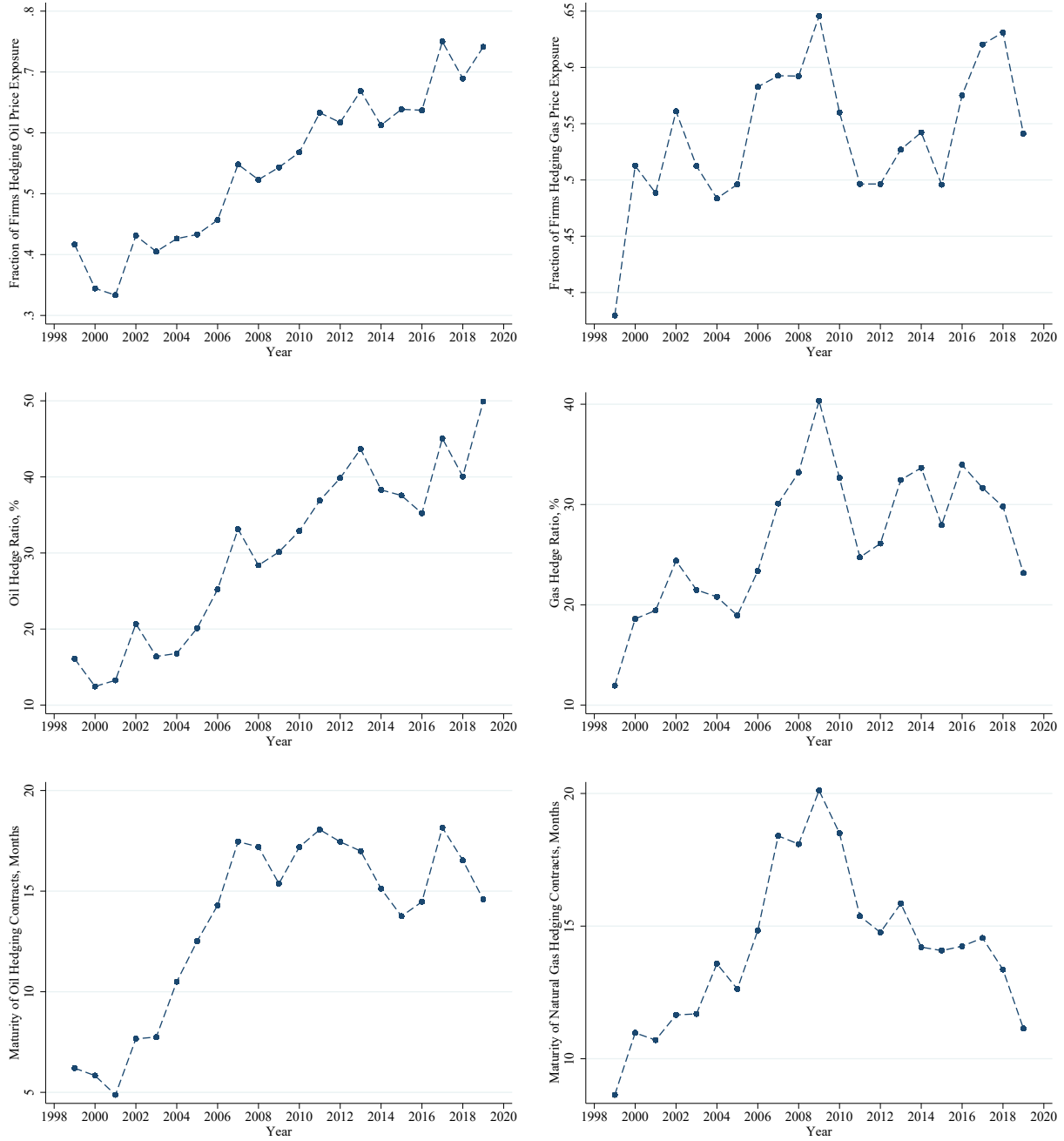


Figure 4. Lender Adoption of Hedging Covenants

The top panels show the fraction of oil and gas producers with any hedging covenants in their lending agreements and the average number of distinct hedging covenants per firm. The left middle panel shows the fraction of firms with covenants requiring hedging, i.e., the minimum hedge ratio, maturity, or the borrowing base reduction upon hedge unwinding. The right middle panel shows the fraction of firms required to report hedging positions to the lender. The bottom panels show the fraction of oil and gas producers subject to non-speculation clause and the requirement of using pre-approved counterparties.

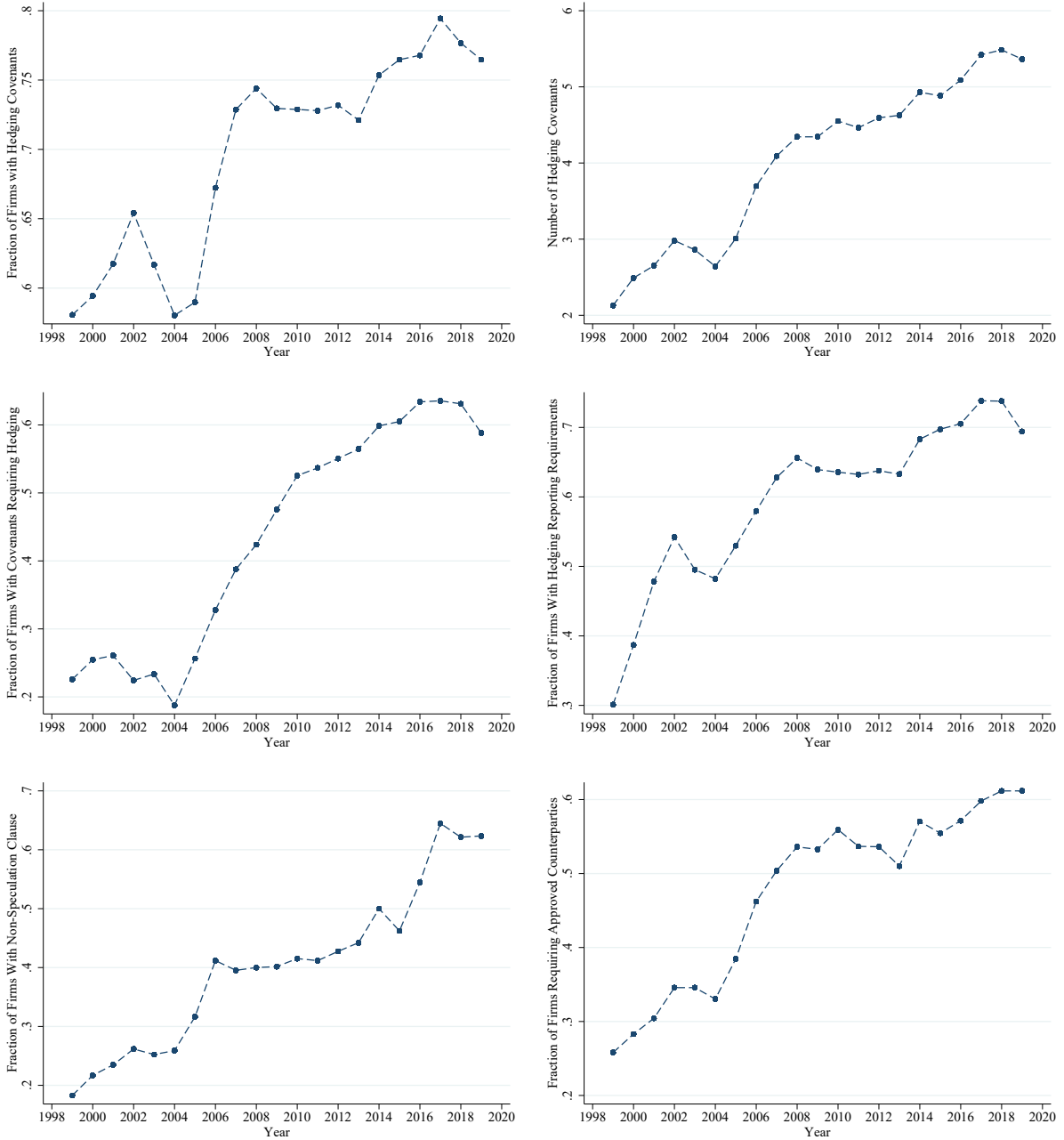


Figure 5. Cumulative Stock Returns of Oil and Gas Firms during the 2020 Pandemic

The figure illustrates the dynamics of cumulative stock returns of oil and gas firms during the COVID-19 pandemic of 2020. The sample consists of all US-incorporated oil and gas firms (SIC 1311) that have non-missing stock return data, are trading at the price above \$1.00 at the beginning of the year, and have non-missing information on hedging covenants and leverage. The sample period starts on Feb 28, 2020 and ends on March 20, 2020, one week before the CARES Act was signed into law (H.R. 748 “Coronavirus Aid, Relief, and Economic Security Act”). *Hedging requirements* is equal to one if the firm’s lending agreements contain covenants requiring hedging and is equal to zero otherwise. *High Leverage Firms* refers to the sample of firms that have book leverage ratios above the sample median.

