Debt Financing and Risk Management *

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ABSTRACT

Using detailed data on derivative positions of U.S. oil and gas producers during 1999-2019, we find that firms' hedge ratios and contract maturities are strongly related to debt issuance. Debt financing comes with restrictive covenants on hedging policy, with 53.6% of outstanding lending agreements containing explicit minimum hedging requirements. Using adoption of capital-intensive technologies during the fracking boom as a shock to firms' financing policies, we show that a sharp increase in debt financing results in more hedging. We rule out lender expropriation as a motive for hedging and show that firms with hedging requirements perform better during the COVID-19 pandemic. Overall, it appears that firms face constrained optimization in their hedging decisions imposed by prior financing choices.

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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.

Over several recent decades academics have developed many appealing theories of corporate risk management (see, e.g., 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)), which prescribe optimal hedge ratios for value-maximizing firms or utility-maximizing managers. Yet, these theories are often unable to explain why in practice firms with similar characteristics pursue widely 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 posit that firms face constrained optimization in their hedging decisions imposed by prior financing choices, which may explain observed risk management behavior.

Our argument is that a firm's reliance on debt financing often dictates a particular risk management policy. First, it is common for lenders to place explicit requirements on firm risk management policy, such as limits on the amount of hedging, non-speculative clauses, requirements of lender-approved counterparties, redetermination of the borrowing base upon hedge unwinding, minimum hedge ratios, and hedge maturities. In fact, hedging covenants are present in 85.2% of all credit and loan agreements, with 53.6% of agreements and 43.7% of firm-years containing explicit minimum hedging requirements. Further, even when hedging covenants are not present, firms may choose to hedge in order to obtain more favorable terms on a loan. For example, Campello, Lin, Ma, and Zou (2011) find that hedgers pay lower interest spreads and have fewer restrictions on their investment policy.

To understand how debt financing shapes risk management policy, we first analyze the relation between debt issuance and firm hedge ratios, contract maturities, and the sophistication of the hedging portfolio. Our data set covers 2,577 firm-years for 308 U.S. oil and gas producers (SIC Code 1311) during the period 1999-2019 and provides a near-ideal setting to study risk management: oil and gas firms face a common and clear exposure to fluctuating energy prices,[1] there is a well-developed market for energy derivatives, and there is significant variation both across firms and time in adopted risk management policies.

Our analysis reveals a strong positive relation between debt issuance and hedging, which is robust to the inclusion of firm-fixed effects and economically important. For example, a one standard deviation increase in debt issuance is associated with 8.2% higher oil hedge ratio and approximately three months longer contract maturity. One potential issue with the interpretation of these results, however, is that firms that hedge more (for some reason) may be more appealing to prospective lenders and therefore are able to secure larger loans. This reverse causality mechanism can bias the OLS coefficients and we address it next.[2]

As a laboratory we use the shock to financing policies of oil and gas producers associated with adoption of new capital-intensive technologies. As hydraulic fracturing and horizontal drilling techniques became commercially viable in mid- to late-2000s, firms dramatically expanded their capital spending programs and financed this expansion primarily by debt. In fact, the average annual capital expenditures in the oil and gas industry grew from $143 million in real terms in 1999 to $1 billion in 2019. This activity had a profound effect on debt financing—the annual long-term debt issuance increased from $150 million to $1.1 billion over the same period.

There are at least two reasons why debt was a marginal source of financing for oil and gas firms in mid- to late-2000s. First, this period was characterized by historically low interest rates, particularly post the 2008 financial crisis. Second, the widespread industry practice of Reserve Base Lending (RBL), whereby a loan is secured by a firm's proved oil and gas reserves, has made it easy for banks to extend credit during the period of high energy prices (Azar (2017)). Indeed, by increasing the available collateral, shale boom facilitated borrowing (see, e.g., Kiyotaki and Moore (1997) and Brunnermeier

[1]The variation in energy prices is high during our sample period. For example, the average monthly spot price for WTI crude oil contract was $12 per barrel in 1999, whereas it reached $140 per barrel in 2008.

[2]Additionally, firms may strategically hedge more in order to obtain a larger loan. This mechanism is part of our explanation that debt financing drives firm hedging behavior. However, to the extent that firms with weak balance sheets are more likely to engage in strategic hedging behavior, it would cause us to underestimate the effect of debt issuance on risk management in panel regressions.

and Oehmke (2013)).

Our empirical strategy leverages the fact that firms disclose in their annual reports whether they apply new technology. Specifically, we use the frequency of terms 'hydraulic fracturing' and 'horizontal drilling' in firms' annual reports as the instrument for debt financing. The key to this strategy is that the new technology required significant new investment, which was financed (often dollar for dollar) by new debt. Indeed, we find that the technological shock strongly predicts debt issuance by firms, with the instrument satisfying the first-stage criteria for strong instruments. The second-stage estimates reveal that a one standard deviation increase in debt issuance more than doubles firms' hedge ratios for both oil and gas commodities and results in substantially longer maturities of hedges.

The next set of tests investigates which mechanism is responsible for the link between debt issuance and risk management. To see whether covenants in firms' lending agreements is what drives hedging policies, we separate debt issuance into two categories: debt that comes with minimum hedging requirements and unrestricted debt. Consistent with lending agreements shaping hedging policies, we find it is debt with minimum hedging requirements that has a positive effect on firm hedge ratios and maturities, whereas unrestricted debt has virtually no effect. These results are robust to firm- and bank-fixed effects, indicating that time-invariant firm or bank characteristics cannot explain this relation. Overall, our results underscore the importance of covenants and suggest that the mechanism, whereby firms voluntarily hedge their production in order to obtain better loan terms is unlikely to be of large importance.

The second potential mechanism is related to expropriation of existing debtholders. Because derivatives are exempt from the automatic stay in bankruptcy, it can be ex post optimal for a firm to hedge default risk with a derivative that is effectively senior to existing debt (Roe (2011), Bolton and Oehmke (2015)). However, we find several pieces of evidence inconsistent with this explanation. First, in many cases lenders do not allow oil and gas firms to collateralize their derivative contracts when they hedge with the third party, which strips derivatives of their seniority over debt claims. Second, the positive effect of debt issuance on risk management is concentrated among highly profitable firms that face a low probability of bankruptcy. Third, it is not unusual in the oil and gas industry for financing and risk management to be bundled, which allows lenders to internalize any transfers between the financing and hedging parts of their portfolio. In fact, 54.5% of lending agreements explicitly allow and 8.8% agreements require firms to use the original lender as a counterparty to any derivative transactions.[3] We find that debt issuance generally has a greater positive effect on hedge ratios and maturities when financing and hedging are bundled together, which is inconsistent with the expropriation channel.

Our final set of tests examines the effectiveness of bank-imposed hedging requirements during the COVID-19 pandemic of 2020. The emergence of the novel coronavirus had a dramatic effect on energy producers, with oil prices dropping from more than $60 per barrel at the beginning of the year to less than $20 at the end of March 2020.[4] Correspondingly, industry market valuations have dropped by more than 50%. Our analysis reveals, however, that firms that had minimum hedging covenants in their loan agreements had a significantly lower sensitivity to the daily crude oil price and the wordwide COVID-19 case count. For example, during the month of March associated with the largest industry decline, firms with minimum hedging requirements posted, on average, a 9.6% higher cumulative return than firms without such requirements. These differences were even more stark for highly levered firms, amounting to 25.8% return differental. Further, we find that hedging requirements imposed by the banks were more effective at mitigating the effect of pandemic on firm value than the voluntary hedging programs, which is likely driven by firms choosing to unwind their voluntary hedges at the beginning of 2020. Overall, our results demonstrate that firms with hedging covenants perform better when industry is hit by a large negative shock.

The remainder of this paper is organized as follows. The next section offers a brief review of the literature. Section II describes the technological revolution in the oil and gas industry that came with the adoption of hydraulic fracturing and horizontal drilling

[3] Lender-counterparty may also receive preferential treatment. For example, derivative transactions with the original lender can be collateralized, whereas derivative transactions with another counterparty have to be unsecured.

[4] In fact, the WTI crude oil price has turned negative for the first time in history on April 20, 2020.

methods and presents evidence on increased firms' reliance on debt financing. Section III describes covenants that lenders place to better control firms' hedging policies and presents summary statistics for the main sample. The empirical analysis linking debt issuance and risk management policies is in Section IV. Section V examines mechanisms, and Section VI offers results on firm performance.

I Literature Review

A vast finance literature focuses on the benefits of corporate risk management. Indeed, 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), Froot, Scharfstein, and Stein (1993), Graham and Smith (1999), Fehle and Tsyplakov (2005), Leland (1998), Graham and Rogers (2002), and Purnanandam (2008)). Risk management also mitigates certain market frictions. By strengthening firm commitment to meet its obligations, hedging facilitates contracting with firm creditors, customers, and suppliers (Bessembinder (1991)). In addition, hedging helps managers to reduce information asymmetries and better communicate their ability to the labor market (DeMarzo and Duffie (1995)).

Another view on risk management is that risk-averse corporate executives engage in hedging not to maximize shareholder value, but instead to increase their personal utility, for example, by decreasing compensation risk (Stulz (1984), Smith and Stulz (1985)). Consistent with this view, Tufano (1996) finds that hedging in gold mining industry is related to compensation structure of firms' executives and Knopf, Nam, and Thornton Jr. (2002) find that firms hedge more when the sensitivity of managers' stock and stock option portfolios to stock price increases.

The literature pioneered by Rampini and Viswanathan (2010) focuses on hedging by constrained firms. In particular, Rampini and Viswanathan (2010) build a dynamic model that highlights the role of collateral constraints. Their main message is that the opportunity cost of engaging in risk management is forgone current investment.

Subsequent work by Rampini, Sufi, and Viswanathan (2014) tests the predictions of theory using a sample of 23 U.S. commercial airlines from 1996 to 2009. The authors show that more financially constrained airlines are less likely to hedge fuel costs both in the cross-section and within a given airline over time. Rampini, Viswanathan, and Vuillemey (2019) provide further evidence that higher capitalization is associated with more hedging using data on interest rate and foreign exchange risk hedging. For identification, the paper uses net worth shocks from the drop of house prices that affect financial institutions.[5]

Many empirical studies show that hedging increases 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)). The notable exceptions 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 hedged risk exposure is too small to have a meaningful effect on firm value.

Our paper is related to studies linking hedging policies and leverage. Using a tax-based instrument, Campello, Lin, Ma, and Zou (2011) show that hedgers pay lower interest spreads and are less likely to have capital expenditure restrictions in their loan agreements, which increases firm value. The main argument in their paper is that hedging improves contracting outcomes for firms, while the focus of our paper is on hedging covenants imposed by the bank and the relation between debt issuance and risk management. Another related paper is Haushalter (2000), who shows, among other things, that hedging is related to firm leverage and contends that corporate risk management alleviates financial contracting costs. There are several differences between his study and ours. First, we focus on the relation between active debt issuance and hedging policies (hedge ratios, maturities, and form of hedging). Second, we focus on a time period of technological revolution in industry, which allows us to use a sharper identification strategy. Finally, by using the detailed data on hedging covenants contained in credit

[5] The main prediction is that financial institutions with lower net worth hedge less since the cost of foregoing lending or cutting credit lines is higher at the margin for such institutions. The authors do not discuss hedging covenants or specifics of credit agreements that the banks are entering into.

agreements, we shed light on the mechanism linking debt issuance to hedging policies.

Finally, our paper contributes to the literature on selective hedging (see, e.g., Stulz (1996), Brown, Crabb, and Haushalter (2006), Adam and Fernando (2006), and Géczy, Minton, and Schrand (2007)). For example, Stulz (1996) gives his view on "selective hedging" as a way for companies to embed their expectations of future commodity prices into firm value. We identify selective hedging not only with respect to hedged volumes, but also with respect to hedge maturities. Further, our contribution lies in showing that selective hedging is more pronounced for firms issuing large amounts of debt–a finding we attribute to lenders using conservative "price decks" for unhedged reserves and therefore encouraging locking-in the high current prices by hedging.

II Background

Hydraulic fracturing is a stimulation technique, in which rock is fractured by a highly pressurized liquid. The first experiments involving hydraulic fracturing ("fracking") date back to late 1950s, but the high initial cost of technology and its relatively low efficiency prevented early adoption by oil and gas firms. In the early- to mid-2000s, hydraulic fracturing was successfully combined with horizontal drilling technique, which resulted in a commercially viable application to shale rock formations. As a result, the new technology was put to use in gas fields around 2005-2006, and the application to longer hydrocarbon chains that make up crude oil followed several years later.[6] Implementation of new technology, however, proved to be capital intensive as it required significant investment by firms in land, mineral rights, equipment, and labor.[7]

Figure 1 shows the evolution of technology adoption by U.S. oil and gas companies during 1999-2019, as illustrated by mentions of hydraulic fracturing and horizontal drilling methods in firms' annual reports. The frequency of word 'horizontal' increased from approximately one mention per annual report before 2005 to more than 11 men-

[6]See "The Texas well that started fracking revolution," *Wall Street Journal*, June 29, 2018.

