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A Study of Hedging at the Firm Level in U.S. Oil and Gas Exploration Firms

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A Study of Hedging at the Firm Level in U.S. Oil and Gas Exploration Firms

BI Norwegian Business School - Thesis

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Abstract

This paper studies the hedging activities of 98 U.S. oil and gas exploration firms between 2004 and 2015. We investigate the following three hypothesis; (1) to what extent does hedging affect firms' stock price exposure towards oil and gas price fluctuations, (2) what are the value implications of hedging, and, (3) what are the determinants of hedging. To test these hypotheses, we collect detailed information on firm specific characteristics and oil and gas prices from the firm's annual reports, Bloomberg and COMPUSTAT. We find that hedging decreases the firms' stock price exposure towards oil and gas prices in the presence of decreasing price patterns, referred to as crisis periods. These periods are also the only periods we find evidence of a hedging premium. Outside crisis periods, the market appears to penalize firms that hedge with a lower market value. We explain this as evidence of investor loss aversion. As for the determinants of hedging, we find that the hedging decision is related to several firm characteristics, like size, the leverage ratio and to some extent the degree of management ownership.

I. Introduction

The motivation behind this study can be summed up in a chart; a chart of historic oil and gas prices. Looking at the massive variability in prices during the last decade we are left wondering in what degree companies with a high exposure manage the risk, whether they are rewarded for hedging their exposure towards oil and gas prices and further what determines a firm's decision to hedge.

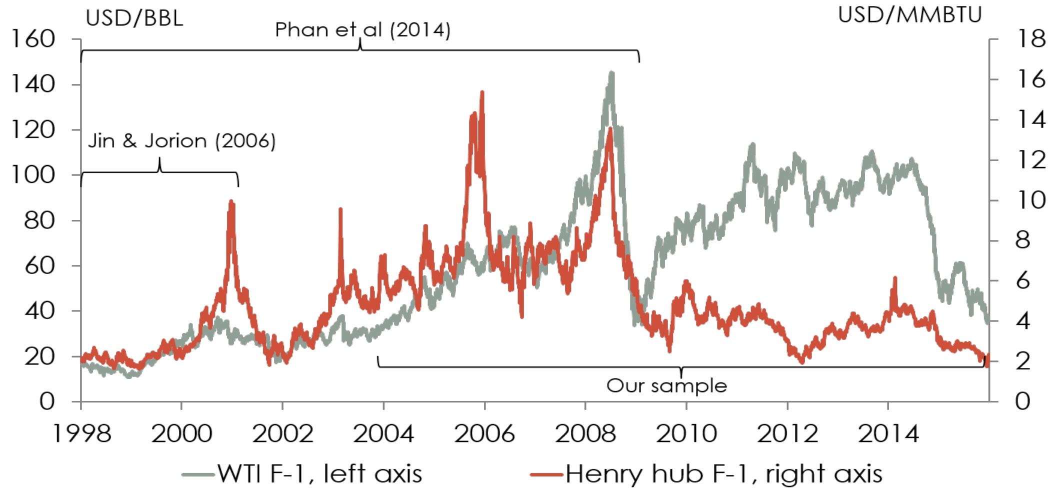

Figure 1. : Oil and Gas 1-Month Futures Prices

According to Miller and Modigliani's (1958) irrelevance proposition, risk management should be irrelevant in a world with perfect capital markets. However, real world frictions may prove to contribute with a value premium for firms that hedge. In this paper we investigate these value implications and further the determinants of hedging in oil and gas exploration firms. In order to make sure we draw valid conclusions, we investigate to what extent these firms are exposed to oil and gas price fluctuations and whether hedging in fact decreases this exposure.

There has been a great deal of research focusing on these questions in several different industries, but the results are quite diverse. Our analysis is conducted in a similar fashion as Jin and Jorion's (2006) and Phan et al. (2014). Jin and Jorion (2006) conduct a study on 119 U. S. oil and gas exploration firms from 1998 to 2001. While Jin and Jorion (2006) verify that hedging reduces firms' stock price sensitivity to oil and gas prices, they do not find that hedging seem to affect the firms' market value. Phan et al. (2014) extend Jin and Jorion's analysis (2006) and study 94 U.S. oil and gas exploration and production firms during the period 1998 to 2009. They suggest the existence of a hedging discount during increasing oil and gas price patterns, and no relationship between hedging and firm value during decreasing price patterns.

Our analysis is conducted on 98 U.S. oil and gas exploration firms during the period 2004 to 2015. We suspect Jin and Jorion's (2006) finding of no relation between hedging and firm value to be due to a low volatility regime in energy prices during their sample period; low volatility in oil and gas prices implies a lower value of risk management activities. Further, we explain Phan et al.'s (2014) finding of a hedging discount by the, in general, increasing trend in oil and gas prices during their sample period; an increasing price pattern, that is not expected by the market, implies higher losses for firms that hedged and higher gains for firms that remained unhedged. Our sample period includes more volatile patterns in oil and gas prices, and additionally two sharp oil price drops. Hence, we believe that with more recent data we are able to not only investigate if the firms receive a premium or not, but also if events like the financial crisis in 2008 and the recent turbulence in oil and gas prices in 2014 and 2015 have changed the outlook of investors. We further extend Jin and Jorion (2006) and Phan et al.'s (2014) studies to also include an analysis on the determinants of hedging at the firm level in oil and gas exploration firms.

As argued by Jin and Jorion (2006), oil and gas exploration companies are ideal for studying the relationship between hedging and market values. Firstly, changes in the commodity prices have substantial effects on cash flows and stock prices. Secondly, the exposure of oil and gas companies to energy prices are easy to identify from the companies' financial reports (10-Ks), which means that investors might take a position in such companies to gain exposure to energy prices. While other researchers, such as Carter et al. (2006), think this causes biased results, as the investors may prefer the companies to be exposed, Jin and Jorion (2006) argue that it creates a situation closer to that of the Miller and Modigliani assumptions. Thirdly, oil and gas exploration firms are quite homogeneous in their firm characteristics but at the same time there are great differences in the firms' hedging ratios. This makes it easier to avoid the problem of omitted variable bias, since we are more likely to avoid the issue of leaving out an important variable when constructing our model. Fourthly, due to detailed information in the firms' 10-Ks on oil and gas reserves, we are able to create more proxies to approximate the replacement cost of assets in the estimation of Tobin's Q than we can in many other industries. Lastly, oil and gas exploration firms are severely capital intensive, which means that we can investigate the effects of leverage, and possibly even the motives for hedging, like mitigation of underinvestment.

To investigate our hypotheses, we collect detailed information on firm specific characteristics and oil and gas prices from annual reports, Bloomberg and COMPUSTAT. Through econometric analysis we find that investors recognize the effects of hedging on stock price exposure towards oil and gas prices in periods of negative price patterns, i.e. in the crisis period of 2008 and the recent turmoil in oil prices in 2014 and 2015. Further, during these periods, we find that investors reward firms with a hedging premium. Outside these periods, investors do not recognize the effect of hedging on reducing firms' stock price exposure towards oil and gas prices, and we find evidence of a hedging discount. We explain this by investor loss aversion, i.e. investors being more sensitive to negative surprises in oil and gas prices than to positive. As for the determinants of hedging at the firm level, our evidence suggest a positive relationship between the extent of hedging and firm size, the current ratio, paying out dividends and production cost. Further, we find that more leveraged firms appear to hedge less, indicating evidence of issues related to debt overhang. We also find some evidence of undiversified managers hedging for personal utility maximization.

The remainder of this paper is structured as follows. In section II we give a review of relevant previous empirical research. In section III we provide the theoretical background. In section IV we present our hypotheses. In section V we describe our data and the main variables to test our hypothesis. In section VI we present the methodology utilized in our study and present the empirical results. Section VII concludes our research.

II. Empirical Background

Previous empirical evidence on whether hedging enhances firm value contribute with conflicting results. While some empirical evidence supports the economical rationales of hedging (e.g. Allayannis & Weston, 2001; Prez-Gonzlez & Yun, 2013; Krause & Tse, 2015; Carter et al., 2006), other suggests that hedging is insignificant for firm value (e.g. Guay & Kothari, 2003; Jin & Jorion, 2006) and some suggests that hedging actually affect firm value negatively (e.g. Lookman, 2009). Another argument is that the effect of hedging depends on different price trend scenarios (e.g. Chang et al., 2010; Phan et al., 2014).