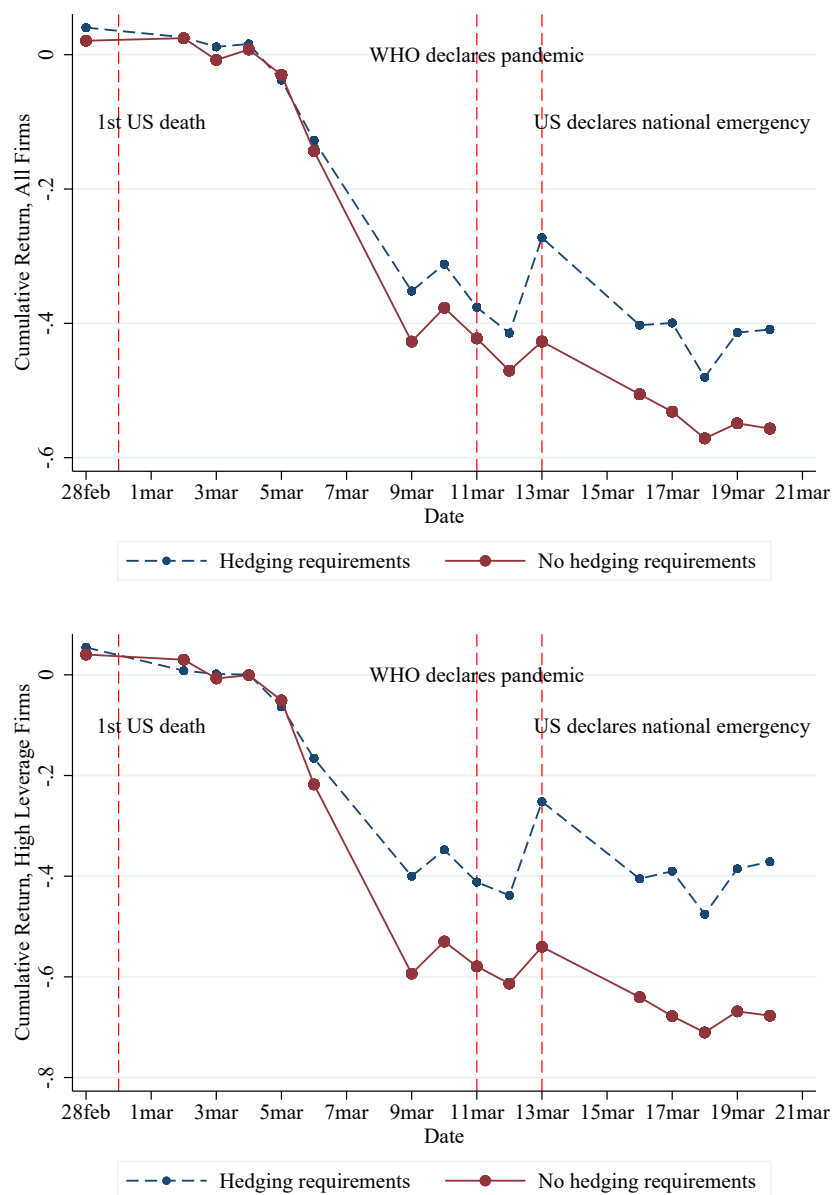


Table 1. Summary Statistics

The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. The variables are defined in Appendix B.

Panel A: Use of Derivatives

Variable	Obs.	Mean
Derivative user	2,591	0.670
Use derivatives for hedging commodity prices	2,591	0.640
Use derivatives for hedging oil price	2,591	0.541
Use derivatives for hedging natural gas price	2,591	0.539
Use interest rate derivatives	2,591	0.203
Use currency derivatives	2,591	0.083

Panel B: Oil and Gas Production and Hedge Ratios

Variable	Obs.	Mean	SD	25th	50th	75th
Annual oil production, MMBbl	2,587	8.484	26.054	0.085	0.765	4.203
Annual natural gas production, Bcf	2,586	66.792	169.171	0.384	6.491	41.096
Oil hedge ratio, %	2,535	30.06	36.85	0	12	55
Gas hedge ratio, %	2,476	26.52	32.67	0	10	49
Maturity of oil hedging derivatives	2,582	13.53	16.80	0	12	24
Maturity of gas hedging derivatives	2,575	14.31	19.16	0	12	24

Panel C: Other Variables

Variable	Obs.	Mean	SD	25th	50th	75th
Book assets, \$M	2,591	3,363	9,610	48	355	2,006
Log of assets	2,591	5.743	2.518	3.881	5.873	7.604
Number of employees	2,539	547	1,596	13	84	330
Market-to-book ratio	2,506	1.925	8.271	0.816	1.110	1.647
Return on assets	2,587	-0.175	1.406	-0.100	0.009	0.062
Tax-loss carryforwards	2,591	0.610	3.455	0.000	0.012	0.262
Leverage	2,590	0.359	0.515	0.114	0.286	0.454
Debt issuance	2,527	0.184	0.226	0.000	0.102	0.290
Firm default	2,591	0.013	0.114	0	0	0
Capex	2,566	0.214	0.155	0.101	0.187	0.299
Cash	2,591	0.100	0.165	0.008	0.030	0.111
Asset tangibility	2,553	4.081	4.204	1.996	3.052	4.750
S&P credit rating	2,591	4.889	7.627	0	0	17
Interest paid, %	2,103	10.307	14.927	5.482	7.129	9.635
Crude oil spot price, per Bbl	2,591	61.663	26.041	41.600	63.920	91.230
Volatility of oil price	2,591	8.014	6.254	4.210	6.120	8.810
Natural gas spot price, per Mcf	2,591	4.525	1.938	2.970	4.020	5.590
Volatility of gas price	2,591	0.957	0.759	0.480	0.600	1.390
Technological shock	1,185	6.612	1.982	5.464	6.657	7.952

Table 2. Commodity Hedgers and Non-Hedgers

The table shows the means for firm characteristics for firms that use derivatives for commodity hedging and those that do not. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. All variables are defined in Appendix B. The last column shows the t-test for the difference in means; the standard errors are clustered by firm. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variable	Hedger	Non-Hedger	Difference	T-test
Annual oil production, MMBbl	12.053	2.136	9.917	4.69***
Annual gas production, Bcf	98.454	10.412	88.042	5.45***
Book assets, \$M	4,916	606	4,310	5.06***
Market-to-book ratio	1.223	3.143	-1.920	-2.14**
Return on assets	-0.051	-0.394	0.343	2.47**
Tax-loss carryforwards	0.184	1.370	-1.186	-3.37***
Book leverage	0.390	0.305	0.084	1.74*
S&P credit rating	7.074	1.014	6.060	12.09***
Debt issuance	0.231	0.101	0.130	8.94***
Firm default	0.008	0.021	-0.013	-2.45**
Interest paid, %	8.013	16.053	-8.040	-5.53***
Crude oil spot price, per Bbl	63.46	58.48	4.98	3.25***
Natural gas price, per Mcf	4.45	4.67	-0.22	-2.18**

Table 3. Summary Statistics on Hedging Covenants

The table reports summary statistics on hedging covenants in firm lending agreements. The data are from credit agreements, debtor-in-possession (DIP) agreements, term loan agreements, indentures, promissory notes, and other debt contracts, which are commonly located in 10-K, 8-K, 10-Q, S-1, or S-4 filings. When some credit agreements or loans are mentioned in the firm's 10-K report, but the actual agreements are not filed with the SEC or cannot be located, the data are set to missing. When no lending agreements are mentioned in the firm's 10-K, all hedging covenants are set to zero. *Hedging covenants* is equal to one if the lending agreement places any restriction on the firm's hedging policy; zero otherwise. *Number of hedging covenants* is the number of distinct hedging covenants specified (0 to 11). *Covenants require minimum hedge ratio* is one if the agreement requires the firm to maintain a minimum hedge ratio; zero otherwise. *Covenants limit maximum hedge ratio* is one if the agreement does not allow the firm to have hedge ratios higher than the specified limit; zero otherwise. *Non-speculation clause* is one if the agreement allows the firm to enter derivative positions only for non-speculative purposes; zero otherwise. *Lender-approved counterparties* is one if the agreement allows to hedge only with the lender or with pre-approved counterparties; zero otherwise. *Report hedge positions to the lender* is one if the agreement requires the firm to provide a list of all hedge positions to the lender; zero otherwise. *Borrowing base reduction upon hedge unwinding* is one if the agreement specifies that the borrowing base of the loan will be reduced if the firm unwinds or terminates any existing hedge positions; zero otherwise. *Covenants require hedging* is one if there is a minimum hedge ratio requirement, borrowing base reduction upon hedge unwinding, and/or the minimum hedge maturity requirement. *Covenants limit hedging* is one if there is a maximum allowed hedge ratio covenant and/or the maximum allowed hedge maturity covenant. *Other (posting collateral, cross-default provisions, strike prices, indebtedness, option positions, etc.)* is equal to one if the lending agreement contains any other hedging covenants, such as the requirements for strike prices, restrictions on selling puts or calls, restrictions on posting collateral to counterparties, *pari passu* and other cross-default provisions, restrictions on hedging-related indebtedness; zero otherwise. Panel A provides summary statistics only for firm-years with credit, DIP, or term loan agreements present. Panel B is for the full sample, and Panel C presents summary statistics by the lender (loan administrative agent).

