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Phan, Dinh; Nguyen, Hoa; Faff, Robert

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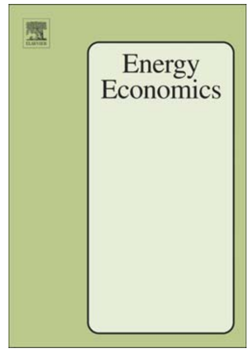

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Uncovering the asymmetric linkage between financial derivatives and firm value – the case of oil and gas exploration and production companies

Dinh Phan*, Hoa Nguyen* and Robert Faff**

* School of Accounting, Economics and Finance
Faculty of Business and Law
Deakin University
221 Burwood Highway
Burwood VIC 3125
Australia

** UQ Business School
University of Queensland
St Lucia QLD 4072
Australia

Corresponding author Hoa Nguyen Email: hoa.nguyen@deakin.edu.au;
Phone: 03 92446190 Fax: 03 92446283

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Abstract

We investigate the role of derivatives in enhancing firm value of US oil and gas exploration and production companies over the period 1998-2009, using both cross-sectional and time-series tests. Initially focusing on Tobin's Q, we document a 'hedging discount' in periods of increasing oil and gas prices, while there is some evidence that hedging leads to an increase in firm value in periods of decreasing prices. In the companion time-series tests our core finding indicates that hedger portfolios underperform compared to non-hedger portfolios i.e. confirming a hedging discount. We extend these time series tests to provide a range of conditional analyses exploring the circumstances in which this discount manifests. Here we find that the hedging discount is specifically related to periods of elevating oil and gas prices, especially if the price is high.

Key words: oil and gas, financial derivatives, hedging, firm value

JEL Classification: G21, G32

1. Introduction

Can corporate risk management via the use of financial derivatives enhance firm value? This basic question motivates our study as part of an important stream of the corporate finance literature. Studies that examine incentives for corporate hedging suggest that hedging can be a value-enhancing exercise since corporations hedge to minimize expected taxes, underinvestment costs and financial distress costs (Nance et al. 1993; Aretz and Bartram, 2010).[1] Nevertheless, studies that investigate the direct relationship between hedging and firm value have uncovered conflicting results. Allayannis and Weston (2001) examine the relationship between foreign currency hedging and Tobin's Q and concludes that hedging activities enhance firm value. The notion of a hedging premium is further supported by **Carter** et al. (2006) in a sample of US airlines. On the other hand, Jin and Jorion (2006) find that hedging does not seem to affect firm value in oil and gas producers and that it even seems to impact firm value negatively in gold mining companies (Jin and Jorion, 2007).[2] Utilizing a large international sample, Bartram et al. (2011) also report that the impact of derivatives on firm value tends to be weak and inconsistent over time.

While a number of factors could potentially explain the inconsistency across these empirical findings, it appears that the success of a hedge in monetary terms is largely dependent on Treasury forecasts and, once the hedging decision has been made, the behaviour of the underlying source of risk. For example, in the context of a resources producer that has revenue-based commodity price exposures, hedging is most (least) financially beneficial, at least in the short run, when commodity prices fall (increase). Indeed, the notion that firms should hedge more of their revenue-based exposures when price falls and hedge less when price increases is the central tenet of a body of literature that investigates the degree of selective hedging undertaken by corporations.[3]

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[1] In particular, Smith and Stulz (1985) argue that firm hedging activities using derivatives could produce significant benefits in countries where companies have a convex tax schedule. Hedging reduces the volatility of taxable income which leads to a decrease in the expected tax liability, and these tax savings have a potential to enhance firm value. Hedging can also enhance shareholder value through the mitigation of financial distress costs which include bankruptcy, legal fees and court costs as it reduces the variance of cash flows — leading to a reduction in the probability that the firm will encounter financial distress (Smith and Stulz, 1985). In addition, firm managers use derivatives to minimize the difference between the availability of liquidity and the obligated payments caused by volatile cash flows (Mayers and Smith, 1982). As a result, underinvestment can be avoided by using hedging as it helps companies maintain sufficient internal funds for profitable investment opportunities (Stulz, 1985). Examples of other studies in this broader literature include Berkman et al. (2002), Nguyen and Faff (2002; 2003), Benson and Oliver (2004), Nguyen, Faff and Hodgson (2010) and Birt et al. (2013).

[2] Recently, Talbot et al. (2013) test theoretical drivers of the oil price beta of oil industry stocks. While they find strongest statistical and economic support for market conditions-type variables, there is weaker support for the prediction that financial risk management reduces the exposure of oil stocks to crude oil price variation.

[3] Selective hedging is a term coined by Stulz (1996) that describes the practice of managers varying their hedge ratios according to their forecasts of future price movements.

In this paper, we aim to reinvestigate the relationship between hedging and firm value in a sample of US oil and gas exploration and production companies — as is the focus in Jin and Jorion (2006) — but over a more contemporary sample period, 1998 to 2009. Moreover, the novelty and key contribution of our study is that we pay particular attention to the key conditioning influences that affect the dynamics of the hedging-firm value relation.

To better understand the impact of derivatives hedging on firm value, it is important to distinguish between two potential value sources: corporate cash flows and cost of capital. With regard to the impact of hedging on cash flows, hedging can potentially enhance firm value because it reduces the volatility of operating cash flows and, hence, a range of costs associated with highly volatile cash flows such as expected taxes, financial distress costs and underinvestment as discussed above. The conjecture that hedging should improve firm value is further supported by Gay et al. (2011), who report that hedging is associated with a lower cost of equity. They argue that the lower cost of equity primarily arises from a reduction in the market beta and the SML beta.

While the impact of hedging on a firm's expected cash flows and cost of capital is suggestive of a positive influence on firm value, the magnitude of such benefits is not so well understood.[4] In addition, it is important to recognize that derivatives hedging is most likely to add value in the presence of downside risk. Stulz (1996), for example, suggests that diversified shareholders are not concerned about volatility in general, but are concerned if such volatility can increase the risk of financial distress. Guay and Kothari (2003) also make an important assumption in estimating the expected cash flow benefits from hedging: firms only hedge their downside risk. Gay et al. (2011) also contend that the reduction in the cost of equity for derivatives users is attributable to lower financial distress costs — a source of systematic risk that is priced in equity returns. Drawing these arguments together, while hedging can be a valuable exercise in the presence of downside risk, there is little reason to expect that hedging can add value in the opposite scenario, i.e. when the volatility of the underlying asset is on the upside.

Specific to our sample of oil and gas exploration and production companies, a short hedge on future production is expected to have a positive value when oil and gas prices decline below the contracted price. Nevertheless, the ultimate impact of derivatives hedging on firm value does not only depend on price movements, but also on the nature of the derivatives instrument used. Specifically, futures and forwards provide symmetric payoffs while options have asymmetric payoffs — the extent of gains is not the same as the extent of losses. As a result, when oil and gas prices increase after the hedges are in place, a hedging program employing options is expected to have a less

[4] Extant evidence suggests that the cash flow benefit of hedging is economically small relative to firm size and operating cash flows. Guay and Kothari (2003) find that the median value addition as a result of a three standard deviation change in interest rate, exchange rate and commodity price is $31 million, of which $15 million comes from the derivative portfolio or the hedge outcome. Graham and Rogers (2002) report a median value addition of $9.8 million for firms that hedge in response to tax incentives.

severe impact on firm value than one that is comprised entirely of linear payoff contracts such as futures and/or forwards. We, therefore, hypothesize that hedging enhances firm value when oil and gas prices decline, irrespective of the derivatives instruments that the firm employs. On the other hand, when oil and gas prices increase, hedging is expected to be associated with a firm value discount. Further, the more prominent the linear payoff contracts are, the more severe the extent of discount is expected compared to the use of options.

Oil and gas is the industry of choice for a number of reasons. First, the movement in oil and gas prices has a direct and immediate effect on the cash flow of oil and gas companies. Second, the strong homogeneity of the oil and gas industry provides a unique perspective from which to analyze the value of firms' hedging activities. In particular, oil and gas producers, by the nature of their business, have inherent *ex-ante* exposures to oil and gas prices. More importantly, their exposure tends to be relatively more transparent and easy to identify compared to industrial firms. In addition, as pointed out by Jin and Jorion (2006), not only are exposures of multi-sector firms complex, but not all the exposures are fully hedgeable using financial derivatives.

Third, hedging in the oil and gas industry can have significant impact on firm value because oil and gas reserves make up a significant portion of the total value of companies in this industry. This is a very important observation as Guay and Kothari (2003) argue that for a sample of cross sectional non-financial firms, the potential impact of derivatives hedging gains on overall cash flows is small at best, and derivatives use cannot be fully attributable to the hedging premium documented in the literature. Finally, our focus on a single industry mitigates many of the endogeneity concerns relating to the propensity to hedge by firms belonging to different industries. More reliable conclusions can be made in relation to the impact of derivatives on firm value as some of the firms choose to hedge while others do not, despite similar propensities to do so.

Investigating the impact of derivatives hedging on firm value in the oil and gas industry is apt as the market value of oil/gas producers is more sensitive to commodity price hedging outcomes in comparison to other downstream industries that belong to the same supply chain (for example, users of oil and gas). The strength of our argument is based on the fact that oil/gas production is the core business of our sample firms and, accordingly, it is of paramount importance for these firms to maximize their sales revenue through a combination of market pricing and fixed price contracts. In other words, the market expects oil/gas producers to be more active and selective hedgers as hedged cash flows make up a substantial proportion of overall cash flows. The importance of oil/gas price hedging in the industry also means that oil/gas producing companies are expected to be more sophisticated hedgers and that their programs are perhaps more scrutinized by the market compared to, say, airline companies who are also active oil/gas hedgers. This is due to the fact that for airlines, hedging is of secondary importance to their core business.

As is apparent from Figure 1, the price of oil and gas experienced unusually high volatility, partly due to the turmoil in financial markets caused by the global financial crisis. It can also be seen that compared to oil prices, gas prices experienced significantly more volatility during this period of interest. Hedging, by definition, adds value by reducing the volatility of the firm's expected cash flows. As a result, the value of hedging activities is expected to be maximized during this volatile sampling period. We also choose to focus on a sample of US firms since, from the 1990s, they are required to disclose relatively detailed information regarding market risk and usage of derivatives in their financial statements.