A study suggesting evidence of a hedging premium is the one conducted by Pérez-González and Yun (2013). Using the introduction of weather derivatives as an exogenous shock to firms' ability to hedge weather risk, the study suggests that the use of derivatives lead to higher valuations, investment, and leverage. Another study suggesting a hedging premium is the one conducted by Allayannis and Weston (2001). Using a sample of 720 large US non-financial firms exposed to exchange rate volatility, the study suggests a hedging premium of on average 4,87% of firm value. Further, Krause and Tse (2015) examine 70 studies in recent risk management theory and suggest that it is becoming increasingly clear that there is value in risk management. Their evidence points to the benefits of risk management in the creation of firm value in the way of lower cost of capital and decreased potential cost of financial distress.

In examining risk management activities in relation to hedging commodity price risks, Kruse and Tse (2015) found that higher firm value only seems to accrue to commodity consumers (e.g. airlines) as opposed to commodity producers (e.g. oil and gas producers). Such a hedging premium for airlines was suggested in a study by Carter et al. (2006). They find an average hedging premium for airlines in the range of 5% to 10%. This value premium suggests that hedging allows airlines greater ability to fund investment during periods of high jet fuel prices. Further, the positive relation between hedging and value suggest that investors view such investment as positive net present value projects.

A study supporting Krause and Tse's (2015) finding of a lack of hedging premium for commodity producers, is the study on 119 U.S. oil and gas companies from 1998 to 2008 by Jin and Jorion (2006). Jin and Jorion (2006) verify that hedging reduces the firm's stock price sensitivity, but find that hedging does not seem to affect the market value of firms in this industry. They argue that the positive value effect of hedging found by Allayannis and Weston (2001) might be hard to interpret because of a biased selection of data. Allayannis and Weston's (2001) sample includes firms across industries, but only firms with assets greater than $500 million. Hence, it is unclear whether their results are transferable to smaller firms as well, or if the hedging premium suggested is due to other effects that are common in larger firms. Examples of such effects are operational hedges, that typically are correlated with the derivatives positions. On the other hand, Carter et al. (2006) criticize the study by Jin and Jorion (2006) as their results may be biased from, by their own admission, selecting a sample in which investors might not prefer firms to hedge. Through oil and gas exploration firms' 10-Ks, investors can easily identify the firms exposure towards oil and gas prices and accordingly investors might take positions in such companies to gain exposure to commodity prices.

Guay and Kothari (2003) also question the validity of Allayannis and Weston' (2001) study, and, as Jin and Jorion (2006), they suggest the insignificance of hedging policies. Through investigating 234 large non-financial corporations using derivatives, Guay and Kothari (2003) examine the economic importance of financial derivatives as a part of corporate risk management. They find that the magnitudes of the derivatives positions are quite small compared to cash flows or movements in equity values. This is explained by the fact that much of the overall risk facing non-financial firms cannot be managed through the use of standard derivatives contracts. Further, they point out that some studies, like Allayannis and Weston (2001), do not measure if the derivatives position is sufficiently large to produce benefits for the firms by such magnitudes that are found. Guay and Kothari (2003) conclude that the observed increase in market values is driven by other risk management activities that are positively correlated with derivatives positions, or that the observed increase in market values is spurious.

When it comes to research on whether hedging adds value in oil and gas exploration and production firms, the results also differ across studies. Similarly to Jin and Jorion, Lookman (2009) finds no relation between derivatives use and firm value in the aggregate. However, he finds that for exploration and production firms where commodity price risk is a primary risk, hedging destroys firm value. Further, for more diversified firms where commodity price risk is a secondary risk, hedging contributes with higher firm values. Another study, by Chang et al. (2010), measures hedging effectiveness in different price scenarios in energy futures markets through eight hedging models. The study suggests that hedging effectiveness of crude oil and gas futures is significantly better during an increasing price pattern than in a decreasing price pattern. Thus to optimize the use of derivatives, firms should switch between different hedging models within different price-movement patterns. Phan et al. (2014) find similar results in their study on 94 U.S. oil and gas exploration and production firms. They suggest the existence of a hedging discount during periods of increasing oil and gas prices, and no relation between hedging and firm value during decreasing prices.

Although the effect of hedging on firm value cannot be clearly established in empirical research, hedging through derivatives is still considered to be an important part of a firm's risk management strategy. In Carter et al.'s (2006) investigation of hedging in the airline industry, they find that the benefits of hedging are related to capital investments in the way of protecting airlines from underinvesting in bad times. This is in accordance with Froot et al. (1993), who suggest that when external financing is costlier than internally generated sources of funds, it can make sense for firms to hedge. Carter et al. (2006) find little evidence of hedging benefits from tax convexity, expected and direct bankruptcy costs and increases in debt tax shields. In a study by Guay and Kothari (2003) it is further questioned what determines a firm's decision to hedge. When it comes to characteristics of firms that hedge, they suggest that there is increased use of derivatives for large firms and for firms with greater investment opportunities. There is also increased use of derivatives among more geographically diverse firms and among firms for which the CEO's sensitivity of wealth to stock price is relatively large. Additionally, they point out that optimizing firms will use derivatives only if the benefits of the programs exceed the cost.

The determinants of hedging suggested above can also, according to Hausehalter (2000), be applicable to oil and gas producers. Hausehalter (2000) studies the hedging policies of oil and gas producers between 1992 and 1994. He finds that the extent of hedging is related to financing costs in the way that firms with greater financial leverage manage price risk more extensively. Further, he suggests that the extent of hedging is related to the size of firms and to the basis risk associated with hedging instruments. The latter refers to firms being more likely to manage risks if they are located in regions where the prices of the commodities they offer have a higher correlation with the prices of the underlying assets of the exchange traded derivatives that are used to manage the risks.

III. Theoretical Perspective

Miller and Modigliani's (1958) irrelevance proposition implies that hedging should not affect firm value, when assuming no taxes, costs of financial distress, and transaction costs. The reason is analogous to the irrelevance of capital structure; the value of the company is determined by the value of its assets, i.e. the future cash flows and the required rate of return, not by the way they are financed. However, we do not live in a world where Miller and Modigliani's (1958) assumptions hold. In the real world, frictions in capital markets may create dead weight losses, which affect cash-flows. Hence, hedging might prove to be of relevance to firm value.

As argued in the previous section, we frequently observe firms devoting intellectual and financial resources to financial risk management. Rationalizing this devotion to risk management is, however, no easy task. In particular, most corporate financial exposures represent nonsystematic or diversifiable risks. Shareholders should be able to eliminate this risk on their own either through hedging, of which they can do at the same costs as the company, or by having a well-diversified portfolio (Stultz, 1996). Further, the systematic risk, which investors cannot diversify, should be reflected in the expected returns (Aretz et al., 2007). Hence, hedging of market risks at the firm level should simply shift firms along a line that reflects the risk-reward tradeoff in the market (Dufey & Srinivasulu, 1983).

Before trying to rationalize a firm's decision to hedge, we wish to differentiate between the two kinds of risks firms face: business risk and financial risk. Business risk arises from uncertainties at the operational level of the firm, examples are risks associated with product quality, input costs, technological factors, changes in consumer demand and so on. This kind of risk would further create moral hazard, which is the situation where one party takes on more risk because others bear the costs. Business risk may be difficult, and sometimes even impossible to hedge. It can also be argued that it is not advantageous for firms to hedge this kind of risk as they typically have a comparative advantage in managing their business and the associated operations. The other kind of risk is financial risk, of which arises from unexpected changes in, e. g., commodity prices, exchange rates and interest rates. As firms often do not have a comparative advantage in managing this sort of risk, it may be economically sensible for firms to hedge their financial exposure through selling them to the broader markets (Aretz et al., 2007).

Hedging financial risks will be the focus throughout this paper. In particular, if reducing the cash-flow variability arising from financial exposures has the potential to reduce "real" costs on the firm, hedging may prove to be value adding. We will in the following elaborate on the theories behind financial risk management, and here under focus on the following arguments supporting risk management activities; (A) Hedging reduces the probability of bankruptcy, (B) Hedging reduces expected taxes, and, (C) Hedging reduces payments to firms' stakeholders. Further, we will discuss the link between risk management and capital structure and include a discussion on the issues related to measuring the relationship between hedging and firm value.