<i>Panel A: Sample with Lending Agreements</i>	N	Mean
Hedging covenants	1,996	0.853
Number of hedging covenants	1,996	4.974
Covenants require hedging	1,996	0.540
Covenants limit hedging	1,996	0.699
Non-speculation clause	1,996	0.490
Firm can hedge only with the lender	1,996	0.088
Firm is explicitly allowed to hedge with the lender	1,996	0.547

<i>Panel B: Full Sample</i>	N	Mean	SD	p25	p50	p75
Credit agreement, loan, or other debt contract	2,459	0.867	0.339	1	1	1
Maximum loan commitment (\$M)	2,061	591	994	50	250	750
Hedging covenants	2,459	0.699	0.459	0	1	1
Number of hedging covenants	2,459	4.063	3.349	0	4	7
Covenants require hedging	2,459	0.440	0.497	0	0	1
Covenants limit hedging	2,459	0.570	0.495	0	1	1
Covenants require minimum hedge ratio	2,459	0.261	0.439	0	0	1
Covenants limit maximum hedge ratio	2,459	0.570	0.495	0	1	1
Covenants require minimum hedge maturity	2,459	0.166	0.372	0	0	0
Covenants limit maximum hedge maturity	2,459	0.320	0.467	0	0	1
Minimum allowed hedge maturity	297	26.10	14.11	12	24	36
Maximum allowed hedge maturity	790	45.62	18.66	36	48	60
Minimum allowed hedge ratio	339	54.17	22.84	50	50	75
Maximum allowed hedge ratio	1,357	82.22	11.66	75	85	85
Lender-approved counterparties	2,459	0.478	0.500	0	0	1
Firm can hedge only with the lender	2,459	0.072	0.259	0	0	0
Firm is explicitly allowed to hedge with the lender	2,459	0.446	0.497	0	0	1
Non-speculation clause	2,459	0.402	0.490	0	0	1
Report hedge positions to the lender	2,459	0.600	0.490	0	1	1
Borrowing base reduction upon hedge unwinding	2,459	0.307	0.462	0	0	1
Covenants for interest rate derivatives	2,459	0.353	0.478	0	0	1
Other (posting collateral, cross-default provisions, strike prices, indebtedness, option positions, etc.)	2,459	0.534	0.499	0	1	1

<i>Panel C: Covenants Placed by Different Lenders</i>	N	Hedging covenants	Covenants require hedging	Covenants limit hedging
J.P. Morgan and Chase	438	0.840	0.555	0.632
Wells Fargo Bank	228	0.973	0.833	0.864
Bank of America	141	0.809	0.319	0.610
Bank One	118	0.983	0.339	0.881
BNP Paribas	91	1	0.846	0.989
Bank of Montreal	81	1	0.741	0.852
Union Bank	65	1	0.400	0.708
Citigroup	63	1	0.508	0.841
Bank of Oklahoma	56	0.750	0.429	0.554
Royal Bank of Canada	48	1	0.771	0.979

Table 4. Determinants of Hedging Covenants

The dependent variable in columns 1-2 is equal to 1 if the lending agreement specifies any hedging-related covenant and is equal to 0 otherwise. The dependent variable in columns 3-4 is the number of distinct hedging covenants in the lending agreement (0 to 11). Columns 1 and 3 report the estimates of the OLS regressions, column 2 reports the estimates from probit model, and column 4 reports the estimates from Tobit model. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. All other variables are defined in Appendix B. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Dependent Variable:</i>	<i>Hedging Covenants</i>		<i>Number of Covenants</i>	
	OLS (1)	Probit (2)	OLS (3)	Tobit (4)
Log of assets	0.005 [0.22]	0.023 [0.29]	-0.057 [-0.37]	-0.058 [-0.31]
Market-to-book ratio	-0.064*** [-3.31]	-0.295*** [-3.52]	-0.566*** [-3.98]	-0.768*** [-3.51]
Return on assets	0.080* [1.70]	0.304 [1.53]	1.014*** [3.15]	1.162*** [3.03]
Firm default	0.112** [2.52]	1.014** [2.00]	0.542 [1.08]	0.641 [1.20]
Book leverage	0.132* [1.85]	0.592** [2.16]	1.433** [2.28]	1.758** [2.41]
Capex	0.422*** [4.03]	2.577*** [4.31]	4.235*** [5.25]	5.001*** [5.03]
Cash	-0.350* [-1.80]	-1.271* [-1.80]	-4.132*** [-2.88]	-4.979*** [-2.83]
Asset tangibility	-0.011** [-2.33]	-0.038** [-2.27]	-0.050 [-1.41]	-0.068 [-1.49]
S&P credit rating	-0.007** [-2.34]	-0.031** [-2.51]	-0.087*** [-4.03]	-0.101*** [-3.96]
Observations	1,904	1,904	1,904	1,904
R-squared	0.118	0.141	0.241	0.055
Firm FE	No	No	No	No
Year FE	Yes	Yes	Yes	Yes

Table 5. OLS Regressions for Hedge Ratios

The table reports the estimates of the OLS regressions. The dependent variable in columns 1-3 is the hedge ratio for crude oil (%); the dependent variable in columns 4-6 is the hedge ratio for natural gas (%). The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. All variables are defined in Appendix B. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Dependent Variable:</i>	<i>Oil Hedge Ratio</i>			<i>Gas Hedge Ratio</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
Debt issuance	36.662*** [7.51]	-1.540 [-0.17]	9.846*** [2.64]	28.120*** [6.56]	10.852 [1.28]	9.122** [2.43]
Crude oil spot price		0.614*** [4.17]				
*Debt issuance						
Natural gas spot price					3.814** [2.25]	
*Debt issuance						
Log of assets	5.290*** [7.90]	5.231*** [7.95]	7.074*** [6.65]	4.675*** [8.29]	4.646*** [8.27]	5.779*** [4.28]
Market-to-book ratio	-0.163 [-0.70]	-0.129 [-0.58]	0.346* [1.96]	-0.048 [-0.41]	-0.059 [-0.51]	-0.042 [-0.59]
Return on assets	-0.044 [-0.10]	-0.158 [-0.38]	-0.376 [-0.68]	-0.948 [-1.43]	-1.038 [-1.52]	-0.710 [-1.02]
Firm default	-8.357 [-1.37]	-7.927 [-1.25]	-27.008*** [-4.21]	-16.709*** [-3.84]	-16.326*** [-3.77]	-30.238*** [-5.30]
Tax-loss carryforwards	0.099 [0.54]	0.059 [0.34]	-0.151 [-0.47]	0.026 [0.12]	0.012 [0.06]	0.278 [1.22]
Crude oil spot price	0.346 [1.37]	0.260 [1.04]	0.264 [1.39]			
Volatility of oil price	-0.019 [-0.07]	-0.072 [-0.27]	-0.015 [-0.06]			
Natural gas spot price				5.880*** [3.53]	5.327*** [2.91]	2.580 [1.55]
Volatility of gas price				-7.750** [-2.58]	-7.596** [-2.45]	-3.453 [-1.30]
Observations	2,397	2,397	2,388	2,344	2,344	2,335
R-squared	0.293	0.303	0.643	0.231	0.234	0.619
Firm FE	No	No	Yes	No	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 6. Debt Issued With Minimum Hedging Requirements and Without

The table reports the estimates of the OLS regressions. The dependent variables are hedge ratios for crude oil and natural gas price exposures. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. *Debt issuance, no requirements* is long-term debt issuance divided by the book value of assets, multiplied by one if there are no covenants requiring hedging; zero otherwise. *Debt issuance, hedging requirements* is long-term debt issuance divided by the book value assets, multiplied by one if there are covenants requiring hedging; zero otherwise. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The last row reports *t*-statistics for the difference in coefficients in (a) and (b), as indicated.

