

Firm Value and Hedging: Evidence from U.S. Oil and Gas Producers

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ABSTRACT

This paper studies the hedging activities of 119 U.S. oil and gas producers from 1998 to 2001 and evaluates their effect on firm value. Theories of hedging based on market imperfections imply that hedging should increase the firm's market value (MV). To test this hypothesis, we collect detailed information on the extent of hedging and on the valuation of oil and gas reserves. We verify that hedging reduces the firm's stock price sensitivity to oil and gas prices. Contrary to previous studies, however, we find that hedging does not seem to affect MVs for this industry.

IN A CLASSIC MODIGLIANI AND MILLER (M&M) WORLD with perfect capital markets, risk management should be irrelevant. When there are no information asymmetries, taxes, or transaction costs, hedging financial risk should not add value to the firm because shareholders can undo any risk management activities implemented by the firm at the same cost.

In practice, imperfections in capital markets create a rationale for lowering the volatility of earnings through hedging. Conventional explanations relate to the cost of financial distress, tax incentives, and the underinvestment problem. Risk management may also add value if hedging positions in derivatives contracts carry a premium that is not commensurate with risk, or if active trading activities create a profit.

Most empirical studies on this topic focus on the relation between corporate hedging and firm characteristics, and try to determine whether the behavior of firms that hedge is consistent with extant theories. The empirical evidence does not support any single theory, however. In addition, most of these empirical studies provide only indirect evidence that hedging increases firm value. Recently, however, Allayannis and Weston (2001) directly test the relation between firm value and the use of foreign currency derivatives. Using a sample of 720 large firms between 1990 and 1995, they find that the value of firms that hedge, on average, is higher by about 5%. This hedging premium is statistically and economically significant. With a median market value (MV) of about

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\$4 billion, this translates into an average value added of almost \$200 million for firms using foreign currency derivatives—a very large effect.¹

More recently, Carter, Rogers, and Simkins (2005) examine the case of fuel hedging for a sample of U.S. airlines and report an even higher hedging premium of about 14%, albeit with a very large confidence interval. They show that this financial risk is economically very significant for airlines. Moreover, they argue that hedging allows airlines to expand operations when times are bad for the industry, thereby alleviating the underinvestment problem. Apparently, these issues are sufficiently important in this industry to warrant a large hedging premium.

The interpretation of these results is debated, however. Guay and Kothari (2003) analyze the economic effects of derivatives positions for a sample of non-financial derivatives users. They conclude that potential gains on derivatives are small compared to cash flows or movements in equity values, and cannot possibly have an effect of the magnitude claimed. Their interpretation is that either the observed increase in MVs is driven by other risk management activities, such as operational hedges, that are value enhancing and positively correlated with derivatives positions, or it is spurious.

More generally, the finding of a correlation between hedging and firm value may instead reflect the association between two endogenous variables. If hedging increases firm value, why do we not observe all companies operating at the optimum? Coles, Lemmon, and Meschke (2003) discuss a similar endogeneity question in the context of the relation between firm value and managerial ownership. We empirically observe that, up to some point, higher levels of ownership are associated with higher Q ratios, defined as the ratio of MV to replacement value of assets. However, this may reflect different levels of labor productivity and Q ratios across industries. For instance, labor is more productive in service industries, say relative to mining, which justifies higher ownership. At the same time, some service industries are more profitable and grow faster than others, which justifies higher Q ratios. Thus, this endogeneity creates the association between the Q ratio and managerial ownership. A similar dynamic may arise with hedging.

This debate highlights the importance of sample selection. The endogeneity problem should be alleviated by selecting firms within the same industry. We need, however, an industry for which both financial exposure is important and firms vastly differ in terms of their hedging ratios.

This paper revisits the question of the hedging premium for a sample of U.S. oil and gas firms, an ideal controlled sample for studying the relationship between the use of derivatives and the firm's MV. First, movements in energy prices have substantial effects on the cash flows of oil and gas firms. Second, compare an oil producer facing oil price risk with a multinational firm with sales in many foreign countries. An investor cannot easily hedge the currency

¹ On the other hand, Bartram, Brown, and Fehle (2003) examine a larger sample of 7,292 U.S. and non-U.S. firms. They report insignificant effects on currency hedging but a higher Q ratio for firms that engage in interest rate hedging.

risk of the multinational, as the sources of risk are complex and not totally hedgeable.² In fact, Jorion (1990) demonstrates that the foreign currency betas of U.S. multinationals are close to zero. If investors cannot ascertain the extent of the firm's currency exposure, the multinational might benefit from hedging foreign currency risk in the presence of information asymmetries. On the other hand, an investor can easily identify the oil firm's price exposure from its financial reports and hedge it. Accordingly, one might even argue that investors take positions in oil producers precisely to gain exposure to oil prices. If so, an oil firm should not necessarily benefit from hedging oil price risk. Thus, the situation is closer to that of the M&M assumptions.

An oil and gas sample has other benefits. The Allayannis–Weston sample is limited to large firms with assets greater than \$500 million; it is unclear whether hedging adds value to smaller firms as well, given the fixed costs of setting up risk management programs. More importantly, the Allayannis–Weston results could be due to other effects, such as operational hedges, that are correlated with positions in derivatives. The Allayannis–Weston sample covers a large number of firms in different industries with different growth rates. Comparisons of *Q* ratios may be contaminated by the effect of other variables not included in the analysis. In contrast, while the oil and gas industry is more homogeneous, it still offers substantial variation in hedging ratios. The oil and gas industry also discloses much more value-relevant information than other industries. Oil and gas reserves are measured and valued separately from other assets. The industry also discloses extraction costs and a net present value measure of profits from reserves. This information is useful because it lessens the possibility of contamination due to omitted variables.

Our paper helps shed light on the issue of the hedging premium. We study the hedging activities of 119 U.S. oil and gas producers from 1998 to 2001 and examine the relation between hedging and firm value. To our knowledge, this is the largest same-industry sample used to assess the hedging premium, with 330 firm-year observations. The sample size is less than the 720 firms covered by Allayannis and Weston (2001), but larger than the 27 airlines covered by Carter et al. (2005) and the 100 oil and gas firms covered by Haushalter (2000) over 3 years—our tests should have good statistical power. We also have more detailed information about exposures and hedges than other studies. The commodity price exposure of oil and gas firms can be clearly established from the annual 10-K financial reports, as required by the Securities and Exchange Commission's (SEC's) new market risk disclosure rules (1997). We manually collect data from the annual reports and aggregate the delta of all hedging positions, including futures, options, or swaps contracts as well as fixed-price physical delivery contracts and volumetric production payments. These are then compared to current production and total reserves. This procedure is more precise

² For example, Géczy, Minton, and Schrand (1997) study foreign currency derivatives of Fortune 500 firms in 1990, and argue that measuring foreign currency exposure is difficult. They use many sources as an indication of foreign currency exposure, including foreign sales, foreign-denominated debt, pre-tax foreign income, foreign tax expenses, etc.

than using notional amounts and certainly more so than using a simple hedging dummy variable.³

The empirical analysis then proceeds as follows. First, we examine the relation between stock return sensitivity to commodity prices and hedging. We find that oil and gas betas are negatively related to the extent of hedging. Since the market recognizes the effect of hedging, we can test if the market rewards firms that hedge with higher MVs, as measured by using different definitions of Tobin's Q . Tobin's Q is generally defined as the ratio of the MV to the replacement value of assets, where the latter is usually measured as the book value (BV) of assets. In addition, we use the current value of reserves both before and after extraction costs, which should yield more precise estimates of the replacement value of assets. Contrary to previous research, we show that hedging has no discernible effect on firm value for oil and gas producers.

The remainder of the paper is organized as follows. Section I gives a brief review of risk management theories and the empirical evidence. Section II describes the sample and explains the measure of hedging activities and firm value. Section III examines the relation between stock return sensitivity and hedging. Section IV tests the relation between hedging and firm value. Section V concludes.

I. Risk Management Theory and Empirical Evidence

Two classes of theories explain why managers undertake risk management activities. The first is based on shareholder value maximization. The other is based on diversification motives for owners or personal utility maximization for managers.

The shareholder maximization argument states that firms hedge to reduce the various costs involved with highly volatile cash flows. The literature advances three typical lines of explanation. First, hedging reduces the expected cost of financial distress (Mayers and Smith (1982), Smith and Stulz (1985)). Second, hedging may also be motivated by tax incentives. When firms face a convex tax function, hedging should help reduce expected taxes (Mayers and Smith (1982), Smith and Stulz (1985)). Hedging can also increase a firms's debt capacity, therefore generating greater tax advantages from greater leverage (Leland (1998)). Finally, hedging may also help relieve the problem of underinvestment, that is, when firms have many growth opportunities and external financing is more expensive than internally generated funds (Froot, Scharfstein, and Stein (1993)). This underinvestment problem arises when investment opportunities are negatively correlated with cash flows. For instance, airlines suffer from underinvestment when opportunities to buy distressed assets at a good price occur during a down cycle for the industry. The present value of these saved costs should be reflected in a higher market valuation.

³ Tufano (1996) also calculates the delta of the hedging portfolio in a study of the gold mining industry. However, the hedging positions are collected from a quarterly survey, rather than from publicly available financial reports.