A. Hedging Reduces the Probability of Bankruptcy

If cash-flow variability caused by swings in, e. g., foreign exchange rates or commodity prices materializes into increased probability of financial distress, shareholders may reward firms with a value premium (Stultz, 1996). Extreme swings in cash-flows, like those experienced by oil and gas exploration firms during 2014, can reduce the operating cash-flows to the extent that leveraged companies no longer are able to service their debt and consequently are forced into bankruptcy. The most obvious costs of bankruptcy are direct costs such as payments to lawyers and court costs, but there also exists some potentially even larger indirect costs (Stultz, 1996). A study by Andrade and Kaplan (1998) found the bankruptcy costs to be approximately 10% to 20% of pre-distress market value. If shareholders view bankruptcy as a real possibility, the expected present value of the costs should be reflected in the current market value. According to Stultz (1996), the probability of bankruptcy can costlessly be reduced to zero through a risk management program, and accordingly increase the market value of a firm. The size of this hedging premium should be the bankruptcy costs multiplied by the probability of default if the firm remains unhedged.

We can further extend the financial distress argument to distress costs in general. As firms become weaker financially, agency conflicts caused by debt overhang may arise. One such conflict is underinvestment, which arises when managers of levered companies choose not to invest in positive NPV projects, since the payoffs of the investment almost entirely accrues to bondholders (Aretz et al., 2007). In such cases, the equity-value maximizing investment is lower than the level that maximizes the value to all claimants. Further, shareholders will often resist reducing debt, even if such a reduction would not change, and even might increase, the total value of the firm. Reducing debt is costly to shareholders as it transfers value from them to the debt-holders. Hence, once debt is in place shareholders will not voluntarily reduce debt even though it benefits the firm. On the contrary, they will want to increase debt if existing covenants permit it (Admati et al., 2012). Because debtholders anticipate this opportunistic behaviour, they will demand either higher yields on the capital provided or protective covenants. Both these alternatives create additional costs for the firm (Aretz & Bartram, 2010).

The underinvestment problem can be solved through rewriting or renegotiation debt contracts, shortening the maturity of outstanding debt, or issuing less debt. However, these remedies will create additional costs. Hedging at the firm level potentially creates a stable cash-flow ensuring that gains from projects are less often below their initial investment plus obligations to bondholders. As a result, the creditors' required rate of return and the likelihood of underinvestment will decrease (Aretz et al., 2007).

B. Hedging Reduces Expected Taxes

Tax benefits of risk management arise from the interaction between the reduction in volatility of reported income and the convexity of taxes (Stultz, 1996). The convexity of taxes can not only be caused by marginal tax rates increasing progressively with taxable income, but also by limitations of special tax items, like the inability to carry losses forward or backward for an unlimited number of years (Aretz et al., 2007). When a firm facing convex taxes hedge, the tax increase in situations where income would have been low is smaller than the tax reduction in situations where income would have been high. Hence, hedging can reduce expected taxes and accordingly increase future cash flows (Stultz, 1996).

C. Hedging Reduces Payments to Firms' Stakeholders

While shareholders often are able to manage a company's financial risk just as efficiently as the company itself, the case may be different for stakeholders such as managers and employees who tend to have a large portion of their wealth tied up in the firm. Therefore their required rates of return are likely to reflect both systematic and nonsystematic risk, i.e. also risk that can be removed through diversification or hedging. This argument can be extended to all stakeholders who typically cannot diversify or hedge away large financial exposures on their own. To the extent that risk management can protect the investments and interests of the corporate stakeholders, the company can improve the terms on which it contracts with them and accordingly increase firm value (Stultz, 1996).

A related argument suggests that hedging stems from the incentive of managers to maximize their personal utility (Jin & Jorion, 2006). In particular, hedging can be viewed as a way for risk-averse managers to reduce firm-specific risks in their portfolio. Managers may have a large portion of their assets invested in the firm, since they are likely to receive some form of equity as part of their compensation package and probably need to invest in a lot of company- and industry specific knowledge. Since their ability to diversify their position is severely limited, they can be made strictly better off by reducing the variance of total firm value through hedging (Froot et al., 1993). This rationale might explain why firms hedge, even though there is no hedging premium attached. However, Stultz (1996) argue that hedging based on this rationale may still be value adding as it can enhance managers' incentives to improve operating performance by removing the noise from financial risk that is beyond management's control.

On the other hand, managers with stock options but little equity ownership might leave their financial exposures unhedged. Options have the power to influence hedging behavior because management gains more from increases in firm value than they lose from reductions in firm value. Such incentive packages could thus result in misalignment of managers' and stockholders' interests. A better policy could be to balance managers' upside potential by giving them a share of the downside risk (Stultz, 1996).

D. The Link Between Risk Management and Capital Structure

When discussing the rationales for risk management, we find it important to address the link between risk management and capital structure. As argued above, firms should manage financial risks in a way that decreases the probability of financial distress, and, in doing so, preserves the financing flexibility necessary to carry out positive net present value projects. Given that this is the primary objective of a firm's risk managing strategy, one would not expect companies with little or no debt financing, and accordingly a quite small probability of financial distress, to benefit from hedging. As risk management reduce firms' financial exposure it consequently increases firms' debt capacity. Hence, risk management can be viewed as a means to substitute equity for debt financing. This substitution may be desirable as debt has, among others, a tax advantage over equity, the potential to strengthen management incentives to improve efficiency and leads the firm to pay out excess capital, which in turn allows for greater concentration of equity ownership. Thus, in evaluating the optimal corporate risk management strategy one must question both what the optimal capital structure is and what the optimal ownership structure is. While it may be value adding for some firms to raise debt and, e.g., increase management's percentage ownership, other firms are better off keeping exposures unhedged and maintaining a lower debt-ratio (Stultz, 1996).

E. The Issue of Measuring the Effect of Hedging

On the basis of the previous paragraphs, we argue that academic literature do provide us with rationales for hedging at the firm level, and suggest the existence of a hedging premium. However, how to measure this hedging premium is not straightforward. A popular proxy for market value in previous literature is Tobin's Q, also known as the average Q. The average Q is based on the Q-theory suggested by Tobin (1969).

According to the Q-theory, the rate of investment is a function of the marginal Q; the ratio of the market value of an additional investment to the investment's replacement cost. Tobin and Brainard (1977) argue that if the marginal Q is greater than 1, i.e. that the market value of an additional investment is greater than its replacement cost, investors should invest. Conversely, if the marginal Q is smaller than 1 investors would have incentive to liquidate, although liquidating has costs. It is clear that if all such investment opportunities where exploited, the marginal Q should converge to 1. But in the presence of intangible assets, like growth opportunities, the marginal Q will diverge from unity (Ciner & Karagozoglu, 2008).

However the marginal Q cannot be observed. What we can observe is the average Q, namely the ratio of the market value of a firm's existing capital to its replacement cost. Empirical work thus utilize the average Q as a proxy for the marginal Q (Hayashi, 1982). We will do the same throughout this paper, and refer to the average Q as Tobin's Q or the Q-ratio.

Compared to other proxies of firm value, like stock return or accounting performance measures, Tobin's Q relieves us from having to adjust for risk and any other kind of normalization when comparing the measure across companies (Lang & Stultz, 1994). However, Tobin's Q is a noisy measure since it can be subject to speculation, and overreaction, as it is based on market values (Ciner & Karagozoglu, 2008). This might become especially relevant after the sharp drops in oil prices in 2008 and 2014. Nevertheless, it is expected to be uncorrelated to hedging practices and hence optimal to use when studying the relationship between hedging and firm value. While Tobin's Q in itself is a proxy for firm value, the determinants of Tobin's Q - the market value of the firm and the replacement cost of the firm's assets - are also proxies. Thus, in order to draw valid inferences from empirical models utilizing Tobin's Q we find it important to experiment with different proxies to make sure that the results are not sensitive to the measures used to perform comparisons across firms.

IV. Hypotheses

In light of the theoretical background and previous empirical studies, we investigate the hedging activities of oil and gas exploration firms through the following three hypotheses.

Hypothesis 1: Oil and gas exploration firms are exposed to oil- and gas price fluctuations and this exposure can be reduced through hedging

Guay and Kothari (2003) criticized previous studies for not investigating whether the sample firms' derivatives positions were sufficiently large to produce benefits of the magnitudes that are found. To control for this in our study, we test whether the firms' stock returns are in fact exposed to oil and gas price fluctuations. Further, we investigate the extent to which hedging affects exposure. If a firm's hedging decision does not affect the firms exposure towards energy prices, there is little reason for hedging to affect firm value.

Hypothesis 2: Cash-flow hedging through financial derivatives is irrelevant to firm value in U.S. oil and gas exploration firms

Previous empirical studies provide conflicting results on the relation between firm value and hedging through financial derivatives contracts. We add on to previous literature and investigate whether there exists a hedging premium or discount in oil and gas exploration firms during the period 2004 to 2015.