	(1)	(2)	(3)	(4)	(5)	(6)
	Oil	Oil	Oil	Gas	Gas	Gas
Debt issuance, hedging requirements <i>(a)</i>	55.144*** [8.44]	18.004*** [3.54]	17.019*** [3.25]	40.358*** [7.60]	16.090*** [3.34]	12.612** [2.58]
Debt issuance, no requirements <i>(b)</i>	7.816 [1.34]	-2.752 [-0.54]	-1.312 [-0.21]	8.484* [1.74]	-1.694 [-0.37]	0.437 [0.08]
Log of assets	5.251*** [7.91]	6.884*** [6.39]	7.018*** [5.05]	4.623*** [8.07]	5.887*** [4.35]	4.898*** [3.29]
Market-to-book ratio	-0.070 [-0.36]	0.263 [1.44]	0.379* [1.82]	-0.062 [-0.56]	-0.083 [-1.39]	-0.021 [-0.32]
Return on assets	-0.136 [-0.36]	-0.432 [-0.78]	0.412 [0.35]	-1.190* [-1.68]	-0.780 [-1.17]	-0.298 [-0.47]
Firm default	-7.944 [-1.45]	-26.311*** [-4.11]	-28.997*** [-3.93]	-16.738*** [-3.85]	-29.021*** [-4.93]	-33.274*** [-4.71]
Tax-loss carryforwards	0.101 [0.65]	-0.139 [-0.44]	-0.375 [-0.85]	0.007 [0.04]	0.328 [1.53]	0.366 [1.49]
Crude oil spot price	0.365 [1.34]	0.333 [1.63]	0.497** [2.23]			
Volatility of oil price	-0.134 [-0.52]	-0.045 [-0.20]	0.110 [0.39]			
Natural gas spot price				5.137*** [2.73]	1.051 [0.59]	-0.100 [-0.07]
Volatility of gas price				-8.082** [-2.37]	-3.629 [-1.10]	-2.408 [-0.92]
Observations	2,282	2,271	2,213	2,231	2,218	2,167
R-squared	0.312	0.641	0.672	0.242	0.624	0.662
Firm FE	No	Yes	Yes	No	Yes	Yes
Bank FE	No	No	Yes	No	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
<i>(a)-(b)</i>	5.40***	2.88***	2.25**	4.42***	2.68***	1.66*

Table 7. Assessing Alternatives

The table reports the estimates of the OLS regressions. The dependent variables in Panel A and Panel B are the hedge ratios for crude oil and natural gas price exposures, respectively. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. *Debt issuance, common lender allowed* is long-term debt issuance divided by the book assets and multiplied by one if the lending agreement explicitly allows the firm to hedge with the lender. *Debt issuance, common lender not allowed* is long-term debt issuance divided by the book assets and multiplied one if the lending agreement does not explicitly allow to hedge with the lender. *Debt issuance, hedge only with lender* is long-term debt issuance divided by the book assets and multiplied by one if the lending agreement requires the lender to be the counterparty for firm hedging. *Debt issuance, hedge not only with lender* is long-term debt issuance divided by the book assets and multiplied one if the lending agreement does not require the lender to be the counterparty for firm hedging. *Debt issuance, non-speculation clause* is long-term debt issuance divided by the book assets and multiplied by one if the lending agreement explicitly prohibits speculation with derivatives. *Debt issuance, no non-speculation clause* is long-term debt issuance divided by the book assets and multiplied one if the lending agreement does not explicitly prohibit speculation with derivatives. All other variables are defined in Appendix B. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The last row in each panel reports t-statistics for the difference in OLS coefficients in rows (a) and (b), as indicated.

<i>Panel A: Oil Hedge Ratio</i>	(1)	(2)	(3)	(4)
Debt issuance*Common lender allowed (<i>a</i>)	51.454*** [7.58]			
Debt issuance*Common lender not allowed (<i>b</i>)	15.963*** [2.78]			
Debt issuance*Hedge only with lender (<i>a</i>)		51.701*** [2.97]		
Debt issuance*Hedge not only with lender (<i>b</i>)		35.629*** [7.13]		
Debt issuance			41.179*** [7.76]	
Debt issuance*Return on assets			11.625*** [3.87]	
Debt issuance, Non-speculation clause (<i>a</i>)				47.899*** [7.00]
Debt issuance, No non-speculation clause (<i>b</i>)				26.408*** [4.74]
Log of assets	5.114*** [7.66]	5.315*** [7.66]	5.143*** [7.74]	5.174*** [7.64]
Market-to-book ratio	-0.062 [-0.30]	-0.103 [-0.43]	-0.292 [-1.39]	-0.097 [-0.43]
Return on assets	-0.105 [-0.27]	-0.029 [-0.07]	-0.815 [-1.47]	-0.067 [-0.16]
Firm default	-8.848 [-1.48]	-8.357 [-1.37]	-7.386 [-1.25]	-8.484 [-1.45]
Tax-loss carryforwards	0.040 [0.25]	0.069 [0.37]	0.215 [1.25]	0.055 [0.32]
Crude oil spot price	0.269 [1.03]	0.258 [0.92]	0.339 [1.34]	0.250 [0.93]
Volatility of oil price	-0.130 [-0.45]	-0.176 [-0.65]	-0.074 [-0.29]	-0.134 [-0.47]
Observations	2,282	2,282	2,397	2,282
R-squared	0.298	0.281	0.300	0.287
Firm FE	No	No	No	No
Year FE	Yes	Yes	Yes	Yes
(<i>a</i>)-(b)	3.99***	0.89	N/A	2.44**

<i>Panel B: Gas Hedge Ratio</i>	(1)	(2)	(3)	(4)
Debt issuance*Common lender allowed (<i>a</i>)	41.240*** [7.46]			
Debt issuance*Common lender not allowed (<i>b</i>)	9.401** [2.10]			
Debt issuance*Hedge only with lender (<i>a</i>)		22.863 [1.09]		
Debt issuance*Hedge not only with lender (<i>b</i>)		27.833*** [6.30]		
Debt issuance			29.337*** [6.66]	
Debt issuance*Return on assets			3.303 [1.05]	
Debt issuance, Non-speculation clause (<i>a</i>)				34.253*** [6.06]
Debt issuance, No non-speculation clause (<i>b</i>)				21.984*** [3.88]
Log of assets	4.481*** [7.96]	4.664*** [7.89]	4.634*** [8.22]	4.581*** [7.91]
Market-to-book ratio	-0.066 [-0.59]	-0.039 [-0.34]	-0.106 [-0.81]	-0.049 [-0.42]
Return on assets	-1.296* [-1.81]	-1.001 [-1.47]	-1.381* [-1.71]	-1.077 [-1.54]
Firm default	-17.503*** [-3.88]	-17.101*** [-3.96]	-16.536*** [-3.80]	-17.085*** [-3.94]
Tax-loss carryforwards	-0.059 [-0.32]	-0.018 [-0.08]	0.036 [0.19]	-0.025 [-0.12]
Natural gas spot price	3.654*** [2.73]	4.928*** [2.93]	5.843*** [3.51]	4.521*** [2.88]
Volatility of gas price	-6.266** [-2.06]	-7.871** [-2.36]	-7.699** [-2.57]	-7.492** [-2.32]
Observations	2,231	2,231	2,344	2,231
R-squared	0.242	0.223	0.231	0.226
Firm FE	No	No	No	No
Year FE	Yes	Yes	Yes	Yes
(<i>a</i>)-(b)	4.48***	-0.23	N/A	1.53

Table 8. Daily Stock Returns of Oil and Gas Firms during the COVID-19 Pandemic

Panel A of the table provides the summary statistics; Panel B reports the estimates of the OLS regressions. The dependent variable in Panel B is a firm's daily stock return. The sample consists of all US-incorporated oil and gas firms (SIC 1311) that have non-missing stock return data and are trading above \$1.00 at the beginning of 2020; the sample period covers January 1, 2020 to March 20, 2020. *Hedge ratio* is the total hedged volume for the fiscal year 2020 (as reflected in the 2019 10-K filing), divided by the total production in the fiscal year 2019. *Hedging requirements* is equal to one if the firm's lending agreement contains covenants requiring hedging and is equal to zero otherwise. COVID-19 cases is the logarithm of one plus the total daily number of COVID-19 cases. T-statistics based on standard errors clustered by date and firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Panel A: Summary Statistics</i>	N	Mean	SD	p25	p50	p75
Daily stock return	3,942	-1.614	14.098	-4.525	-1.236	1.031
Hedging requirements	3,942	0.630	0.483	0.000	1.000	1.000
Crude oil spot price	3,942	48.478	10.853	46.780	51.245	55.510
Hedge ratio 2019	3,888	41.819	30.308	18.000	43.500	62.000
COVID-19 cases	3,066	-3.162	1.531	-3.589	-2.570	-2.285