Another strand of theory claims that hedging stems from the incentive of managers to maximize their personal utility functions. Risk-averse managers engage in hedging if their wealth and human capital are concentrated in the firm they manage and if they find the cost of hedging on their own account is higher than the cost of hedging at the firm level (Stulz (1984), Smith and Stulz (1985)). In addition, hedging may serve as a signal that helps outside investors better observe managerial ability (DeMarzo and Duffie (1995)). According to this second group of theories, hedging should not affect MVs.

While the empirical literature focuses on the relation between firm characteristics and hedging, trying to identify which theory best explains actual hedging activities, results have been mixed. For instance, risk management activities are found to be more prevalent in large firms. One would expect to find that small firms, which are more likely to experience financial distress, would be more likely to hedge; however, hedging seems to be driven by economies of scale, reflecting the high fixed costs of establishing risk management programs.⁴ On the other hand, Dolde (1995) and Haushalter (2000) report a positive and significant relation between hedging and leverage, consistent with the theory that hedging helps reduce financial distress. Graham and Rogers (2002) provide evidence that tax convexity does not seem to be a factor in the hedging decision but do find that firms hedge to increase debt capacity. This evidence is in line with the second explanation above. Finally, both Nance et al. (1993) and Géczy et al. (1997) find that hedging firms have greater growth opportunities, which is consistent with the argument that hedging mitigates the potential underinvestment problems.

On the whole, however, there is mixed support for value maximization theories. Mian (1996) surveys their implications and reports that the only reliable observation is that hedging firms tend to be larger. Similarly, Tufano (1996) examines the hedging activities of gold mining firms and finds no support for the value maximization theory. Furthermore, he finds strong evidence that supports the managerial risk-aversion theory, according to which managers who hold more stock tend to undertake more hedging activities.

More recently, researchers have been examining the direct relation between firm value and hedging. Allayannis and Weston (2001) provide the first related evidence. They find that the MV of firms using foreign currency derivatives is 5% higher on average than for nonusers. This result is economically important, but puzzling in view of the mixed empirical evidence on hedging theories. Graham and Rogers (2002) argue that derivatives-induced debt capacity increases firm value by 1.1% on average. However, as mentioned previously, the validity of these results is questioned by Guay and Kothari (2003).

In addition, these results are limited to the management of foreign currency risk for large U.S. multinationals. Such firms have nontransparent risk

⁴ These costs include hiring risk management professionals and purchasing computer equipment and software for risk management. See, for example, Nance, Smith, and Smithson (1993), Mian (1996), Géczy et al. (1997), Haushalter (2000), and Graham and Rogers (2002). Brown (2001) estimates annual costs at about \$4 million for a large multinational with \$3 billion in derivatives positions.

exposures. It is not clear whether this hedging premium exists for other types of market risk that can be easily identified and hedged, or within homogeneous industries. This paper helps shed light on these questions by testing the effect of hedging on firm value for oil and gas producers.

II. Sample Description

Our analysis is based on a sample of 119 U.S. oil and gas firms over the period 1998 to 2001. First, we extract from Compustat the list of firms with Standard Industrial Classification (SIC) codes of 1311, which gives a total of 159 firms or at most 636 firm-years. SIC codes describe a group of companies primarily engaged in producing the same group of products or services. Major group 13 represents "Oil and Gas Extraction." SIC code 1311 further restricts this classification to "Crude Petroleum and Natural Gas."⁵ For example, the five largest firms in our sample are Anadarko Petroleum, Occidental Petroleum, Devon Energy, Kerr-McGee, and Burlington Resources. Other well-known oil industry names such as ExxonMobil or ChevronTexaco belong to SIC group 2911, "Petroleum Refining."

Next, we only retain the firms that meet the following criteria: 10-K reports are available from Edgar; oil and gas production or reserves are reported in the 10-Ks; MV of equity is available at either the fiscal year-end or calendar year-end; and there is sufficient information in the 10-Ks to calculate the hedge position. This results in a sample of 154 firms and 449 firm-years. Finally, we require the BV of total assets to be greater than \$20 million.⁶ The final sample consists of 119 firms from 1998 to 2001, or 330 firm-year observations; 59 firms are present in all 4 years.

Table I describes the range of activities for a subset of firms. The table reports segment information available from Compustat for 84 firms (71% of the sample of 119 firms) and 267 firm-years (81% of the sample of 330 firm-years) and shows the percentage of firms engaged in each segment, as well as the distribution of the ratio of both segment sales to total sales and segment assets to total assets, within each category.

All of the firms in our sample engage in exploration and production. Other segments can be classified into: oil and gas refining, processing, and marketing; gas plant and pipeline; contract drilling and oil field services; and others. The table shows that while some firms engage in multiple activities, exploration and production is by far the dominant segment. For the whole sample, 94% of sales and 96% of assets are attributed to exploration and production. The prevalence

⁵ Other SIC codes within this group are: 1321 (Natural Gas Liquids), 1381 (Drilling Oil and Gas Wells), 1382 (Oil and Gas Field Exploration Services), and 1389 (Oil and Gas Field Services).

⁶ Firms with total assets below \$20 million are "small business issuers." These firms may file an Annual Report on Form 10-KSB, which generally requires less disclosure. Therefore, if no hedging is reported, it is hard to determine whether the firm did not hedge or simply did not disclose hedging information.

Table I
Description of Sample by Segment Information

This table describes segment information for the sample of 267 firm-years for which this information is available. The table reports the proportion of firms with one or more segment activities, as well as the distribution of segment to total sales and segment to total assets.

Segment Activities	Number of Observations	Percentage of Sample	Segment Sales/ Total Sales			Segment Assets/ Total Assets		
			Mean	Median	SD	Mean	Median	SD
Exploration, production	267	100.0%	94%	100%	15%	96%	100%	11%
Refining, processing, marketing	16	6.0%	29%	17%	26%	6%	5%	6%
Gas plant, pipeline	3	1.1%	24%	2%	39%	11%	2%	16%
Contract drilling, oil field service	16	6.0%	11%	9%	10%	4%	5%	2%
Others (corporate, trading, etc.)	21	7.9%	28%	31%	25%	30%	32%	15%

of production activities is important because it implies that hedging should involve selling oil or gas fixed-price contracts.⁷

This accounting information confirms that our sample is relatively homogeneous in terms of type of exposure to commodity price risk, which should minimize the issue of endogeneity or spurious correlation between hedging and other variables. At the same time, the oil and gas industry is interesting to analyze due to a wide dispersion in hedging ratios.

A. Hedging Variable

Hedging information for each firm is obtained from the 1998 to 2001 annual reports. In January 1997, the SEC issued Financial Reporting Release No. 48 (hereafter "FRR 48"), which, effective for all firms for fiscal year ending after June 15, 1998, expands disclosure requirements for market risk.⁸ Under FRR 48, firms are required to present quantitative information about market risk in one of the three formats, namely, tabular, sensitivity analysis, or value-at-risk. Most of the oil and gas producers we investigate chose the tabular disclosure. Under this method, instruments should be classified by the following characteristics: (1) fixed or variable rate assets or liabilities; (2) long or short forwards or futures, including those with physical delivery; (3) written or purchased put or

⁷ For some other activities, the hedging policy may differ. For instance, hedging an oil refining operation involves taking positions in crack spreads, which entail buying crude oil and shorting gasoline contracts.

⁸ Financial Reporting Release No. 48: *Disclosure of Accounting Policies for Derivative Financial Instruments and Derivative Commodity Instruments and Disclosure of Quantitative Information About Market Risk Inherent in Derivative Financial Instruments, Other Financial Instruments, and Derivative Commodity Instruments*. The rules are described in Linsmeier and Pearson (1997). For a description of quantitative risk measurement methods, see Jorion (2001).

call options with similar strike prices; and (4) receive-fixed or variable swaps. FRR 48 requires disclosures of contract amounts and weighted average settlement prices for forwards and futures, weighted average pay and receive rates and/or prices for swaps, and contract amounts and weighted average strike prices for options.

Appendix A provides an example of market risk disclosures for Devon Energy, from item 7A in the Annual Report. The company discloses tabular information about commodity price swaps, costless price collars, and fixed-price physical delivery contracts. Devon also indicates that all of its “market risk sensitive instruments were entered into for purposes other than trading.” In other words, its policy is to hedge market risk.

Other companies have positions in futures and options traded on organized exchanges such as the NYMEX. In addition to fixed-price contracts, volumetric production payments are also sometimes used by oil and gas companies (about 5% of our sample). A volumetric production payment is a loan with repayment set in terms of a specified quantity of oil or gas, and is economically equivalent to a forward contract.

Recognizing that there are many different hedging channels, we write a program to search the body of 10-K reports for all keywords related to hedging.⁹ This covers not only item 7A, but also the entire body of the 10-K report because real contracts are sometimes reported under notes to financial statements. We then collect the positions on all reported market-sensitive instruments.¹⁰

These disclosures enable us to measure the net hedging position of each firm with regard to oil and gas, calculated from the sum of the delta equivalent of each position reported at the fiscal year-end. Specifically, we assume $\Delta = -1$ for short positions in all linear hedging instruments of crude oil and natural gas, such as short futures and forwards, receive-fixed swaps, fixed-price contracts, and volumetric production arrangements.¹¹ Long positions are coded with $\Delta = 1$.