[7]The energy report by Maugeri (2012) indicates that shale gas and tight oil operations are more capital intensive than the application of conventional technology. In particular, hydraulically fractured wells are depleted much faster, so that more frequent drilling of new wells is required to maintain the constant level of production.

tions post-2011. Similarly, the word ‘hydraulic’ that was almost never used prior to 2005, appeared, on average, more than 30 times post-2011. As the bottom panels of Figure 1 show, exploration and extraction of oil and gas increased substantially in mid- and late-2000s.

At the same time, firm capital expenditures (adjusted for inflation to base year of 2019) grew from less than \$265 million before 2005 to more than \$1 billion post-2011 (see Figure 2). Large investment by oil and gas firms and dire need for financing had a profound effect on use of debt. Syndicated bank loans and revolving lines of credit have historically represented the marginal source of funds for these firms and have grown tremendously with firms’ increased appetite for financing. First, the widespread use of Reserve Base Lending (RBL) in the industry, whereby the loan is secured by the proved oil and gas reserves, have made it easy for banks to extend credit during the period when energy prices were relatively high and the firms’ reserves were rapidly increasing (Azar (2017)). Indeed, a large literature argues that increasing asset values make the firm’s collateral more valuable and facilitate borrowing (see, e.g., Kiyotaki and Moore (1997) and Brunnermeier and Oehmke (2013)). Second, this period was characterized by historically low interest rates, particularly post the 2008 financial crisis.

As Figure 2 shows, annual long-term debt issuance increased from less than \$300 million before 2005 to approximately \$800 million post-2011. Equity issuance, however, 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 illustrates the dynamics of LIBOR rates, that are often used by lending firms as a base for determining the interest rate on a loan (e.g., LIBOR rate +3%). Evidently, interest rates were relatively high at the beginning of our sample period, they temporarily decreased following the recession of 2000-2001, then bounced back, and dramatically decreased post 2008. We observe from Figure 2 that book leverage increased from about 35% before 2004 to about 60% by 2016. The last two panels of Figure 2 show the average spot prices for natural gas and crude oil around the same period.

We argue that increased reliance on debt financing significantly shaped firms’ risk management policies. This is not only because of the several-fold increase in debt issuance, but also because new credit agreements reflected the enhanced requirements of the banking industry, particularly in the post-crisis period when banks had lean balance sheets. Many banks started to include "hedging covenants" and specified how derivative portfolios should be treated upon covenant violations or firm bankruptcy. Appendix A provides examples of such hedging covenants. Covenants often specify the minimum and the maximum portion of the estimated production that must be covered by a derivative position. In addition to hedge ratios, some credit agreements place minimum and maximum restrictions on maturity of contracts. A non-speculation clause is often present in credit agreements and typically states that 'the hedge agreement is for the principal purpose of protecting against fluctuations in commodity prices and not for purpose of speculation.' Finally, it is common for banks to require that all derivative positions are reported back to the lender in a timely fashion, including hedged volumes, type of securities used, maturities, and involved counterparties.

In Appendix B, we provide examples from credit agreements and firms' annual reports describing how hedging portfolio is treated upon a covenant violation or default. Evidently, hedge contracts are frequently terminated upon default, with the proceeds from the settlement becoming immediately payable to the lender. Moreover, lenders often restrict the borrower's ability to enter into new hedging contracts, either explicitly by applying the control over the company decisions, or because the credit agreement requires that the only counterparty for a hedge contract can be the lender or its affiliates.

III Sample Construction and Summary Statistics

A Sample of Oil and Gas Firms

We use data from U.S. oil and gas producing firms (SIC Code 1311 'Crude Petroleum and Natural Gas Extraction') that have non-missing accounting data in COMPUSTAT. For each firm, we download the annual statements (10-K or 10-KSB) from SEC EDGAR for the period 1999-2019. We drop 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 2,577 firm-year observations.

We search the annual reports for the keywords related to firms' risk management practices: "hedg," "swap," "derivative," "collar," "risk management," "futures," and "forward." Firms typically report the type of outstanding derivatives they hold, their maturity, hedged volume, and the relevant contract prices. A number of firms also report the additional positions they take in basis, spread, or differential swaps. To avoid double counting, we ignore these additional derivatives for the purposes of calculating the hedged volume.

To calculate a firm's hedge ratio for crude oil and natural gas, we first sum, separately for each commodity, all notional amounts for the reported outstanding derivatives for the fiscal year directly following the reporting year. We then divide the hedged volume by the size of the underlying exposure, which we set to the next year's respective production of oil or gas. Whenever the next year's production is unavailable, we divide the hedged volume by the current year's production.[8] While it is possible that some firms enter into commodity derivative positions to speculate rather than to hedge (and we certainly see cases where firms substantially "over-hedge" their next year production), for the purposes of our analysis we treat all outstanding positions as hedging.[9] We also obtain from the financial statements the stated maximum maturity of hedging contracts, separately for oil and gas derivatives.[10]

Figure 3 demonstrates changes in firms' risk management policies that took place during the period 1999-2019. Consistent with greater firms' reliance on debt financing, which necessitated more hedging, we observe that the fraction of firms hedging oil price exposure increased rather dramatically over the sample period, from approximately 39% before 2005 to more than 65% after 2011. Similar dynamics is observed for the average fraction of next year's oil and gas production hedged. In fact, the average oil hedge ratio was less than 20% prior to 2005 and increased to more than 30% after 2011.

[8] Our 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.

[9] No firms in our sample use commodity derivatives to increase their *net* exposure to crude oil or natural gas price, which is consistent with the findings by Tufano (1996) for gold mining industry. Further, less than 8% of firms report that they use *any* derivatives for trading or speculation purposes.

[10] We record the maximum maturity of all outstanding derivative contracts. Thus, if a firm has regular swaps for the next 24 months and basis swaps for the next 36 months, the recorded maturity is 36 months.

The bottom two panels of Figure 3 present the average maturity of oil and gas hedging contracts. Mirroring the growth in commodity hedge ratios, the maximum maturities of oil and gas hedging contracts increased from about 5-10 months at the beginning of our sample to 14-20 months in the second half of the sample.

Table 1 provides the description of main empirical variables, and Table 2 reports the summary statistics for our sample. Panel A shows that 66.7% oil and gas producers report using derivatives, with 63.6% of firms using derivatives to hedge commodity price exposure. The fraction of firms hedging crude oil prices is 53.7% and is very similar to the fraction of firms hedging natural gas prices (53.9%).[11] We also find that 20.3% firms use interest rate derivatives, such as floating-for-fixed interest rate swaps, and 8.4% firms report using foreign exchange (FX) derivatives, such as currency swaps.

Panel B provides summary statistics for the annual production of oil and gas and the characteristics of firms' outstanding hedging portfolios. On average, hedge ratio is 29.9% for crude oil production and 26.6% for natural gas production. Correspondingly, the average maturity is 13 months for oil hedging contracts and 14 months for natural gas contracts. We also report the average sophistication of hedging contracts, whereby one point is assigned for use of each category of derivatives: (i) swaps/forwards/futures, (ii) collars, and (iii) options. On average, the firm in our sample has a sophistication measure of 1.1. For commodity hedgers, the average sophistication is 1.8, implying that the average hedger uses more than one type of derivatives.

Finally, the last panel in Table 2 reports the statistics for firm-level characteristics. Overall, oil and gas firms have high leverage and relatively low profitability, with the average return on assets being negative. What is perhaps notable is that these firms issue each year, on average, a dollar amount of long-term debt equal to 18.4% of their book value of assets. Consistent with large reliance on debt financing, we find that in 1.3% of firm-year observations the firm is in default as of the year-end (most commonly in Chapter 11). We also find that oil and gas producers have relatively large tax-loss carryforwards, with the median firm having positive tax-loss carryforwards.

[11] In 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.

Table 3 compares firm-characteristics for commodity hedgers and non-hedgers. Consistent with prior literature and economies of scale to risk management, firms with bigger assets and larger annual production are more likely to hedge their commodity exposure. Hedging is negatively related to firms' growth opportunities, measured by market-to-book ratios, and negatively related to firm profitability.

Financing policies are also substantially different for hedgers and non-hedgers. In particular, firms that hedge their commodity exposure have, on average, a book leverage of 38.9%, compared to 29.6% for non-hedgers. Even more dramatic are the differences in active debt issuance for firms that manage their commodity risk and those that do not. Specifically, the average long-term debt issuance constitutes on average 23.1% of book value of assets for oil hedgers, compared to only 10.1% for non-hedgers. Despite having significantly more leverage, firms that engage in risk management are significantly less likely to be in default by the year-end.

B Sample of Hedging Covenants

Before we proceed to the analysis of the relation between debt issuance and risk management, we present evidence on hedging covenants that are present in firms' outstanding lending agreements. To obtain the sample of lending agreements, we first 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).[12] Table 4, Panel A shows that when we are able to identify a credit or loan agreement (1,976 firm-years), it contains hedging covenants in 85.2% of cases. Approximately 53.6% of agreements explicitly require a minimum amount of hedging by indicating the minimum hedge ratio, hedged volume, and maturity, and/or by specifying that the loan commitment will be reduced if the borrower unwinds existing hedges. Since banks are commonly worried about potential speculation with derivatives by the firm once debt is in place,[13] the common practice is to place restrictions on the

[12] We search the annual reports for "credit agreement," "credit facility," and "loan." When multiple agreements are outstanding, we record the information on the most recent one.

[13] See, e.g., the argument in Bolton and Oehmke (2015) why the treatment of derivatives in bankruptcy and their effective seniority to debt claims may induce firms to over-hedge.

maximum allowed hedge ratios and/or maturities (69.8% of firm-years). In 54.5% of firm-years, the lending agreements explicitly mention that the lending bank can be a used as a counterparty to firm derivative transaction. Even more interesting is that some agreements (8.8% firm-years) require the lender to be a counterparty for any firm swap transactions.

Panel B presents the statistics for all firm-years in the sample, including observations when firms do not have loans or have only indentures or notes.[14] In the full sample, hedging covenants are present in 69.8% of firm-years and contain covenants requiring hedging in 43.7% of observations. In 25.9% 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, 54.1%. The requirement to maintain a minimum maturity of hedging contracts is less frequent (16.2% 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 the counterparties pre-approved by the lender or with counterparties that have a credit rating above a certain threshold. In 44.4% 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 59.8% of firm-years, the agreements also require timely reports of all 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.[15] Lenders are also commonly worried about unwinding or termination of any existing hedge and either explicitly prohibit such unwinding or state that the borrowing base will be reduced by a certain amount conditional on hedge termination or entry into any offsetting derivative positions. Many agreements also place restrictions on the use

[14] Indentures, promissory notes, and convertible notes rarely place any restrictions on firm hedging policy.

[15] The 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. Further, it is possible that even when the reporting requirement is not explicitly present in the lending agreement, the banks will have access to the existing hedging positions of the firm and examine it before determining the terms of the loan.

of interest rate swaps or specify other hedging covenants, such as restrictions on posting collateral for hedge contracts, requiring hedges to be unsecured, indebtedness on hedging obligations, entering into option positions, the strike prices on these contracts, and cross-default provisions. These other restrictions occur in 53.1% of firm-years.

The last panel of Table 4 shows that when it comes to hedging covenants there are significant differences in bank styles. Some banks, such as Well Fargo Bank and BNP Paribas, frequently require minimum amount of hedging as part of the loan (83.1% and 84.6%, respectively). Others, such as Bank of America and Bank One, use it seldom (32.6% and 33.9%).

In Figure 4, we plot the fraction of oil and gas firms placing hedging covenants over time. Overall, the propensity to place such covenants increased from 57.1% at the beginning of the sample to 78.9% by the end. Even more dramatic was the increase in the number of covenants 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. The fraction of firms with such covenants increased from 22.0% to approximately 60.6% by the end of the sample period. The figure also shows an increased tendency of firms to add non-speculation clauses for hedging and reporting requirements.

IV Empirical Analysis

A OLS Results: Debt Issuance and Risk Management

Next, we examine the relation between firm debt issuance and risk management policies. Our hypothesis is that increased reliance on debt financing dictates changes in firms' risk management policies.