<i>Panel B: Results</i>	(1)	(2)	(3)	(4)	(5)	(6)
Hedging requirements	6.597** [2.14]		6.808** [2.16]	2.706** [2.22]		2.852** [2.30]
Crude oil spot price	0.167 [1.34]	0.130 [1.20]	0.171 [1.60]			
Hedging requirements *Crude oil spot price	-0.128** [-2.20]		-0.127** [-2.16]			
Hedge ratio 2019		0.048 [1.01]	-0.004 [-0.08]		0.018 [0.95]	-0.004 [-0.20]
Hedge ratio 2019 *Crude oil spot price		-0.001 [-1.22]	-0.000 [-0.12]			
COVID-19 cases				-0.551 [-0.98]	-0.395 [-0.80]	-0.586 [-1.20]
Hedging requirements *COVID-19 cases				0.625** [2.33]		0.591** [2.25]
Hedge ratio 2019 *COVID-19 cases					0.006 [1.51]	0.001 [0.37]
Constant	-9.970 [-1.46]	-7.782 [-1.32]	-9.990* [-1.70]	-4.107 [-1.47]	-3.137 [-1.30]	-4.063* [-1.69]
Observations	3,942	3,888	3,888	3,066	3,024	3,024

Table 9. Interest Paid

The table reports the estimates of the OLS regressions. The dependent variable is the total amount of interest paid on debt during the fiscal year divided by the average of the beginning- and end-of-year book values of debt. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. All other variables are defined in Appendix B. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The last row in each panel reports t-statistics for the difference in OLS coefficients in rows (a) and (b), as indicated.

	(1)	(2)	(3)	(4)	(5)	(6)
Number of hedging covenants	-0.704*** [-4.45]		-0.587*** [-3.35]	-0.270* [-1.74]	-0.281 [-1.33]	-0.715*** [-3.56]
Total hedge ratio, %		-0.043*** [-3.37]	-0.018* [-1.67]	-0.019* [-1.80]	-0.019* [-1.85]	-0.018* [-1.71]
Log of assets	-1.788*** [-5.52]	-1.395*** [-4.36]	-1.582*** [-4.53]	-1.483*** [-3.24]	-1.328*** [-3.91]	-1.619*** [-3.29]
Market-to-book ratio	-0.134 [-1.22]	-0.003 [-0.02]	-0.012 [-0.08]	-0.019 [-0.13]	0.053 [0.33]	-0.013 [-0.08]
Return on assets	-1.391 [-1.22]	-1.595 [-1.60]	-1.863* [-1.89]	-1.886* [-1.92]	-1.024 [-1.01]	-1.854* [-1.88]
Firm default	3.786* [1.68]	0.665 [0.30]	1.804 [0.77]	2.446 [0.93]	2.084 [0.91]	2.415 [0.99]
Tax-loss carryforwards	-0.424 [-1.39]	-0.969** [-2.56]	-1.177*** [-3.01]	-1.171*** [-3.05]	-0.983*** [-2.63]	-1.179*** [-2.96]
Crude oil spot price	0.280 [1.15]	0.269 [0.86]	0.224 [0.71]	0.214 [0.67]	0.299 [0.98]	0.219 [0.69]
Volatility of oil price	0.306 [0.63]	0.202 [0.42]	0.141 [0.28]	0.114 [0.23]	0.184 [0.37]	0.129 [0.26]
Small firm size				2.620 [1.09]		
Number of hedging covenants *Small firm size				-0.686** [-2.46]		
Negative ROA					6.409*** [2.77]	
Number of hedging covenants *Negative ROA					-0.550** [-1.98]	
S&P credit rating						-0.057 [-0.67]
Number of hedging covenants *S&P credit rating						0.026*** [2.67]
Observations	1,958	1,760	1,687	1,687	1,687	1,687
R-squared	0.114	0.079	0.099	0.104	0.114	0.101
Firm FE	No	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Internet Appendix to “Risk Hedging and Loan Covenants”

This Internet Appendix presents additional empirical results to demonstrate robustness of central results, as well as the outcomes of tests that identify exogenous variation in borrowing and covenant usage by means of instrumental variable estimation.

IA.1. Robustness and Additional Results

Table IA.1 reports the results of OLS regressions where the dependent variable is *newly entered hedges*, which is a flow variable. The results are very similar to those reported in Table 5 of the main text, where we use a stock variable (hedge ratio) as the dependent variable. Table IA.2 shows the robustness of our main results to alternative clustering of standard errors. In the main text, we cluster standard errors by firm. The estimation in Table IA.2 is done with clustering of standard errors by year, as well as by year and state, and shows that results are very similar.

Table IA.3 reports results of regressions that are similar to Table 5, except that the dependent variable is the maturity of hedge contracts rather than the hedge ratio. The results show that debt issuance is associated with longer maturity contracts as well.

IA.2. Instrumental Variable Estimation

A bank’s decision to require hedging covenants for a particular firm is plausibly endogenous and might be related to observed or anticipated changes in firm characteristics and risk management. Then, the relation between covenants and hedging may obtain regardless of whether hedging covenants bind. To assess this possibility, we identify the propensity of a firm’s lender to require hedging covenants based on other lending agreements used by the same lender in the same year. As noted, lenders pursue differing styles, with some banks (e.g., Wells Fargo) requiring hedging covenants in most of their contracts, while others (e.g., Bank of America) requiring hedging only occasionally.²¹

More specifically, we use an instrument for covenant placement by measuring for each lending

²¹Figure IA.1 in this appendix shows that the geographic concentration of loans is similar across the banks, which supports the reasoning that differences in lending styles are unlikely to stem from banks’ specialization on particular geographies.

agreement the proportion of the lending bank’s *other* agreements originated during the same year that require hedging. We reason that a bank may decide to tighten or loosen its lending standards by placing more or less hedging-related covenants on its borrowers because of some institutional changes or because of changes in its own balance sheet. For example, [Murfin \(2012\)](#) finds that lender-specific shocks impact the strictness of the loan contract that a borrower receives, although he does not specifically focus on hedging-related covenants. Of course, one may argue that if a firm’s bank places more restrictive covenants, the firm may decide to switch the bank to one that would be willing to offer less restrictive policies. However, as shown by the prior literature on relationship banking, there are significant costs to borrowers who switch lenders that could arise because of adverse selection, higher costs of monitoring for first-time borrowers, or difficulty to lead underwriters in recruiting syndicate participants (see, e.g., [Chodorow-Reich \(2014\)](#), [Sharpe \(1990\)](#), and [Sufi \(2007\)](#)).

The dependent variable in the first stage of the instrumental variable analysis is the indicator variable for the presence of covenants requiring minimum hedging or a covenant that calls for automatic decreases in the firm’s borrowing base if hedges are unwound or terminated. The results in column 1 of Table IA.4 indicate that bank’s propensity to place restrictive hedging covenants on other borrowers strongly predicts the placement of covenant on a firm. The second stage results in columns 2 to 5 indicate that the variation in covenants related to the bank’s propensity to require them is positively related to both hedge ratios and hedge contract maturities, for both oil and gas. For comparison purposes, Table IA.5 presents the corresponding results using the OLS regressions. The implication is that firms with more restrictive hedging-related covenants, for reasons related to the identity of their lender rather than their own characteristics, increase their hedge ratios for both oil and gas commodities and enter into contracts with longer maturities.