We investigate the role of derivatives in enhancing firm value of US oil and gas exploration and production companies over the period 1998-2009, using both cross-sectional and time-series tests. Initially focusing on Tobin's Q, we document a 'hedging discount' in periods of increasing oil and gas prices, while there is some evidence that hedging leads to an increase in firm value in periods of falling oil and gas prices. In our companion time-series tests, based on the Fama French three-factor model, our core finding indicates that hedger portfolios underperform compared to non-hedger portfolios. We extend these time series tests to provide a range of conditional analyses exploring the circumstances in which this discount manifests. Here we find that the hedging discount is specifically related to periods of elevating oil and gas prices, especially if the price is high. Our findings, while intuitive in nature, have several important implications.

First, they offer an alternative viewpoint about the motives behind corporate hedging. Hedging discounts previously documented have been linked to a managerial aversion motive in which hedging is the product of managers aiming to maximize their own utility. In our study, the hedging discount is more likely to be the result of a hedging policy over prolonged periods of increasing oil and gas prices during the sampling period. As a result, the negative impact on firm value from hedging is a manifestation of misplaced expectations of firms in relation to future movements of oil and gas prices, rather than managerial risk aversion. Our finding that hedging activities only result in a discount in an inflationary environment has an important implication for studies that investigate the relationship between firm value and hedging. Our results complement those of Mackay and Moeller (2007) that a discriminating risk management program can add value. Particularly, the market rewards (penalizes) firms that hedge when hedging adds (destroys) value.

Second, our results also offer a plausible explanation for the conflicting empirical evidence on the hedging-firm value relation. The foreign exchange hedging premium documented by Allayannis and Weston (2001), for example, is primarily driven by the gains achieved during the periods when the US dollar depreciated. Such a hedging premium was absent in the period of US dollar appreciation. Similarly, the hedging premium documented by Carter et al. (2006) is somewhat expected as the airline industry is a major consumer of fuel and hedging is valuable when the fuel price increases. Indeed, as reported by the authors, the result was primarily influenced by the positive hedging premium documented over the 2002 – 2003 period, during which high fuel price and volatilities were present.

Along the same line of reasoning, the failure of Jin and Jorion (2006) to document any relationship between firm value and hedging might be due to the behavior of oil and gas prices during the sampling period, when hedging gains in the 1998 – 1999 period were offset by hedging losses during 2000 – 2001. Bartram et al. (2011) also concur that derivatives use is associated with significantly higher value during the economic downturn of 2001 – 2002 as opposed to other time periods. Taken together, it appears that the value of corporate hedging coming from a reduction in the cost of financial distress and underinvestment might not be as important as previously thought. While there is no doubt that corporate hedging can add value through these avenues, the low probability of financial distress and underinvestment for an average firm at a particular point in time means that the value of a hedging program is predominantly determined by 'going concern' considerations relating to the behavior of the underlying source of risk.

The remainder of this paper proceeds as follows. The next section offers a brief literature review. Data and methodology are documented in Section 3. We discuss our results in Section 4 and Section 5 concludes.

2. Literature Review

While existing studies examining the relationship between hedging and firm value provide mixed empirical evidence within the oil and gas industry, there is a general consensus that the stock returns of oil and gas producers are largely driven by commodity prices. Boyer and Fillion (2007), for example, empirically illustrate that the stock return of Canadian energy companies is positively related to appreciations in natural gas and crude oil prices. In a global study, Nandha and Faff (2008) further show that oil price rises have a negative impact on equity returns for all sectors except mining, and oil and gas industries. In light of their findings, they recommend that international portfolio investors consider hedging oil price risk. Also, specific to an oil and gas sample (1992-94), Haushalter (2000) examines the relationship between hedging in US oil and gas producers and their financing policy, tax status, compensation policy, ownership structure and operating characteristics. The study shows that the extent of hedging is related to firms' financing costs. In particular, the fraction of production that is hedged will increase for the firm that has high financial leverage and low financial flexibility. The study also finds a positive relation between hedging and a proxy for firms' ability to hedge.

Jorion (1990) examines foreign currency hedging activities in a sample of US multinational companies and finds that these firms' foreign currency beta is close to zero, which implies that currency hedging would not affect firm value. On the other hand, Gagnon et al. (1998) document that dynamic hedging strategies lead to risk reduction and utility gains by constructing currency portfolios. Rajgopal (1999) examines 38 US oil and gas companies and reports that oil and gas reserves (as a proportion of total assets) have a positive impact on the sensitivities of stock return to oil/gas price changes. Similarly, Jin and Jorion (2006) provide supporting results in a sample of 119 US oil and gas firms that there is no relationship between hedging and firm value, but that hedging plays an important role in reducing stock return sensitivity to changes in oil and gas prices.[5] In contrast, the magnitude of oil and gas reserves increase stock return sensitivity to changes in oil and gas futures prices. In another study that looks at the gold mining industry, Jin and Jorion (2007) find that firms with hedging activities are associated with a discount to their firm value. Bartram et al. (2011) show the corporate use of derivatives globally generally has a weak relationship to firm value, although there is a significant positive relationship between derivatives and firm value during the economic downturn of 2001–2002.

In one of the pioneering papers, Allayannis and Weston (2001) report a positive relationship between foreign currency hedging and firm value as measured by Tobin's Q in a sample of 720 US non-financial firms. Hedged firms are found to be associated with a 5% average hedging premium compared to non-hedged firms. Graham and Rogers (2002) concur with this conclusion by reporting a hedging premium of 1.1% due to hedged firms' ability to increase their debt capacity. However, Guay and Kothari (2003) examine a sample of 234 large non-financial corporations and demonstrate that the proportion of hedging activities is economically small in relation to their entity-level risk exposures and have no significant effect on firm values. They also argue that the result from Allayannis and Weston (2001) could be spurious as the increase in firm value is affected by other risk management activities such as operational hedging, which is correlated to derivatives hedging.

Carter et al. (2006) examine jet fuel price hedging in a sample of 28 American airline companies and report a similar result to that of Allayannis and Weston (2001). Fuel hedging in this industry increases firm value by a significant 12-16% for hedged firms. Similarly, Bartram et al. (2003) find a positive impact of hedging activities on firm value by investigating interest rate hedging in a large sample of multi-industry companies.[6] Mackay and Moeller (2007) advance a corporate risk management model in which hedging can add value if firms discriminately hedge concave revenues and leave concave costs unhedged. They show that the result of this discriminating hedge

[5] Geczy et al. (1997) argue that examining the impact of hedging activities on multinational companies would be difficult because other factors such as foreign sales, foreign denominated debts and foreign tax also significantly affect firm value. Therefore, Jin and Jorion (2006) focuses on a homogeneous industry such as oil and gas or gold mining to provide more reliable results on the relationship between hedging and firm value.

[6] Bartram et al. (2003), however, reported a statistically insignificant relationship between currency hedging and firm value.

program is a value enhancement of the magnitude of 2-3% for 34 oil refiners. Although not addressing the direct relationship between derivatives use and firm value, Gay et al. (2011) report that, all else being equal, derivatives use can lead to an increase in firm value through the reduction in the cost of equity. Their argument is that derivatives use can reduce the cost of financial distress, which is a component of systematic risk that is priced in equity returns. Finally, Aretz and Bartram (2010) provide a comprehensive review of theories and empirical evidence to date that concern corporate hedging and its impact on shareholder value. The study also highlights some of the challenges commonly encountered in this area of research.

3. Data and Empirical Method

3.1 Data

Our initial sample is chosen by extracting from COMPUSTAT the list of firms with a Global Industry Classification Standard code of 1010, i.e. the Energy industry group. This industry group includes five sub-classes: Integrated Oil and Gas, Oil and Gas Exploration and Production, Oil and Gas Refining and Marketing, Oil and Gas Storage and Transportation Coal and Consumable Fuels. However, only companies belonging to the Oil and Gas Exploration and Production sub-classes are retained as these companies are more likely to have direct exposure to fluctuations in oil and gas prices. Further, consistent with Jin and Jorion (2006), only firms that meet the following selection criteria are retained in the sample: book value of total assets is greater than $20 million;[7] 10-K reports are available from EDGAR; proved oil and gas reserves are reported in 10-K reports; and sufficient information in 10-K reports is available for the calculation of the hedge ratios. The application of these filters produce a final sample of 94 firms from 1998-2009, or 840 firm-year observations. A total of 52 different firms appear in all sample years.

3.2 Variable Description

3.2.1 Hedging

Hedging information for each firm-year observation is manually collected from 10-K annual reports from 1998-2009. The oil and gas industry in the US discloses more information compared to other countries because of the strict requirements. The US Security and Exchange Commission issued Financial Reporting Release (FRR) No. 48 in January 1997, which requires the disclosure of market risk information for all firms for fiscal years ending after June 1998. Under this rule, firms are required to report quantitative information about market risk in one of three formats: tabular, sensitivity analysis or value at risk. Oil and gas companies usually choose the tabular format.

Under the tabular disclosure method, financial instruments are classified according to four characteristics: fixed or variable rate assets or liabilities; long or short forwards or futures; written or purchased put or call options; and fixed or variable swaps. In addition, SFAS 105, released by the FASB in June 1990, requires firms to disclose information about financial instruments with off balance sheet risk for fiscal years ending after 1990. In general, SFAS 105 and FRR 48 require firms to report contract amounts and the weighted average prices at which these contracts were entered.

[7] Jin and Jorion (2006) state that firms with total assets of less than $20 million, classified as “small business issuers”, have weaker disclosure requirements. Therefore, it is difficult to identify whether such firms do not hedge or do not disclose hedging information.