Several mechanisms can give rise to a causal relation. First, as we showed in the previous section, lenders often explicitly place specific restrictions on hedging policy and, in particular, require minimum hedge ratios and/or minimum maturities of hedging contracts. While one view is that covenants are not imposed on a firm and are instead an outcome of a bilateral negotiation between firms and lenders, our own reading of firms' annual reports indicates that firms were concerned for having these covenants in place and often had to modify their pre-existing (supposedly optimal) risk management policies.

Second, even when no specific requirements for hedging exist in loan agreements, firms may prefer to cater to lenders by voluntarily engaging in risk management. Such strategy can potentially expand firm's borrowing base, reduce interest rate paid on a loan, and allow to relax loan covenants (e.g., covenants placed on firm investment policy). For example, a firm that plans to invest heavily during the next couple years does not want to suddenly discover that the lenders reduced their commitment after a semi-annual redetermination of a borrowing base simply because commodity prices declined. This mechanism can be especially important during the period of high commodity spot prices. According to Azar (2017), in determining the value of a firm's collateral and the borrowing base for the loan, banks often use highly conservative price decks for commodities relative to their futures prices. Therefore, it may be advantageous for a firm to enter into swap agreements that allow to lock in the current futures prices that lenders can use in their borrowing base determination. Finally, hedgers may pay lower interest spreads and have fewer restrictions placed by the lenders on other firm policies, such as investment (see, e.g., Campello, Lin, Ma, and Zou (2011) for causal evidence on hedging and the cost of loans).

Table 5 presents our main results, where the dependent variable in Panel A is the oil hedge ratio and in Panel B the natural gas hedge ratio. The key variable of interest is debt issuance. We control for standard determinants of risk management, such as firm size, growth options, tax function convexity, firm profitability, incidence of firm default, as well as the average spot commodity prices during the fiscal year and the volatility of commodity prices. Following Nance, Smith, and Smithson (1993), we proxy for tax convexity using the amount tax-loss carryforwards that the firm has accumulated normalized by book value of assets. The first two specifications in each panel do not include firm-fixed effects, and the last two specifications include them to better control for omitted time-invariant firm-characteristics that could drive both debt issuance and risk management policies. In all specifications, we cluster the standard errors by firm to address the potential concern that risk management policies are persistent over time within a given firm.

The estimates in Table 5 reveal a robust positive relation between active debt issuance and firms' hedge ratios. This relation also appears to be economically important. For example, based on the first specification, a one standard deviation increase in debt issuance is associated with roughly 8.2% higher oil hedge ratios when the mean is 29.9%. Inclusion of firm-fixed effects reduces the magnitude of the effect, but the coefficient remains statistically significant.

Another notable result that emerges from Table 5 is that firms that are in default (e.g., in Chapter 11) at the end of the fiscal year, have lower hedge ratios. These results become especially pronounced when we look at within-firm estimates. For example, the estimates in specification 3 of Panel A and Panel B suggest that firms in default reduce their hedge ratios by 28.0% for oil and 29.7% for gas, respectively. These results are consistent with the empirical findings by Rampini, Sufi, and Viswanathan (2014) for the airline industry, who explain this empirical relation by the low willingness of firms to cut their current investment in order to post collateral. However, the mechanism is likely to be different for commodity producers as it is uncommon for these firms to post cash collateral for derivative positions.[16] Instead, the lower hedge ratios may be attributed to termination by counterparties of derivative contracts in default (a standard contract provision) and the inability of oil and gas firms to find new counterparties despite their willingness to do so.

Further, we observe a positive relation between hedging and commodity spot prices. Although several effects could be responsible for this relation, it is likely driven by firm debt.[17] The significant effect of the interaction term between firm leverage and spot

[16] In particular, oil and gas firms can post as collateral their proved developed reserves.

[17] For example, as Stulz (1996) argues, the companies can sometime engage in selective hedging, when managers attempt to lock in the higher commodity prices using their derivative portfolios. Managers may have informational advantage over other market participants or they may believe that they possess such advantage, when in reality they do not. Several papers (see, e.g., Brown, Crabb, and Haushalter (2006), Faulkender (2005), and Adam and Fernando (2006)) find support for the hypothesis that managerial views affect their risk management policies in different settings. Another potential explanation is that a high commodity price is associated with a high firm net worth, while a low price is more likely to be associated with distress and bankruptcy. We have previously documented that low net worth or bankrupt firms tend to have much smaller

prices suggests that firms with debt lock in the high prices to maintain the minimum lending base.

Table 6 reports the results that relate debt issuance to the maturity and sophistication of outstanding hedging contracts. The dependent variable in Columns 1-2 and Columns 3-4 is, respectively, the longest maturity (in months) of a firm's outstanding crude oil and natural gas hedging contracts. The results reveal a positive relation between debt issuance and the maturity of hedging contracts. For example, a one standard deviation in debt issuance is associated with approximately 3 months longer oil hedge maturity when the average maturity is 13 months. As is the case for hedge ratios, we also find a pronounced negative effect of firm default on maturities of hedging positions. In particular, the within-firm estimates suggest that the contract maturities are reduced by 12 months for oil hedges and 13 months for gas hedges.

Finally, in Columns 5-6 we use a measure of commodity hedging sophistication. The hedging sophistication is negatively related to the firms' state of default and positively related to debt issuance. The latter observation is consistent with our view that the risk management strategy, including the type of derivative used in forming the portfolios, is often imposed by the lender.

Overall, the results in Tables 5 and 6 provide strong suggestive evidence that debt issuance drives risk management policies. However, despite the fact that we control for firm-fixed effects, the OLS estimates cannot be interpreted in a causal way. It is still possible that some omitted time-varying variables drive both debt issuance and risk management. In particular, one possibility is that firms with lean balance sheets for which it is more difficult to obtain a large loan, hedge in order to expand debt capacity. If this is the case, then OLS estimates will be biased downward.

In the next section, we therefore sharpen our identification strategy to better capture the exogenous increase in the amount of debt financing that was attributed to the adoption of new technologies.

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hedge ratios.

B Technological Shock and the Instrumental Variables Estimation

Our hypothesis is that debt financing increased sharply in the mid- to late-2000s because of a higher demand by oil and gas firms originating from adoption of capital-intensive technologies. Not all firms, however, implemented the new technology at the same time as there were substantial differences across firms in staff expertise, technological knowledge, and geological formations of land owned.

To capture the firm-specific shocks to adoption of technologies, we therefore use the firms' self-reported adoption, as indicated by the use of terms 'horizontal drilling' and 'hydraulic fracturing' in firms' annual reports. Our general view is that use of the term 'hydraulic fracturing' is more indicative than the term 'horizontal drilling' of a technological shock that took place and we therefore we give it more prominence in our measure of a shock. More specifically, we construct an instrument for debt issuance as the natural logarithm of one plus the number of times a firm's 10-K report mentions the term 'hydraulic fracturing' multiplied by one if the firm uses the term 'horizontal drilling' at least once.[18]

The results of IV analysis with the technological shock as the instrument for debt issuance are presented in Tables 7 and 8. We present the estimates from the first stage, where the dependent variable is debt issuance. We find that technological shock strongly positively predicts debt issuance. The instrument is also fairly strong as judged by the relatively high R-squared from the first stage and the test of excluded instruments. In particular, the F-stastistic for the test of excluded instruments of 25.1 is well above the cutoff of 16.4 proposed by Stock and Yogo (2002), mitigating the concern for weak instruments. However, the test for weak instruments by Stock and Yogo (2002) is derived under the assumption of conditionally homoscedastic serially uncorrelated errors. Olea and Pflueger (2013) obtain the asymptotic properties of an F-test that adjusts for heteroscedasticity, autocorrelation, and clustering, and derive the new critical value of 23.1. Our instrument passes this more stringent criterion as well. The second-stage

[18] Our results are robust to using the logarithm of one plus the number of mentions of term 'hydraulic fracturing' as our instrument or the logarithm of one plus the sum of mentions of 'hydraulic fracturing' and 'horizontal drilling'.

estimates reveal that higher debt issuance causes higher hedge ratios for both oil and gas, as well as longer maturities of such hedges, although the effect on maturity of natural gas contracts is not significant. Consistent with OLS coefficients being biased down because borrowers with weak characteristics hedge to secure a loan, we also find larger magnitudes for the IV estimates.

V Mechanisms

A Debt Issuance and Actual Hedging Covenants

Our next set of tests aims to identify the mechanisms that give rise to a positive relation between debt issuance and risk management. As alluded earlier, the two mechanisms that can be responsible for such a relation are: (i) "catering to lenders" and (ii) "expropriating lenders". For example, catering to lenders may involve acceptance of restrictive covenants on hedging policy and modifying firm risk management practice as a result. Additionally, when lenders do not place explicit covenants, catering to lenders may involve voluntary changes in firm hedging policy with the goal of securing a loan on more favorable terms. In contrast, expropriating lenders refers to firms finding it optimal, after debt has been issued, to hedge with derivatives that are effectively senior to this debt in bankruptcy.

To understand whether hedging covenants that became more prevalent recently play any role in shaping firms' hedging policies, we separate firm debt issuance into two categories: (i) debt issuance with no minimum requirements on risk management policy and (ii) debt issuance that is stapled with minimum hedging requirements in firms' credit agreements, i.e., covenants requiring minimum hedge ratios, minimum maturities, or calling for automatic decreases in the firm's borrowing base following hedge unwinding or terminations.

Table 9 reports the results of the OLS regressions, where the dependent variable is hedge ratios for oil and gas exposure (in Panel A) and hedge maturities (in Panel B). Consistent with the lending agreements playing an important role in determining firms' risk management policies, we find that it is largely debt issuance stapled with the minimum hedging requirements that has a profound positive effect on firm hedge ratios and hedge maturities. For example, a one standard deviation in such debt issuance is associated with 12.4% and 8.8% higher hedge ratios for oil and gas, respectively. Unrestricted debt issuance does not have a significant effect on risk management policies. Further, these results continue to hold if we use firm-fixed effects (Columns 2 and 5), and even if we include firm- and bank-fixed effects (Columns 3 and 6). The robustness to the inclusion of bank-fixed effects implies that hedging policy of the firm changes when the bank that it regularly deals with decides to change the hedging covenants.[19]

Similarly, we observe that hedge maturities are strongly related to debt issuance stapled with the minimum hedge requirements, but are not related to unrestricted debt issuance. For example, a one standard deviation in debt issuance stapled with the minimum hedge requirements is associated with approximately 4 months longer hedge maturities for oil and gas.

B Debt Issuance and Predicted Hedging Covenants

To mitigate a potential concern that banks change their hedging covenants either because they observe or anticipate changes in firm characteristics, we employ a slightly different empirical strategy, whereby we identify the propensity to place hedging covenants by the firm's lender from other observed lending agreements by this lender in the same year. When it comes to propensity to require minimum hedging, lenders pursue quite different styles, with some banks (e.g., Wells Fargo) requiring it for most of their contracts, and others (e.g., Bank of America) placing such covenants only occasionally.

Table 10 presents the results of our tests, where we regress firm hedge ratios and hedge maturities on debt issuance with predicted hedging requirements, where the latter is equal to the average rate at which the firm's bank places hedging requirements during this year on other firms in the industry. The results show that across all specifications, debt issuance that is associated with a high probability of hedging requirements, has a greater effect on firm hedging policy.

[19]Of course, the decision of the bank to change covenants can be endogenous as well, with the bank likely tightening the hedging covenants when the financial condition of the firm deteriorates. We will address this possibility in the next section using a different identification strategy.

C Ruling Out Alternative Mechanisms

As mentioned earlier, one potential explanation why firms hedge more after issuance of debt securities is related to expropriation of debtholders in bankruptcy. In general, this explanation is somewhat at odds with our evidence that unrestricted debt issuance (i.e., without covenants requiring hedging), has almost no effect on firm risk management choices. Nevertheless, it is still possible that covenants are less likely to be placed on financially sound firms.

To assess expropriation of debtholders as a potential mechanism behind the positive relation between debt issuance and use of commodity derivatives more fully, we conduct two additional tests. First, if derivatives are issued primarily because of their effective senior status over debt securities in case of default (Roe (2011)), we would expect more pronounced effects of debt issuance on hedging for less profitable firms that face a high probability of bankruptcy. Second, when the original lender provides a bundle of financing and hedging to the firm, he should internalize any transfers between the two parts of his portfolio, and thus we would expect smaller effect of debt issuance on hedging in such cases.

Our results are contrary to both of these predictions (see Table 11). We find that, if anything, debt issuance has a larger effect on hedging policies for more profitable firms. Further, when the firm is explicitly allowed (or required) to use the lender as a counterparty to its derivative transactions, we tend to find larger effects of debt issuance on hedging as well. Overall, our results indicate that catering to lenders, and in particular, satisfying hedging covenants imposed by them on the firm, is more likely explanation why firms hedge more when they issue debt.