For nonlinear contracts such as options and collars, we calculate delta using Black's option pricing model. Other work on the oil and gas industry assumes a unit hedge ratio. We find, however, that a large fraction (approximately 65%) of derivatives users hold options. The typical option hedge ratio is 60% of notional.

⁹ Keywords searched include: Item 7a, quantitative disclosure, risk management, “hedg,” off balance sheet, derivative, value-at-risk, earnings-at-risk, cash flow at risk, sensitivity analysis, commodity risk, price risk, market risk, option contract, futures contract, forward contract, swap, commodity futures, commodity contract, commodity option, oil future, natural gas future, oil forwards, natural gas forwards, collar, fixed price, and volumetric production.

¹⁰ We only consider directional positions on oil and gas prices. Crack spreads (those between gasoline and crude oil prices), or spreads between oil prices in two different locations are ignored.

¹¹ A more precise measure for delta of linear commodity contracts is: $\Delta = e^{(c-y)r}$, where c is the cost of carry and y is the convenience yield. For linear crude oil contracts, delta decreases over time, since the convenience yield (y) is higher than the cost of carry (c). However, most firms have only very short-term crude oil contracts, normally of 1 year or less. Therefore, a delta of 1 is a good approximation. For linear natural gas contracts, $c - y$ is always close to 0, therefore delta is close to 1 even for long-term contracts. We do observe long-term linear natural gas contracts. For example, in 1999 10-K, Louis Dreyfus reports natural gas swaps with maturities ranging from 2004 to 2017; Devon Energy reports fixed-price natural gas contracts with maturities from 2000 through 2004.

Next, we multiply the notional amounts of each contract by their delta and sum them up, to obtain a total delta for crude oil and natural gas.¹² Appendix B illustrates the computations for the total oil delta for Devon. Out of the entire sample of 330 firm-years, all have zero or negative delta in both crude oil and natural gas contracts. Indeed, these firms are using derivatives to hedge, not to speculate.

The total delta is then scaled by annual production or the stock of reserves. For oil, for instance, we have

$$\text{Relative delta oil production} = -\text{Total delta oil}/\text{Next-year oil production} \quad (1)$$

and

$$\text{Relative delta oil reserve} = -\text{Total delta oil}/\text{Same-year proved oil reserve}. \quad (2)$$

The first number calculates the percentage of next-year production that is effectively hedged. The second computes the proportion of current reserves that is effectively hedged. These numbers are positive for hedging firms.

Table II provides more information on the sample. Out of 330 firm-years, 319 have exposure to both oil and gas prices; 11 others have exposure to one risk factor only. For these 319 firms, hedging policies tend to be similar across oil and gas, as shown in Panel B, with most firms hedging both commodities or neither commodity: 106 firms hedge both oil and gas risk; 113 hedge neither. In sum, the hedging variables are collinear across the oil and gas samples.

B. *Q Ratio*

Each firm's MV is measured using a *Q* ratio similar to Tobin's *Q*. Traditionally, Tobin's *Q* is calculated as the ratio of the MV of financial claims on the firm to the current replacement cost of the firm's assets. The resulting unitless metric, used in many other studies,¹³ allows for direct comparisons across firms.

The calculation of Tobin's *Q* is usually quite involved due to the need to compute the MV of long-term debt and the replacement cost of fixed assets.¹⁴ Following previous work, our first measure uses the BV of debt and the BV of assets. In this industry, however, the major assets are oil and gas reserves.

¹² The notional amount of crude oil contracts is expressed in Barrels (Bbl). That of natural gas contracts is stated in Millions of British Thermal Units (Mmbtu). Positions in Natural Gas Liquids (NGL) are also measured in Bbls and, when reported separately from crude oil and natural gas, are assimilated with those in oil. NGL products are distilled with crude oil in refineries and have prices that are highly correlated with oil prices.

¹³ See, for example, Lang and Stulz (1994) and Yermack (1996).

¹⁴ The market value of long-term debt is often calculated using a recursive methodology that estimates the maturity structure of the debt and accounts for changes in the yield. See, for example, Perfect and Wiles (1994). The replacement cost of fixed assets (RCFA) is usually calculated using one of two methods, either by assuming an initiation date on which the RCFA is assumed to be equal to its book value, or by inferring the vintage and depreciation pattern of in-place gross fixed assets. See Lindenberg and Ross (1981) and Lewellen and Badrinath (1997), respectively.

Table II
Description of Sample by Distribution of Exposures
and Hedging Decisions

Panel A breaks down the total sample of 330 firm-years into observations with and without oil exposure, and with and without gas exposure. Panel B displays the number of firms that report some hedging activities into oil and nonoil hedgers, and gas and nongas hedgers.

Panel A: Distribution of Exposures Across Firm-Years			
	Oil Exposure	Nonoil Exposure	Total
Gas exposure	319	6	325
Nongas exposure	5	0	5
Total	324	6	330

Panel B: Distribution of Hedging Decisions for Firm-Years with Exposure to Both Factors			
	Oil Hedgers	Nonoil Hedgers	Total
Gas hedgers	106	63	169
Nongas hedgers	37	113	150
Total	143	176	319

Therefore, we have more information than do other studies. We approximate the replacement costs of oil and gas assets by measures of reserves reported in 10-Ks.

We construct three measures of the Q ratio. All share the same numerator, which approximates the MV of the firm by the BV of total assets minus the BV of common equity plus the MV of common equity.¹⁵ The denominator should approximate the replacement cost of assets. The first measure, $Q1$, uses the BV of total assets minus the BV of proved oil and gas reserves, plus the “standardized measure of oil and gas reserves.” The latter is the estimated future net revenue, after extraction costs and income taxes, generated from the production of proved reserves discounted to present value using an annual discount rate of 10%. This net present value (NPV) computation approximates the value of proved oil and gas reserves, the major fixed assets.¹⁶ Next, the second measure, $Q2$, replaces the standardized measure of oil and gas reserves by the current MV of existing proved reserves, without adjustment. Finally, for comparison with previous literature, $Q3$ uses the BV of assets.¹⁷

¹⁵ MV (market value) of common equity in $Q1$ and $Q2$ is calculated as of the date of fiscal year-end. Oil and gas reserve values are also reported at fiscal year-end and the numbers are sensitive to the report date. This ensures that the Q measure is consistent across firms. We also use MV of common equity at calendar year-end, with similar results.

¹⁶ Oil and gas firms are required to report the present value of earnings from total oil and gas reserves per SFAS No. 69. Revenues of oil and gas are calculated using the spot price at the fiscal year-end, after projected extraction costs and income taxes. All future net cash flows are discounted at 10% to obtain the present value.

¹⁷ In measuring $Q1$ and $Q2$, we rely on reserve quantity information provided in the 10-K per SFAS No. 69. The total reserve value is derived by multiplying the oil and gas reserve by the spot price of oil and gas on that day. For discussions of this measure, see Clinch and Magliolo (1992).

Normally, we would expect that the present value of reserves would be a better measure of replacement value than BV, which represents accumulated exploration costs after amortization and depreciation.¹⁸ In summary, the three measures of the Q ratio are defined as follows:

$$Q1 = \frac{\text{BV total assets} - \text{BV common equity} + \text{MV common equity}}{\text{BV total assets} - \text{BV oil/gas proved reserves} + \text{NPV oil/gas proved reserves}}, \quad (3)$$

$$Q2 = \frac{\text{BV total assets} - \text{BV common equity} + \text{MV common equity}}{\text{BV total assets} - \text{BV oil/gas proved reserves} + \text{MV oil/gas proved reserves}}, \quad (4)$$

and,

$$Q3 = \frac{\text{BV total assets} - \text{BV common equity} + \text{MV common equity}}{\text{BV total assets}}. \quad (5)$$

Cross-sectionally, we find that the three variables are positively correlated, with correlations of 0.70, 0.34, and 0.27 between $Q1$ and $Q2$, $Q1$ and $Q3$, and $Q2$ and $Q3$, respectively. By construction, $Q2$ must be smaller than $Q1$ due to the treatment of the value of reserves. These two measures are highly correlated with each other, but less so than with the measure based on BV of assets.

Summary statistics for firm characteristics are presented in Table III. Panel A describes the distribution of firm assets, equity values, oil and gas reserves, and the various Q ratios for the whole sample. Note that the firms in our sample are smaller than the Allayannis–Weston sample, which only includes firms with more than \$500 million in assets. Ten percent of our firms have assets equal to less than \$32 million. If small firms are more susceptible to financial distress, theories of hedging would predict more hedging by small firms, and a positive correlation between hedging and MVs.

Panels B and C describe subgroups of firms with oil hedging activities and gas hedging activities. Panel D describes firms without hedging activities. Out of 119 firms, 92 firms reported hedging activities at least once during 1998 to 2001, 47 firms engaged in oil hedging activities each sample year, and 68 firms engaged in gas hedging activities each sample year. More specifically, of 324 firm-years with oil exposure, 146 report oil hedging activities. An average (median) firm hedges about 33% (24%) of next-year oil production, which amounts to about 4% (2%) of the oil reserve. No firm in the sample has a negative ratio, which implies that all firms with oil hedging activities truly hedge, or have a net short total delta. Out of 325 firm-years with gas exposure, 174 hedge their gas production. An average (median) firm hedges 41% (33%) of next-year gas production, which is approximately 5% (4%) of the gas reserve. Again, no firm in the sample has a negative ratio, which implies that all firms with gas hedging activities truly hedge.