Following Jin and Jorion (2006), we measure hedging as the sum of delta equivalents of each position reported at the fiscal year-end.[8] It is assumed that Δ = -1 for short positions and Δ=1 for long positions in all linear hedging instruments of crude oil and gas, such as short futures and forwards, swaps and fixed price contracts. For non-linear contracts such as options and collars, hedging deltas are calculated by using the Black and Scholes' option pricing model. After determining the delta for each contract, the deltas are aggregated to obtain the total delta for crude oil and gas. We develop two measures of delta relating to production and reserves as follows:

Relative delta oil (gas) production = - Total delta oil (gas)/Next year oil (gas) production (1)

Relative delta oil (gas) reserve = - Total delta oil (gas)/Same-year proved oil (gas) reserves (2)

Panel A of Table 1 provides a snapshot of the number of observations that have exposure to oil and gas prices, while Panel B shows the number of observations that engage in hedging. A firm is said to have oil/gas exposure when the firm explores and produces oil/gas and is thus exposed to the oil/gas price in that year. Out of 840 firm-year observations, 812 have exposure to both oil and gas while 24 (4) have exposure to only gas (oil). Panel B partitions the sample into observations of oil hedgers and non-oil hedgers, and gas hedgers and non-gas hedgers. Most firms either hedge both oil and gas exposures (331 firm-years) or hedge neither of them (350 firm-years).

3.2.2 Firm Value

Consistent with the literature, in this study, firm value is measured by Tobin's Q as defined by the market value of a company divided by the replacement value of total assets. Following Jin and Jorion (2006), three measures of Q are employed:

$$Q_1 = \frac{BV\ total\ assets - BV\ common\ equity + MV\ common\ equity}{BV\ total\ assets} \tag{3}$$

$$Q_2 = \frac{BV\ total\ assets - BV\ common\ equity + MV\ common\ equity}{BV\ total\ assets - BVoil\,(gas)\ proved\, reserves + MVoil\,(gas)\ proved\, reserves} \tag{4}$$

$$Q_3 = \frac{BV\ total\ assets - BV\ common\ equity + MV\ common\ equity}{BV\ total\ assets - BVoil\,(gas)\ proved\, reserves + NPVoil\,(gas)\ proved\, reserves} \tag{5}$$

While the numerators in Equations (3), (4) and (5) are identical and approximate the market value of the firm, the denominators in these equations take different forms. Q_1 is a simple Q ratio that uses the book value of total assets as a proxy for replacement cost. For Q_2, the replacement cost is calculated as the book value of total assets plus the difference between the market value and the book value of the oil (gas) proved reserves. For Q_3, the denominator is calculated by taking the book value of total assets

[8] This procedure provides a more reliable measure of the extent of hedging than notional amounts or a hedging dummy. This method also follows Tufano (1996).

minus the book value of oil/gas proved reserves, plus a "standardized measure of oil/gas proved reserves" — determined in accordance with the rules and regulations of the SEC and SFAS. The Net Present Value (NPV) of oil and gas proved reserves is measured as the present value of estimated future net revenues to be generated from the production of proved reserves less expenses such as general and administrative, debt service, future income tax, depreciation, depletion and amortization and discounted using an annual discount rate of 10%.[9]

Descriptive statistics for the sample firms are presented in Table 2. Panel A describes the whole sample. The sub-sample of oil hedging activities and gas hedging activities are reported in Panels B and C, respectively. Panel D reports descriptive statistics for companies without hedging activities. Total assets are measured at book value. The value of oil and gas reserves is the standardized measure of proved oil and gas reserves, as reported in annual 10-K reports. Oil (gas) production hedged, *Delta Pro*, is the amount of production hedged divided by the actual oil (gas) production next year. As indicated earlier, this measure effectively gives an indication of the proportion of next year's production that is hedged using financial derivatives. The oil (gas) reserves hedged, *Delta Res*, is the amount of reserves hedged divided by the oil (gas) reserves for the same year.

As shown in Panel A of Table 2, the average total assets across the entire sample is around $2.42 billion. In addition, 10% of the companies have assets equal to or less than $34 million and, similarly, 10% of firms have total assets of approximately more than $5.3 billion. The median total assets is also considerably less than the mean, which implies a skewed distribution caused by a number of extreme observations.

Panels B, C and D further show that the average total assets for oil hedging firms is around $4.12 billion, $4.108 billion for gas hedging firms and $0.421 billion for non-hedging firms. The mean total assets of non-hedging firms is significantly less than that of firms that hedge. This result is consistent with previous studies, which show that larger firms are more likely to hedge than smaller firms. The market value of equity (MVE) demonstrates similar patterns. The mean of proved reserves value for the sample is around $1.96 billion, which is more than 80% of average total assets across

[9] The information needed for the calculation of NPV is obtained from the 10-K annual reports. The market value of the reserve is calculated by multiplying the quantity of the reserve by the market oil/gas price as at 31 December of a particular year. Oil and gas firms are required to report the present value of earnings from total oil and gas reserves as per SFAS No. 69. In addition, they are required to show the present value of their reserves by using Discounted Future Net Cash Flows with a standard rate of 10%. Estimates of the quantities of proved reserves and the future periods during which they are expected to be produced are made, based on year-end economic conditions. Therefore, the number of years that the proved reserve can be extracted should be determined by the ratio between the proved reserve and the production of the firm. On average across our sample, the ratios are 10.65 and 10.80 years for oil and gas reserves, respectively.

the sample. For oil and gas hedging firms, the proved oil and gas reserves make up 82% and 81% of their total assets, on average, respectively.

The values of Q_1 and Q_3 are quite similar in all settings and are much higher than the value of Q_2. This is due to the fact that the denominator of Q_2 includes the market value of oil and gas reserves. This variable is calculated by multiplying the quantity of proved oil and gas reserves by the market price, and these values are substantially greater than the book value of oil and gas reserves — leading to a higher denominator for Q_2. For the whole sample, the average values of Q_1, Q_2, and Q_3 are 1.86, 0.52, and 1.76, respectively, while the associated medians are 1.42, 0.40, and 1.44. More importantly, it is observed that the Q ratios for oil and gas hedging firms are lower than those of non-hedging firms. This observation holds for all three measures of Q ratios.

Of the firms that hedge, the mean (median) production delta is 37.94% (31.34%) of next year's oil production, which is approximately 3.78% (2.75%) of proved oil reserves. The mean (median) gas delta is approximately 37.43% (33.61%) of next year's gas production, which amounts to approximately 3.73% (3.02%) of proved gas reserves. These figures are comparable to Jin and Jorion (2006).

Table 3 further reveals information regarding the type of instruments used in hedging. For oil hedgers, 104 (27.6%) hedge using options only, and 173 (45.9%) hedge using only linear payoff contracts such as futures, forwards or swaps. In contrast, 100 (26.5%) employ both types of contracts in their hedging programs. The statistics are somewhat similar for gas hedgers, with 90 (20.3%) utilizing options only, 176 (39.6%) using non-option contracts only and 178 (40.1%) using both types of contracts.

Further descriptive statistics presented in Table 4 confirm the more important role that linear payoff contracts play in hedging commodity price risk. In particular, 24.5% (25.7%) of next year's oil (gas) production is hedged using either futures/forwards or swaps, while options hedging only accounts for 13.4% (11.7%) of next year's oil (gas) production. Similarly, 2.5% of the current reserves (oil or gas) are hedged using linear payoff contracts and about 1.25% are hedged using options.

3.2.3 Control Variables

Following previous studies (Allayannis and Weston, 2001; Jin and Jorion, 2006), several control variables are employed: firm size **(**natural logarithm of total assets), profitability (return on assets), investment growth (capital expenditures to total assets), access to financial markets (a dummy variable equaling 1 if the firm makes any payout to shareholders in a particular fiscal year and 0 otherwise), leverage (book value of debt to market value of equity) and production costs (the cost of extracting oil and natural gas, which includes both the lifting cost and production taxes). Information regarding production cost is collected manually from firms' 10-K annual reports on the basis of per Boe (Barrel of oil equivalent) for oil production and per Mcfe (thousand cubic feet equivalent) for gas production.

3.3 Method

3.3.1 Cross-sectional Regression Analysis

To test the relationship between hedging and firm value, the following basic pooled cross-sectional regressions are estimated:

$$LnQ = \alpha + \beta \times HedDum + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (6)$$

$$LnQ = \alpha + \beta \times DeltaPro + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (7)$$

$$LnQ = \alpha + \beta \times DeltaRes + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (8)$$

where the Q ratio proxies for firm value and is log transformed following Jin and Jorion (2006), Lang and Stulz (1994) and Allayannis and Weston (2001) among others. Hedging variables include a hedging dummy (*HedDum*), delta production (*DeltaPro*) and delta reserves (*DeltaRes*). The hedging dummy takes the value of 1 if the firm implements hedging activities in that year and is 0 otherwise. Delta production is the ratio between total hedging positions and next year's oil/gas production. Delta reserves is the ratio of total hedges to proved oil/gas reserves in the same year. Equations (6) to (8) are estimated for both the oil and gas samples.

One of our important goals is to examine how commodity price regimes impact the dynamics between hedging and firm value. In particular, derivatives usage is expected to provide benefits for the firm when oil and gas prices fall, as derivatives contracts allow them to lock in a selling price that is likely to be higher than the market price at the time of delivery. To test for this potential effect, we undertake two approaches. In the first instance, we develop an "up-market" dummy variable, D_U, which equals 1 if the return on oil/gas is positive during a particular year and 0 otherwise. The dummy variable is allowed to interact with the hedging variables as follows:

$$LnQ = \alpha + \beta_1 \times HedDum \times D_U + \beta_2 \times HedDum \times (1 - D_U) + \beta_3 \times D_U + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (9)$$

$$LnQ = \alpha + \beta_1 \times DeltaPro \times D_U + \beta_2 \times DeltaPro \times (1 - D_U) + \beta_3 \times D_U + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (10)$$

$$LnQ = \alpha + \beta_1 \times DeltaRes \times D_U + \beta_2 \times DeltaRes \times (1 - D_U) + \beta_3 \times D_U + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (11)$$

We predict a negative sign for β_1 and a positive sign for β_2 as hedging is expected to add (reduce) value when oil/gas prices decline (rise).