VI Firm Performance during the COVID-19 Pandemic

Up to this point, we have focused on the hedging requirements imposed by lenders and the determinants of risk management policies. The analysis that follows examines the effectiveness of hedging requirements and voluntary hedging programs at the time when the industry is hit by a large negative shock. Specifically, we use as experiment the emergence of the novel COVID-19 coronavirus that disrupted firm operations, reduced global demand for oil, and resulted in a large decrease in energy prices.

To understand how firms with different hedging policies perform during the crisis, we obtain daily stock returns of all US-incorporated oil and gas firms between January 1, 2020 and March 23, 2020. We end the sample in late March because by this time the U.S. stock market had likely incorporated most of the negative news associated with the pandemic and because the Senate passed the first stimulus package on March 25 (H.R. 748 "Coronavirus Aid, Relief, and Economic Security Act").[20] We measure firm performance by the daily stock return and capture the evolution of the shock by two variables: the daily WTI crude oil spot price and the global count of COVID-19 cases.[21] The summary statistics for this sample are reported in Panel A of Table 12. Not surprisingly, oil and gas firms perform poorly during the development of the COVID-19 pandemic and post, on average, -1.66% daily stock return. Approximately 62.0% of firms have minimum hedging requirements in their lending agreements, and the average hedge ratio as of the end of 2019 is 42.0%.

Table 12 reports our regression results. The key variable of interest is the interaction between hedging requirements and the shock (lower oil price or higher case count). As expected, the daily stock returns are positively correlated to crude oil price and are negatvely correlated to the number of confirmed virus cases. Further, firms that have hedging requirements imposed by the lenders as well as firms that choose to hedge voluntarily, tend to do better during this time period. More important, we observe that presence of hedging requirements and hedging programs reduces the sensitivity of firm's stock returns to the negative shock. Finally, in Columns 3 and 6, we examine whether the reduced sensitivity to the negative shock is driven by voluntary hedges put in place in 2019 or the hedging requirements imposed by the lenders, and find it is the latter. One potential explanation for these results is that firms that voluntarily put in place hedging programs at the end of 2019, unwound their hedges at the beginning of

[20]According to data from Jonh Hopkins University, the first COVID-19 case in the United States was confirmed on January 22, 2020, and the first death was reported on February 29, 2020. The World Health Organization (WHO) declared the coronavirus outbreak a global pandemic on March 11, 2020, and the national emergency was declared in the United States on March 13, 2020.

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

2020 when the energy prices started to fall. The lenders, however, did not appear to relax the hedging covenants.

Figure 5 further illustrates the dynamics of the cumulative returns in March 2020, which is the most sensitive time period. For reference, we use the red vertical line to denote the date when the WHO declared the coronavirus outbreak a global pandemic. We observe that the cumulative returns of firms with hedging requirements are approximately 9.6% higher by the end of the period. Note, however, that this magnitude may be difficult to interpret because firms that have hedging requirements that come with loans are more likely to have higher leverage. To mitigate this concern, in the next panel we focus on the subsample of highly levered firms. When leverage across firms that have hedging requirements and those that do not is more comparable, we observe even starker differences in returns. In fact, firms with hedging requirements earn approximately 25.8% higher return by the end of the period. Overall, our results show that hedging requirements are effective in mitigating the exposure of oil and gas firms to negative shocks.

VII Conclusion

In this paper, we argue that firms often face constrained optimization in determining their risk management policies, which is shaped by their prior financing choices. Once debt is in place, firms may have the incentive to dilute the existing creditors by entering into derivative positions that are effectively senior to debt. They also have the incentive to lock-in the current commodity prices by hedging in order to prevent the downwards adjustments by banks of their borrowing base. Finally, the lending agreements often place rigid constraints on firms' risk management policy, leaving little room for deviations and causing firm to solve constrained optimization problem.

Using a sample of oil and gas producing firms over 1999 to 2019, we show that firms' increased reliance on debt financing that came with higher capital needs during shale gas and tight oil revolution in industry, caused higher hedge ratios, longer hedge maturities, and increased the sophistication of hedging contracts.

Appendix A. Sample Hedging Covenants

Below we provide several examples of language used in credit agreements to specify various hedging covenants.

Minimum and maximum hedge ratio requirements

1. *"The Administrative Agent shall have received evidence that the Loan Parties shall have entered into commodities Hedging Agreements with respect to its Hydrocarbon production with one or more counterparties, each of which are rated at least BBB by Standard & Poor's and Baa2 by Moody's, with the aggregate notional volumes of Hydrocarbons covered by such commodities Hedging Agreements ... constituting not less than 25% and not more than 75% of the aggregate amount of the Loan Parties' estimated Hydrocarbon production volumes on an mcf equivalent basis ... for the succeeding six calendar months..."* (KCS Energy credit agreement, March 31, 2003)

2. *"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, July 14, 2008)

3. *"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 Inc., 10-K report for 2007)

4. *"Under the terms of its revolving credit facility, the Company was required to hedge at least 50%, but not more than 75%, of its daily oil production at a price not lower than the lowest price used in the bank's price deck, for a period between 12 and 18 months.'* (Equity Oil, 10-K report for 1999)

5. *"...Borrower shall not, and shall not permit any of its Subsidiaries to, directly or indirectly: ... Enter into, or suffer to exist, any Hedging Agreement unless approved in advance in writing by the Administrative Agent."* (DHS credit agreement, December 20, 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, February 5, 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, April 22, 2010)

Reporting requirement and lender counterparty

1. *"...each 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, October 19, 2016)

2. *"The Company's Credit Facility requires that counterparties in derivative transactions be limited to the Lenders, including affiliates of the Lenders."* (Meredian Resource, 10-K report for 2010)

Appendix B. Treatment of Hedging Contracts in Default

Termination of outstanding hedge contracts in default

1. *"The Company's Bankruptcy Petition in July 2015 represented an event of default under Sabine's existing derivative agreements resulting in a termination right by counterparties on all derivative positions at July 15, 2015. Additionally, certain of the Company's derivative positions were terminated prior to July 15, 2015 as a result of defaults under Sabine's derivative agreements that occurred prior to the filing of the Bankruptcy Petition."* (Forest Oil Group, 10-K report for 2015, in Chapter 11 bankruptcy)

2. *"On June 14, 2018, the Company's hedging counterparty, Koch Supply & Trading LP, terminated the only outstanding hedge contract resulting in a settlement of $0.5 million."* (PetroQuest Energy Inc., 2019, in Chapter 11 bankruptcy)

3. *"The convertible note hedging transactions have since been terminated in connection with our Chapter 11 proceedings."* (Stone Energy Corp. 2016-12-31, in Ch. 11 bankruptcy)

4. *"In February 2010, the administrative agent under our credit facilities liquidated all of our existing hedge contracts and applied the proceeds thereof to amounts owed under the facilities. As a result, our production is currently unhedged."* (Saratoga Resources Inc., 10-K report for 2010, in Chapter 11 bankruptcy)

5. *"Our hedging arrangements contain standard events of default, including cross default provisions, that, upon a default, provide for (i) the delivery of additional collateral, (ii) the termination and acceleration of the hedge, (iii) the suspension of the lenders' obligations under the hedging arrangement"* (ATP Oil and Gas, 10-K report for 2010)

6. *"The filing of the Chapter 11 Petitions triggered an event of default under each of the agreements governing our derivative transactions ("ISDA Agreements")... As a result, our counterparties were permitted to terminate, and did terminate, all outstanding transactions governed by the ISDA Agreements."* (Breitburn Energy Partners, 10-K report for 2016)

Inability to enter new hedges

1. *"As substantial doubt exists that we will be able to continue as a going concern, finding counterparties for commodity hedges has proven difficult."* (EV Energy Partners, 10-K report for 2017, in Chapter 11 bankruptcy)

2. *"...potential reduced counterparty willingness to enter into new hedges with us*

while under Chapter 11..." (Vanguard Natural Resources, 10-K report for 2018, filing bankruptcy petition)

3. *"Due to our default under the Credit Facility, the Lenders have not allowed the Company to enter into any additional hedging agreements."* (Meredian Resource Corp. 2010, covenant violation)

4. *"During the Chapter 11 proceedings, our ability to enter into new commodity derivatives covering additional estimated future production will be dependent upon either entering into unsecured hedges or obtaining Bankruptcy Court approval to enter into secured hedges. As a result, we may not be able to enter into additional commodity derivatives covering our production in future periods on favorable terms or at all."* (Forest Oil Group, 10-K report for 2015)

References

Adam, Tim R., and Chitru S. Fernando, 2006, Hedging, speculation, and shareholder value, *Journal of Financial Economics* 81, 283–309.

Allayannis, George, and James P. Weston, 2001, The use of foreign currency derivatives and firm market value, *Review of Financial Studies* 14, 243–276.

Azar, Air, 2017, Reserve base lending and the outlook for shale oil and gas finance, Report, Center on Global Energy Policy.

Bartram, Söhnke M., Gregory W. Brown, and Jennifer Conrad, 2011, The effects of derivatives on firm risk and value, *Journal of Financial and Quantitative Analysis* 46, 967–999.

Bessembinder, Hank, 1991, Forward contracts and firm value: Investment incentive and contracting effects, *Journal of Financial and Quantitative Analysis* 26, 519–532.

Bolton, Patrick, Hui Chen, and Neng Wang, 2011, A unified theory of tobin's q, corporate investment, financing, and risk management, *Journal of Finance* 66, 1545–1578.

Bolton, Patrick, and Martin Oehmke, 2015, Should derivatives be privileged in bankruptcy?, *Journal of Finance* 70, 2353–2394.

Brown, Gregory W., Peter R. Crabb, and David Haushalter, 2006, Are firms successful at selective hedging?, *Journal of Business* 79, 2925–2949.

Brunnermeier, Markus K, and Martin Oehmke, 2013, Bubbles, financial crises, and systemic risk, in *Handbook of the Economics of Finance*vol. 2 . pp. 1221–1288 (Elsevier).

Campello, Murillo, Chen Lin, Yue Ma, and Hong Zou, 2011, The real and financial implications of corporate hedging, *Journal of Finance* 66, 1615–1647.

Cornaggia, Jess, 2013, Does risk management matter? Evidence from the U.S. agricultural industry, *Journal of Financial Economics* 109, 419–440.

DeMarzo, Peter M., and Darrell Duffie, 1995, Corporate incentives for hedging and hedge accounting, *Review of Financial Studies* 8, 743–771.

Ellul, Andrew, and Vijay Yerramilli, 2013, Stronger risk controls, lower risk: Evidence from U.S. bank holding companies, *Journal of Finance* 68, 1757–1803.

Faulkender, Michael, 2005, Hedging or market timing? Selecting the interest rate exposure of corporate debt, *Journal of Finance* 60, 931–962.

Fehle, Frank, and Sergey Tsyplakov, 2005, Dynamic risk management: Theory and evidence, *Journal of Financial Economics* 78, 3–47.

Froot, Kenneth A., David S. Scharfstein, and Jeremy C. Stein, 1993, Risk management: Coordinating corporate investment and financing policies, *Journal of Finance* 48, 1629–1658.

Geczy, Christopher, Bernadette A. Minton, and Catherine Schrand, 1997, Why firms use currency derivatives, *Journal of Finance* 52, 1323–1354.

Géczy, Christopher C, Bernadette A Minton, and Catherine M Schrand, 2007, Taking a view: Corporate speculation, governance, and compensation, *Journal of Finance* 62, 2405–2443.

Graham, John R., and Daniel A. Rogers, 2002, Do firms hedge in response to tax incentives?, *Journal of Finance* 57, 815–838.

Graham, John R., and Clifford W. Smith, 1999, Tax incentives to hedge, *Journal of Finance* 54, 2441–2262.

Guay, Wayne R., and S.P. Kothari, 2003, How much do firms hedge with derivatives?, *Journal of Financial Economics* 70, 423–461.

Haushalter, David G., 2000, Financing policy, basis risk, and corporate hedging: Evidence from oil and gas producers, *Journal of Finance* 55, 107–152.

Jin, Yanbo, and Philippe Jorion, 2006, Firm value and hedging: Evidence from U.S. oil and gas producers, *Journal of Finance* 61, 893–919.

Kiyotaki, Nobuhiro, and John Moore, 1997, Credit cycles, *Journal of political economy* 105, 211–248.

Knopf, John D., Jouahn Nam, and John H. Thornton Jr., 2002, The volatility and price sensitivities of managerial stock option portfolios and corporate hedging, *Journal of Finance* 57, 801–813.

Leland, Hayne, 1998, Agency costs, risk management, and capital structure, *Journal of Finance* 53, 1213–1243.

Mackay, Peter, and Sara B. Moeller, 2007, The value of corporate risk management, *Journal of Finance* 52, 1379–1419.