We also present results based on an alternative identification strategy. In particular, we construct an instrument for firms’ exposure to the fracking technology shock based on their geographical presence in individual U.S. states *prior* to the widespread adoption of fracking. Table IA.6 shows that, prior to the technological revolution in the oil and gas industry (1999-2006), firms that later

extensively adopted the new technology and those that did not were similar in terms of observable firm characteristics. We use the number of times each state is mentioned in each firm’s 10-K report to calculate the importance (or weight) of each state for a firm’s operations in 2006.²² We then multiply the firm’s pre-determined weights in each state by the number of horizontal wells in the state each year, and sum the values across all states for each firm-year. The reasoning is that the extent to which firms benefitted from the adoption of fracking technology varied across states, e.g., as a function of the geological structure of the resources owned, the quantity of “held-by” production leases in the state, or new state-specific field discoveries (e.g., Marcellus shale play discovered in the Appalachian Basin of Pennsylvania and West Virginia in 2008). Because the adoption of new technology was largely financed by new debt and lending agreements typically contained restrictive hedging covenants, the adoption of fracking technology resulted in a greater probability that hedge covenants would be entered. Indeed, the first-stage results reported on Table IA.7 show that this technological shock instrument positively predicts the probability of covenant placement. The second-stage estimates in Table IA.7 provide results that are similar to those in Table IA.4, indicating that the covenants attributable to the technological shock are associated with higher hedge ratios and longer maturity of hedges. These results help to mitigate the concern that the relation between covenants and hedging outcomes obtains not because covenants bind but because of some omitted firm characteristics.

Table IA.8 uses the same technological shock variable as employed for Table IA.7 when we instrument for the quantity of debt issued. The results reported to Table IA.8 indicate that the technological shock variable strongly positively predicts debt issuance, with a t-statistic of 4.04. Further, higher debt issuance attributable to the technological shock is associated with higher hedge ratios for both oil (t-statistic = 3.31) and natural gas (t-statistic = 4.03).

We also report on an alternative identification strategy, where the excluded instrument follows [Ivashina and Scharfstein \(2010\)](#) and [Chodorow-Reich \(2014\)](#) and measures exposure of bank port-

²²The data on the number of state mentions is from [Bird, Karolyi, and Ruchti \(2021\)](#). Our results are robust to the number of state mentions in 2004 or 2005, instead of 2006. When we use state weights from 1999 the sample size is decreased by about twenty percent. However, second stage results regarding hedge ratios are robust, though those regarding hedge maturities are no longer statistically significant.

folios to the Lehman Brothers bankruptcy through the syndicated market. The idea is that banks that were more exposed during the crisis suffered a greater shock, and as a result they tightened their lending standards by placing more covenants or stricter covenants on their borrowers. For example, [Murfin \(2012\)](#) finds that banks generally use tighter covenants after suffering payment defaults to their own loan portfolios, but he does not consider specifically covenants requiring hedging. The instrument we use is the fraction of the firm's bank's syndication portfolio where Lehman Brothers had a lead role. The firm's bank is identified as of 2006, the estimation sample is restricted to the post-crisis period of 2008-2009, and the instrument is constructed following [Ivashina and Scharfstein \(2010\)](#) and [Chodorow-Reich \(2014\)](#). Table IA.9 compares characteristics of firms that had loans with the banks that had a high exposure to Lehman Brothers bankruptcy to those that had loans with the low-exposure banks. The results from the first stage in Table IA.10 show that indeed more exposed banks are more likely to place restrictive hedging covenants in the aftermath of the financial crisis. More important, we find that firms that are subject to tighter hedging-related covenants respond with higher hedge ratios and longer hedge maturities.

Additional Variable Definitions

<i>Variable</i>	<i>Definition</i>
Asset tangibility	Total value of gas and oil reserves, divided by the book value of assets.
Debt issuance	The annual issuance of long-term debt (DLTIS), divided by the end-of-year book value of assets.
Oil hedge ratio, %	The sum of the outstanding notional amounts of oil derivatives for the next fiscal year, divided by the next year oil production.
Gas hedge ratio, %	The sum of the outstanding notional amounts of natural gas derivatives for the next fiscal year, divided by the next year natural gas production.
Oil hedge maturity	The maturity of outstanding oil hedging contracts (months).
Gas hedge maturity	The maturity of outstanding natural gas hedging contracts (months).
Crude oil spot price	The average WTI crude oil spot price per Bbl during the fiscal year.
Volatility of oil price	The standard deviation of monthly WTI crude oil price.
Natural gas spot price	The average Henry Hub natural gas spot price per Mcf during the fiscal year.
Volatility of gas price	The standard deviation of monthly Henry Hub natural gas price.
Technological shock	The sum of the logarithm of one plus the number of horizontal wells in state j at time t multiplied by the weight of state j in a firm's 10-K in 2006 (state j mentions divided by all state mentions). State mentions data are from Bird, Karolyi, and Ruchti (2021) ; horizontal wells data are from the EIA.
Newly entered oil hedges, %	The sum of the outstanding notional amounts of oil derivatives for the next year minus the carryover from the prior year, all divided by the next year oil production. The carryover is equal to $0.5 \times \min(1, (maturity - 12)/12)$ if the maturity of outstanding oil hedges was greater than 12 months in the prior year and is zero otherwise.
Newly entered gas hedges, %	The sum of the outstanding notional amounts of natural gas derivatives for the next year minus the carryover from the previous year, all divided by the next year oil production. The carryover is equal to $0.5 \times \min(1, (maturity - 12)/12)$ if the maturity of outstanding oil hedges was greater than 12 months in the prior year and is zero otherwise.
Covenants require hedging	The variable is set to one if the firm's outstanding loan agreements have covenants that require a minimum hedge ratio, minimum hedge maturity, or prohibit the unwinding of outstanding hedge positions.
Exposure of bank portfolio to Lehman Brothers	The fraction of the bank's syndication portfolio where Lehman Brothers had a lead role in 2006 (see Chodorow-Reich (2014) and Ivashina and Scharfstein (2010) for details).

Table IA.1. Newly Entered Hedges

The table reports the estimates of the OLS regressions. The dependent variable in columns 1-3 is the newly entered hedges for crude oil (%); the dependent variable in columns 4-6 is the newly entered hedges for natural gas. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Dependent Variable:</i>	<i>Newly Entered Oil Hedges</i>			<i>Newly Entered Gas Hedges</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
Debt issuance	18.572** [2.51]	-11.623 [-0.62]	9.846*** [2.64]	28.120*** [6.56]	10.852 [1.28]	9.122** [2.43]
Crude oil spot price		0.480** [2.03]				
*Debt issuance						
Natural gas spot price					3.814** [2.25]	
*Debt issuance						
Log of assets	2.927*** [3.98]	2.892*** [3.99]	7.074*** [6.65]	4.675*** [8.29]	4.646*** [8.27]	5.779*** [4.28]
Market-to-book ratio	-1.107 [-1.64]	-1.026 [-1.49]	0.346* [1.96]	-0.048 [-0.41]	-0.059 [-0.51]	-0.042 [-0.59]
Return on assets	0.188 [0.28]	0.071 [0.11]	-0.376 [-0.68]	-0.948 [-1.43]	-1.038 [-1.52]	-0.710 [-1.02]
Firm default	-36.614** [-2.25]	-36.197** [-2.27]	-27.008*** [-4.21]	-16.709*** [-3.84]	-16.326*** [-3.77]	-30.238*** [-5.30]
Tax-loss carryforwards	-0.433 [-1.40]	-0.434 [-1.42]	-0.151 [-0.47]	0.026 [0.12]	0.012 [0.06]	0.278 [1.22]
Crude oil spot price	1.040 [1.47]	0.962 [1.36]	0.264 [1.39]			
Volatility of oil price	-0.780 [-0.89]	-0.823 [-0.95]	-0.015 [-0.06]			
Natural gas spot price				5.880*** [3.53]	5.327*** [2.91]	2.580 [1.55]
Volatility of gas price				-7.750** [-2.58]	-7.596** [-2.45]	-3.453 [-1.30]
Observations	2,110	2,110	2,388	2,344	2,344	2,335
R-squared	0.044	0.045	0.643	0.231	0.234	0.619
Firm FE	No	No	Yes	No	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table IA.2. Main Results: Clustering of Standard Errors by Year or Year by State

The table reports the estimates of the OLS regressions. The dependent variable in columns 1-3 is the hedge ratio for crude oil (%); the dependent variable in columns 4-6 is the hedge ratio for natural gas (%). The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. Intercept and controls from Table 5 of the main text are included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Dependent Variable:</i>	(1)	(2)	(3)	<i>Oil Hedge Ratio, %</i>			(6)	(7)	(8)	<i>Gas Hedge Ratio, %</i>		
				(4)	(5)					(10)	(11)	(12)
Debt issuance	36.619*** [8.23]	-1.507 [-0.19]	9.950** [2.44]	36.662*** [7.34]	-1.540 [-0.18]	9.846** [2.08]	28.099*** [7.86]	10.964 [1.20]	9.132*** [3.12]	28.120*** [6.92]	10.852 [1.12]	9.122** [2.72]
Oil spot price		0.613*** [5.37]			0.614*** [4.78]							
*Debt issuance								3.789** [2.06]			3.814* [1.74]	
Gas spot price												
*Debt issuance												
Observations	2,374	2,374	2,365	2,397	2,397	2,388	2,326	2,326	2,326	2,317	2,344	2,335
R-squared	0.292	0.301	0.643	0.293	0.303	0.643	0.233	0.236	0.236	0.231	0.234	0.619
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustering		<i>State × Year</i>			<i>Year</i>			<i>State × Year</i>			<i>Year</i>	