¹⁸ Harris and Ohlson (1987), however, offer evidence that book values also contain significant information in explaining market values.

Table III
Summary Statistics for Firm Characteristics

Panel A describes the sample of 119 oil and gas producers from 1998 to 2001, with a total of 330 firm-year observations. Subsamples of firm-years with oil hedging activities and with gas hedging activities are reported in Panels B and C, respectively. Panel D describes firm-years without any hedging activities. Assets represent book value (BV) of assets. The value of reserves is the standardized measure of oil and gas reserves, as reported in annual reports. Oil/gas production hedged is the amount of hedging divided by the actual production next year. Oil/gas reserve 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 *Q1*, *Q2*, *Q3*, respectively, are BV total assets – BV oil/gas proved reserves + NPV proved reserves, BV total assets – BV oil/gas proved reserves + MV proved reserves, and BV of assets.

	Observation	Mean	<i>SD</i>	Median	10 th Percentile	90 th Percentile
Panel A: All Firm-Years						
Total assets (\$m)	330	974	2,319	208	32	2,453
Market value of equity (\$m)	330	793	2,021	91	14	1,970
Value of reserve (\$m)	329	935	2,238	205	24	2,410
<i>Q1</i>	329	1.11	0.53	1.05	0.50	1.79
<i>Q2</i>	330	0.41	0.26	0.37	0.13	0.73
<i>Q3</i>	330	1.39	0.54	1.31	0.89	1.95
Panel B: Firm-Years with Oil Hedging Activities						
Total assets (\$m)	146	1,465	3,030	310	55	3,633
Market value of equity (\$m)	146	1,239	2,729	134	18	4,355
Value of reserve (\$m)	146	1,473	3,068	336	47	4,575
Oil production hedged (%)	145	33	30	24	4	68
Oil reserve hedged (%)	146	4	4	2	0.5	7
<i>Q1</i>	146	1.08	0.49	1.03	0.52	1.69
<i>Q2</i>	146	0.38	0.22	0.34	0.12	0.68
<i>Q3</i>	146	1.40	0.53	1.31	0.94	1.88
Panel C: Firm-Years with Gas Hedging Activities						
Total assets (\$m)	174	1,277	2,668	357	65	3,271
Market value of equity (\$m)	174	1,064	2,450	200	29	2,166
Value of reserve (\$m)	174	1,287	2,782	353	58	3,694
Gas production hedged (%)	172	41	40	33	6	80
Gas reserve hedged (%)	174	5	6	4	0.6	11
<i>Q1</i>	174	1.15	0.48	1.11	0.52	1.74
<i>Q2</i>	174	0.42	0.24	0.40	0.17	0.74
<i>Q3</i>	174	1.43	0.51	1.33	0.95	1.91
Panel D: Firm-Years without Hedging Activities						
Total assets (\$m)	116	456	1,419	50	25	818
Market value of equity (\$m)	116	321	979	38	11	472
Value of reserve (\$m)	115	361	983	75	12	692
<i>Q1</i>	115	1.06	0.57	0.98	0.45	1.79
<i>Q2</i>	116	0.41	0.30	0.35	0.13	0.78
<i>Q3</i>	116	1.34	0.61	1.27	0.75	1.95

As reported in other studies, hedgers are generally larger than nonhedgers. We do not observe much difference, however, between the Q ratios of hedging and nonhedging firms. This is examined further in Section IV. In the next section, we ascertain whether hedging does have an effect on the stock return sensitivity to commodity price changes. If this is not the case, it would be difficult to rationalize an effect of hedging on MV.

III. Stock Return Sensitivity and Hedging

Our test expands on that of Rajgopal (1999), who runs a pooled cross-sectional time-series regression of a company's stock returns on oil and gas price changes, adjusting for hedging. Figure 1 plots futures prices for crude oil and natural gas over the period 1998 to 2002, based on NYMEX near-month contracts. The graph shows very large volatilities in oil and gas prices during the period. At the end of 2000, for instance, gas prices spiked to \$10/Mmbtu, only to fall back a month later.

A. Exposures of Oil and Gas Firms

We first estimate the oil and gas betas for each firm using a two-factor model:

$$R_{i,t} = \alpha_i + \beta_{m,i} \times R_{\text{mkt},t} + \beta_{\text{oil},i} \times R_{\text{oil},t} + \varepsilon_{i,t} \quad (6a)$$

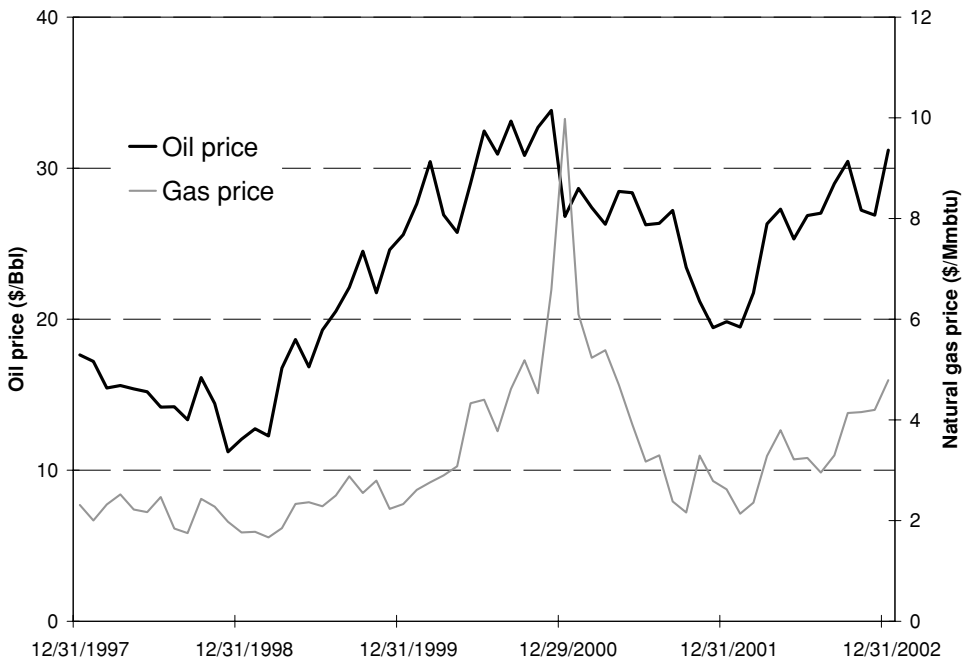


Figure 1. Crude oil and natural gas price (NYMEX near-month futures prices).

and

$$R_{i,t} = \alpha_i + \beta_{m,i} \times R_{\text{mkt},t} + \beta_{\text{gas},i} \times R_{\text{gas},t} + \varepsilon_{i,t},$$

(6b)

where $R_{i,t}$ is the total stock rate of return for firm i in month t , $R_{\text{mkt},t}$ is the monthly rate of change in the stock market index, taken here to be the S&P 500 index, $R_{\text{oil},t}$ is the monthly rate of change in the price of the NYMEX near-month futures contract for oil, $R_{\text{gas},t}$ is the monthly rate of change in the price of the NYMEX near-month futures contract for natural gas.

Table IV presents the results estimated with monthly data over the period 1999 to 2002, the years following the annual disclosures, as derivatives positions generally serve to hedge next-year production. During this period, 38 firms, including hedging and nonhedging firms, had complete return data.

Table IV
Statistical Properties of Stock Price Exposures

This table presents the statistical properties of the exposure coefficients from the two-factor model:

$$R_{i,t} = \alpha_i + \beta_{m,i} \times R_{\text{mkt},t} + \beta_{\text{oil},i} \times R_{\text{oil},t} + \varepsilon_{i,t}$$

and

$$R_{i,t} = \alpha_i + \beta_{m,i} \times R_{\text{mkt},t} + \beta_{\text{gas},i} \times R_{\text{gas},t} + \varepsilon_{i,t},$$

where $R_{\text{mkt},t}$, $R_{\text{oil},t}$, and $R_{\text{gas},t}$ are the S&P return, the change in the NYMEX crude oil futures price, and the change in the NYMEX natural gas futures price, respectively. The cross-sectional distribution of the slope coefficients is reported in Panel A. Panel B describes a three-factor model, with the stock market, oil, and gas prices. The sample consists of 38 firms with complete monthly stock returns from January 1999 to December 2002. Statistical significance is assessed for a one-sided hypothesis.