Maugeri, Leonardo, 2012, Oil: The next revolution, *Belfer Center for Science and International Affairs Discussion Paper.*

Mian, Shehzad L., 1996, Evidence on corporate hedging policy, *Journal of Financial and quantitative Analysis* 31, 419–439.

Morellec, Erwan, and Clifford W. Smith, 2007, Agency conflicts and risk management, *Review of Finance* 11, 1–23.

Nance, Deana R., Jr. Clifford W. Smith, and Charles W. Smithson, 1993, On the determinants of corporate hedging, *Journal of Finance* 48, 267–284.

Olea, José Luis Montiel, and Carolin Pflueger, 2013, A robust test for weak instruments, *Journal of Business & Economic Statistics* 31, 358–369.

Pérez-González, Francisco, and Hayong Yun, 2013, Risk management and firm value: Evidence from weather derivatives, *Journal of Finance* 68, 2143–2176.

Purnanandam, Amiyatosh, 2008, Financial distress and corporate risk management: Theory and evidence, *Journal of Financial Economics* 87, 706–739.

Rampini, Andriano A., Amir Sufi, and S. Viswanathan, 2014, Dynamic risk management, *Journal of Financial Economics* 111, 271–296.

Rampini, Andriano A., and S. Viswanathan, 2010, Collateral, risk management, and the distribution of debt capacity, *Journal of Finance* 65, 2293–2322.

——— , and Guillaume Vuillemey, 2019, Risk management in financial institutions, working paper, Duke University.

Roe, Mark J., 2011, The derivatives players' payment priorities as financial crisis accelerator, *Stanford Law Review* 63, 539–590.

Smith, Clifford W., and Rene Stulz, 1985, The determinants of firms' hedging policies, *Journal of Financial and Quantitative Analysis* 20, 391–405.

Stock, James H., and Motohiro Yogo, 2002, Testing for weak instruments in linear iv regression, .

Stulz, René M, 1984, Optimal hedging policies, *Journal of Financial and Quantitative analysis* 19, 127–140.

———, 1996, Rethinking risk management, *Journal of applied corporate finance* 9, 8–25.

Tufano, Peter, 1996, Who manages risk? An empirical examination of risk management practices in the gold mining industry, *Journal of Finance* 51, 1097–1137.

Table 1. Variable Definitions

Variable	Definition
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.
Book leverage	The sum of long-term and short-term debt, divided by the book value of assets.
Tax-loss carryforwards	The amount of tax-loss carryforwards (TLCF), 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).
Hedging sophistication	The score for hedging policy sophistication (0 to 3); one point is added for using swaps, forwards, or futures, one point for use of collars, and one point is added for use of options.
Crude oil spot price	The average monthly WTI crude oil spot price per Bbl during the fiscal year.
Volatility of oil price	The standard deviation of monthly WTI crude oil price during the fiscal year.
Natural gas spot price	The average monthly 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 during the fiscal year per Mcf.
Technological shock	The logarithm of one plus the number of times the word "hydraulic" is mentioned in a firm's 10-K report multiplied by one if the word "horizontal" is mentioned at least once, zero otherwise.
Firm default	A dummy variable 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.

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 two panels show the average number of times a firm mentions new technologies in its 10-K or 10-KSB filings, i.e., *horizontal drilling* and *hydraulic fracturing* terms. The bottom two panels show the average annual production of oil and gas, measured in thousands of barrels and millions of cubic feet, respectively.