Hypothesis 3: Oil and gas exploration firms hedge their cash-flows to reduce expected costs of financial distress, reduce expected taxes, decrease the *risk of underinvestment, due to managerial incentives and/or because of other operating characteristics*

In the theoretical background we highlighted the main determinants of hedging. If hedging adds value, it will most likely be through one of those channels. If hedging does not add value, the incentives to hedge might stem from managerial motives which creates private benefits for the manager. We investigate the relationship between each determinant and the percentage of production hedged in each firm and try to explain firms' motives to hedge. Further, we test whether there exist a relationship between the extent of hedging and firm characteristics like, e.g., size.

V. Data Description

The dataset contains information on 98 U.S. oil and gas exploration firms collected from Bloomberg, COMPUSTAT, and each company's 10-Ks. The time horizon is set to 2004 to 2015. During this period, several companies went bankrupt and some came into existence. Thus, in order to avoid potential biases, like survivorship bias, we are utilizing an unbalanced panel. This means that our panel dataset will have some cross-sectional elements with fewer observations, or observations at different times than others (Brooks, 2014, p. 529). A discussion on the implications of utilizing a panel dataset can be found in Appendix C.

As Jin and Jorion (2006), the firms in our sample are selected by filtering out every company with the SIC code 1311 from the Russell 3000 index, which contains 98% of the firms in the U.S. public equity market (FTSE, 2017). SIC codes describe groups of companies that primarily produce the same group of products or services. The major group 13 represents "Oil and Gas Extraction", and the code 1311 further restricts this classification to "Crude Petroleum and Natural Gas". We repeat the filtering out procedure each year to make sure that we collect every firm in existence during our time horizon. The resulting sample consist of 141 companies. We further exclude some companies due to a total asset-hurdle; companies with less than $ 20 million in total assets are not required by U.S. law to submit 10-Ks. As we cannot obtain any information on a firm's hedging position without looking into their 10-K, these firms had to be excluded. We also require that their 10-Ks are available in the EDGAR database and that they disclose sufficient information on their hedging positions. Filtering out based on these criteria left us with a sample of 98 companies (a list of the companies included can be found in appendix B), and 756 firm-years in total.

A. Oil and Gas Prices

We use 1-month futures contracts on oil and gas instead of the spot prices. The reason is that the one month futures contract specifies the earliest delivery date for oil and gas, and accordingly is the price faced by producers and buyers in transactions (EIA, 2017). Hence, the one month futures contract can effectively be regarded as the spot price in the market for oil and gas. We use West Texas Intermediate Crude Oil as a benchmark for oil prices, and Henry Hub Natural Gas as a benchmark for gas prices. These benchmarks should reflect the supply and demand for oil and gas wherever it is used, and are particularly influenced by the U.S. market (The Economist, 2016; EIA, 2016).

B. Hedging Variable

Information on hedging activity is collected from each firm's 10-K. Since 1997, disclosure of quantitative information about market risk and hedging activities have been mandatory. Companies are required to disclose contract amounts, 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 (Jin & Jorion, 2006). In constructing the hedging variables we borrowed inspiration from Haushalter (2000) and Allayannis and Weston (2001). In general, we will put most weight on the hedging variable representing percentage of total production hedged (PPH), but we will also in some instances utilize percentage of gas production hedged (PPH_{gas}) and percentage of oil production hedged (PPH_{oil}). Further, in order to investigate the robustness of our results we will repeat some regression analysis using a simple hedging dummy. We define the hedging variables as follows:

$$
\begin{aligned}
PPH = {} & \frac{Gas\ hedged}{Gas\ production}\ \frac{Gas\ production}{Total\ production} \\
& + \frac{Oil\ hedged}{Oil\ production}\ \frac{Oil\ production}{Total\ production}
\end{aligned}
$$

$$
PPH_{gas} = \frac{Gas\ hedged}{Gas\ production} \qquad PPH_{oil} = \frac{Oil\ hedged}{Oil\ production}
$$

$$
HedgingDummy = \begin{cases} 1 & \text{if firm hedges} \\ 0 & \text{otherwise} \end{cases}
$$

The first hedging variable, percentage of total production hedged (PPH), is a weighted sum of oil and gas production hedged, relative to the size of their contribution to total production. To create this variable, we had to convert the units of gas into barrels of oil equivalent. See appendix A for an example of how we have constructed PPH. The second and third hedging variable, percentage of gas production hedged (PPH_{gas}) and percentage of oil production hedged (PPH_{oil}), are defined as the volume of gas and oil hedged divided by each commodity's production. Note that for these hedging variables, we use volume hedged a particular year relative to *same year* production, meaning that we use a one-year horizon. Lastly, the hedging dummy *(HedgingDummy)* takes the value 1 if a firm hedges and zero otherwise.

C. Tobin's Q

Traditionally, Tobin's Q is calculated as the market value of financial claims divided by current replacement cost of the firm's assets. The result is a unitless measure that allows for market value comparisons across firms. Due to the need to compute the market value of long term debt and the replacement cost of fixed assets, the estimation of Tobin's Q is quite intricate. However, oil and gas exploration firms provide us with more information than many other firms as the major assets are oil and gas reserves. Due to comprehensive information on oil and gas reserves in the firms' 10-Ks we are able to approximate the replacement cost of oil and gas assets (Jin & Jorion, 2006). Thus, to proxy for Tobin's Q we are able to construct three different measures:

$$Q_{NPV} = \frac{BVtotal\ assets - BVofcommon\ equity + MVofcommon\ equity}{BVoftotassets - BVoilreserves + NPV\ reserves}$$

$$Q_{MV} = \frac{BVtotal\ assets - BVofcommon\ equity + MVofcommon\ equity}{BVoftotassets - BVreserves + MVreserves}$$

$$Q_{BV} = \frac{BVtotal\ assets - BVofcommon\ equity + MVofcommon\ equity}{BVoftotal\ assets}$$

All measures of Tobin's Q share the same numerator; we approximate the market value of the firm by the book value of total assets minus the book value of common equity plus the market value of common equity. The market value of common equity is calculated at fiscal year end. As oil and gas reserve values and book value of common equity also are reported at fiscal year end, this ensures that the Q-ratios are consistent across firms. The difference between the two first measures is that the replacement cost of oil and gas reserves are approximated by net present value in Q_{NPV} and by the current market value in Q_{MV}. The market value of reserves is found by multiplying the volume of oil and gas reserves by their respective prices at fiscal year end. Since oil and gas exploration firms are obligated to report the present value of earnings from oil and gas reserves, we find net present value of reserves in the firms' 10-Ks. Revenues from oil and gas are calculated using the spot price at the fiscal year end, after projected extraction costs and income taxes. To obtain present value, all future net cash flows are discounted at 10%. In Q_{BV} we use the book value of total assets as a proxy for replacement cost.

As in most previous studies, we put the most weight on Q_{BV} in our analysis. This measure uses the book value of oil and gas reserves, which is calculated as the accumulated exploration costs after amortization and depreciation. Jin and Jorion (2006) argue that net present value and the market value approach are better measures of the replacement cost of reserves than the book value approach. We, on the other hand, argue that since oil and gas exploration is the dominant activity in oil and gas exploration firms, the most correct replacement value is the cost each firm would incur if they where to replace current oil and gas assets, i.e. the book value. Further, the net present value and the market value approach are subject to year-to-year swings in energy prices and are sensitive to the date of which spot prices are collected. We thus use these two measures mainly to check the robustness of our results. Further, Q_{BV} have gained a lot of support in previous empirical studies and will thus be the most suitable measure for comparison across studies.

Table I. : Descriptive Statistics

This table describes some of the most important firm characteristics. The information is first displayed for the entire sample of 756 firm-years and then divided into hedgers and non-hedgers. The variable LDA is short for the ratio of long-term debt to total assets, and BV of reserves is short for the book value of combined oil and gas reserves in USD. The fraction of oil and gas production to total production are both stated in percentage, as is the fraction of the combined oil and gas revenues to total revenues.