In the second approach, the continuously compounded return on oil/gas prices during a particular year, $R_{oil/gas}$, is interacted with the hedging variables as follows:

$$LnQ = \alpha + \beta_1 \times HedDum \times R_{Oil/Gas} + \beta_2 R_{Oil/Gas} + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (12)$$

$$LnQ = \alpha + \beta_1 \times Delta\,\mathrm{Pr}o \times R_{Oil/Gas} + \beta_2 R_{Oil/Gas} + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (13)$$

$$LnQ = \alpha + \beta_1 \times Delta\,\mathrm{Re}s \times R_{Oil/Gas} + \beta_2 R_{Oil/Gas} + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (14)$$

Our coefficient of interest, β_1, is expected to be negative. A negative relationship between the annual return on oil/gas and firm market value is also expected in Equations (12) to (14).

Finally, we distinguish between contracts with linear payoffs and non-linear payoffs. Specifically, we re-calculate the continuous hedging variables to differentiate between the extent of production and reserve hedging that is attributable to non-linear payoff contracts (*DeltaPro_Option* and *DeltaRes_Option*) and hedging that is attributable to linear payoff contracts (*DeltaPro_NonOption* and *DeltaRes_NonOption*). The following regressions are estimated:

$$LnQ = \alpha + \beta_1 \times Delta\,\mathrm{Pr}o\_Option \times D_U + \beta_2 \times Delta\,\mathrm{Pr}o\_Option \times (1 - D_U) + \beta_3 \times Delta\,\mathrm{Pr}o\_NonOption \times D_U + \beta_3 \times Delta\,\mathrm{Pr}o\_NonOption \times (1 - D_U) + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon \quad (15)$$

$$LnQ = \alpha + \beta_1 \times Delta\,\mathrm{Re}s\_Option \times D_U + \beta_2 \times Delta\,\mathrm{Re}s\_Option \times (1 - D_U) + \beta_3 \times Delta\,\mathrm{Re}s\_NonOption \times D_U + \beta_3 \times Delta\,\mathrm{Re}s\_NonOption \times (1 - D_U) + \sum_{j=1}^{n} \gamma_j \times Control_j + \varepsilon$$

(16)

We hypothesize that when commodity prices decrease, linear and non-linear payoff derivatives contracts are not discernible from each other in enhancing firm value as both of these contract types allow producers to lock in selling prices that are more favourable than prevailing market prices. However, when commodity prices increase, the use of non-linear payoff contracts should be more valuable as they limit the losses from the hedged positions, resulting in a lower hedging discount. In particular, we expect that $\beta_3 < \beta_1 < 0$.

3.3.2 Time-series tests – Fama French Framework

To complement the multivariate regressions described above, we pursue an asset pricing approach using the Fama French three-factor model to examine whether a hypothetical portfolio consisting of a long position in the hedged firms and a short position in the non-hedged firms produces a positive alpha. Moreover, within this alternative setting, we investigate whether the alpha is conditional on particular market conditions.

Assessing the value of corporate hedging using the Fama-French three-factor model has a number of benefits. First, the alpha coefficient provides an *ex-ante* measure of the hedging premium which is far more meaningful than an *ex-post* assessment of the value of hedging.[10] Second, the alpha coefficient is a more reliable measure of the value of hedging compared to Tobin's Q. Tobin's Q, while very popular, is a biased measure of firm value for hedged firms to the extent that hedging has the potential to maintain firm liquidity at a desired level and thus improve the firm's ability to invest and acquire new oil/gas reserves. The ability to invest and acquire new oil/gas reserves associated with hedging can be viewed as a flexibility option, with its value not necessarily reflected in the calculation of Tobin's Q.[11]

In the initial stage, we test for a hedging premium by running the following regression (similar to e.g. Aboody and Lev, 2000; Nguyen et al., 2010):

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha + \beta\left(R_{M,t} - R_{F,t}\right) + sSMB_t + hHML_t + \varepsilon_t \tag{17}$$

where $R_{HEDGER,t}$ ($R_{NONHEDGER,t}$) is the production hedging-weighted (equal weighted) return in month t of a portfolio comprising (non-) hedgers. $R_{M,t}$ is the market return and $R_{F,t}$ is the risk free rate. SMB_t is the difference between the return on a portfolio of small stocks and a portfolio of big stocks. HML_t is the difference between the return on a portfolio of high book-to-market ratio stocks and a portfolio of low book-to-market stocks.[12] A positive (negative) α indicates a hedging premium (discount).

To extend the analysis, we further partition the intercept into two parts that relate to market conditions defined by an oil/gas price increase versus a counterpart price decrease. In particular, the regression is specified as follows:

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha_1 D_{Up,t} + \alpha_2 D_{Down,t} + \beta\left(R_{M,t} - R_{F,t}\right) + sSMB_t + hHML_t + \varepsilon_t \tag{18}$$

where $D_{Up,t}$ ($D_{Down,t}$) is a dummy variable equaling 1 if the price of crude oil/natural gas increases (decreases). Comparing coefficients α_1 and α_2 allows us to make inferences on the value of hedging subject to different market conditions.

One of the defining characteristics of our sampling period is elevated oil and gas prices. As a result, we also aim to test for a "price level" effect by estimating the following modified model:[13]

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha_1 D_{High,t} + \alpha_2 D_{Low,t} + \beta\left(R_{M,t} - R_{F,t}\right) + sSMB_t + hHML_t + \varepsilon_t \tag{19}$$

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[10] Although hedgers and non-hedgers can generally only be identified *ex-post*, decisions to hedge between years are highly correlated. That is, a firm that hedges in year *t* is most likely to hedge in year *t+1*. Similarly, a firm that doesn't hedge in year *t* is not likely to hedge in year *t+1*. In addition, hedgers can sometimes be identified in prior year(s) due to long-dated hedging contracts that remain effective in future years. As a result, an *ex-ante* trading strategy can be constructed based on firm hedging history.

[11] We are extremely grateful to an anonymous referee who alerted us to these important points.

[12] All data for the right hand side variables are collected from Kenneth R. French's website at: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[13] We thank an anonymous referee for suggesting this line of inquiry.

where $D_{High,t}$ = 1 ($D_{Low,t}$ = 1) if crude oil/gas price is greater (less) than the sample median or 0 otherwise. In addition, we employ a two-way interaction between D_{High}/D_{Low} and $D_{Up}/\ D_{Down}$ to investigate the price effect in times of crude oil/natural gas price increase/decrease.

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha_1 D_{High,t} * D_{Up,t} + \alpha_2 D_{Low,t} * D_{Up,t} + \alpha_3 D_{High,t} * D_{Down,t} + \alpha_4 D_{Low,t} * D_{Down,t} + \beta(R_{M,t} - R_{F,t}) + sSMB_t + hHML_t + \varepsilon_t \quad (20)$$

Finally, to investigate how commodity price volatility impacts the dynamics between hedging and firm value, we construct two dummy variables based on the implied volatility of one-year options on oil and natural gas futures contracts that are traded on the New York Mercantile Exchange. The dummy IV_{High} = 1 (IV_{Low} = 1) if implied oil/gas price volatility is greater (less) than the sample median or 0 otherwise. We then estimate the following regression:

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha_1 IV_{High,t} + \alpha_2 IV_{Low,t} + \beta(R_{M,t} - R_{F,t}) + sSMB_t + hHML_t + \varepsilon_t \quad (21)$$

To vary the analysis, we condition the intercept on a continuous implied volatility measure as follows:

$$R_{HEDGER,t} - R_{NONHEDGER,t} = (\alpha_0 + \alpha_1 * \mathrm{IV}_t) + \beta(R_{M,t} - R_{F,t}) + sSMB_t + hHML_t + \varepsilon_t \quad (22)$$

where (to aid interpretation) the implied volatility (IV) variable is "median-adjusted". Therefore, α_0 reflects the average hedging premium when the median IV occurs, while α_1 represents the rate that the hedging premium changes as the IV changes.

4. Results

4.1 Tobin's Q Analysis

The results of multivariate modeling of Tobin's Q are reported in Table 5, where Panel A shows the outcome of pooled cross-sectional time-series least squares regression with firm value measured by Ln(Q_1), while in Panels B and C, the dependent variable is Ln(Q_2) and Ln(Q_3), respectively. To make the analysis comparable to other studies, initially we focus on results from Panel A with the Q1 measure for which the denominator is the book value of total assets.

The estimated coefficient on the hedging dummy is negative and significant at the 1% level for both oil and gas, which suggests a hedging discount. Based on these results in Panel A, firms with oil (gas) hedging activities are associated with a lower market value of 11.9% (14.7%). The result is similar in Panel C where firm value is measured by Q_3. Firms with oil hedging activities have a 14.3% lower market value. The result in relation to the hedging dummy is rather striking in that hedging is associated with a firm value discount of a substantial magnitude.

Panel A also reports negative and significant coefficients on production hedging for both oil and gas regressions — once again indicating that hedging is associated with lower firm value. Specifically, the coefficient of delta production for oil (gas) companies is –0.215 (-0.171), which implies that a 1% increase in the extent of which next year's production is hedged is associated with a 0.215% (0.171%) decrease in firm value. An alternative interpretation is that if a non-hedger were to switch from a no hedging policy to a full hedging policy, i.e. hedge 100% of their oil (gas) production the following year, their firm value would be lowered by 21.5% (17.1%). However, as oil (gas) producers in our sample, on average, hedge around 37.94% (37.43%) of their gas production in the next year, the implied average effect of hedging activities on firm value is a discount of 8.2% (6.4%). The delta production coefficients are also not significant for regressions using Q2 and Q3.

The results are mixed in relation to the delta reserves variable, measured as the ratio of the total hedge position over proven oil/gas reserves in the same fiscal year. A strong negative (i.e. discount) result is obtained from the Q_1 measure as reported in Panel A. In terms of economic significance, when taking into account the fact that firms on average only hedge 3.78% (3.73%) of their total oil (gas) reserves, the hedging discount can be realistically estimated to be 7.4% and 6.7% for oil and gas hedgers, respectively.