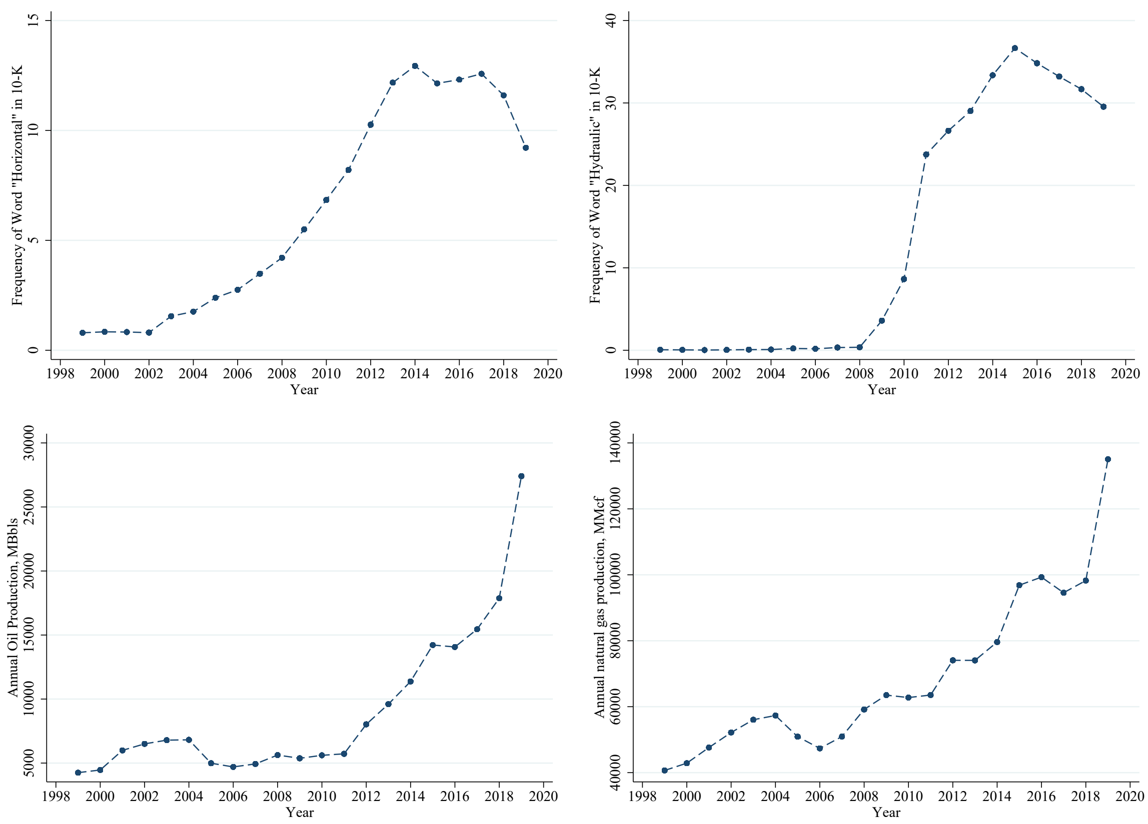


Figure 2. Oil and Gas Firms' Leverage and Commodity Prices

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

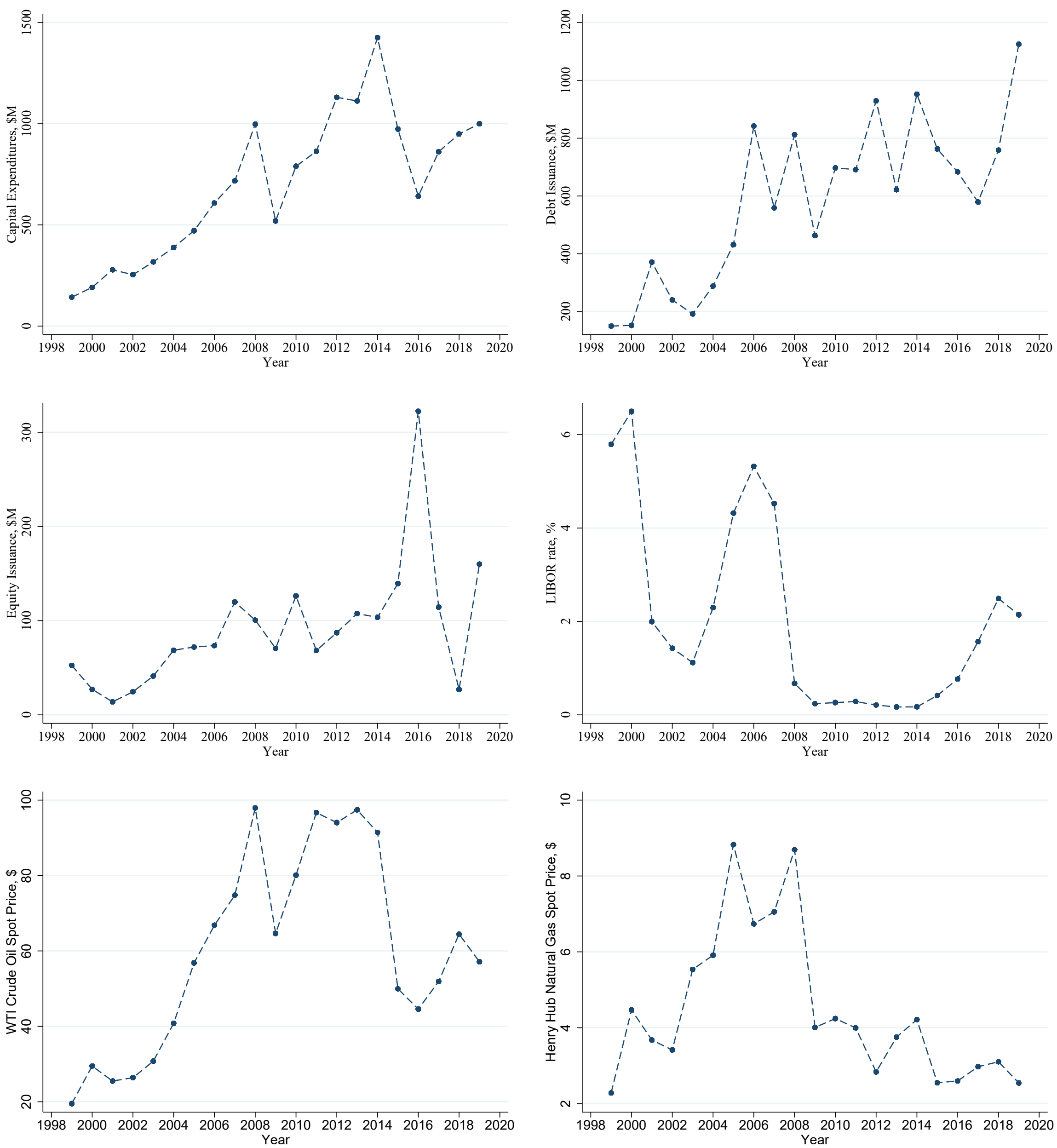


Figure 3. Evolution of Oil and Gas Firms' Risk Management Policies

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

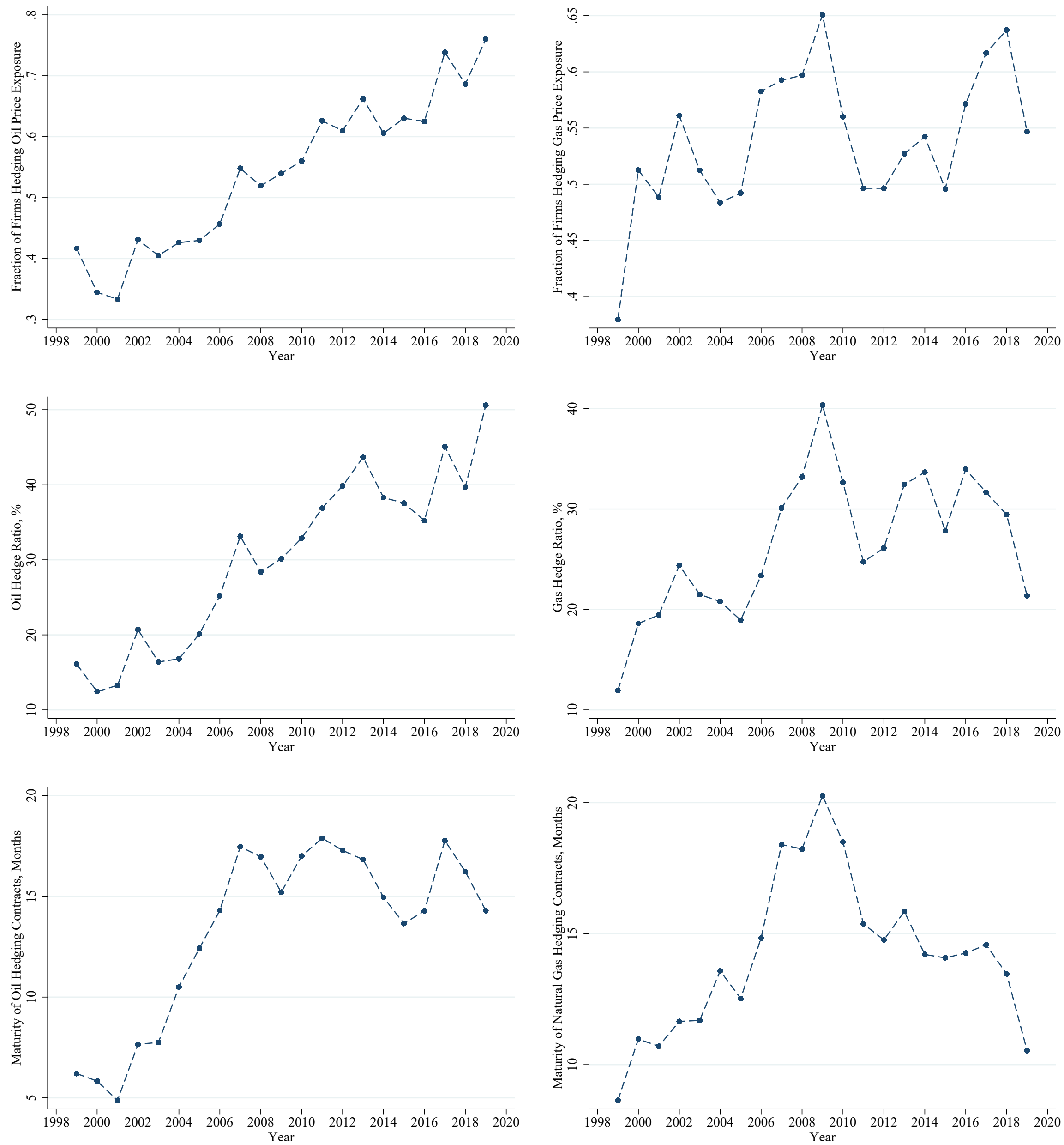


Figure 4. Lender Adoption of Hedging Covenants

The left top panel of the figure illustrates the fraction of oil and gas producers that have outstanding lending agreements with any hedging covenants, whereas the right panel shows the fraction of firms that are required to report hedging positions to the lender. The left middle panels present the fraction of firms that are subject to covenants requiring hedging, i.e., the minimum hedge ratio, maturity, or the borrowing base reduction upon hedge unwinding. The right middle panel illustrates the fraction of firms that have outstanding loans with limits on maximum amount of hedging, i.e., the maximum allowed hedge ratio and/or maturity. The bottom two panels show the fraction of oil and gas producers that have outstanding loans with non-speculation clauses and the requirement of using pre-approved counterparties, respectively.

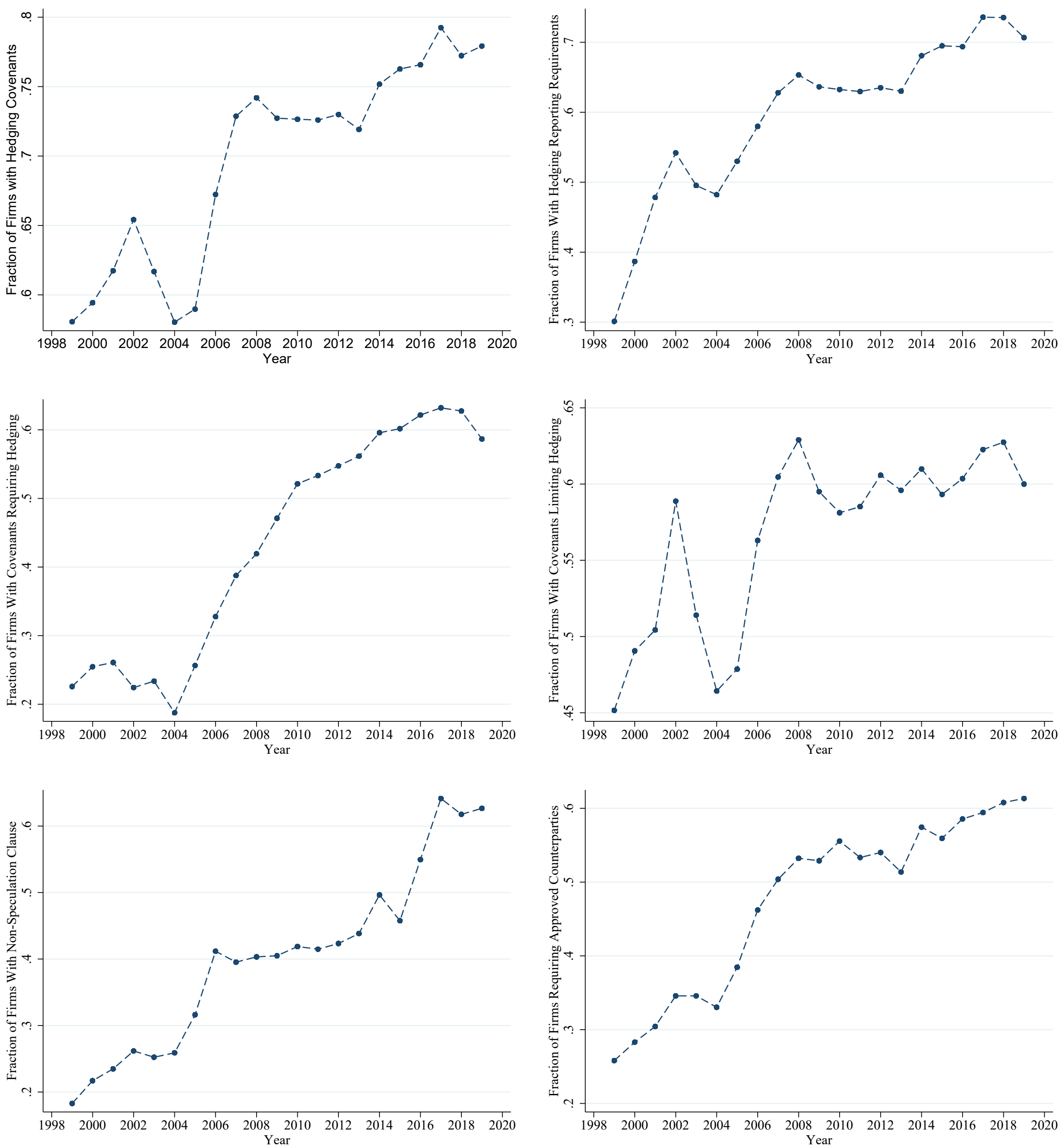
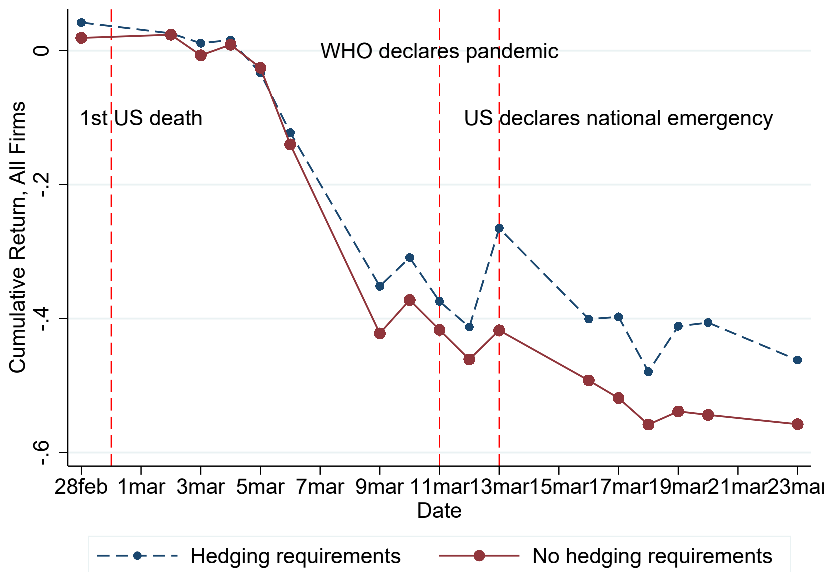


Figure 5. Cumulative Stock Returns of Oil and Gas Firms during the 2020 Pandemic

This 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 one dollar 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 23, 2020, one day before the passage by the Senate of the $2.2 trillion stimulus bill (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.



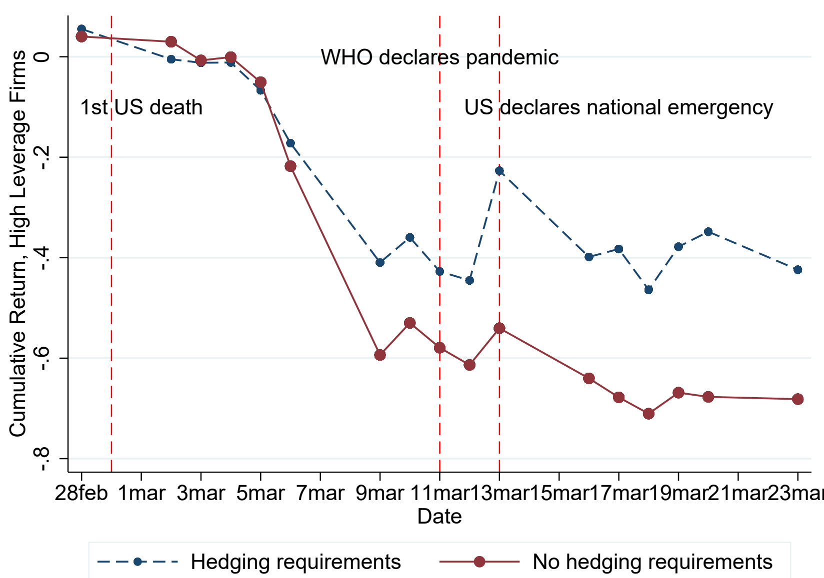


Table 2. Summary Statistics

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. All variables are defined in Table 1.

Panel A: Use of Derivatives

Variable	Obs.	Mean
Derivative user	2,577	0.667
Use derivatives for hedging commodity prices	2,577	0.636
Use derivatives for hedging oil price	2,577	0.537
Use derivatives for hedging natural gas price	2,577	0.539
Use interest rate derivatives	2,577	0.203
Use currency derivatives	2,577	0.084

Panel B: Oil and Gas Production and Hedge Ratios

Variable	Obs.	Mean	SD	25th	50th	75th
Annual oil production, MMBbl	2,564	8.531	26.165	0.084	0.753	4.182
Annual natural gas production, Bcf	2,563	67.195	169.776	0.384	6.558	41.300
Oil hedge ratio, %	2,512	29.91	36.90	0	12	55
Gas hedge ratio, %	2,453	26.62	32.71	0	10	49
Maturity of oil hedging derivatives	2,568	13.40	16.78	0	12	24
Maturity of gas hedging derivatives	2,561	14.31	19.18	0	12	24
Hedging sophistication	2,552	1.137	1.023	0	1	2

Panel C: Other Variables

Variable	Obs.	Mean	SD	25th	50th	75th
Book assets, $M	2,577	3,472	9,804	48.310	354.600	2,046
Log of assets	2,577	5.752	2.533	3.878	5.871	7.623
Number of employees	2,525	550	1,600	13	84	331
Market-to-book ratio	2,498	1.880	7.039	0.818	1.110	1.647
Return on assets	2,573	-0.174	1.409	-0.100	0.009	0.063
Tax-loss carryforwards	2,577	0.600	3.406	0	0.010	0.252
Book leverage	2,576	0.355	0.466	0.114	0.286	0.454
Debt issuance	2,515	0.184	0.226	0	0.101	0.289
Firm default	2,577	0.013	0.114	0	0	0
Crude oil spot price, per Bbl	2,505	61.81	26.46	41.60	63.92	91.23
Volatility of oil price	2,505	8.149	6.290	4.215	6.115	8.811
Natural gas spot price, per Mcf	2,496	4.601	1.934	3.110	4.016	5.597
Volatility of gas price	2,496	0.983	0.762	0.506	0.626	1.405
Number of ‘hydraulic’ mentions in 10-K	2,568	13.640	21.060	0	0	25
Number of ‘horizontal’ mentions in 10-K	2,568	6.328	11.830	0	1	8

Table 3. 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 Table 1. 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	12.147	2.145	10.002	4.68***
Annual gas production, Bcf	99.290	10.147	88.838	5.45***
Book assets, $M	4,959	879.2	4,080	4.52***
Market-to-book ratio	1.222	3.001	-1.780	-2.32**
Return on assets	-0.051	-0.389	0.338	2.47**
Tax-loss carryforwards	0.184	1.325	-1.142	-3.37***
Book leverage	0.389	0.296	0.093	2.18**
Debt issuance	0.231	0.101	0.130	8.88***
Firm default	0.009	0.021	-0.013	-2.42**
Crude oil spot price, per Bbl	63.65	58.67	4.99	3.17***
Natural gas price, per Mcf	4.53	4.72	-0.19	-1.95*

Table 4. Summary Statistics on Hedging Covenants

The table reports summary statistics on hedging covenants contained in firm lending agreements. The data are from firms' 10-K reports, 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 restrictions on the firm's hedging policy; zero otherwise. *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-speculative purposes* 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 loan agreements present. Panel B is for the full sample, and Panel C presents summary statistics by the lender (administrative agent for the loan).