	Mean	Median	Std. dev	10^{th}-percentile	90^{th}-percentile
Total Sample (Firm-years: 756)					
LDA	0.333	0.231	0.612	0	0.604
BV of Reserves	6440.377	1794.603	13013.9	77.272	15662
Total Assets	5561.617	1714.05	10702.03	121.866	13993.11
Market Cap	4959.254	1224.804	9982.827	112.727	13633.68
$\frac{Gas\ Production}{Total\ Production}$	0.604	0.6434	0.302	0.142	0.961
$\frac{Oil\ Production}{Total\ Production}$	0.396	0.357	0.302	0.039	0.858
$\frac{Oil\ and\ Gas\ Revenues}{Total\ Revenues}$	0.906	1	0.217	0.142	0.961
Q_{BV}	1.727	1.501	1.121	0.876	2.901
Q_{NPV}	2.383	2.061	8.843	-1.964	6.716
Q_{MV}	0.559	0.452	1.264	0.203	1.012
Hedgers (Firm-years: 604)					
LDA	0.343	0.262	0.424	0.05	0.618
BV of Reserves	7400.705	2436.987	13321.27	275.998	17862
Total Assets	5561.617	1714.05	10702.03	121.866	13993.11
Market Cap	4959.254	1224.804	9982.827	112.727	13633.68
$\frac{Gas\ Production}{Total\ Production}$	0.641	0.671	0.274	0.238	0.969
$\frac{Oil\ Production}{Total\ Production}$	0.359	0.329	0.274	0.031	0.762
$\frac{Oil\ and\ Gas\ Revenues}{Total\ Revenues}$	0.934	1	0.1564	0.769	1
Q_{BV}	1.564	1.4231	0.8877	0.876	2.412
Q_{NPV}	2.389	2.136	8.602	-2.316	6.974
Q_{MV}	0.503	0.440	1.304	0.2126	0.957

Table I continues on next page

Table I continued

Non-Hedgers (Firm-years: 152)					
LDA	0.293	0.076	1.07	0	0.49
BV of Reserves	3297.036	169.92	11771	22.047	7262.6
Total Assets	2416.923	233.645	6994.253	41.358	4829.75
Market Cap	2303.119	352.92	6142.445	83.8146	7285.102
$\frac{Gas\ Production}{Total\ Production}$	0.473	0.4389	0.353	0.0128	0.942
$\frac{Oil\ Production}{Total\ Production}$	0.527	0.561	0.353	0.033	0.987
$\frac{Oil\ and\ Gas\ Revenues}{Total\ Revenues}$	0.895	1	0.239	0.6	1
Q_{BV}	2.384	1.893	1.617	0.875	4.691
Q_{NPV}	2.355	1.742	9.795	-0.121	5.510
Q_{MV}	0.782	0.520	1.064	0.139	1.649

VI. Empirical Analysis

In the following section, we outline the models utilized to examine our three hypotheses and present the empirical results. In the multivariate analyses, we decide between the fixed and random effects model with a Hauseman test. A comprehensive description of the panel data model estimation technique utilized in this paper can be found in Appendix C.

A. Hypothesis 1

In order to investigate whether hedging has an effect on oil and gas exploration firms' stock price exposure towards oil and gas price fluctuations, we first conduct a time series analysis to determine the size of each firm's exposure. Next, we conduct a multivariate analysis, utilizing the model estimation techniques described in Appendix C, to investigate the effects of hedging on this exposure.

A.1. Exposure

Following Jin and Jorion (2006), we start by testing each firm's exposure to oil and gas prices using a three-factor model. The three factors are oil and gas price returns, and the return on the market portfolio. The reason for including the market exposure is that a firm's stock return is likely to be driven by overall market conditions, which means that the stock returns are likely to be correlated with the return on the market portfolio. Further, even though the prices for oil and gas prices may be manipulated by large suppliers, their change is likely to be correlated to the market conditions. Hence, excluding the market exposure might introduce endogeneity. If this is the case, the oil and gas coefficients will be biased. Hence, we utilize the following regression:

$$R_{i,t} = \alpha_i + \beta_{m,i} R_{m,t} + \beta_{oil,i} R_{oil,t} + \beta_{gas,i} R_{gas,t} + \epsilon_{i,t} \tag{2}$$

Where $R_{i,t}$ is the rate of return of company i in month t. $R_{m,t}$ is the monthly return on the market portfolio. We use S&P 1500 as a proxy for the market portfolio since we are looking exclusively at US companies. $R_{oil,t}$ and $R_{gas,t}$ represent rates of changes in oil and gas prices. Since all companies in our sample are on the supply side, we expected the exposures to all factors to be positive before running the regression.

A.1.1 Results

The results for the time-series regression testing each firms' stock price exposure to oil and gas prices and to the market portfolio are listed in table II. We find that all companies have long exposures towards oil prices, meaning that they loose money when the oil price declines. The mean exposure is 0.618, and is statistically significant at all conventional levels. The interpretation is that a 1% increase in the oil price on average leads to a 0.618% increase in a firm's stock returns. The exposures towards gas are mostly long, with a mean of 0.083. However, there are some companies that exhibits negative exposure to the gas price, the lowest observed exposure is -0.642. Still, we note that none of the negative exposures are statistically significant at a 5%-level. The reason exposures towards gas are lower relative to the exposures to oil might be due to the relative importance of gas revenues. As we recall from the descriptive statistics in table I, oil production consisted of on average 39.6% of production in the total sample. If we take into account that oil prices are many times as high as gas prices, the fraction of revenues originating from the sale of oil will be considerably higher than the fraction of gas revenues. Lastly, the mean market exposure is 0.997, which means that, on average, stock returns are close to following the market returns 1-to-1.

A.2. Effects of Hedging

We now extend the above three-factor model and examine whether hedging has an effect on a firm's exposure towards oil and gas prices. In order to maintain parsimony of the model, we examine the effects on oil and gas betas in two separate regressions. The estimated equations are:

$$R_{i,t} = \alpha + \beta_m R_{m,t} + [\gamma_1 + \gamma_2 PPH_{oil,i,t} + \gamma_3 D_{fc,t} PPH_{oil,i,t} + \gamma_4 D_{bw,t} PPH_{oil,i,t} + \gamma_5 D_{oc,t} PPH_{oil,i,t} + \gamma_6 (OilReserve_{i,t}/MVE_{i,t})] R_{oil,t} + \beta_{gas} R_{gas,t} + \beta_{fc} D_{fc,t} + \beta_{fc} D_{bw,t} + \beta_{fc} D_{oc,t} + \omega_{i,t} \quad (3)$$

$$R_{i,t} = \alpha + \beta_m R_{m,t} + [\gamma_7 + \gamma_8 PPH_{gas,i,t} + \gamma_9 D_{fc,t} PPH_{gas,i,t} + \gamma_{10} D_{bw,t} PPH_{gas,i,t} + \gamma_{11} D_{oc,t} PPH_{gas,i,t} + \gamma_{12} (GasReserve_{i,t}/MVE_{i,t})] R_{gas,t} + \beta_{oil} R_{oil,t} + \beta_{fc} D_{fc,t} + \beta_{fc} D_{bw,t} + \beta_{fc} D_{oc,t} + \omega_{i,t} \quad (4)$$

Where PPH_{oil} is the volume of oil hedged in year t divided by same-year oil production. The same procedure is used for the gas equivalent. We also include time dummies to account for time specific effects. D_{fc} is a "financial crisis dummy", set to equal 1 in 2008. D_{oc} is an "oil crisis dummy", set to equal 1 during the rapid reduction in prices in 2014 and 2015. Lastly, we include a dummy for the period between the crises, D_{bw}, set to equal 1 from 2009 to 2013. Since we suspect the intercept to differ during the different sub-periods, we include the dummies as single variables. Further, since we suspect that the marginal effect of hedging on the exposure towards oil and gas prices to differ between the different sub-periods we include the dummies interacted with this variable as well. This effectively means that we control for possible structural breaks. Both the volume of oil and gas hedged and the reserves are collected from the firms' 10-Ks. For the market value of equity (MVE) we use each company's market capitalization.

A.2.1 Results

The results presenting the effect of hedging on the firms' exposure towards oil and gas prices are tabulated in table III. The results suggest a time-varying effect of hedging on the stock returns' exposure towards oil and gas prices. Between 2004 and 2007, the total effect of hedging on exposure, represented by the coefficient of $PPH * R_{Oil}$ and $PPH * R_{Gas}$, is positive and statistically significant at the 5%-level. Specifically, if the interacted variable $PPH * R_{Oil}$ ($PPH * R_{Gas}$) increase by 1%, the firms' stock returns increase by 1.141% (1.3%). Further, the marginal effect of hedging on firms' oil exposure is -1.602 during the financial crisis (set to 2008) and -1.244 during the oil crisis (set to 2014 and 2015). For gas, the same marginal effects are -2.234 and -1.295 respectively. Thus, in the financial crisis, the total effect of hedging on oil exposure is -0.461 (=1.141-1.602) and on gas exposure is -0.934 (=1.3-2.234). In the oil crisis, the same total effects are -0.103 (=1.141-1.244) on oil exposure and 0.005 (=1.3-1.295) on gas exposure. Between the two crises, the marginal effects of hedging on oil exposure is not significant at any conventional levels, but is significant at the 1%-level for gas exposure. Accordingly, we assume the total effect of hedging on oil exposure to be the same before the financial crisis and between the crisis, while the total effect of hedging on gas exposure changes to 0.159 (=1.3-1.141).