Panel A: Two-Factor Model				
	Beta_oil	Beta_gas		
Mean	0.332	0.371		
Median	0.279	0.408		
<i>SD</i>	0.291	0.199		
Minimum	−0.117	−0.088		
Maximum	1.028	0.774		
Percent >0	92.11%	94.74%		
Percent >0 and significant at $p < 0.05$	31.58%	86.84%		
Percent <0 and significant at $p < 0.05$	0.00%	0.00%		
Panel B: Three-Factor Model				
	Beta_mkt	Beta_oil	Beta_gas	Adjusted R^2
Mean	0.609	0.256	0.354	0.273
Median	0.669	0.215	0.395	0.297
<i>SD</i>	0.412	0.290	0.199	0.154
Minimum	−0.434	−0.186	−0.127	−0.041
Maximum	1.356	0.942	0.729	0.589
Percent >0	89.47%	84.21%	92.11%	
Percent >0 and significant at $p < 0.05$	47.37%	28.95%	86.84%	
Percent <0 and significant at $p < 0.05$	0.00%	0.00%	0.00%	

Panel B also reports results for a three-factor model, in which both energy variables are included in the equation; this specification, however, is more susceptible to collinearity.

Table IV confirms that exposures to oil and gas prices are mostly positive and generally significant.¹⁹ We find that about 92% of the oil betas and 95% of the gas betas are positive. For the median firm, a 1% increase in oil (gas) prices leads to a 0.28% (0.41%) increase in the stock price. These numbers are similar to those of Rajgopal (1999) over the 1993 to 1996 period.

B. Effect of Hedging on β_{oil} and β_{gas}

Next, we examine whether hedging has an effect on oil and gas betas. The estimated equations are

$$R_{i,t} = \alpha_1 + \beta_m \times R_{mkt,t} + \left(\gamma_1 + \gamma_2 \Delta_{oil,i} + \gamma_3 \frac{\text{oil reserve}_i}{MVE_i} \right) R_{oil,t} + \beta_{gas} \times R_{gas,t} + \varepsilon_{i,t} \quad (7)$$

and

$$R_{i,t} = \alpha_1 + \beta_m \times R_{mkt,t} + \beta_{oil} \times R_{oil,t} + \left(\gamma_4 + \gamma_5 \Delta_{gas,i} + \gamma_6 \frac{\text{gas reserve}_i}{MVE_i} \right) R_{gas,t} + \eta_{i,t}, \quad (8)$$

where Δ_{oil} and Δ_{gas} are the relative production deltas at the end of the previous calendar year, which represents hedging, and oil reserve/MVE and gas reserve/MVE are the dollar value of reserves divided by the total MV of equity.²⁰

Our main hypothesis is that hedging reduces the stock price sensitivity to oil and gas prices. We predict a negative sign on both γ_2 and γ_5 . In addition, the fraction of reserves should be positively related to the stock price exposure to energy prices. The rationale for this is that firms that have a greater proportion of their assets in the form of oil reserves should have a greater exposure to oil prices.²¹ We predict a positive sign on both γ_3 and γ_6 .

Out of 330 firm-years, 146 firm-years had oil hedging activities and 174 firm-years reported gas hedging activities. To facilitate the matching of equity returns to price changes in oil and gas, we further exclude firms with a non-December fiscal year-end. Using monthly stock returns from 1999 to 2002, this

¹⁹ We repeat the analysis using the residuals of the regression on the stock market and find similar results. This is because oil and gas variables are basically uncorrelated with the stock market, with correlations of 0.09 and -0.03 for our sample. Also note that this orthogonalization raises econometric difficulties, as highlighted by Pagan (1984) and examined by Jorion (1991) in the context of measuring foreign currency exposure.

²⁰ For increased precision, both the numerator and denominator are updated each month using changes in energy and stock prices. The ratio is reset to the number reported at the end of each year.

²¹ Rajgopal (1999) derives the functional form for equations (7) and (8). Because the dependent variable involves the price of equity, he shows that the denominator for the reserve ratio should be the market value of equity.

yields 110 firm-years with which to estimate the oil price equation, and 148 firm-years with which to estimate the gas price equation.

The top panel in Table V presents estimation results for the separate sample of oil and gas hedging firms. The bottom panel in Table V displays the results of combining both the oil and gas price sensitivity for all 165 firm-years with both oil and gas exposure and some oil or gas hedging. We see that oil and gas hedging reduces the sensitivity, as expected, with significantly negative coefficients for γ_2 and γ_5 in Panels A and B. Greater oil and gas reserves increase the sensitivity, also as expected, with significantly positive coefficients for γ_3 and γ_6 . Rajgopal (1999) also reports significant hedging effects for both oil and gas.

In general, these results indicate that the market recognizes the effect of hedging activities on a stock's exposure to commodity prices. The next step is to ask whether greater hedging is associated with greater MVs.

IV. Firm Value and Hedging

A. Univariate Analysis

In this section, we test the main hypothesis, which is whether hedging firms have higher Q ratios than nonhedging firms. Univariate results are presented in Table VI. In contrast to Allayannis and Weston (2001), we do not find statistically significant differences in firm values between hedging and nonhedging firms.

Panels A and B consider firms with oil exposure. Panel A compares oil hedging firms with nonoil hedging firms. Panel B compares oil hedging firms with firms that do not hedge at all, which is a smaller sample. For both panels, the Q ratios are not much different across groups. In Panel A, for example, hedgers have slightly lower $Q1$ and $Q2$ but slightly higher $Q3$ ratios. The differences are on the order of 4%, but are not significant. We find similar results for the group of firms with gas exposures, as reported in Panels C and D. Thus, there is no evidence of systematic difference in Q ratios for hedgers and nonhedgers.

The table also compares firm sizes across these two groups. Here, we find strong results. Consistent with the previous literature, hedging firms are much larger than nonhedgers. On average, hedgers are two to three times the size of nonhedgers. Size, however, may also affect the Q ratios.

B. Multivariate Analysis

Because Q ratios are affected by many factors, we isolate the effect of hedging with multivariate tests. We estimate three specifications for the regression models:

$$Q = \alpha + \beta \times \text{Hedging_dummy} + \sum_j \gamma_j \times \text{Control variable}_j + \varepsilon, \quad (9)$$

$$Q = \alpha + \beta \times \text{Delta_production} + \sum_j \gamma_j \times \text{Control variable}_j + \varepsilon, \quad (10)$$

Table V
Effect of Hedging on Oil and Gas Betas

This table summarizes pooled cross-sectional time-series regressions of stock returns on the market and oil (gas) price changes, with coefficients adjusted for the effect of hedging and reserves, over the years 1999 to 2002. The top panel models the oil and gas betas separately. For instance, the oil regression is

$$R_{i,t} = \alpha_1 + \beta_m \times R_{mkt,t} + \left(\gamma_1 + \gamma_2 \Delta_{oil,i} + \gamma_3 \frac{\text{oil reserve}_i}{\text{MVE}_i} \right) R_{oil,t} + \beta_{gas} \times R_{gas,t} + \varepsilon_{i,t},$$

where Δ_{oil} is the relative production delta and oil reserve/MVE is the dollar value of reserves divided by the total market value of equity. The bottom panel jointly models the oil and gas beta

$$R_{i,t} = \alpha_1 + \beta_m \times R_{mkt,t} + \left(\gamma_1 + \gamma_2 \Delta_{oil,i} + \gamma_3 \frac{\text{oil reserve}_i}{\text{MVE}_i} \right) R_{oil,t} + \left(\gamma_4 + \gamma_5 \Delta_{gas,i} + \gamma_6 \frac{\text{gas reserve}_i}{\text{MVE}_i} \right) R_{gas,t} + \varepsilon_{i,t}.$$

In the top panel, regressions include oil (gas) hedging firms only. In the bottom panel, regressions include all firms with both oil and gas exposures and some hedging activities. White-adjusted t -statistics are reported between parentheses. ** and * denote significance at the 1% and 5% levels, respectively.

Panel A: Separate Oil and Gas Beta Model		
Independent Variable	Oil Regression	Gas Regression
R_mkt	0.951 (10.80)**	0.842 (11.09)**
R_oil	0.203 (2.58)**	0.202 (4.37)**
R_gas	0.383 (16.22)**	0.284 (7.48)**
Delta_(oil/gas) $\times$ R_(oil/gas)	-0.446 (-2.91)**	-0.118 (-2.20)*
[Reserve_(oil/gas)/MVE] $\times$ R_(oil/gas)	0.012 (3.52)**	0.025 (3.15)**
Adjusted R^2	27.14%	23.73%
Number of firm-years	110	148
Number of observations	1,320	1,776
Panel B: Joint Oil and Gas Beta Model		
Independent Variable	Coefficients	t -Statistics
R_mkt	0.854**	(12.04)
R_oil	0.248**	(4.37)
Delta_oil $\times$ R_oil	-0.443**	(-3.15)
[Reserve_oil/MVE] $\times$ R_oil	0.013	(1.39)
R_gas	0.293**	(8.68)
Delta_gas $\times$ R_gas	-0.120**	(-2.43)
[Reserve_gas/MVE] $\times$ R_gas	0.023**	(2.89)
Adjusted R^2	24.45%	
Number of firm-years	165	
Number of observations	1,980	

and

$$Q = \alpha + \beta \times \text{Delta_reserve} + \Sigma_j \gamma_j \times \text{Control variable}_j + \varepsilon. \tag{11}$$

The hedging dummy is set to one if the company hedges. For the oil exposure, for instance, Delta_production is taken to be the relative delta oil production

Table VI
Comparison of Hedgers and Nonhedgers

This table compares the means and medians of Q ratios, total assets, and MV of equity for hedgers and nonhedgers. Panel A compares the firms with and without oil hedging activities, while Panel B compares firms with oil hedging activities to firms with neither oil nor gas hedging activities. Similarly, Panel C compares the firms with and without gas hedging activities, and Panel D compares firms with gas hedging activities to firms with neither oil nor gas hedging activities. Comparison of means is constructed using a t -test assuming unequal variances; comparison of medians is constructed using Wilcoxon rank-sum Z -test. Two-sided p -values are reported.