Panel A: Sample with Lending Agreements	N	Mean
Hedging covenants	1,976	0.852
Covenants require hedging	1,976	0.536
Covenants limit hedging	1,976	0.698
Firm can hedge only with the lender	1,976	0.088
Firm is explicitly allowed to hedge with the lender	1,976	0.545

Panel B: Full Sample	N	Mean	SD	p25	p50	p75
Credit agreement, loan, or other debt contract	2,438	0.867	0.340	1	1	1
Maximum loan commitment ($M)	2,041	592.5	997.0	50	250	750
Hedging-related covenants	2,438	0.698	0.459	0	1	1
Covenants require hedging	2,438	0.437	0.496	0	0	1
Covenants limit hedging	2,438	0.569	0.495	0	1	1
Covenants require minimum hedge ratio	2,438	0.259	0.438	0	0	1
Covenants limit maximum hedge ratio	2,438	0.568	0.495	0	1	1
Covenants require minimum hedge maturity	2,438	0.162	0.369	0	0	0
Covenants limit maximum hedge maturity	2,438	0.317	0.465	0	0	1
Minimum allowed hedge maturity	286	25.89	14.29	12	24	36
Maximum allowed hedge maturity	776	45.57	18.73	36	48	60
Minimum allowed hedge ratio	327	54.07	22.85	50	50	75
Maximum allowed hedge ratio	1,341	82.16	11.43	75	80	85
Lender-approved counterparties	2,438	0.477	0.500	0	0	1
Firm can hedge only with the lender	2,438	0.072	0.259	0	0	0
Firm is explicitly allowed to hedge with the lender	2,438	0.444	0.497	0	0	1
Non-speculative purposes	2,438	0.401	0.490	0	0	1
Report hedge positions to the lender	2,438	0.598	0.490	0	1	1
Borrowing base reduction upon hedge unwinding	2,438	0.306	0.461	0	0	1
Covenants for interest rate derivatives	2,438	0.350	0.477	0	0	1
Other (posting collateral, cross-default provisions, strike prices, indebtedness, option positions, etc.)	2,438	0.531	0.499	0	1	1

Panel C: Covenants Placed by Different Lenders	N	Hedging covenants	Covenants require hedging	Covenants limit hedging
J.P. Morgan and Chase	438	0.840	0.555	0.632
Wells Fargo Bank	224	0.970	0.831	0.862
Bank of America	135	0.800	0.326	0.644
Bank One	118	0.983	0.339	0.881
BNP Paribas	91	1.000	0.846	0.989
Bank of Montreal	80	1.000	0.738	0.850
Union Bank	65	1.000	0.400	0.708
Citibank	63	1.000	0.508	0.841
Bank of Oklahoma	57	0.754	0.439	0.561
Royal Bank of Canada	48	1.000	0.771	0.979

Table 5. OLS Regressions for Hedge Ratios

The table reports the estimates of the OLS regressions. The dependent variable in Panel A is the hedge ratio for crude oil (%); the dependent variable in Panel B 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 Table 1. 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.

Panel A: Oil Hedge Ratio	(1)	(2)	(3)	(4)
Debt issuance	36.302***	-2.311	9.497**	0.703
	[7.41]	[-0.25]	[2.39]	[0.07]
Crude oil spot price*debt issuance		0.620***		0.139
		[4.20]		[0.95]
Log of assets	5.251***	5.189***	6.396***	6.288***
	[7.88]	[7.95]	[5.74]	[5.62]
Market-to-book ratio	-0.158	-0.125	0.282	0.278
	[-0.70]	[-0.57]	[1.56]	[1.56]
Return on assets	0.042	-0.070	-0.349	-0.371
	[0.10]	[-0.17]	[-0.58]	[-0.62]
Firm default	-9.746	-9.303	-27.977***	-27.868***
	[-1.59]	[-1.46]	[-3.98]	[-3.94]
Tax-loss carryforwards	0.113	0.074	-0.153	-0.166
	[0.61]	[0.43]	[-0.43]	[-0.47]
Crude oil spot price	0.337	0.250	0.256	0.235
	[1.34]	[1.00]	[1.26]	[1.15]
Volatility of oil price	0.042	-0.010	0.008	-0.007
	[0.16]	[-0.04]	[0.03]	[-0.03]
Observations	2,311	2,311	2,311	2,311
R-squared	0.286	0.296	0.643	0.644
Firm FE	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Panel B: Gas Hedge Ratio	(1)	(2)	(3)	(4)
Debt issuance	28.031***	10.678	9.066**	-3.299
	[6.49]	[1.26]	[2.31]	[-0.39]
Natural gas spot price*debt issuance		3.792**		2.694*
		[2.22]		[1.72]
Log of assets	4.792***	4.760***	5.236***	5.156***
	[8.38]	[8.36]	[3.47]	[3.43]
Market-to-book ratio	-0.070	-0.083	-0.073	-0.079
	[-0.46]	[-0.55]	[-0.71]	[-0.76]
Return on assets	-1.031	-1.111	-0.768	-0.829
	[-1.40]	[-1.48]	[-1.00]	[-1.04]
Firm default	-16.545***	-16.163***	-29.702***	-29.382***
	[-3.69]	[-3.63]	[-4.67]	[-4.60]
Tax-loss carryforwards	0.016	0.004	0.256	0.241
	[0.08]	[0.02]	[1.12]	[1.05]
Natural gas spot price	5.797***	5.219***	2.599	2.105
	[3.47]	[2.85]	[1.46]	[1.15]
Volatility of gas price	-7.750**	-7.559**	-3.470	-3.225
	[-2.59]	[-2.45]	[-1.23]	[-1.15]
Constant	-24.975***	-22.094***	-18.654**	-16.236**
	[-5.90]	[-4.87]	[-2.48]	[-2.14]
Observations	2,252	2,252	2,252	2,252
R-squared	0.237	0.239	0.625	0.626
Firm FE	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 6. OLS Regressions for Maturity and Sophistication 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 dependent variable in Columns 5-6 is a measure of hedging sophistication (0 to 3), whereby one point is added for use of swaps, futures, or forwards, one for use of two-way or three-way collars, and one point for use of options. 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 Table 1. 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.

	(1)	(2)	(3)	(4)	(5)	(6)
Debt issuance	14.992***	7.333***	13.162***	6.368***	0.776***	0.215**
	[6.53]	[4.42]	[5.77]	[3.56]	[6.46]	[2.40]
Log of assets	2.909***	1.951***	3.819***	3.337***	0.249***	0.194***
	[9.82]	[3.18]	[10.54]	[3.98]	[18.31]	[6.15]
Market-to-book ratio	0.021	-0.000	-0.012	-0.061	0.002	0.002
	[0.51]	[-0.00]	[-0.25]	[-1.10]	[0.69]	[0.83]
Return on assets	0.070	-0.015	-0.285	-0.254	-0.014	-0.012
	[0.35]	[-0.06]	[-1.51]	[-0.98]	[-1.62]	[-1.18]
Firm default	-5.176**	-11.772***	-8.291***	-12.633***	-0.559***	-0.842***
	[-2.40]	[-4.74]	[-4.44]	[-4.18]	[-3.61]	[-4.66]
Tax-loss carryforwards	0.160**	0.062	0.298***	0.298***	0.009*	0.000
	[2.00]	[0.32]	[3.25]	[2.62]	[1.93]	[0.05]
Crude oil spot price	0.188*	0.237**			0.006	0.010**
	[1.96]	[2.38]			[1.10]	[2.10]
Volatility of oil price	-0.000	0.009			-0.004	0.002
	[-0.00]	[0.08]			[-0.62]	[0.50]
Natural gas spot price			1.504*	0.904		
			[1.69]	[1.16]		
Volatility of gas price			-3.088***	-1.837*		
			[-2.60]	[-1.73]		
Observations	2,363	2,363	2,347	2,347	2,340	2,340
R-squared	0.315	0.643	0.301	0.633	0.446	0.744
Firm FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 7. Technological Shock and Hedge Ratios, IV Estimates

The table reports the estimates of the two-stage least squares. Columns 1 and 3 provide the estimates from the first stage, where the dependent variable is debt issuance. The excluded instrument is the technological shock, which is equal to the logarithm of one plus the number of time the word "hydraulic" is mentioned in firm's annual report multiplied by one if the word "horizontal" is mentioned at least once; zero otherwise. Columns 2 and 4 provide the estimates from the second stage, where the dependent variable is the hedge ratio for crude oil (%) and the hedge ratio for natural gas (%), 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. All variables are defined in Table 1. 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.

	(1) First Debt issuance	(2) Second Oil hedge ratio	(3) First Debt issuance	(4) Second Gas hedge ratio
Technological shock	0.028***		0.028***	
	[5.01]		[4.80]	
Debt issuance		149.940***		141.140***
		[3.83]		[3.40]
Log of assets	0.016***	3.126***	0.016***	2.696***
	[3.56]	[3.45]	[3.50]	[3.03]
Market-to-book ratio	-0.000	-0.138	-0.004	0.361
	[-0.11]	[-0.26]	[-1.64]	[1.20]
Return on assets	-0.017	1.876	-0.038**	3.163
	[-1.49]	[1.13]	[-2.10]	[1.33]
Firm default	0.007	-9.987	0.003	-16.345**
	[0.14]	[-1.17]	[0.05]	[-1.96]
Tax-loss carryforwards	-0.002	0.302	-0.005	0.566
	[-0.63]	[0.69]	[-1.41]	[0.97]
Crude oil spot price	0.001	0.331		
	[0.41]	[0.87]		
Volatility of oil price	0.002	-0.175		
	[0.65]	[-0.42]		
Natural gas spot price			-0.020	8.573**
			[-0.067]	[1.97]
Volatility of gas price			-0.003	-8.007
			[-0.07]	[-1.43]
Observations	2,306	2,306	2,249	2,249
Test of excl. instruments	25.10	25.10	23.07	23.07
First stage R-squared	0.077	0.077	0.080	0.080

Table 8. Technological Shock and Maturity of Hedging Contracts, IV Estimates

The table reports the estimates of the two-stage least squares. Columns 1, 3, and 5 provide the estimates from the first stage, where the dependent variable is debt issuance. The excluded instrument is the technological shock, which is equal to the logarithm of one plus the number of time the word "hydraulic" is mentioned in firm's annual report multiplied by one if the word "horizontal" is mentioned at least once; zero otherwise. Columns 2, 4, and 6 provide the estimates from the second stage, where the dependent variable is the maturity of oil hedging contracts (months), the maturity of natural gas hedging contracts (%), and the measure of hedging contract sophistication, 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. All variables are defined in Table 1. 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.

	(1) First Debt iss.	(2) Second Oil mat.	(3) First Debt iss.	(4) Second Gas mat.	(5) First Debt iss.	(6) Second Sophis.
Technological shock	0.028***		0.027***		0.028***	
	[5.05]		[4.23]		[5.02]	
Debt issuance		42.375**		47.531**		3.508***
		[2.05]		[2.06]		[3.61]
Log of assets	0.015***	2.471***	0.016***	3.244***	0.015***	0.199***
	[3.57]	[4.27]	[3.61]	[5.31]	[3.59]	[8.70]
Market-to-book ratio	-0.002	0.072	-0.002	0.052	-0.002	0.006
	[-1.05]	[0.87]	[-1.06]	[0.54]	[-1.02]	[1.01]
Return on assets	-0.017	0.513	-0.016	0.269	-0.016	0.030
	[-1.59]	[0.91]	[-1.58]	[0.45]	[-1.59]	[0.81]
Firm default	0.006	-5.302**	0.007	-8.475***	0.006	-0.564**
	[0.14]	[-1.99]	[0.15]	[-3.00]	[0.14]	[-2.55]
Tax-loss carryforwards	-0.001	0.201	-0.001	0.345**	-0.001	0.013
	[-0.53]	[1.53]	[-0.47]	[2.33]	[-0.57]	[1.25]
Crude oil spot price	0.001	0.188			0.001	0.006
	[0.41]	[1.47]			[0.40]	[0.75]
Volatility of oil price	0.002	-0.057			0.002	-0.009
	[0.69]	[-0.43]			[0.70]	[-1.01]
Natural gas spot price			-0.009	1.976		
			[-0.34]	[1.38]		
Volatility of gas price			-0.011	-2.863		
			[-0.30]	[-1.56]		
Observations	2,350	2,350	2,334	2,334	2,335	2,335
Test of excl. instruments	25.45	25.45	24.35	24.35	25.23	25.23
First stage R-squared	0.077	0.077	0.079	0.079	0.078	0.078