Table 5 further shows that most control variables have expected signs across all panels. The coefficient on log total assets is negative and significant at the 1% level in Panels A and B, consistent with Lang and Stulz (1994) and Allayannis and Weston (2001). The coefficient on growth (measured as the ratio of capital expenditure over total assets) shows a statistically positive relationship with respect to firm value. The market gives a premium to firms with high capital expenditure and investment opportunities, which supports the evidence from Allayannis and Weston (2001). Firms with any form of payout (dividend or share repurchase) during the fiscal year have a significantly higher Q ratio as payouts can indicate positive signals from management about future profitability. Firms with higher leverage are associated with a lower Q ratio. Production costs, on the other hand, do not appear to have any impact on firm value. Return on assets (ROA) is the only variable that does not conform to expectations: ROA is associated with lower firm value, which is counter intuitive as profitable firms are expected to be more highly valued by the market.

4.2 *The Value of Hedging Conditional on Commodity Price Movements*

The impact of commodity price movements on the dynamics of the relationship between hedging and firm value are reported in Table 6.[14] As previously explained, we capture the effect of commodity price movements using two different approaches. In the first instance, we use a dummy variable indicating whether the oil/gas price has risen in a particular year. Second, we calculate a continuous variable that measures the return on the oil/gas price.

As is evident in Table 6, regardless of the way Tobin's Q is calculated, corporate hedging of oil and gas is directly related to a discount during periods of increasing prices (significant at the 1% level in most cases). The strength of this relationship manifests in both facets of the hedging decision: to hedge or not and how much to hedge. In general, firms that hedge during periods of increasing prices experience lower firm value than non-hedgers. In addition, as firms hedge more and more of their future production and current oil/gas reserves, their firm value is further penalized by the market. In economic terms, the existence of an oil hedging program during inflationary price periods results in a hedging discount of about 20-23% if firms are fully hedged. Similarly, the incidence of gas hedging is related to lower firm value (14-20% under a fully hedged scenario).

The results for the other hedging variables, *DeltaPro* and *DeltaRes*, also support the hypothesis that hedging activities during periods of upward price movements are associated with lower firm value. For oil, the significant negative coefficients for delta production suggest a 13% value discount for an average firm that hedges 38% of future production. The extent of oil reserves hedged, as measured by *DeltaRes*, similarly shows a hedging discount of up to 10% for a typical firm that hedges 3.8% of their current oil reserves. The gas models produce qualitatively similar results, although the discounts are somewhat smaller.

Of particular note, however, is the fact that the hedging discount is only present during periods of increasing prices. During periods when oil and gas prices fall, hedging is either value neutral or, in some cases, associated with higher firm value as measured by Q_2 and Q_3. This finding, however, appears to be stronger for gas as opposed to oil. In terms of economic significance, the extent of any hedging premium is, on average, around 12%. These figures are broadly consistent with Allayannis and Weston (2001), Carter et al. (2006) and Lookman (2003), who report that hedging creates a premium of 3.6% to 14% and can, in some excessive cases, reach 16%-26%.

The results documented in Table 6 highlight the important conditioning effect of price movement in the relationship between hedging and firm value. Indeed, the overall negative relationship between hedging and firm value documented in Table 5 appears to be driven predominantly by the fact that despite short term fluctuations, oil and gas

[14] To conserve space, the coefficients relating to the control variables are not reported here or in all remaining tables. They are available from authors upon request.

prices have generally followed an upward trend over our sample period. In particular, the price of oil and gas has increased in 7 and 8 years, respectively, out of 12 sampling years.

Our finding that the relationship between hedging and firm value is largely conditional on the movement of the underlying asset price is further reinforced in our analysis whereby continuous return measures are used to gauge the extent of the price movement. We find overwhelmingly strong evidence that when oil/gas prices increase, hedging destroys rather than adds to firm value.[15]

4.3 *Fama French Three-factor Alpha*

The results from our initial Fama French specification that aims at identifying the baseline "ex ante" value of hedging are presented in Panel A of Table 7. The coefficient of interest, alpha, is a risk-adjusted measure of the value of hedging. In particular, it shows the risk-adjusted difference between the return of a portfolio of hedgers and a portfolio of non-hedgers.

As can be seen from Panel A, both oil and gas hedgers are found to underperform compared to their respective non-hedger counterparts by a magnitude of approximately 1% a month. This result is largely consistent with the previously documented notion of a hedging discount for our sample period.[16] In Panel B, we extend the analysis to identify whether the hedging discount is related to specific market conditions. In this vein, we split the intercept into two parts that relate to market conditions, defined by increasing versus decreasing oil and gas prices. Interestingly, our analysis shows that hedgers only underperform against non-hedgers during periods of increasing oil and gas prices. Specifically, we find that compared to non-hedgers, oil and gas hedgers have monthly stock returns that are around 2% lower when the price of oil/gas increases. On the other hand, during periods characterized by falling oil and gas prices, the risk-adjusted market performance of hedgers is not statistically distinguishable from that of non-hedgers.

Table 8 presents results relating to the price level effect. We find that the price level *per se* does not play a major role in affecting the market value of hedging, with the exception of gas hedgers who seem to underperform when gas price levels are below the median price (Panel A). Interacting the price level variable with the direction of the price movement, however, produces interesting results. Specifically, as shown in Panel B, oil and gas hedgers severely underperform against their non-hedging counterparts in the vicinity of 2.2-2.5% per month when the price is *both* high and increasing.

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[15] To conserve space, we refrain from tabulating these results. They are available from authors upon request.

[16] In unreported results, we also find that firms that never hedged over the entire sample window significantly outperform hedged firms. In addition, we fail to find any evidence that active hedgers (those that have larger than the median standard deviation of the annual hedge ratios) perform any better than non-active hedgers (those that have smaller than the median standard deviation of the annual hedge ratios). We thank an anonymous referee for prompting us to undertake these additional analyses.

Additionally, when the gas price is low *and* increasing, gas hedgers underperform as well. For all other market conditions, we fail to find any difference in the performance of hedgers and non-hedgers.

Our final set of Fama French model results focus on the impact of *ex ante* volatility on the value of hedging–firm value paradigm presented in Table 9. Using implied volatility as an *ex-ante* measure of oil and gas price volatility, the results in Panel A show that volatility does not appear to impact the hedging–firm value relationship for oil companies. Regardless of the volatility level, oil hedgers and non-hedger portfolios do not demonstrate any statistically significant difference in their market returns. In contrast, there is some evidence that gas hedgers underperform against their non-hedger counterparts in a low volatility environment. This result is largely consistent with the widely-held belief that hedging is more valuable when there is high volatility in the price of the underlying asset. In Panel B of Table 9, we present results that aim to identify the impact of hedging on firm value as volatility changes (as a continuous variable). No significant pattern is evident.

In summary, the Fama-French three factor model results are consistent with our findings documented in the preceding section. In general, there is a hedging discount for oil and gas exploration and production companies over our sample period. Importantly, this hedging discount is specifically related to periods of elevating oil and gas prices (especially if the price is high). The findings provide strong support to our main conjecture that, in assessing the value of hedging for oil and gas exploration and production companies, it is the direction of oil and gas price movements that matters.

4.4 Robustness Checks[17]

4.4.1 Hedging and Firm Value: Linear Payoff Versus Non-linear Payoff Derivatives

As a first robustness check, we examine the merit of linear payoff contracts as opposed to non-linear payoff contracts in hedging commodity price risk. In unreported results, and in the presence of commodity price increases, we find that the use of non-option contracts consistently relates to lower firm value for both oil and gas producers. Interestingly, there is some evidence to indicate that despite price increases, the use of options contracts has a positive correlation with firm value. Taken together, it can be concluded that the market penalizes linear payoff contracts more severely during periods of adverse price movements.

Nevertheless, when oil and gas prices decrease, options hedging in general does not portray any statistically significant relationship to firm value — plausibly, due to the fact that any potential gains on the contracts are somewhat offset by the initial premiums. Linear payoff hedging contracts, as expected, are generally associated with a hedging premium in this situation. Overall, our results provide some support for the

[17] To conserve space, we refrain from tabulating the results relating to sub-sections 4.4.1 to 4.4.3. They are available from the authors upon request.

widely-believed notion that options are more valuable to oil and gas producers than linear payoff contracts in periods of adverse price movements.

4.4.2 *Outlier Removal*

The main purpose of this exercise is to minimize the noise in the data and to depict the relationship between hedging and firm value more reliably. Specifically, observations with production hedging ratios (delta) in excess of 1 are removed from the sample. A delta greater than 1 suggests that the firm hedges more than 100% of next year's production. As a result, derivatives usage in these firms may be driven by factors other than a desire to hedge oil and gas exposures. A total of 22 firm-year observations are removed in total from both oil and gas samples. This process has minimal impact, however, as hedging continues to be associated with lower firm value when oil and gas prices increase, while the relationship takes on a positive value when oil/gas prices decrease.

4.4.3 *Fixed Effects*

As another robustness check, the fixed effect model is used to estimate the coefficients instead of the pooled OLS model. There are characteristics that are difficult to observe or measure, and which vary across firms but remain constant over time, or vary across periods but remain constant across firms. By using the simplest and most common method of balanced panel data — pooled OLS — the estimator can be biased because this method does not take into account the effect of heterogeneity. The (unreported) results are very robust to the alternative estimation technique; there is a negative relationship between hedging and firm value conditional on increasing oil/gas prices while, in the presence of falling prices, hedging has a positive impact on firm value.

4.4.4 *Causality Test*

In this section, we address the potential causality issue in which both firm value and derivatives usage are endogenously determined. For this purpose, we re-estimate our baseline regressions using 2 stage least squares (2SLS). Identifying good instrumental variables that are correlated with hedging but only influence firm value through their impact on hedging is a challenging task. In the context of Equations (6) to (8), we choose the lagged variable *HedDum (-1)*, percentage of Directors with an accounting background and percentage of CEO compensation in cash as the instrumental variables.[18] A director with an accounting background is defined as having either a degree in accounting or holding an industry certification such as CPA or CA. CEO compensation in cash is defined as cash salary plus cash bonuses. The logic underlying our choice of these instrumental variables is as follows. A board that is more dominated by directors with an accounting background is more likely to be conservative and, hence, the company is more likely to hedge. On the other hand, the higher is the percentage of cash remuneration to which the CEO is entitled, the lower are the

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[18] Due to extreme difficulty involved in collecting reliable and complete data on director's accounting background and CEO compensation, we confine this extended analysis to the period 2005 – 2009.

incentives for the CEO to participate in activities with uncertain outcomes. A higher propensity to hedge is therefore likely to follow.