These results are not in accordance with our initial expectations. We expected hedging to decrease a firm's stock price exposure to oil and gas prices during all sub-periods, and accordingly have a negative sign. This seem only to be true for both commodities during the financial crisis, and true only for the oil exposure during the oil crisis. In the other sub-periods, our results suggest a positive effect of hedging on firms' stock price exposure towards oil and gas prices. If we take into account that oil revenues contribute with a higher fraction of a firm's total revenues than gas revenues, the results in sum show that hedging decrease a firms exposure to oil and gas prices in crisis periods, and increase the exposure outside crises periods. One possible explanation for the increased exposure outside crises periods is that after a firm has hedged, investors penalize firms that experience losses on the upside with lower market values and reward firms that expect gains on the downside with higher market values. In such cases, having hedged might in fact contribute with increased exposures towards oil and gas prices compared to not hedging at all. These results will be crucial when we test the value implications of hedging in the next section. In particular, if hedging does not decrease the exposure outside crisis periods, it should not be value-adding.

Further, the coefficient of $\frac{OilReserves}{MVE} * R_{Oil}$ is 0.149%, statistically significant at the 10% level. The interpretation is that if oil reserves increase relative to total market value of equity, a firm is more sensitive towards fluctations in oil prices. We get similar results in the extended regression for the gas exposure, where the coefficient of $\frac{GasReserves}{MVE} * Re_{gas}$ is 0.003 and is statistically significant at all conventional levels, and the interpretation is the same. The dummy variables, representing each sub-period, are in general negative in both extended regressions. In the extended regression for oil exposure, only the dummies for the financial crisis and the oil crisis are statistically significant. In the extended regression for gas, the oil crisis dummy is the only statistically significant dummy. These statistically significant dummies indicate that the intercept is lower during the crises-periods, and is the same as before the financial crisis between the crises. This was as expected.

Interestingly, the coefficients of R_{Oil} in the extended regression for oil is not statistically significant, and neither is the coefficient of R_{Gas} in the extended regression for gas. This implies that the relationship between oil and gas prices and stock returns in oil and gas exploration firms can be captured by two effects. Firstly, if there is an increase in oil and gas prices, firms should be able to collect higher revenues from current production if they are largely unhedged. This effect is captured by the coefficient of $PPH * R_{Oil}$ and $PPH * R_{Gas}$. Secondly, the value of the firm increases due to increased value of the reserves and accordingly higher value of future production. This effect is captured by the coefficients of $\frac{OilReserves}{MVE} * R_{Oil}$ and $\frac{GasReserves}{MVE} * R_{gas}$.

Table II. : **Exposure**

This table presents the results of the time-series regression on each firms' stock price exposure towards the market portfolio as well as oil- and gas prices. The coefficients of R_{SPR}, R_{Oil} and R_{Gas} are found by running the following time-series regression on each company's stock returns:

$$R_{i,t} = \alpha_i + \beta_{m,i} R_{m,t} + \beta_{oil,i} R_{oil,t} + \beta_{gas,i} R_{gas,t} + \epsilon_{i,t}$$

The variables are explained in section VI.A.1.

	Risk Factors		
	R_{SPR}	R_{Oil}	R_{Gas}
Mean	0.997	0.618	0.083
T-stat	13.349	18.040	4.313
Median	0.928	0.543	0.116
Std. Dev	0.739	0.339	0.190
Min	-1.142	0.027	-0.642
Max	4.165	1.598	0.441
$Pct > 0$	0.939	1	0.786
$Pct > 0$ & $p \leqslant 0.05$	0.663	0.816	0.265
$Pct < 0$ & $p \leqslant 0.05$	0	0	0

Table III. : Effects of Hedging on Exposure

Hedging's effect on stock returns are tabulated below. The results are achieved by running two separate panel regressions:

$$R_{i,t} = \alpha + \beta_m R_{m,t} + [\gamma_1 + \gamma_2 PPH_{oil,i,t} + \gamma_3 D_{fc,t} PPH_{oil,i,t} + \gamma_4 D_{bw,t} PPH_{oil,i,t} + \gamma_5 D_{oc,t} PPH_{oil,i,t} + \gamma_6 (OilReserve_{i,t}/MVE_{i,t})] R_{oil,t} + \beta_{gas} R_{gas,t} + \beta_{fc} D_{fc,t} + \beta_{fc} D_{bw,t} + \beta_{fc} D_{oc,t} + \omega_{i,t}$$

$$R_{i,t} = \alpha + \beta_m R_{m,t} + [\gamma_7 + \gamma_8 PPH_{gas,i,t} + \gamma_9 D_{fc,t} PPH_{gas,i,t} + \gamma_{10} D_{bw,t} PPH_{gas,i,t} + \gamma_{11} D_{oc,t} PPH_{gas,i,t} + \gamma_{12} (GasReserve_{i,t}/MVE_{i,t})] R_{gas,t} + \beta_{oil} R_{oil,t} + \beta_{fc} D_{fc,t} + \beta_{fc} D_{bw,t} + \beta_{fc} D_{oc,t} + \omega_{i,t}$$

The variables are described in section VI.A.2. The t-stats are listed below each variable in parenthesis. Variables which are statistical significant at or below a 10%-level are written in bold.

	Oil	Gas
R_m	0.188	**0.792**
	(1.0)	(3.23)
R_{Oil}	**0.217**	**0.419**
	(2.8)	(3.39)
R_{Gas}	0.124	-0.072
	(0.86)	(-0.62)
$PPH * R_{Oil/Gas}$	**1.141**	**1.3**
	(2.1)	(5.28)
$PPH * R_{Oil/Gas} * D_{fc}$	**-1.602**	**-2.234**
	(-2.59)	(-3.25)
$PPH * R_{Oil/Gas} * D_{oc}$	**-1.244**	**-1.295**
	(-2.04)	(-2.81)
$PPH * R_{Oil/Gas} * D_{bw}$	-0.104	**-1.141**
	(-0.18)	(-2.93)
$\frac{Oil/Gas\ Reserves}{MVE} * R_{Oil/Gas}$	**0.149**	0.003
	(1.82)	(0.03)
D_{fc}	**-0.615**	-0.19
	(-3.34)	(-1.1)
D_{oc}	**-0.665**	**-0.64**
	(-3.34)	(-5.22)
D_{bw}	-0.042	-0.106
	(-0.6)	(-1.6)
R-squared	0.365	0.378
Fixed/Random Effects	Fixed	Fixed
Sample Size	657	657

B. *Hypothesis 2*

To investigate the relationship between hedging and firm value we conduct both a univariate analysis and a multivariate analysis. In the univariate analysis we test whether firms that hedge have higher Q-ratios than firms that do not hedge. Because Q-ratios are affected by many factors, we further isolate the effect of hedging in the multivariate analysis . In the multivariate analyisis we utilize the model estimation techniques described in Appendix C.

B.1. Univariate Analysis

The univariate analysis gives us a simplistic answer to the question: "do firms that hedge have higher Q-ratios?". We compare the average and median Q-ratio of firms that hedge to the average and median Q-ratio of firms that do not hedge, and test if the difference is significant. Our test is two-sided, with the null hypothesis being that the difference in the Q-ratios is zero. If the difference is significantly positive, it indicates that investors reward firms that hedge. If the difference is significantly negative, it indicates that investors penalize firms that hedge.

B.1.1 Results

Our results for the univariate analyisis are presented in table IV. We find that non-hedgers on average have a higher Q-ratio than hedgers for the Q-ratios Q_{BV} and Q_{MV}. These results are statistically significant at all conventional levels. For the Q-ratio Q_{NPV}, hedgers seem to have a higher average Q than non-hedgers, however the difference is not statistically significant. Looking at the median, we see a similar pattern for Q_{BV} and Q_{MV}, where non-hedgers have statistically significant higher medians than hedgers. However, we note that the difference in medians are smaller than the differences in the means. Again, Q_{NPV} differs from the other measures and show that non-hedgers have a lower median than hedgers, statistically significant at the 5% level. In sum, we find the univariate analysis to indicate a hedging discount on firm value. However, we note that the results are sensitive to the Q-ratio utilized. With regards to the other factors, we find that hedgers have higher means and median values for total assets, market capitalization and the leverage ratio (LDA). With the exception of the mean leverage ratio, all differences are statistically significant at all conventional levels.