Table 9. Debt Issued With Minimum Hedging Requirements and Without

The table reports the estimates of the OLS regressions. The dependent variables in Panel A are hedge ratios for crude oil and natural gas price exposures; the dependent variables in Panel B are the maturities of outstanding crude oil and natural gas hedging contracts (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. *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. All other variables are defined in Table 1. 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.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Hedge Ratio	Oil	Oil	Oil	Gas	Gas	Gas
Debt issuance, no	8.461	-3.135	-1.710	8.470*	-1.455	0.120
requirements	[1.45]	[-0.56]	[-0.25]	[1.73]	[-0.30]	[0.02]
Debt issuance,	55.035***	17.952***	16.742***	40.818***	16.338***	12.204**
hedging requirements	[8.25]	[3.30]	[2.87]	[7.54]	[3.21]	[2.32]
Log of assets	5.208***	6.160***	6.261***	4.736***	5.280***	4.370***
	[7.84]	[5.50]	[4.59]	[8.14]	[3.46]	[2.60]
Market-to-book ratio	-0.069	0.195	0.316	-0.084	-0.078	-0.029
	[-0.36]	[1.01]	[1.51]	[-0.60]	[-0.72]	[-0.29]
Return on assets	-0.061	-0.405	0.304	-1.256*	-0.825	-0.357
	[-0.16]	[-0.66]	[0.24]	[-1.66]	[-1.06]	[-0.50]
Firm default	-8.677	-26.952***	-29.841***	-16.078***	-28.222***	-32.321***
	[-1.60]	[-3.84]	[-3.66]	[-3.63]	[-4.26]	[-3.99]
Tax-loss carryforwards	0.117	-0.140	-0.377	0.001	0.279	0.301
	[0.76]	[-0.40]	[-0.78]	[0.00]	[1.22]	[1.09]
Crude oil spot price	0.356	0.328	0.483**			
	[1.31]	[1.49]	[2.01]			
Volatility of oil price	-0.087	-0.026	0.106			
	[-0.34]	[-0.11]	[0.35]			
Natural gas spot price				5.039***	1.617	-0.010
				[2.67]	[1.06]	[-0.01]
Volatility of gas price				-8.118**	-3.583	-2.754
				[-2.39]	[-1.17]	[-0.97]
Observations	2,197	2,197	2,161	2,144	2,144	2,114
R-squared	0.305	0.641	0.678	0.248	0.629	0.668
Firm FE	No	Yes	Yes	No	Yes	Yes
Bank FE	No	No	Yes	No	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Hedge Maturity	(1) Oil	(2) Oil	(3) Oil	(4) Gas	(5) Gas	(6) Gas
Debt issuance, no requirements	2.322	0.352	-0.695	1.454	-3.353	-4.817
	[1.03]	[0.14]	[-0.23]	[0.68]	[-0.72]	[-0.80]
Debt issuance, hedging requirements	23.451***	12.343***	11.790***	21.181***	13.610***	14.100***
	[7.21]	[4.61]	[4.07]	[6.49]	[4.76]	[4.35]
Log of assets	2.923***	1.796***	2.293***	3.811***	3.268***	3.633***
	[9.74]	[3.03]	[3.41]	[10.40]	[4.20]	[3.29]
Market-to-book ratio	0.019	-0.018	0.062	-0.012	-0.073	-0.055
	[0.56]	[-0.31]	[1.07]	[-0.28]	[-1.12]	[-0.63]
Return on assets	0.008	-0.051	0.246	-0.328*	-0.302	-0.293
	[0.05]	[-0.21]	[0.63]	[-1.68]	[-1.08]	[-0.61]
Firm default	-4.817**	-11.065***	-11.810***	-8.056***	-11.571***	-11.495***
	[-2.49]	[-4.41]	[-3.71]	[-4.33]	[-3.57]	[-2.95]
Tax-loss carryforwards	0.168**	0.067	-0.070	0.305***	0.308***	0.263*
	[2.25]	[0.35]	[-0.28]	[3.29]	[2.74]	[1.74]
Crude oil spot price	0.188*	0.269**	0.293**			
	[1.69]	[2.42]	[2.44]			
Volatility of oil price	-0.080	-0.030	-0.012			
	[-0.76]	[-0.25]	[-0.10]			
Natural gas spot price				1.303	0.889	0.667
				[1.21]	[1.00]	[0.70]
Volatility of gas price				-2.986**	-1.793	-1.563
				[-2.17]	[-1.49]	[-1.31]
Observations	2,236	2,236	2,200	2,224	2,224	2,188
R-squared	0.341	0.646	0.701	0.323	0.643	0.673
Firm FE	No	Yes	Yes	No	Yes	Yes
Bank FE	No	No	Yes	No	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 10. Predicted Hedging Covenants and Hedging Contracts

The table reports the estimates of the OLS regressions. The dependent variables in Panel A are the hedge ratios for crude oil and natural gas price exposures. The dependent variables in Panel B are the hedge maturities (in months) 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, predicted hedging requirements* is long-term debt issuance divided by the book value of assets and multiplied by the average fraction of this bank's lending agreements for this year (excluding firm) that contain covenants requiring hedging. *Debt issuance, no predicted requirements* is long-term debt issuance divided by the book value of assets and multiplied by one minus the average fraction of this bank's lending agreements for this year (excluding firm) that contain covenants requiring hedging. All other variables are defined in Table 1. 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.

Panel A: Hedge Ratio	(1) Oil	(2) Oil	(3) Gas	(4) Gas
Debt issuance, no	21.941***	3.524	25.779***	8.623
predicted requirements	[2.91]	[0.54]	[3.16]	[1.22]
Debt issuance,	52.077***	15.774**	35.356***	11.518
predicted requirements	[5.24]	[2.01]	[4.45]	[1.48]
Log of assets	4.981***	5.814***	4.489***	4.599**
	[6.66]	[3.83]	[6.69]	[2.22]
Market-to-book ratio	-0.099	0.235	-0.140	0.014
	[-0.36]	[0.93]	[-0.83]	[0.12]
Return on assets	0.448	0.337	-1.364	-1.399
	[0.34]	[0.23]	[-1.48]	[-1.38]
Firm default	-9.590	-33.205***	-15.303**	-35.570***
	[-1.07]	[-3.37]	[-2.23]	[-4.88]
Tax-loss carryforwards	0.294	-0.322	-0.004	-0.342
	[0.83]	[-0.50]	[-0.01]	[-0.64]
Crude oil spot price	0.523	0.583*		
	[1.43]	[1.94]		
Volatility of oil price	0.085	-0.087		
	[0.21]	[-0.22]		
Natural gas spot price			2.785*	0.464
			[1.81]	[0.28]
Volatility of gas price			-1.645	1.726
			[-0.52]	[0.60]
Observations	1,712	1,712	1,697	1,697
R-squared	0.282	0.651	0.223	0.646
Firm FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes

Panel B: Hedge Maturity	(1) Oil	(2) Oil	(3) Gas	(4) Gas
Debt issuance, no	10.139***	3.386	10.652***	-0.397
predicted requirements	[2.61]	[1.01]	[2.89]	[-0.04]
Debt issuance,	20.320***	11.710***	17.311***	14.076**
predicted requirements	[4.43]	[2.79]	[3.77]	[2.26]
Log of assets	2.977***	2.209***	3.933***	3.336***
	[7.76]	[3.17]	[8.73]	[3.15]
Market-to-book ratio	0.063	-0.027	-0.003	-0.059
	[1.28]	[-0.51]	[-0.05]	[-0.67]
Return on assets	0.596	0.620	-0.246	-0.217
	[1.41]	[1.52]	[-0.58]	[-0.38]
Firm default	-4.543	-12.845***	-7.897***	-14.018***
	[-1.43]	[-3.26]	[-2.90]	[-3.42]
Tax-loss carryforwards	0.299**	0.364	0.280	0.275
	[2.27]	[1.58]	[1.64]	[0.89]
Crude oil spot price	0.179	0.303**		
	[1.52]	[2.16]		
Volatility of oil price	0.016	0.062		
	[0.11]	[0.34]		
Natural gas spot price			-0.348	-0.212
			[-0.30]	[-0.20]
Volatility of gas price			-0.493	0.202
			[-0.39]	[0.19]
Constant	-12.663***	-9.075**	-9.848***	-3.869
	[-4.43]	[-1.98]	[-2.94]	[-0.76]
Observations	1,745	1,745	1,736	1,736
R-squared	0.316	0.683	0.294	0.636
Firm FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes

Table 11. Ruling Out Alternative Mechanisms

The table reports the estimates of the OLS regressions. The dependent variables in Columns 1-3 and Columns 4-6 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. All other variables are defined in Table 1. 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.

Hedge Ratio	(1) Oil	(2) Oil	(3) Oil	(4) Gas	(5) Gas	(6) Gas
Debt issuance*common	51.313***			41.639***		
lender allowed	[7.46]			[7.38]		
Debt issuance*common	15.957***			9.200**		
lender not allowed	[2.77]			[2.04]		
Debt issuance*hedge		53.012***			24.158	
only with lender		[2.84]			[1.07]	
Debt issuance*hedge		35.226***			27.646***	
not only with lender		[7.02]			[6.22]	
Debt issuance			40.938***			29.351***
			[7.65]			[6.60]
Debt issuance*			11.960***			3.580
return on assets			[3.78]			[1.10]
Log of assets	5.069***	5.278***	5.099***	4.589***	4.786***	4.745***
	[7.62]	[7.63]	[7.73]	[8.03]	[7.99]	[8.30]
Market-to-book ratio	-0.062	-0.097	-0.292	-0.092	-0.056	-0.147
	[-0.30]	[-0.41]	[-1.43]	[-0.65]	[-0.38]	[-0.90]
Return on assets	-0.029	0.058	-0.743	-1.374*	-1.065	-1.508*
	[-0.07]	[0.13]	[-1.41]	[-1.81]	[-1.42]	[-1.79]
Firm default	-10.196*	-9.755	-8.713	-17.296***	-16.903***	-16.363***
	[-1.69]	[-1.59]	[-1.47]	[-3.71]	[-3.80]	[-3.65]
Tax-loss carryforwards	0.057	0.081	0.247	-0.065	-0.028	0.033
	[0.36]	[0.43]	[1.43]	[-0.37]	[-0.13]	[0.18]
Crude oil spot price	0.261	0.250	0.329			
	[1.00]	[0.89]	[1.30]			
Volatility of oil price	-0.073	-0.118	-0.013			
	[-0.25]	[-0.43]	[-0.05]			
Natural gas spot price				3.530***	4.823***	5.734***
				[2.63]	[2.89]	[3.42]
Volatility of gas price				-6.245**	-7.888**	-7.668**
				[-2.05]	[-2.38]	[-2.56]
Observations	2,197	2,197	2,311	2,144	2,144	2,252
R-squared	0.292	0.274	0.294	0.248	0.229	0.237
Firm FE	No	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 12. 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 23, 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 (in million). 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.

Panel A: Summary Statistics	N	Mean	SD	p25	p50	p75
Daily stock return	3,905	-1.660	14.104	-4.605	-1.260	1.010
Hedging requirements	3,976	0.620	0.486	0.000	1.000	1.000
Crude oil spot price	3,977	48.259	11.301	46.780	51.360	56.760
Hedge ratio	3,920	42.029	30.153	19.000	43.500	61.000
COVID-19 cases	3,053	-3.111	1.549	-3.589	-2.566	-2.175

Panel B: Results	(1)	(2)	(3)	(4)	(5)	(6)
Hedging requirements	4.860**		4.679**	2.001**		1.985**
	[2.49]		[2.15]	[2.61]		[2.25]
Crude oil spot price	0.148***	0.126***	0.156***			
	[8.93]	[4.86]	[6.71]			
Hedging requirements	-0.096**		-0.089**			
*crude oil spot price	[-2.60]		[-2.17]			
Hedge ratio		0.041*	0.008		0.015*	0.001
		[1.74]	[0.30]		[1.70]	[0.09]
Hedge ratio		-0.001**	-0.000			
*crude oil spot price		[-2.00]	[-0.59]			
COVID-19 cases				-0.496***	-0.405***	-0.543***
				[-6.20]	[-3.39]	[-4.95]
Hedging requirements				0.467***		0.413**
*COVID-19 cases				[2.83]		[2.30]
Hedge ratio					0.005**	0.002
*COVID-19 cases					[2.34]	[0.90]
Constant	-8.925***	-7.588***	-9.154***	-3.830***	-3.195***	-3.859***
	[-10.29]	[-5.62]	[-7.68]	[-11.45]	[-6.08]	[-8.81]
Observations	3,905	3,850	3,850	3,053	3,010	3,010
R-squared	0.006	0.005	0.007	0.001	0.001	0.001