Table IA.3. OLS Regressions for Maturity of Hedging Contracts

The table reports the estimates of the OLS regressions. The dependent variable in columns 1-2 (columns 3-4) is the longest maturity of outstanding crude oil (natural gas) hedging contracts in months. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. All variables are defined in Appendix B. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Dependent Variable:</i>	<i>Oil Maturity</i>		<i>Gas Maturity</i>	
	(1)	(2)	(3)	(4)
Debt issuance	14.902*** [6.60]	7.402*** [4.83]	12.710*** [5.66]	6.393*** [3.74]
Log of assets	2.912*** [10.11]	1.915*** [3.43]	3.807*** [10.82]	3.469*** [4.42]
Market-to-book ratio	0.022 [0.69]	0.008 [0.21]	-0.015 [-0.40]	-0.043 [-1.04]
Return on assets	0.103 [0.51]	0.051 [0.21]	-0.257 [-1.38]	-0.226 [-0.90]
Firm default	-5.090** [-2.40]	-11.256*** [-4.91]	-8.606*** [-4.70]	-12.738*** [-4.69]
Tax-loss carryforwards	0.166** [1.99]	0.072 [0.40]	0.324*** [3.25]	0.309*** [2.77]
Crude oil spot price	0.186* [1.94]	0.241*** [2.60]		
Volatility of oil price	0.006 [0.06]	0.029 [0.27]		
Natural gas spot price			1.438 [1.64]	0.861 [1.18]
Volatility of gas price			-2.945** [-2.50]	-1.729* [-1.75]
Observations	2,441	2,430	2,433	2,422
R-squared	0.318	0.639	0.302	0.626
Firm FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes

Table IA.4. Covenants Requiring Hedging: IV Estimates Using Bank Covenant Adoption

The table reports the estimates of the two-stage least squares. The excluded instrument is the bank covenant adoption for other O&G loans, which is equal for each lending agreement to the proportion of the lending bank's *other* agreements originated during the same year that require hedging. Column 1 provides the estimates from the first stage, where the dependent variable is equal to one if the firm's outstanding loan is subject to a covenant requiring minimum hedging. Columns 2-5 provide the second-stage estimates, where the dependent variable is the hedge ratio for crude oil (%), the hedge ratio for natural gas (%), maturity for crude oil hedges, and maturity for natural gas hedges. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. All variables are defined in Appendix B. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. The bottom row reports F-test for excluded instruments based on the corresponding first-stage results. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
<i>Estimation stage:</i>	1st	2nd	2nd	2nd	2nd
<i>Dependent variable:</i>	Cov. req. hedg.	Oil hedg.	Gas hedg.	Oil maturity	Gas maturity
Bank covenant adoption for other O&G loans	0.588*** [9.48]				
Covenants require hedging		35.605*** [4.36]	20.949*** [3.12]	8.696** [2.33]	7.582** [2.36]
Log of assets	0.004 [0.30]	4.713*** [6.40]	4.378*** [6.66]	2.914*** [7.00]	3.818*** [8.40]
Market-to-book ratio	-0.009** [-2.19]	-0.034 [-0.14]	-0.131 [-0.79]	0.020 [0.64]	-0.030 [-0.49]
Return on assets	-0.036** [-2.12]	-0.535 [-0.51]	-1.932* [-1.83]	0.239 [0.79]	-0.525 [-1.12]
Firm default	0.081 [0.72]	-12.325* [-1.70]	-17.364*** [-2.95]	-5.251** [-1.97]	-9.224*** [-3.74]
Tax-loss carryforwards	-0.009 [-1.53]	0.264 [0.81]	-0.068 [-0.22]	0.285** [2.02]	0.270 [1.45]
Crude oil spot price	-0.003 [-0.72]	0.334 [0.84]		0.089 [0.66]	
Volatility of oil price	-0.003 [-0.81]	-0.012 [-0.03]		-0.048 [-0.39]	
Natural gas spot price			2.504* [1.71]		-0.688 [-0.64]
Volatility of gas price			-0.843 [-0.27]		0.171 [0.13]
Observations	1,817	1,817	1,802	1,850	1,845
F-test of excl. instruments	89.83	89.83	78.79	88.61	84.90

Table IA.5. Covenants Requiring Hedging and Firm Risk Management Policy

The table reports the estimates of the OLS regressions. The dependent variable in columns 1-2 is the hedge ratio for crude oil (%); the dependent variable in columns 3-4 is the hedge ratio for natural gas (%). The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Dependent Variable:</i>	<i>Oil Hedge Ratio</i>		<i>Gas Hedge Ratio</i>	
	(1)	(2)	(3)	(4)
Covenants require hedging	26.265*** [8.80]	12.396*** [4.29]	18.759*** [7.33]	8.750*** [3.58]
Log of assets	5.018*** [7.83]	6.131*** [5.53]	4.443*** [7.96]	5.248*** [3.87]
Market-to-book ratio	-0.036 [-0.21]	0.307 [1.58]	-0.129 [-0.91]	-0.043 [-0.58]
Return on assets	-0.515 [-1.30]	-0.447 [-0.84]	-2.010** [-1.98]	-1.007 [-1.26]
Firm default	-10.956** [-1.97]	-28.069*** [-4.83]	-18.507*** [-4.48]	-30.533*** [-5.42]
Tax-loss carryforwards	0.190 [1.13]	-0.174 [-0.54]	-0.063 [-0.34]	0.189 [0.90]
Crude oil spot price	0.295 [1.17]	0.348* [1.78]		
Volatility of oil price	0.001 [0.00]	0.020 [0.08]		
Natural gas spot price			3.669** [2.34]	1.576 [1.04]
Volatility of gas price			-6.896** [-2.17]	-3.368 [-1.30]
Constant	-28.188* [-1.78]	-32.284** [-2.46]	-17.469** [-2.54]	-11.525 [-1.13]
Observations	2,328	2,320	2,270	2,259
R-squared	0.337	0.640	0.253	0.617
Firm FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes

Table IA.6. Comparison of Firm Characteristics Prior to Technological Revolution

The table shows the means for firm characteristics during the pre-fracking period (1999-2006) for firms that are subject to relatively large or relatively small technological shock during the post-fracking period (2007-2019). The sample is split at the median value of technological shock. The last column shows the t-test for the difference in means; the standard errors are clustered by firm. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variables, 1999-2006	Large Techno- logical Shock	Small Techno- logical Shock	Difference	T-test
Annual oil production, MMBbl	3.884	12.454	-8.571	-1.59
Annual gas production, Bcf	55.905	105.522	-49.617	-1.32
Book assets, \$M	1,658	3,272	-1,614	-1.28
Market-to-book ratio	1.339	1.690	-0.352	-1.39
Return on assets	0.039	-0.006	0.044	1.64
Tax-loss carryforwards	0.063	0.176	-0.113	-1.05
Book leverage	0.328	0.346	-0.018	1.48
Asset tangibility	3.762	4.074	-0.312	-0.64
S&P credit rating	5.463	7.900	-2.437	-1.25