Panel A: Oil Hedging versus Nonoil Hedging Firm-Years					
Variable	Hedgers (146 Observations)	Nonhedgers (178 Observations)	Difference	t -Statistics (Mean) Z-Score (Median)	p -Value
$Q1$ (mean)	1.08	1.12	−0.04	−0.58	0.56
$Q1$ (median)	1.03	1.06	−0.03	−0.41	0.69
$Q2$ (mean)	0.38	0.43	−0.05	−1.94	0.05
$Q2$ (median)	0.34	0.40	−0.06	−1.56	0.12
$Q3$ (mean)	1.40	1.36	0.04	0.80	0.43
$Q3$ (median)	1.31	1.30	0.01	0.49	0.63
Total assets (\$m, mean)	1,465	595	870	3.18	0.00
Total assets (\$m, median)	310	117	193	5.08	0.00
MV of equity (\$m, mean)	1,239	441	798	3.32	0.00
MV of equity (\$m, median)	134	66	68	3.41	0.00
Panel B: Oil Hedging versus Nonhedging Firm-Years					
Variable	Hedgers (146 Observations)	Nonhedgers (115 Observations)	Difference	t -Statistics (Mean) Z-Score (Median)	p -Value
$Q1$ (mean)	1.08	1.05	0.03	0.46	0.64
$Q1$ (median)	1.03	0.98	0.05	0.84	0.40
$Q2$ (mean)	0.38	0.41	−0.03	−0.97	0.33
$Q2$ (median)	0.34	0.35	−0.01	−0.44	0.66
$Q3$ (mean)	1.40	1.32	0.08	1.25	0.21
$Q3$ (median)	1.31	1.27	0.04	1.23	0.22
Total assets (\$m, mean)	1,465	460	1,005	3.54	0.00
Total assets (\$m, median)	310	51	259	7.02	0.00
MV of equity (\$m, mean)	1,239	322	917	3.76	0.00
MV of equity (\$m, median)	134	37	97	5.19	0.00

(continued)

Table VI—Continued

Panel C: Gas Hedging versus Nongas Hedging Firm-Years					
	Hedgers (174 Observations)	Nonhedgers (151 Observations)	Difference	<i>t</i> -Statistics (Mean) Z-Score (Median)	<i>p</i> -Value
<i>Q</i> 1 (mean)	1.15	1.08	0.07	1.23	0.22
<i>Q</i> 1 (median)	1.11	0.99	0.12	1.91	0.06
<i>Q</i> 2 (mean)	0.43	0.39	0.04	1.30	0.20
<i>Q</i> 2 (median)	0.40	0.34	0.06	2.23	0.03
<i>Q</i> 3 (mean)	1.43	1.36	0.07	1.10	0.27
<i>Q</i> 3 (median)	1.33	1.30	0.03	1.32	0.19
Total assets (\$m, mean)	1,277	654	623	2.48	0.01
Total assets (\$m, median)	357	83	274	6.98	0.00
MV of equity (\$m, mean)	1,065	505	560	2.59	0.01
MV of equity (\$m, median)	200	48	152	6.12	0.00
Panel D: Gas Hedging versus Nonhedging Firm-Years					
	Hedgers (174 Observations)	Nonhedgers (114 Observations)	Difference	<i>t</i> -Statistics (Mean) Z-Score (Median)	<i>p</i> -Value
<i>Q</i> 1 (mean)	1.15	1.07	0.08	1.26	0.21
<i>Q</i> 1 (median)	1.11	1.00	0.11	1.82	0.07
<i>Q</i> 2 (mean)	0.43	0.41	0.02	0.52	0.61
<i>Q</i> 2 (median)	0.40	0.35	0.05	1.35	0.18
<i>Q</i> 3 (mean)	1.43	1.35	0.08	1.24	0.22
<i>Q</i> 3 (median)	1.32	1.28	0.05	1.59	0.11
Total assets (\$m, mean)	1,277	464	813	3.35	0.00
Total assets (\$m, median)	357	52	305	7.87	0.00
MV of equity (\$m, mean)	1,065	326	739	3.56	0.00
MV of equity (\$m, median)	200	39	161	6.70	0.00

measure defined in equation (1). Here, we also measure the extent of hedging activities. These tests should be more informative than tests based solely on the existence of any hedging activities.

Because raw *Q* ratios are skewed to the right, the dependent variables are the logs of the *Q* ratios. The coefficients can then be interpreted as elasticities. Because the regressions involve multiple years, we also include annual dummies, which are not reported. Even so, the residuals for each firm may not be fully independent across years, which would tend to understate the ordinary least squares standard errors. We therefore implement a Huber–White–Sandwich estimate of standard errors that accounts for clustering across firms and heteroskedasticity.

We include the following control variables, as in Allayannis and Weston (2001).

1. *Firm size*: Previous empirical evidence on the effect of firm size on firm value is ambiguous. However, it is important to control for size because large firms are more likely to hedge than small firms. The proxy is log of total assets.
2. *Profitability*: Profitable firms are more likely to have higher Q s than less profitable firms. The proxy used is the ROA, defined as the ratio of net income to total assets. We expect a positive coefficient on this variable.
3. *Investment growth*: Firm value may also depend on future investment opportunities. We use capital expenditures over total assets as a proxy. We expect a positive coefficient on this variable.
4. *Access to financial markets*: If hedgers have limited access to financial markets, their Q ratios may be high because they are constrained to take on only those projects with the highest NPVs. To proxy for a firm's ability to access financial markets, we use a dividend dummy that equals one if the firm paid dividends on common equity in the current year. Given this interpretation, the coefficient should be negative. On the other hand, dividends can be viewed as a positive signal from management, which should imply a positive coefficient.
5. *Leverage*: A firm's capital structure may be related to its value. We use a leverage variable defined as the BV of long-term debt over the MV of common equity.

Next, we add a new variable that is specific to the oil and gas industry.

6. *Production costs*: This refers to the cost of extracting oil and natural gas and includes both the lifting cost and production taxes. Lifting cost is defined as "the out-of-pocket costs per barrel of oil and natural gas produced to operate and maintain wells and related equipment and facilities after hydrocarbons have been found, acquired, and developed for production."²² Oil and gas firms consistently report their production costs in their 10-Ks, either on the basis of per Boe (Barrel of oil equivalent) or per Mcfe (thousand cubic feet equivalent). We expect the Q ratio to be negatively related to production costs.

Finally, we exclude other variables that appear in Allayannis and Weston (2001).

1. *Industrial and geographic diversification*: Previous empirical evidence suggests that diversification is negatively related to firm value. However, out of the 330 firm-years in our sample, only about 20% conduct business in more than one segment. Similarly, there is insufficient geographic diversification. As a result, we exclude these variables from the list of control variables.
2. *Credit rating (quality)*: Many firms in our samples are small and do not carry a credit rating. Adding this variable would unduly reduce the sample

²² See EIA (2002), pp. 31–33.

size. In addition, adding seven credit dummies may reduce the power of the test, given the relatively small sample size in the multivariate regression.

Table VII presents the regression results. For comparability with other studies, let us initially focus on the Q3 measure in Panel C, which is based on the

Table VII
Hedging and Firm Value

This table presents the pooled cross-sectional time-series least squares regressions of the impact of hedging on firm value. Models used are

$$Q \text{ ratio} = \alpha + \beta \times \text{Hedging_dummy} + \sum_j \gamma_j \times \text{Control variable}_j + \varepsilon,$$
$$Q \text{ ratio} = \alpha + \beta \times \text{Delta_production} + \sum_j \gamma_j \times \text{Control variable}_j + \varepsilon, \text{ and}$$
$$Q \text{ ratio} = \alpha + \beta \times \text{Delta_reserve} + \sum_j \gamma_j \times \text{Control variable}_j + \varepsilon.$$

The Q ratios are measured by the natural log of Q1, Q2, and Q3. The sample includes 119 firms over calendar years of 1998 to 2001, or a total of 330 firm-years; 324 firm-years have exposure to oil price risk and 325 have exposure to gas price risk. The variable Hedging_dummy is a dummy variable equal to one if the company hedges; delta_production is the ratio of total hedges to production; and, delta_reserve is the ratio of total hedges to reserves. The control variables are as follows: log(asset) is the log of BV of total assets; ROA is defined as the ratio of net income to total assets; Inv_growth is measured by capital expenditure over total assets; Leverage is defined as the BV of long-term debt over MV of common equity; Dividend dummy equals one if the firm paid dividend on its common equity in the current year; and, Production cost is dollar cost per barrel of oil equivalent. Annual dummies are included in the regressions but are not reported here. Standard errors are corrected for firm-level correlation and for heteroskedasticity using the Huber–White–Sandwich estimator. *t*-statistics are reported in the parentheses. * and ** denote significance at the 5% and 1% levels, respectively.