Table 10 reports the 2SLS results and we see that for LnQ1 there is still evidence of a negative relationship between hedging and firm value, although such evidence is weaker and limited to gas producers only. However, in terms of economic significance, the 2SLS results suggest a higher hedging discount. For example, firms with gas hedging activities are associated with a lower market value of 19.1%, compared to a hedging discount of 14.7% reported previously. Not only is the incidence of hedging behaviour related to lower firm value for gas producers, the extent of hedging as measured by *DeltaRes* also appears to be associated with more severe hedging discounts. Specifically, a 1% increase in the hedging of next year's total gas reserves is associated with a 4.279% decrease in firm value for gas hedgers under a fully hedged scenario. Given that firms on average only hedge 3.73% of their total gas reserves, the hedging discount can meaningfully be expressed as approximately 16% for gas hedgers. Similar to the OLS results, when LnQ2 and LnQ3 are used as measures of firm value, we find no evidence of a hedging discount.

In unreported results, we also re-estimate Equations (9) to (11) using 2SLS. This alternative analysis reinforces our findings reported earlier that the relationship between firm value and hedging is strongly conditional on commodity price movements. In particular, the hedging discount is largely symptomatic of increasing oil and gas prices.

We also report test statistics for the Sargan test in Table 10, whereby the null hypothesis is that the instrumental variables are exogenous, i.e. they are uncorrelated to some set of residuals. We fail to reject this null hypothesis in all cases, which suggests that our chosen instrumental variables are valid. However, the Hausman test shows that the hedging variable is exogenous, which suggests that using 2SLS might not be necessary (at least from a statistical point of view).

5. Conclusion

In this paper, we present an empirical study of the impact of hedging on firm value across a broad sample of 94 US oil and gas exploration and production companies over the period of 1998 to 2009. We document a negative and significant relationship between hedging and firm value, i.e. a hedging discount. At a theoretical level, hedging can enhance firm value by reducing the costs relating to underinvestment and financial distress. Nevertheless, there is little reason to expect that these costs materialize in the presence of upside risk. As a result, unlike the previously believed notion that hedging always adds value, we hypothesize that hedging adds value only in the presence of downside risk, when underinvestment and financial distress risks are more substantial. Empirically, we provide strong evidence that for a sample of oil and gas producers, when oil and gas prices increase, hedging generally relates to lower firm value. In contrast, when oil and gas prices decline, hedging and firm value are unrelated.

The main contribution of this paper relates to our key finding that the ability of corporate hedging via the use of derivatives in influencing firm market value is asymmetric and largely conditional on the movement of the underlying asset price. This finding helps explain the variation in results previously documented in the literature regarding the relationship between hedging and firm value.

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Figure 1: Crude Oil and Natural Gas Prices 1998 – 2009

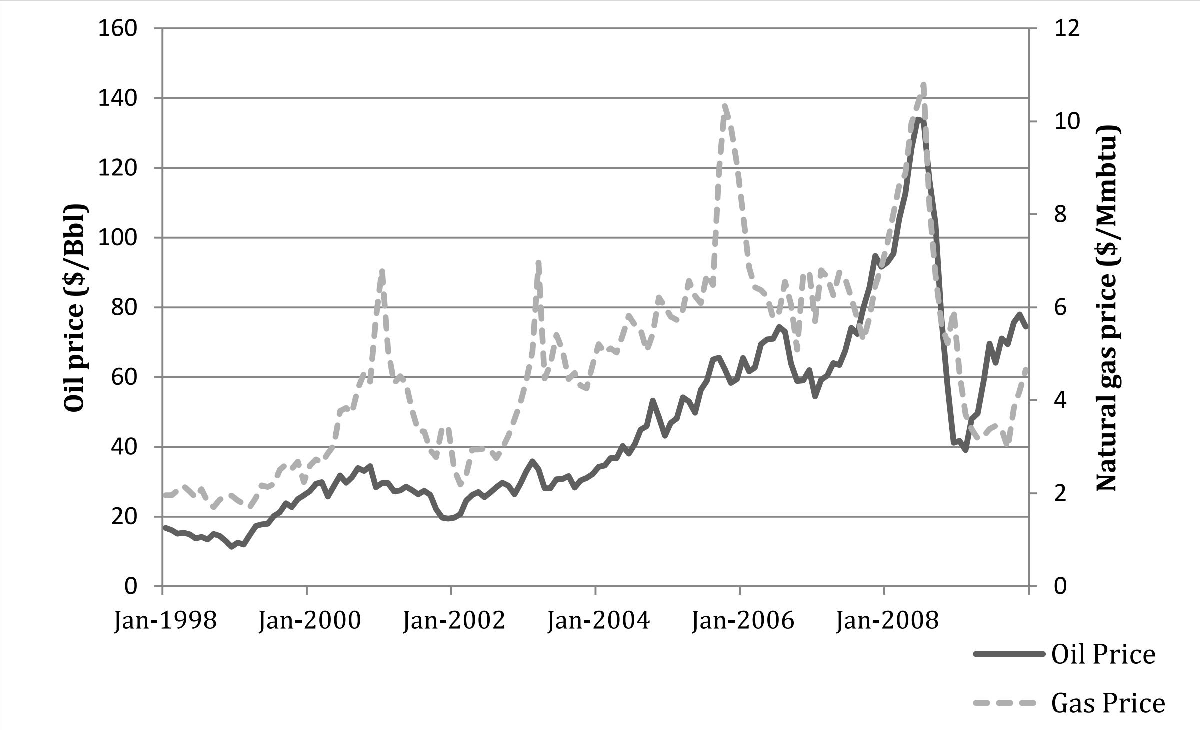

Table 1: Description of Sample by Exposure and Hedging Decisions

Panel A splits the total sample of 840 firm-years into observations with and without oil exposure, and with and without gas exposure. The observation is said to have oil/gas exposure when the firm explores and produces oil/gas and thus are exposed to oil/gas prices in that year. Panel B partitions the sample into observations with or without hedging activities as oil hedgers and non-oil hedgers and as gas hedgers and non-gas hedgers.

Panel A: Distribution of Exposures Across Firm-Years

	Oil exposure	Non-oil exposure	Total
Gas exposure	812	24	836
Non-gas exposure	4	0	4
Total	816	24	840

Panel B : Distribution of Hedging Decisions for Firm-Years with Exposure to Both Factors

	Oil Hedgers	Non-oil Hedgers	Total
Gas hedgers	331	113	444
Non-gas hedgers	46	350	396
Total	377	463	840

Table 2: Summary Statistics for Firm Characteristics

Panel A describes the sample of 94 US oil and gas companies from 1998 to 2009. Sub-samples of firm-years with oil hedging activity are reported in Panel B and those with gas hedging activity are reported in Panel C. Panel D describes firm-years without any hedging activity. Total assets represent BV of assets. The value of reserves is the standardized measure of oil and gas reserves, as reported in 10-K annual reports. Oil/gas production hedged is the total amount of hedging divided by the actual production next year. Oil/gas reserves hedged is the amount of hedging divided by the oil/gas reserves reported for the same year. The three Q ratios share the same numerator and differ only in the denominator. Numerator = BV total assets – BV common equity + MV common equity. The denominators for Q_1, Q_2, Q_3, are BV total assets; BV total assets – BV oil/gas proved reserves + MV proved reserves; and BV total assets – BV oil/gas proved reserves + NPV proved reserves, respectively.

	Mean	SD	Median	10^{th} perc	90^{th} perc	Max
Panel A: All Firm-Years (N=840)						
Total Assets ($m)	2,420	6,339	387	34	5,287	58,844
MVE ($m)	2,035	4,939	341	26	4,739	39,495
Reserves ($m)	1,962	4,997	315	21	4,473	48,739
Q_1	1.86	1.83	1.42	0.90	2.99	16.22
Q_2	0.52	0.80	0.40	0.19	0.88	6.60
Q_3	1.76	1.73	1.44	0.66	2.98	12.72
Panel B: Firm-Years with Oil Hedging Activity (N=377)						
Total Assets ($m)	4,120	8,196	908	162	10,247	58,844
MVE ($m)	3,214	5,942	844	82	8,583	35,803
Reserves ($m)	3,370	6,575	797	118	8,478	48,739
Oil Delta Pro (%)	37.94	30.10	31.34	5.77	78.56	182.34
Oil Delta Res (%)	3.78	3.73	2.75	0.47	8.59	30.86
Q_1	1.51	0.54	1.39	0.93	2.17	4.35
Q_2	0.43	0.33	0.40	0.18	0.71	2.13
Q_3	1.59	1.49	1.44	0.71	2.44	7.70
Panel C: Firm-Years with Gas Hedging Activity (N=444)						
Total Assets ($m)	4108	8237	942	147	10539	58,844
MVE ($m)	3429	6413	879	67	9638	39,495
Reserves ($m)	3327	6484	822	118	8495	48,739
Gas Delta Pro (%)	37.43	26.49	33.61	5.60	72.50	166.98
Gas Delta Res (%)	3.73	3.14	3.02	0.57	7.81	19.97
Q_1	1.57	0.89	1.37	0.95	2.29	10.54
Q_2	0.43	0.29	0.40	0.21	0.69	2.13
Q_3	1.67	1.44	1.48	0.78	2.62	7.42
Panel D: Firm-Years without Hedging Activity (N=350)						
Total Assets ($m)	421	922	86	19	1,249	8,934
MVE ($m)	391	742	120	13	956	6,839

Reserves ($m)	355	855	59	7	1,164	8,013
Q_1	2.24	2.59	1.46	0.79	4.13	16.22
Q_2	0.63	1.18	0.43	0.17	1.18	6.60
Q_3	1.90	2.08	1.32	0.55	3.81	12.72

Table 3: Types of Financial Derivatives by Frequency of Usage

This table details the frequency of usage for linear-payoff instruments such as futures, forwards and swaps versus non-linear payoff instruments such as options for hedgers. Panel A presents the frequency of usage for oil hedgers and Panel B shows the results for gas hedgers.