Table IA.7. Covenants Requiring Hedging: IV Estimates Using Technological Shock

The table reports the estimates of the two-stage least squares. The excluded instrument is $Tech\ shock_{it} = \sum_j w_{ij2006} \times \log(1 + Horizontal\ wells_{jt})$, where w_{ij2006} is the number of state j mentions by firm i in its 10-K report in 2006 divided by all state mentions in 2006 (data on state mentions are from Bird, Karolyi, and Ruchti (2021)), and $Horizontal\ wells_{jt}$ is the number of horizontal wells in state j in year t (EIA data). Column 1 provides the estimates from the first stage, where the dependent variable is equal to one if the firm's outstanding loan is subject to a covenant requiring minimum hedging. Columns 2-5 provide the second-stage estimates, where the dependent variable is the hedge ratio for crude oil (%), the hedge ratio for natural gas (%), maturity for crude oil hedges, and maturity for natural gas hedges. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 1999-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. The bottom row reports F-test for excluded instruments based on the corresponding first-stage results. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
<i>Estimation stage:</i>	1st	2nd	2nd	2nd	2nd
<i>Dependent variable:</i>	Cov. req. hedg.	Oil hedg.	Gas hedg.	Oil maturity	Gas maturity
Tech shock	0.068*** [3.84]				
Covenants require hedging		41.884*** [3.09]	41.937*** [2.89]	12.611* [1.65]	18.591** [2.28]
Log of assets	-0.011 [0.56]	4.942*** [5.03]	4.443*** [4.79]	3.231*** [6.48]	4.377*** [5.84]
Market-to-book ratio	-0.030 [-1.47]	-0.436 [-0.39]	-1.007 [-0.78]	-0.884 [-1.42]	-0.638 [-0.97]
Return on assets	-0.124** [-2.18]	3.502 [1.04]	-7.984** [-2.17]	2.313* [1.66]	-0.676 [-0.29]
Firm default	-0.339** [-2.21]	-9.912 [-1.02]	-19.079** [-2.05]	-5.299 [-1.54]	-8.918** [-2.28]
Tax-loss carryforwards	-0.006 [-0.78]	0.785 [1.57]	-0.231 [-0.08]	0.683*** [2.87]	0.793** [2.32]
Crude oil spot price	-0.012** [-2.32]	1.266** [1.98]		0.528 [1.51]	
Volatility of oil price	0.014 [-1.20]	0.642 [1.21]		0.248 [1.31]	
Natural gas spot price			4.770 [0.98]		1.511 [0.67]
Volatility of gas price			-4.182 [-0.61]		-0.239 [-0.07]
Observations	1,045	1,045	1,023	1,057	1,050
F-test of excl. instruments	14.73	14.73	15.81	15.58	14.72

Table IA.8. Debt Issuance and Hedging: IV Estimates Using Technological Shock

The table reports the estimates of the two-stage least squares. Column 1 provides the first-stage estimates, where the dependent variable is debt issuance. The excluded instrument is $Tech\ shock_{it} = \sum_j w_{ij2006} \times \log(1 + Horizontal\ wells_{jt})$, where w_{ij2006} is the number of state j mentions by firm i in its 10-K report in 2006 divided by all state mentions in 2006 (data on state mentions are from Bird, Karolyi, and Ruchti (2021)), and $Horizontal\ wells_{jt}$ is the number of horizontal wells in state j in year t (EIA data). Columns 2-5 provide the second-stage estimates, where the dependent variable is the hedge ratio for crude oil (%), the hedge ratio for natural gas (%), maturity for crude oil hedges, and maturity for natural gas hedges. The sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 2000-2019 that have non-missing accounting information in COMPUSTAT, non-zero oil/gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. The bottom row reports F-test for excluded instruments based on the corresponding first-stage results. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
<i>Estimation stage:</i>	1st	2nd	2nd	2nd	2nd
<i>Dependent variable:</i>	Debt issuance	Oil hedg.	Gas hedg.	Oil maturity	Gas maturity
Tech shock	0.025*** [4.04]				
Debt issuance		114.075*** [3.31]	112.593*** [4.03]	36.216* [1.82]	53.793*** [3.10]
Log of assets	0.012* [1.80]	3.291*** [3.55]	2.674*** [3.34]	2.819*** [4.34]	3.647*** [5.96]
Market-to-book ratio	-0.016*** [-2.87]	0.339 [0.38]	-0.521 [-0.60]	-0.377 [-0.78]	-0.094 [-0.20]
Return on assets	-0.123*** [-3.72]	11.570* [1.74]	-1.385 [-0.30]	4.582* [1.73]	3.418 [1.10]
Firm default	-0.067 [-0.91]	-16.758 [-1.38]	-25.855** [-2.47]	-7.419** [-2.07]	-11.601*** [-2.58]
Tax-loss carryforwards	0.006 [1.44]	-0.137 [-0.32]	-3.178 [-1.45]	0.380** [2.18]	0.340 [1.40]
Crude oil spot price	0.001 [0.32]	0.545 [0.96]		0.289 [1.05]	
Volatility of oil price	-0.001 [-0.14]	0.183 [0.19]		0.152 [0.48]	
Natural gas spot price			11.677** [2.42]		2.943 [1.09]
Volatility of gas price			-14.067** [-2.53]		-4.011 [-1.41]
Observations	1,066	1,066	1,040	1,079	1,071
F-test of excl. instruments	16.35	16.35	18.84	17.10	15.83

Table IA.9. Comparison of Firm Characteristics Based on Bank Exposure to Lehman

The table shows the means for firm characteristics during the pre-crisis period (1999-2006) for firms that have loans in 2006 with banks that have high exposure to Lehman Brothers bankruptcy during the financial crisis of 2007-2008 or low exposure. Bank exposure is measured by the fraction of the syndication portfolio where Lehman Brothers had a lead role (see Chodorow-Reich (2014)), and the sample is split at the median value of bank exposure. All variables are defined in Appendix B. The last column shows the t-test for the difference in means; the standard errors are clustered by firm. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Variables, 1999-2006	High Bank Exposure to Lehman	Low Bank Exposure to Lehman	Difference	T-test
Annual oil production, MMBbl	5.333	14.134	-8.801	-1.10
Annual gas production, Bcf	77.800	86.522	-8.722	-0.18
Book assets, \$M	1,935	3,682	-1,743	-0.97
Market-to-book ratio	1.478	1.666	-0.187	-0.61
Return on assets	0.042	-0.004	0.046	1.31
Tax-loss carryforwards	0.024	0.329	-0.305	-1.76*
Book leverage	0.347	0.317	0.030	0.49
Asset tangibility	4.012	4.794	-0.781	-0.94
S&P credit rating	8.172	5.980	2.191	0.94

Table IA.10. Covenants Requiring Hedging: IV Estimates Using Bank Exposure to Lehman

The table reports the estimates of the two-stage least squares. Column 1 provides the estimates from the first stage, where the dependent variable is equal to one if the firm's outstanding loan is subject to a covenant requiring minimum hedging. The excluded instrument follows [Ivashina and Scharfstein \(2010\)](#) and [Chodorow-Reich \(2014\)](#) and measures exposure of bank portfolio to Lehman Brothers bankruptcy through the syndicated market. Firm bank is identified as of 2006, and the sample consists of all US-incorporated oil and gas producing firms (SIC Code 1311) during the period 2008-2009 that have non-missing accounting information in COMPUSTAT, non-zero oil and/or gas production volumes, and non-missing hedging data in 10-K or 10-KSB public filings. Columns 2-5 provide the estimates from the second stage, where the dependent variable is the hedge ratio for crude oil (%), the hedge ratio for natural gas (%), maturity for crude oil hedges, and maturity for natural gas hedges. Intercept is included in all specifications, but not shown. T-statistics based on heteroskedasticity-consistent standard errors clustered by the firm are reported in brackets. The bottom row reports F-test for excluded instruments based on the corresponding first-stage results. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
<i>Estimation stage:</i>	1st	2nd	2nd	2nd	2nd
<i>Dependent variable:</i>	Cov. req. hedg.	Oil hedg.	Gas hedg.	Oil maturity	Gas maturity
Exposure of bank portfolio to Lehman Brothers	13.386** [2.44]				
Covenants require hedging		69.489** [2.30]	29.395* [1.93]	29.347** [2.42]	23.133** [2.13]
Log of assets	-0.076* [-1.84]	6.519* [1.82]	1.745 [0.85]	5.408*** [2.77]	5.285** [2.03]
Market-to-book ratio	-0.225 [-2.29]	2.368 [0.14]	-11.018 [-1.09]	-1.861 [-0.26]	-4.990 [-0.95]
Return on assets	-0.064 [-0.35]	21.262* [1.82]	3.327 [0.36]	8.115* [1.77]	3.935 [0.62]
Tax-loss carryforwards	-0.058 [-0.40]	-1.376 [-0.10]	-6.684 [-0.62]	4.820 [0.93]	2.058 [0.32]
Crude oil spot price	0.140 [1.28]	0.194 [0.22]		0.076 [0.20]	
Volatility of oil price	-0.507** [-2.13]	-0.039 [-0.04]		0.345 [0.77]	
Natural gas spot price			4.858 [0.53]		-8.924* [-1.68]
Volatility of gas price			1.218 [0.05]		0.524 [0.05]
Observations	105	105	109	109	109
F-test of excl. instruments	6.08	6.08	5.97	5.87	5.97

Figure IA.1. Concentration of Lending by Leading Banks

The figure shows the geographical concentration of lending by the four leading banks (J.P. Morgan Chase, Wells Fargo, Bank of America, and Bank One) across the firms in the United States. Firm headquarters are used to identify firm locations.