	Oil			Gas		
	1	2	3	1	2	3
Panel A: Dependent Variable is ln(Q1), Q1 = (MV Assets)/(BV Total Assets – BV Oil/Gas Reserves + Net Present Value of Reserves)						
Observations	318	317	318	319	317	319
R ²	0.457	0.462	0.456	0.456	0.450	0.447
Hedging dummy	–0.018 (–0.35)			–0.043 (–0.88)		
Delta_production		–0.129 (–1.39)			–0.083 (–1.50)	
Delta_reserve			–0.001 (–0.00)			–0.128 (–0.25)
Log (asset)	0.067 (3.51)**	0.068 (3.71)**	0.065 (3.55)**	0.059 (3.12)**	0.059 (3.18)**	0.055 (2.95)**
ROA	–0.035 (–0.41)	–0.037 (–0.43)	–0.036 (–0.41)	–0.036 (–0.42)	–0.016 (–0.18)	–0.035 (–0.40)
Inv_growth	0.580 (3.67)**	0.570 (3.59)**	0.578 (3.68)**	0.572 (3.62)**	0.571 (3.62)**	0.555 (3.46)**
Leverage	0.003 (1.59)	0.003 (1.71)	0.003 (1.57)	0.003 (1.61)	0.003 (1.62)	0.003 (1.51)
Dividend dummy	0.083 (1.54)	0.073 (1.33)	0.085 (1.59)	0.098 (1.77)	0.092 (1.63)	0.103 (1.84)
Production cost	–0.021 (–1.77)	–0.021 (–1.77)	–0.021 (–1.76)	–0.024 (–2.09)*	–0.023 (–1.99)*	–0.023 (–1.98)*

(continued)

Table VII—*Continued*

	Oil			Gas		
	1	2	3	1	2	3
Panel B: Dependent Variable is $\ln(Q2)$, $Q2 = (MV \text{ Assets})/(BV \text{ Total Assets} - BV \text{ Oil/Gas Reserves} + MV \text{ Reserves})$						
Observations	319	318	319	320	318	320
R^2	0.412	0.423	0.411	0.414	0.416	0.416
Hedging dummy	-0.085 (-1.12)			0.030 (0.39)		
Delta_production		-0.312 (-2.37)*			-0.103 (-1.11)	
Delta_reserve			1.082 (1.35)			0.874 (1.34)
Log(asset)	0.024 (0.78)	0.023 (0.82)	0.014 (0.48)	-0.003 (-0.09)	0.005 (0.17)	-0.003 (-0.12)
ROA	-0.027 (-0.19)	-0.033 (-0.23)	-0.028 (-0.19)	-0.074 (-0.53)	-0.090 (-0.64)	-0.065 (-0.45)
Inv_growth	0.909 (3.50)**	0.882 (3.43)**	0.881 (3.39)**	0.796 (3.78)**	0.840 (3.88)**	0.772 (3.63)**
Leverage	0.003 (1.99)*	0.004 (2.58)*	0.003 (1.70)	0.003 (1.58)	0.003 (1.58)	0.003 (1.71)
Dividend dummy	-0.059 (-0.73)	-0.078 (-0.98)	-0.041 (-0.52)	-0.011 (-0.14)	-0.028 (-0.33)	-0.003 (-0.04)
Production cost	-0.067 (-3.69)**	-0.069 (-3.68)**	-0.066 (-3.57)**	-0.071 (-4.06)**	-0.073 (-4.20)**	-0.070 (-3.98)**
Panel C: Dependent Variable is $\ln(Q3)$, $Q3 = (MV \text{ Assets})/(BV \text{ Assets})$						
Observations	319	318	319	320	318	320
R^2	0.274	0.273	0.274	0.251	0.251	0.251
Hedging dummy	0.007 (0.18)			-0.037 (-0.85)		
Delta_production		-0.040 (-0.57)			-0.060 (-1.46)	
Delta_reserve			0.005 (0.01)			-0.469 (-1.10)
Log(asset)	0.025 (1.38)	0.027 (1.56)	0.026 (1.45)	0.020 (1.03)	0.019 (0.96)	0.018 (0.91)
ROA	-0.034 (-0.42)	-0.034 (-0.42)	-0.034 (-0.41)	-0.019 (-0.22)	-0.007 (-0.08)	-0.023 (-0.27)
Inv_growth	0.815 (5.08)**	0.809 (5.00)**	0.816 (5.09)**	0.828 (5.04)**	0.823 (4.91)**	0.830 (4.87)**
Leverage	0.001 (0.46)	0.001 (0.55)	0.001 (0.47)	0.001 (0.45)	0.001 (0.40)	0.001 (0.32)
Dividend dummy	0.134 (2.24)*	0.128 (2.11)*	0.133 (2.26)*	0.147 (2.28)*	0.144 (2.19)*	0.146 (2.22)*
Production cost	-0.009 (-1.14)	-0.009 (-1.13)	-0.009 (-1.13)	-0.013 (-1.49)	-0.012 (-1.42)	-0.013 (-1.51)

BV of total assets. The coefficients on the hedging variables in the regressions are all insignificant, and most of them carry a negative sign. For instance, the existence of a gas hedging program is associated with a lower MV of 3.7%. An oil hedging program is associated with an increase in MV of 0.7%. Neither

number is significant. Firms that hedge 100% of their oil (gas) production the next year have lower MV by 4.0% (6.0%). These effects are not statistically significant, however. For the $Q1$ and $Q2$ regressions, we also find mainly negative coefficients. The only significant coefficient ($Q2$ for oil hedging of production) has a negative sign, suggesting that hedging decreases MV. Thus, there is no evidence that hedging has any significant positive effect on firm value.

Only one control variable has a strong and consistent effect across all Q -ratio measures. Investment growth is significantly positively related to Q across all models, indicating that firms with more investment opportunities are valued with higher Q ratios, as expected. Other variables are not significant across all three measures but have consistent signs. Production costs are negatively related to Q ratios, as expected. They are strongly significant using $Q2$, based on the MV of reserves and less so with $Q1$, based on the NPV of reserves. These results were expected because $Q1$ incorporates production costs, but $Q2$ does not. Asset size and leverage have positive signs. The remaining variables, ROA and dividends, have weak and inconsistent effects.

In summary, there is no support to the hypothesis that hedgers have higher Q ratios than nonhedgers for oil and gas firms. These results beg the question of the motivation behind these hedging activities. If hedging has no impact on MVs, the explanation probably lies in management acting for personal utility maximization purposes.

V. Conclusions

This paper investigates the hedging activities of a sample of 119 U.S. oil and gas producers from 1998 to 2001. We test for a difference in firm value between firms that hedge and those that do not hedge their oil and gas price risk.

Focusing on the sample of oil and gas firms has many advantages. Notionals and delta equivalents can be measured precisely. Data on reserves and production costs can be used to refine the measurement of the Q ratios. The industry is more homogeneous than a sample of U.S. multinationals, thereby lessening the possibility of spurious results due to confounding factors. This allows for a clean test of the hypothesis that using derivatives helps increase MVs.

Using Q ratios constructed with various measures of market to BVs, we find that there is generally no difference in firm values between firms that hedge and firms that do not hedge. This is contrary to the findings reported in Allayannis and Weston (2001) for a sample of U.S. multinationals.

The disappearance of the hedging premium refutes the hypothesis that risk management is always a positive-value proposition, suggesting that there exists a crucial difference between the nature of the commodity risk exposure of oil and gas producers and the foreign currency risk exposure of large U.S. multinationals. For oil and gas producers, the commodity risk exposure is both easy to identify and easy to hedge by individual investors. Hedging by the firm does not confer a special advantage since investors can hedge on their own, using for instance futures contracts traded on organized exchanges. Thus, the oil and gas context is closer to that described by the M&M irrelevance conditions. On the other hand, the foreign currency exposure of U.S. multinationals is much

harder to identify by outside investors and could involve exotic currencies for which there is no easily available derivative. Hence, this price risk is more difficult to hedge away by individual investors.

An alternative explanation is that the hedging premium observed for multinationals reflects other factors, such as informational asymmetries or operational hedges, which add value but happen to be positively correlated with the presence of derivatives. In a sample without such spurious correlation, the effect of derivatives disappears.

Undoubtedly, this important question of the hedging premium will be subject to further empirical research. For the time being, however, this paper demonstrates that the question of whether derivatives add value or not does not have a simple answer. At a minimum, the hedging premium depends on the types of risks to which the firm is exposed.

Appendix A: Excerpts from Market Risk Disclosure in Devon Energy's 2001 Annual Report

Item 7A. Quantitative and Qualitative Disclosures about Market Risk

The primary objective of the following information is to provide forward-looking quantitative and qualitative information about Devon's potential exposure to market risks. The term "market risk" refers to the risk of loss arising from adverse changes in oil and gas prices, interest rates and foreign currency exchange rates. (...) All of Devon's market risk sensitive instruments were entered into for purposes other than trading.

Commodity Price Risk

Devon's major market risk exposure is in the pricing applicable to its oil and gas production. (...) Devon periodically enters into financial hedging activities with respect to a portion of its projected oil and natural gas production through various financial transactions which hedge the future prices received. (...)

Price Swaps

Through various price swaps, Devon has fixed the price it will receive on a portion of its oil and natural gas production in 2002, 2003 and 2004. The following tables include information on this production. (...)