Panel A: Oil Producers			
	Options	No Options	Total
Futures/Swaps	100	173	273
No Futures/Swaps	104	0	104
Total	204	173	377
Panel B: Gas Producers			
	Options	No options	Total
Futures/Swaps	178	176	354
No Futures/Swaps	90	0	90
Total	268	176	444

Table 4: Descriptive Statistics for the Types of Financial Derivatives used by Oil and Gas Hedgers

This table presents the descriptive statistics for hedging deltas corresponding to different types of financial derivatives. Non-option Delta_Pro is the ratio of next year's production hedged using non-option contracts such as futures/forwards and swaps. Option Delta_Pro is the ratio of next year's production hedged using options. Non-option Delta_Res is the proportion of total reserves hedged using non-option contracts. Similarly, Option Delta_Res is the proportion of total reserves hedged using option contracts. Panel A and Panel B present the descriptive statistics in relation to oil hedgers and gas hedgers, respectively.

Panel A: Oil Hedgers

	Non-Option Delta_Pro	Option Delta_Pro	Non-Option Delta_Res	Option Delta_Res
Mean	24.51%	13.43%	2.50%	1.28%
Median	16.65%	1.30%	1.39%	0.06%
SD	27.96%	20.94%	3.36%	2.08%
Min	0.00%	0.00%	0.00%	0.00%
Max	138.48%	140.77%	19.61%	13.91%

Panel B: Gas Hedgers

	Non-Option Delta_Pro	Option Delta_Pro	Non-Option Delta_Res	Option Delta_Res
Mean	25.72%	11.71%	2.48%	1.25%
Median	19.26%	3.14%	1.75%	0.31%
SD	26.43%	17.03%	2.87%	2.08%
Min	0.00%	0.00%	0.00%	0.00%
Max	137.52%	100.59%	19.97%	13.20%

Table 5: Hedging and Firm Value — Baseline Cross-sectional Results

This table presents the results of the pooled cross-sectional time-series least squares regressions on the impact of hedging on firm value. The models are presented as Equations (6), (7) and (8) in the main text. The three alternative dependent variables are measured by the natural log of Q_1, Q_2, and Q_3. The sample includes 94 firms from 1998 to 2009, or a total of 840 firm-year observations. The variable HedDum is a dummy variable equal to 1 if the company hedges; DeltaPro is delta production and is calculated as the ratio of the total value of hedges to production; and delta reserves (DeltaRes) is the ratio of total value of hedges to reserves. The control variables are as follows: log (assets) is the log of BV of total assets; *ROA* is the ratio of net income to total assets; Investment growth is the ratio of capital expenditure over total assets; Leverage is the BV of long-term debt over MV of common equity; Payout dummy equals 1 if the firm has some form of payout via either dividends or share repurchases in the current year; and Production cost is the dollar cost per barrel of oil equivalent. For brevity, the reporting of control variables is suppressed in Panels B and C. *t*-statistics are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

	Oil			Gas		
	1	2	3	1	2	3
Panel A: Dependent Variable is LnQ_1						
Constant	0.468***	0.488***	0.547***	0.486***	0.532***	0.526***
	(6.40)	(6.86)	(7.73)	(6.49)	(7.30)	(7.33)
Hedging dummy	-0.119***			-0.147***		
	(-2.80)			(-3.36)		
DeltaPro		-0.215***			-0.171**	
		(-3.02)			(-2.38)	
DeltaRes			-1.968***			-1.798***
			(-3.25)			(-2.70)
Log(assets)	-0.093***	-0.107***	-0.123***	-0.074***	-0.108***	-0.103***
	(-3.43)	(-4.32)	(-5.06)	(-2.62)	(-4.39)	(-4.20)
ROA	0.134	0.132	0.058	0.140	0.141	0.150
	(1.45)	(1.43)	(0.61)	(1.52)	(1.53)	(1.64)
Invest Growth	0.847***	0.840***	0.830***	0.860***	0.845***	0.835***
	(6.53)	(6.47)	(6.40)	(6.77)	(6.63)	(6.62)
Payout dummy	0.086*	0.086*	0.128***	0.074*	0.081*	0.071
	(1.94)	(1.95)	(2.88)	(1.67)	(1.82)	(1.60)
Leverage	-0.002*	-0.002*	-0.002*	-0.002*	-0.002*	-0.002*
	(-1.78)	(-1.81)	(-1.92)	(-1.84)	(-1.79)	(-1.93)
Production Cost	0.005	0.005	0.003	-0.001	0.002	-0.003
	(1.42)	(1.49)	(0.74)	(-0.06)	(0.10)	(-0.16)
Observations	735	735	715	739	739	737
R-squared	9.93%	10.09%	11.17%	10.11%	9.42%	9.40%
Panel B: Dependent Variable is LnQ_2						
Constant	-0.647***	-0.644***	-0.578***	-0.675***	-0.652***	-0.638***
	(-7.03)	(-7.18)	(-6.33)	(-7.15)	(-7.12)	(-6.99)
Hedging dummy	-0.044			-0.058		
	(-0.82)			(-1.05)		
DeltaPro		-0.109			-0.032	
		(-1.22)			(-0.35)	
DeltaRes			1.459*			1.304
			(1.87)			(1.54)
Observations	734	734	714	738	738	736
R-squared	3.84%	3.94%	4.54%	4.05%	3.92%	4.14%
Panel C: Dependent Variable is LnQ3						
Constant	-0.140*	-0.086	-0.088	-0.138	-0.102	-0.117
	(-1.67)	(-1.04)	(-1.05)	(-1.60)	(-1.22)	(-1.41)

Hedging dummy	-0.143***			-0.048		
	(-2.92)			(-0.95)		
DeltaPro		-0.074			0.103	
		(-0.90)			(1.25)	
DeltaRes			-0.429			0.469
			(-0.60)			(0.61)
Observations	734	734	714	738	738	736
R-squared	9.38%	8.41%	8.92%	9.04%	9.12%	9.04%

Table 6: Hedging and Firm Value Conditioned on the Direction of Commodity Price Movement

This table presents the results of the pooled cross-sectional time-series least squares regression on the impact of hedging on firm value, conditioned on the annual direction of the movement in oil and gas prices. The models are presented as Equations (9), (10) and (11) in the main text. The reporting of control variables is suppressed to conserve space. The dependent variables are measured by the natural log of Q_1, Q_2, and Q_3. The sample includes 94 oil/gas firms from 1998 to 2009, or a total of 840 firm-year observations. D_U is the dummy variable equaling 1 if the annual return of oil/gas is positive during year I and 0 otherwise. Other variables remain the same as described above. *t*-statistics are reported in parentheses. *,**,*** denote significance at the 10%, 5% and 1% levels, respectively. For brevity, the coefficients relating to the constant and control variables are not reported.

	Oil			Gas		
	1	2	3	1	2	3
Panel A: Dependent Variable is LnQ_1						
Constant	0.453***	0.493***	0.555***	0.439***	0.511***	0.512***
	(5.91)	(6.71)	(7.61)	(5.44)	(6.60)	(6.73)
Hedging*D_U	-0.199***	-0.363***	-2.843***	-0.205***	-0.271***	-2.346***
	(-3.67)	(-3.62)	(-3.36)	(-3.93)	(-2.85)	(-2.80)
Hedging*(1-D_U)	-0.019	-0.080	-1.062	-0.054	-0.051	-0.934
	(-0.33)	(-0.85)	(-1.27)	(-0.85)	(-0.49)	(-0.90)
D_U	0.023	-0.014	-0.022	0.082	0.037	0.026
	(0.46)	(-0.32)	(-0.53)	(1.54)	(0.80)	(0.57)
R-squared	10.96%	10.95%	11.70%	10.62%	9.74%	9.54%
Panel B: Dependent Variable is LnQ_2						
Constant	-0.559***	-0.561***	-0.484***	0.595***	-0.566***	-0.536**
	(-5.92)	(-6.21)	(-5.25)	(-5.97)	(-5.96)	(-5.67)
Hedging*D_U	-0.101	-0.343***	0.372	-0.143**	-0.304**	-0.506
	(-1.51)	(-2.78)	(0.35)	(-2.23)	(-2.61)	(-0.49)
Hedging*(1-D_U)	0.055	0.113	2.783**	0.094	0.209	3.466**
	(0.77)	(0.97)	(2.64)	(1.20)	(1.63)	(2.68)
D_U	-0.198***	-0.193***	-0.223***	-0.129*	-0.156***	-0.172***
	(-3.29)	(-3.67)	(-4.28)	(-1.96)	(-2.74)	(-3.07)
R-squared	8.55%	9.27%	9.05%	8.49%	8.77%	8.41%
Panel C: Dependent Variable is LnQ_3						
Constant	-0.148*	-0.088	-0.081	-0.163	-0.112	-0.109
	(-1.69)	(-1.04)	(-0.95)	(-1.76)	(-1.26)	(-1.24)
Hedging*D_U	-0.230***	-0.345***	-2.186**	-0.138**	-0.109	-0.843
	(-3.68)	(-2.99)	(-2.20)	(-2.31)	(-1.00)	(-0.87)
Hedging*(1-D_U)	-0.033	0.171	1.367	0.101	0.337***	2.341*
	(-0.50)	(1.57)	(1.39)	(1.39)	(2.82)	(1.95)
D_U	0.007	0.000	-0.021	0.049	0.017	-0.011
	(0.12)	(-0.01)	(-0.44)	(0.80)	(0.31)	(-0.20)
R-squared	10.48%	10.29%	10.20%	10.35%	10.41%	9.92%

Table 7: Value of Hedging using Fama-French Three-factor Model Alpha

This table presents the results from testing the hedging premium using the Fama-French three-factor model. The models relevant to Panels A and B, respectively, are:

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha + \beta(R_{M,t} - R_{F,t}) + sSMB_t + hHML_t + \varepsilon_t \quad (17)$$