B.2. Multivariate Analysis

While a univariate analysis' main purpose is to describe data, the multivariate analysis in this section will be more informative in isolating the effect of hedging on Q-ratios. Borrowing inspiration from Allayannis and Weston (2001) and Haushalter (2000), we regress the Q-ratio on both a hedging dummy and the percentage of production hedged (PPH):

$$ln(Q_{i,t}) = \alpha + (\beta_1 + \beta_2 D_{fc,t} + \beta_3 D_{bw,t} + \beta_4 D_{oc,t})PPH_{i,t} + \sum_{j=0}^{6} \gamma_j ControlVariable_{i,t} + \delta_1 D_{fc,t} + \delta_2 D_{bw,t} + \delta_3 D_{oc,t} + \omega_{i,t} \quad (5)$$

$$ln(Q_{i,t}) = \alpha + (\beta_1 + \beta_2 D_{fc,t} + \beta_3 D_{bw,t} + \beta_4 D_{oc,t})HedgingDummy_{i,t} + \sum_{j=0}^{6} \gamma_j Controlvariable_{i,t} + \delta_1 D_{fc,t} + \delta_2 D_{bw,t} + \delta_3 D_{oc,t} + \omega_{i,t} \quad (6)$$

As stated in the data description in section V, we are using three different proxies for the value of reserves to construct the Q-ratios, which means that we are running a total of six regressions testing the relationship between firm value and hedging. The purpose of running multiple regressions using different proxies of both Q-ratios and hedging variables is to test the sensitivity of our results. Because Q-ratios are skewed to the right, the dependent variables are the logs of the Q-ratios. Thus, the coefficients can be interpreted as elasticities. As in hypothesis 1, we include both separate time dummies and time dummies interacted with the hedging variable. The time dummies D_{fc}, D_{bw} and D_{oc} are defined as before. This means that we are able to test whether the the constant and the marginal effect of hedging differs across sub-samples. As pointed out in the last section, this effectively means that we control for possible structural breaks. We are also including several control variables to avoid potential omitted variable bias. If hedging proves to be value adding in all sub-periods, β_1 to β_4 should be positive.

B.2.1 Choice of Control Variables

When choosing control variables, we faced the trade-off between parsimony and excluded variable bias. That is, to isolate the effect of hedging, we need to include as many variables that are relevant for Q as possible, without decreasing the efficiency of our estimators. In order to be as exhaustive as possible, we borrowed inspiration from Jin and Jorion (2006) and Allayannis and Weston (2001), and choose the following variables:

- *ln(Total Assets)*: The jury is still out on whether or not size decreases accounting profitability (which would decrease the Q-ratios). However, it is important to control for size since large firms are more likely to hedge than small firms (Bodnar et al., 1995; Guay & Kothari, 2003;

Haushalter, 2000). To control for this, we use the log of total assets. In accordance with Lang and Stultz (1994) and Allayannis and Weston (2001) we expected to get a negative sign of this coefficient.

- *ROA*: We expected to find higher Q-ratios for more profitable firms. We use return on assets to control for this effect.
- *LDA*: Capital structure might also be linked to firm value. To control for capital structure, we borrow inspiration from Allayannis and Weston (2001) and use long-term debt divided by total assets. We expected positive relationship between capital structure and Q-ratios.
- *Production Costs*: Production costs refers to a firm's lifting costs per barrel of oil equivalent. We expected that firms with higher production costs have lower Q-ratios.
- *CAPEX/Sales*: Future investment opportunities are likely to be linked to firm value. We use the ratio of capital expenditures to sales as a proxy for this effect, and expected the coefficient to be positive.
- *Dividend Dummy*: If hedgers have limited access to financial markets, their Q-ratios may be high because they are limited to only undertaking the highest NPV projects. To capture this effect, we use a dividend dummy as a proxy. The intuition is that firms that pay dividends are less likely to be capital constrained. However, due to dividend stickiness, this measure might not be perfect. Given this interpretation, the coefficient should be negative. However, dividends can also be viewed as a positive signal from management, which could imply a positive coefficient.

We excluded the following variables suggested by Allayannis and Weston (2001):

- *Industrial Diversification and Industry Effect*: Since we are only using exploration companies, we should not need to look at industrial diversification or industry effects.
- *Geographic Diversification*: This variable will not give any additional value as our entire sample consists of U.S. companies.
- *Credit rating*: Since many of the firms in our sample are small, they do not carry a credit rating. Adding this variable would thus constrain our sample.

B.2.2 Results

The results for the multivariate analysis are presented in table V. As previously argued in the data description, we put most weight on the standard Q-ratio Q_{BV}, where replacement cost of oil and gas reserves is based on book values, and the hedging variable percentage of production hedged, PPH. In the table presenting our results, the coefficient of PPH represents the total effect of hedging on firms' Q-ratios before 2008. The coefficient of PPH is negative and equal to -0.232, and is statistically significant at the 10% level. The economic interpretation is that if a firm hedges 100% of its oil and gas production the marked penalizes it with a 23.2% lower market value. An alternative interpretation is that if a firm hedges 1% more of their oil and gas production, the market will penalize it with a 0.232% lower firm value. The marginal effect of the financial crisis, set to 2008, is measured by the coefficient of $PPH * D_{fc}$. This coefficient is statistically significant at the 5%-level, and is positive and equal to 0.456. This indicates that, during the financial crisis, the market rewards firms that hedge 100% of their production with a 22.4% higher firm value (=-0.232+0.456). These results are similar to the results we get during what we define as the oil crisis, set to 2014 and 2015. The marginal effect of hedging during this period is measured by the coefficient of $PPH*D_{oc}$. The coefficient of $PPH * D_{oc}$ is also positive and is equal to 0.327, statistically significant at the 10% level. Thus, the total effect of hedging 100% of production during the oil crisis is a value premium of 9.5% (=-0.232+0.327). Lastly, the variable measuring the marginal effect of hedging between the two crisis is measured by $PPH * D_{bw}$. This variable is also positive, but contrary to the other coefficients it is not statistically significant at any conventional levels. Thus, we assume the total effect of hedging between the crises to be the same as the effect before the financial crisis, i.e. markets penalize firms that hedge 100% of their production with a 22.4% lower market value.

Interestingly, it is only in the periods we define as crises we find evidence of a hedging premium. Outside crisis periods, the market seems to penalize firms that hedge. This is well in line with our results for Hypothesis 1, suggesting that investors only recognize the effect of hedging in crisis periods. Phan et al. (2014) suggest the existence of a hedging discount during periods of increasing energy prices, and no relation between hedging and firm value during decreasing prices. This argument is in accordance with our results as well, with the exception of the hedging discount found during the sub-period of 2008. In 2008, we observe an increasing price pattern in the first half of the year and a decreasing price pattern the second half of the year. According to Phan et al. (2014), the hedging losses in the first part of 2008 should have been offset by the hedging gains during the second part of 2008.

Instead of looking at the price pattern, we explain the pattern by carrying over our results from Hypothesis 1. We found that investors only seem to recognize the effects of hedging during the periods we define as crisis, and not outside crisis periods. This can be explained by investor loss aversion, i.e. investors are more sensitive to negative shocks than to positive (Thaler et al., 1997). Empirical research find that losses are weighed about twice as strongly as gains (e.g. Tversky & Kahneman, 1991; Kahneman et al., 1990). Hence, the hedging losses during the second half of 2008 would outweigh the hedging gains during the first half of 2008. However, we also note that the hedging discounts are larger than the hedging premiums. Hence, while firms will be rewarded with a hedging premium during crises, it will not make up for the hedging discounts outside crises. This may represent the costs related to hedging and in general the implementation of a risk management program.

We are able to transfer this argument to Phan et al. (2014). We suggest their finding of different effects of hedging during different price patterns to instead be due to differences in investor risk aversion. In their sample, oil and gas prices had, in general, an upward trend. Hence, investors were not as concerned about losses in stock returns and accordingly were willing to take on risk. As a result, firms that hedged were penalized with a lower firm value. Compared to our sample period, we do not deem Phan et al.'s (2014) sample period to be long enough during a decreasing price pattern to draw any valid conclusion. Further, during Jin and Jorion's (2006) time horizon, set to 1998 to 2001, there were significantly less volatility in oil and gas prices compared to both our sample period and Phan et al.'s (2014) sample period. Hence, investors were neutral with regards to risk taking, and accordingly also hedging at the firm level.