	Oil Production			
	First Half of 2002		Second Half of 2002	
	Bbls/Day	Price (\$/Bbls)	Bbls/Day	Price (\$/Bbls)
United States	22,000	\$23.85	22,000	\$23.85
Canada	4,350	\$20.33	4,350	\$20.33

Costless Price Collars

Devon has also entered into costless price collars that set a floor and ceiling price for a portion of its 2002 and 2003 oil and natural gas production. The following tables include information on these collars for each geographic area. (...)

	Oil Production					
	First Half of 2002			Second Half of 2002		
	Bbls/ Day	Floor Price (\$/Bbls)	Ceiling Price (\$/Bbls)	Bbls/ Day	Floor Price (\$/Bbls)	Ceiling Price (\$/Bbls)
United States	20,000	\$23.00	\$28.19	20,000	\$23.00	\$28.19

Fixed-Price Physical Delivery Contracts

In addition to the commodity hedging instruments described above, Devon also manages its exposure to oil and gas price risks by periodically entering into fixed-price contracts.

The price Devon will receive on a portion of its 2002 oil production has been fixed through certain forward oil sales assumed in the 2000 Santa Fe Snyder merger. From January 2002 through August 2002, 311,000 barrels of oil production per month have been fixed at an average price of \$16.84 per barrel. For each of the years 2002 through 2011, Devon has fixed-price gas contracts that cover approximately 24 Bcf, 19 Bcf, 19 Bcf, 19 Bcf, 19 Bcf, 17 Bcf, 16 Bcf, 16 Bcf, 15 Bcf and 13 Bcf, respectively, of Canadian production. (...)

Appendix B: Computation of Oil Delta

This appendix illustrates the computation of the relative oil delta from the disclosures in Devon's 2001 annual report. The firm hedges using swaps, collars, and fixed-price physical delivery contracts.

For instance, the volume sold under the first swap (United States) is 22,000 Bbls/day, or 8,030,000 barrels for the year. With a hedge ratio of -1.00 for the short position, this gives a total delta of $-8,030,000$. Next, we compute the hedge ratio for the collar, which is a short position in a call combined with a long position in a put. Using Black's model for valuing futures options, we have

$$\Delta(\text{call}) = e^{-rT} N(d_1) \quad \text{and}$$

$$\Delta(\text{put}) = -e^{-rT} N(-d_1) \quad \text{where } d_1 = \frac{\ln(F_0/X) + \sigma^2 T/2}{\sigma \sqrt{T}}. \quad (\text{B1})$$

Since the collar covers the production for 2002, the average maturity of the contract is 6 months, or $T = 0.5$ years. As of December 31, 2001, the price of the

6-month oil futures contract is $F_0 = \$20.49/\text{Bbl}$. In addition, the interest rate is $r = 1.79\%$ and the implied volatility is $\sigma = 49.06\%$. We solve for the call at $X = 28.19$ and find $\Delta(\text{call}) = 0.24$. For the put at $X = 23$, we find $\Delta(\text{put}) = -0.56$. Therefore, we have $\Delta(\text{collar}) = -(0.24) + (-0.56) = -0.80$. Finally, we aggregate the deltas across the contracts. This gives a total delta of $-17,945,750$.

Contract Production Period	Swap-United States 2002	Swap-Canada 2002	Collar 2002	Fixed Price January– August 2002	Total
Volume (Bbls/day)	22,000	4,350	20,000	10,032	
Volume (Bbls)	8,030,000	1,587,750	7,300,000	2,488,000	
Price (\$/Bbls)	\$23.85	\$20.33	\$23–\$28.19	\$16.84	
Delta	-1.00	-1.00	-0.80	-1.00	
Total delta	-8,030,000	-1,587,750	-5,840,000	-2,488,000	-17,945,750

For Devon, the oil production over 2002 is 61 million barrels, including natural gas liquids. Proved oil reserves are estimated at 707 million barrels. Scaling, this gives

$$\begin{aligned}\text{Relative delta oil production} &= -\text{Total delta oil}/\text{Next-year oil production} \\ &= 17.946/61 = 29.42\%\end{aligned}$$

and

$$\begin{aligned}\text{Relative delta oil reserve} &= -\text{Total delta oil}/\text{Same-year oil reserve} \\ &= 17.946/707 = 2.54\%.\end{aligned}$$

REFERENCES

- Allayannis, George, and James Weston, 2001, The use of foreign currency derivatives and firm market value, *Review of Financial Studies* 14, 243–276.
- Bartram, Sohnke, Gregory Brown, and Frank Fehle, 2003, International evidence on financial derivatives usage, Working paper, University of North Carolina.
- Brown, Gregory, 2001, Managing foreign exchange risk with derivatives, *Journal of Financial Economics* 60, 401–448.
- Carter, David, Daniel Rogers, and Betty Simkins, 2005, Does fuel hedging make economic sense? The case of the U.S. airline industry, *Financial Management*, forthcoming.
- Clinch, Greg, and Joseph Magliolo, 1992, Market perceptions of reserve disclosures under SFAS No. 69, *Accounting Review* 67, 843–861.
- Coles, Jeffrey, Michael Lemmon, and Felix Meschke, 2003, Structural models and endogeneity in corporate finance: The link between managerial ownership and corporate performance, Working paper, Arizona State University.
- DeMarzo, Peter, and Darrell Duffie, 1995, Corporate incentives for hedging and hedge accounting, *Review of Financial Studies* 8, 743–771.
- Dolde, Walter, 1995, Hedging, leverage, and primitive risk, *Journal of Financial Engineering* 4, 187–216.
- EIA, 2002, Performance profiles of major energy producers 2000, Energy Information Administration, Office of Energy Markets and End Use, U.S. Department of Energy.

- Froot, Kenneth, David Scharfstein, and Jeremy Stein, 1993, Risk management: Coordinating corporate investment and financing policies, *Journal of Finance* 48, 1629–1658.
- Géczy, Christopher, Bernadette Minton, and Catherine Schrand, 1997, Why firms use currency derivatives, *Journal of Finance* 52, 323–354.
- Graham, John, and Daniel Rogers, 2002, Do firms hedge in response to tax incentives? *Journal of Finance* 57, 815–839.
- Guay, Wayne, and S. P. Kothari, 2003, How much do firms hedge with derivatives? *Journal of Financial Economics* 80, 423–461.
- Harris, Trevor, and James Ohlson, 1987, Accounting disclosures and the market's valuation of oil and gas properties, *Accounting Review* 62, 651–670.
- Haushalter, David, 2000, Financing policy, basis risk, and corporate hedging: Evidence from oil and gas producers, *Journal of Finance* 55, 107–152.
- Jorion, Philippe, 1990, The exchange-rate exposure of U.S. multinationals, *Journal of Business* 63, 331–345.
- Jorion, Philippe, 1991, The pricing of exchange rate risk in the stock market, *Journal of Financial and Quantitative Analysis* 26, 363–376.
- Jorion, Philippe, 2001, *Value at Risk: The New Benchmark for Managing Financial Risk* (McGraw-Hill, New York).
- Lang, Larry, and René Stulz, 1994, Tobin's Q, corporate diversification, and firm performance, *Journal of Political Economy* 102, 1248–1280.
- Leland, Hayne, 1998, Agency cost, risk management, and capital structure, *Journal of Finance* 53, 1213–1243.
- Lewellen, Wilbur, and S. G. Badrinath, 1997, On the measurement of Tobin's Q, *Journal of Financial Economics* 44, 77–122.
- Lindenberg, Eric, and Stephen Ross, 1981, Tobin's Q ratio and industrial organization, *Journal of Business* 54, 1–32.
- Linsmeier, Thomas, and Neil Pearson, 1997, Quantitative disclosure of market risk in the SEC release, *Accounting Horizons* 11, 107–135.
- Mayers, David, and Clifford Smith, 1982, On the corporate demand for insurance, *Journal of Business* 55, 281–296.
- Mian, Shehzad, 1996, Evidence on corporate hedging policy, *Journal of Financial and Quantitative Analysis* 31, 419–439.
- Nance, Deana, Clifford Smith, and Charles Smithson, 1993, On the determinants of corporate hedging, *Journal of Finance* 48, 267–284.
- Pagan, Adrian, 1984, Econometric issues in the analysis of regressions with generated regressors, *International Economic Review* 25, 221–247.
- Perfect, Steven, and Kenneth Wiles, 1994, Alternative constructions of Tobin's Q: An empirical comparison, *Journal of Empirical Finance* 1, 313–341.
- Rajgopal, Shivaram, 1999, Early evidence on the informativeness of the SEC's market risk disclosures: The case of commodity price risk exposure of oil and gas producers, *Accounting Review* 74, 251–280.
- Smith, Clifford, and René Stulz, 1985, The determinants of firms' hedging policies, *Journal of Financial and Quantitative Analysis* 20, 391–405.
- Stulz, René, 1984, Optimal hedging policies, *Journal of Financial and Quantitative Analysis* 19, 127–140.
- Tufano, Peter, 1996, Who manages risk? An empirical examination of risk management practices in the gold mining industry, *Journal of Finance* 51, 1097–1137.
- Yermack, David, 1996, Higher market valuation of companies with a small board of directors, *Journal of Financial Economics* 40, 185–211.

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