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha_1 D_{Up,t} + \alpha_2 D_{Down,t} + \beta(R_{M,t} - R_{F,t}) + sSMB_t + hHML_t + \varepsilon_t \quad (18)$$

where $R_{HEDGER,t}$ is the return in month t of a portfolio comprising of hedgers and $R_{NONHEDGER,t}$ is the return in month t of a portfolio comprising of non-hedgers. The portfolio weights are based on the percentage of the production hedged for the hedger portfolio and equal weights for the non-hedger portfolio. $R_{M,t}$ is the market return and $R_{F,t}$ is the risk free rate. SMB_t is the difference between the returns on a portfolio of small stocks and a portfolio of big stocks. HML_t is the difference between the returns on a portfolio of high book-to-market ratio stocks and a portfolio of low book-to-market stocks. Market return, risk free rate, SMB and HML data are collected from the Kenneth French website. $D_{Up,t}$ and $D_{Down,t}$ are dummy variables equaling 1 if the crude oil/natural gas price increases or decreases, respectively, and is 0 otherwise. For brevity, the table reports the alpha coefficient estimates only. *t-statistics* are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A: Baseline Results		
	Alpha Estimate	t-value
Oil_Hedger - Oil_NonHedger	-0.980*	(-1.66)
Gas_Hedger - Gas_NonHedger	-1.172**	(-2.07)
Panel B: Hedging Premium with Price Increase/Decrease		
Oil_Hedger - Oil_NonHedger (Up)	-2.001**	(-2.47)
Oil_Hedger - Oil_NonHedger (Down)	0.144	(0.17)
Gas_Hedger - Gas_NonHedger (Up)	-1.929***	(-2.66)
Gas_Hedger - Gas_NonHedger (Down)	0.034	(-0.04)

Table 8: Value of Hedging using Fama-French Three-factor Model Alpha Conditioned on Price Level Effect

This table presents the results from testing the hedging premium using the Fama-French three-factor model. The models relevant to Panels A and B, respectively, are:

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha_1 D_{High,t} + \alpha_2 D_{Low,t} + \beta(R_{M,t} - R_{F,t}) + sSMB_t + hHML_t + \varepsilon_t \quad (19)$$

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha_1 D_{High,t} * D_{Up,t} + \alpha_2 D_{Low,t} * D_{Up,t} + \alpha_3 D_{High,t} * D_{Down,t} + \alpha_4 D_{Low,t} * D_{Down,t} + \beta(R_{M,t} - R_{F,t}) + sSMB_t + hHML_t + \varepsilon_t \quad (20)$$

where $R_{HEDGER,t}$ is the return in month t of a portfolio comprising of hedgers and $R_{NONHEDGER,t}$ is the return in month t of a portfolio comprising of non-hedgers. The portfolio weights are based on the percentage of the production hedged for the hedger portfolio and equal weights for the non-hedger portfolio. $R_{M,t}$ is the market return and $R_{F,t}$ is the risk free rate. SMB_t is the difference between the returns on a portfolio of small stocks and a portfolio of big stocks. HML_t is the difference between the returns on a portfolio of high book-to-market ratio stocks and a portfolio of low book-to-market stocks. Market return, risk free rate, SMB and HML data are collected from the Kenneth French website. $D_{High,t}$= 1 if oil/gas price is greater than sample median or 0 otherwise and $D_{Low,t}$= 1 if oil/gas price is less than sample median or 0otherwise. $D_{Up,t}$ and $D_{Down,t}$ are dummy variables equaling 1 if the crude oil/natural gas price increases or decreases, respectively. For brevity, the table reports the alpha coefficient estimates only. *t-statistics* are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A: Hedging Alpha Conditioned on Price Level Effect		
	Alpha Estimate	t-value
Oil_Hedger - Oil_NonHedger (High)	-1.043	(-1.28)
Oil_Hedger - Oil_NonHedger (Low)	-0.912	(-1.07)
Gas_Hedger - Gas_NonHedger (High)	-0.736	(-0.89)
Gas_Hedger - Gas_NonHedger (Low)	-1.559**	(-2.01)
Panel B: Hedging Alpha Conditioned on Price Level Effect with Price Increase/Decrease		
Oil_Hedger - Oil_NonHedger (High*Up)	-2.483**	(-2.24)
Oil_Hedger - Oil_NonHedger (Low*Up)	-1.487	(-1.29)
Oil_Hedger - Oil_NonHedger (High*Down)	0.602	(0.51)
Oil_Hedger - Oil_NonHedger (Low*Down)	-0.339	(-0.28)
Gas_Hedger - Gas_NonHedger (High*Up)	-2.176**	(-2.05)
Gas_Hedger - Gas_NonHedger (Low*Up)	-1.757*	(-1.83)
Gas_Hedger - Gas_NonHedger (High*Down)	1.395	(1.07)
Gas_Hedger - Gas_NonHedger (Low*Down)	-1.321	(-1.02)

Table 9: Value of Hedging using Fama-French Three-Factor Model Alpha Conditioned on Implied Volatility

This table presents the results for testing the hedging premium using the Fama-French three-factor model. The models relevant to Panels A and B, respectively, are:

$$R_{HEDGER,t} - R_{NONHEDGER,t} = \alpha_1 IV_{High,t} + \alpha_2 IV_{Low,t} + \beta\left(R_{M,t} - R_{F,t}\right) + sSMB_t + hHML_t + \varepsilon_t \tag{21}$$

$$R_{HEDGER,t} - R_{NONHEDGER,t} = (\alpha_0 + \alpha_1 * \mathrm{IV}_t) + \beta\left(R_{M,t} - R_{F,t}\right) + sSMB_t + hHML_t + \varepsilon_t \tag{22}$$

where $R_{HEDGER,t}$ is the return in month t of a portfolio comprising of hedgers and $R_{NONHEDGER,t}$ is the return in month t of a portfolio comprising of non-hedgers. The portfolio weights are based on the percentage of the production hedged for the hedger portfolio and equal weights for the non-hedger portfolio. $R_{M,t}$ is the market return and $R_{F,t}$ is the risk free rate. SMB_t is the difference between the returns on a portfolio of small stocks and a portfolio of big stocks. HML_t is the difference between the returns on a portfolio of high book-to-market ratio stocks and a portfolio of low book-to-market stocks. Market return, risk free rate, SMB and HML data are collected from the Kenneth French website. $IV_{High,t}$ = 1 if oil/gas implied volatility is greater than sample median or 0 otherwise and $IV_{Low,t}$ = 1 if oil/gas price implied volatility is less than sample median or 0 otherwise. The implied volatility is calculated from one year options on oil and natural gas futures contracts that are traded on the New York Mercantile Exchange. For brevity, the table reports the alpha coefficient estimates only. *t-statistics* are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A: Hedging Alpha Conditioned on Implied Volatility		
	Alpha Estimate	t-value
Oil_Hedger - Oil_NonHedger (High)	-1.195	(-1.37)
Oil_Hedger - Oil_NonHedger (Low)	-0.806	(-1.02)
Gas_Hedger - Gas_NonHedger (High)	-0.642	(-0.82)
Gas_Hedger - Gas_NonHedger (Low)	-1.769**	(-2.13)
Panel B: Hedging Alpha Conditioned on Changes in Implied Volatility		
Constant_Oil	-0.965	(-1.62)
IV_Oil	0.018	(0.22)
Constant_Gas	-1.223**	(-2.11)
IV_Gas	0.051	(0.47)

Table 10: Robustness Check of Hedging and Firm Value — 2SLS approach

This table reports the results relating to the effect of hedging activities on firm value using 2SLS. The models are given as Equations (6), (7) and (8) in the main text. The three alternative dependent variables are measured by the natural log of *Q1, Q2*, and *Q3*. The sample includes 94 firms from 2005 to 2009, or a total of 470 firm-year observations. The variable HedDum is a dummy variable equal to 1 if the company hedges; DeltaPro is delta production and is calculated as the ratio of total value of hedges to production; and delta reserves (DeltaRes) is the ratio of total value of hedges to reserves. The control variables are as follows: log (assets) is the log of BV of total assets; ROA is the ratio of net income to total assets; Investment growth is the ratio of capital expenditure over total assets; Leverage is the BV of long-term debt over MV of common equity; Payout dummy equals 1 if the firm has some form of payout via either dividends or share repurchases in the current year; and Production cost is the dollar cost per barrel of oil equivalent. Reporting of control variables is suppressed to conserve space. The instrumental variables are: lagged HedDum, percentage of Directors with an accounting background and percentage of CEO compensation in cash. The first two rows in each panel present the coefficients and *t-statistics* of the hedging variables. The null hypothesis of the Sargan test is that the IVs are exogenous, i.e. they are uncorrelated to some set of residuals. The null hypothesis of the Hausman test is that the hedging variable is exogenous. The p-values for the Sargan and Hausman tests are reported in the third and fourth columns of each panel. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

	Oil			Gas		
	HedDum	DeltaPro	DeltaRes	HedDum	DeltaPro	DeltaRes
Panel A: Dependent Variable is LnQ_1						
Coefficient	-0.107	-0.210	-3.154	-0.191*	-0.351	-4.279*
t-value	(-1.14)	(-1.07)	(-1.45)	(-1.65)	(-1.49)	(-1.69)
Sargan test	0.75	0.698	0.625	0.662	0.548	0.773
Hausman test	0.804	0.566	0.312	0.79	0.334	0.226
Panel B: Dependent Variable is LnQ_2						
Coefficient	0.074	-0.050	2.447	0.083	0.169	2.238
t-value	(0.13)	(-0.06)	(0.29)	(0.52)	(0.53)	(0.66)
Sargan test	0.879	0.873	0.738	0.775	0.776	0.834
Hausman test	0.978	0.938	0.995	0.723	0.902	0.602
Panel C: Dependent Variable is LnQ_3						
Coefficient	0.052	0.138	0.927	0.202	0.384	3.661
t-value	(0.50)	(0.65)	(0.38)	(1.59)	(1.53)	(1.35)
Sargan test	0.579	0.624	0.707	0.626	0.545	0.442
Hausman test	0.219	0.832	0.853	0.303	0.586	0.399

Uncovering the asymmetric linkage between financial derivatives and firm value – the case of oil and gas exploration and production companies

Highlights

- We explore the value enhancing role of hedging in a sample of oil and gas companies
- The value of hedging depends on the movement of oil and gas prices
- Hedging is related to lower firm market value when oil and gas prices increase
- Hedger portfolios in general underperform non-hedger portfolios