To check the reliability of our results, it is worth examining the size of the hedging premiums and discounts and compare it to previous studies utilizing a similar sample. Phan et al. (2014) uses, among others, the sum of delta equivalents of each hedging positions relative to production as a hedging variable. This hedging variable is similar to our percentage of production hedged, and the coefficients are -0.215 and 0.171 for oil and gas production respectively. Seeing as Pan et al. (2014) investigates the value of oil and gas exploration firms during the period 1998-09, it is most comparable to PPH. Our result for this variable at -0.232 thus seem well in line with Phan et al. (2014).

To further check the sensitivity of our results, we have run the regression using hedging dummies and using Q_{NPV} and Q_{MV}. These results can be found in table V. While the value of the coefficients of the hedging variables vary, the sign is in general the same across regressions. Further, the coefficients in Q_{NPV} and Q_{MV} are larger for both the hedging dummy and the percentage of production hedged. This is not surprising, as these Q-ratios use proxies that are much more volatile as a result of higher sensitivity to oil and gas price fluctuations. We also note that the coefficients of the hedging dummy is always lower than the coefficient of the percentage of production hedged. This makes sense, as the hedging dummy simply states whether a firm hedges or not, while the percentage of production hedged quantifies the amount of hedging and in general should always be less than 1.

With regard to the control variables, table V show that the coefficients in general have expected signs, at least those of statistical significance. Using Q_{BV} and PPH, we find statistical significance of firm size being negatively related to the Q-ratio and return on assets, leverage and investment growth to be positively related to the Q-ratio. Further, the dummies for the financial crisis, the oil crisis and the period in between are all significantly negative. Hence, our results show significant evidence of structural breaks in our sample; both the intercept and the effects of hedging on firm value, as mentioned above, differs between the sub-samples. We did not find any statistically significant relationship between firms' Q-ratios and production costs and market access (represented by the dividend dummy).

Table IV. : Univariate Analysis

The results of the univariate analysis on whether hedging adds value are listed below. The results were obtained by performing a t-test on the means and a Wilcoxon rank-sum test on the medians. Every difference is performed by subtracting hedgers from non-hedgers. The variables that are statistically significant at or below a 10%-level are written in bold.

	Non-Hedgers	Hedgers	Difference	p-Value
Q_{BV} (mean)	2.384	1.564	**0.820**	0.000
Q_{BV} (median)	1.893	1.423	**0.469**	0.000
Q_{MV} (mean)	0.782	0.503	**0.279**	0.016
Q_{MV} (median)	0.520	0.439	**-0.035**	0.017
Q_{NPV} (mean)	2.355	2.389	-0.423	0.966
Q_{NPV} (median)	1.742	2.136	**-0.395**	0.022
Total Assets (mean)	2303.12	5724.092	**-3420.972**	0.000
Total Assets (median)	233.6445	2323.732	**-2090.088**	0.000
Market Cap (mean)	2303.119	5734.092	**-3430,973**	0.000
Market Cap (median)	352.92	1691.481	**-1338.561**	0.000
LDA (mean)	0.293	0.343	-0.05	0.362
LDA (median)	0.076	0.262	**-0.186**	0.000

Table V. : Effects of Hedging on Firm Value

This table presents the regression results of the multivariate analysis on the relationship between hedging and firm value. The models used are:

$$ln(Q_{i,t}) = \alpha + (\beta_1 + \beta_2 D_{fc,t} + \beta_3 D_{bw,t} + \beta_4 D_{oc,t})PPH_{i,t} + \sum_{j=0}^{6} \gamma_j ControlVariable_{i,t} + \delta_1 D_{fc,t} + \delta_2 D_{bw,t} + \delta_3 D_{oc,t} + \omega_{i,t}$$

$$ln(Q_{i,t}) = \alpha + (\beta_1 + \beta_2 D_{fc,t} + \beta_3 D_{bw,t} + \beta_4 D_{oc,t})HedgingDummy_{i,t} + \sum_{j=0}^{6} \gamma_j Controlvariable_{i,t} + \delta_1 D_{fc,t} + \delta_2 D_{bw,t} + \delta_3 D_{oc,t} + \omega_{i,t}$$

The variables are explained in section VI.B.2 and B.2.1. The T-stats are listed below each variable in parenthesis. The variables that are statistically significant at or below a 10%-level are written in bold.

	Q-ratios					
	Q_{BV}		Q_{NPV}		Q_{MV}	
	PPH	Dummy	PPH	Dummy	PPH	Dummy
$PPH/Dummy$	**-0.232**	**-0.169**	-0.697	-0.193	**-0.358**	**-0.175**
	(-1.67)	(-2.01)	(-2.55)	(-1.19)	(-2.07)	(-1.67)
$PPH/Dummy * D_{fc}$	**0.456**	**0.445**	0.028	-0.047	0.288	0.126
	(1.97)	(2.88)	(0.07)	(-0.16)	(0.99)	(0.64)
$PPH/Dummy * D_{oc}$	**0.327**	0.23	**0.823**	**0.665**	**0.445**	**0.474**
	(1.7)	(1.62)	(2.13)	(2.28)	(1.83)	(2.57)
$PPH/Dummy * D_{bw}$	0.169	0.128	**0.785**	**0.429**	**0.317**	**0.231**
	(1.11)	(1.23)	(2.61)	(2.03)	(1.68)	(1.77)
ln(Total Assets)	**-0.085**	**-0.084**	-0.003	-0.027	-0.025	-0.035
	(-2.41)	(-2.4)	(-0.04)	(-0.36)	(-0.55)	(-0.78)
ROA	**0.008**	**0.008**	**0.006**	**0.006**	**0.003**	0.004
	(7.1)	(7.02)	(2.0)	(2.08)	(2.22)	(2.3)
LDA	**0.226**	**0.214**	0.089	0.058	**0.247**	**0.225**
	(4.2)	(3.88)	(0.81)	(0.54)	(3.53)	(3.19)
Production costs	0.0002	-0.0001	0.001	0.001	**0.002**	0.002
	(0.14)	(-0.12)	(0.5)	(0.45)	(1.66)	(1.53)
CAPEX/sales	**0.244**	**0.214**	0.346	0.266	**0.369**	**0.321**
	(1.92)	(1.69	(1.16)	(0.88)	(2.03)	(1.75)

Table V continues on the next page.

Table V continued

Dividend Dummy	-0.059	-0.055	-0.1	-0.084	0.127	0.138
	(-0.86)	(-0.79)	(-0.69)	(-0.58)	(1.44)	(1.56)
D_{fc}	**-0.565**	**-0.773**	-0.065	-0.04	**0.224**	0.211
	(-5.7)	(-5.56)	(-0.36)	(-0.15)	(1.81)	(1.2)
D_{oc}	**-0.446**	**-0.516**	-0.176	-0.412	**0.332**	0.11
	(-4.37)	(-3.92)	(-0.81)	(-1.53)	(2.54)	(0.64)
D_{bw}	**-0.125**	**-0.174**	**0.274**	0.188	0.087	0.006
	(-1.86)	(-1.85)	(1.96)	(0.97)	(1.03)	(0.05)
R-squared	0.1932	0.1963	0.0254	0.0389	0.0246	0.0268
Fixed/Random	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Sample Size	738	738	595	595	706	706

C. *Hypothesis 3*

To investigate the determinants of hedging we conduct a multivariate analysis where the percentage of production hedged is the dependent variable. We also here utilize the model estimation techniques described in Appendix C.

C.1. Multivariate Analysis

Due to lack of data on managerial incentives we are forced to run three iterations of the regression, which contain different variables over different time periods. From Bloomberg, we were able to collect data on insider ownership from 73 companies in the time period 2010 to 2015. From COMPUSTAT, we were able to collect information on both manager ownership and manager options for 34 companies from 2004 to 2015. Finally, we the run regression excluding managerial incentives. Excluding this variable should not cause a bias since managerial incentives are not likely to be correlated with the other explanatory variables.

The estimated equation is thus as follows:

$$\begin{aligned} PPH_{i,t} = \alpha &+ \beta_1 LDA_{i,t} + \beta_2 ln(TotalAssets)_{i,t} + \beta_3 ln(TotalAssets)_{i,t} * LDA_{i,t} \\ &+ \beta_4 ln(LossCarryforward)_{i,t} + \beta_5 Price/Book_{i,t} + \beta_6 CurrentRatio_{i,t} \\ &+ \beta_7 DividendDummy_{i,t} + \beta_8 ROA_{i,t} + \beta_9 Reserves/TotalAssets_{i,t} \\ &+ \beta_{10} ProductionCosts_{i,t} + \beta_{11} Oil_{i,t} + \beta_{12} Gas_{i,t} + \beta_{13} OilVolatility_{i,t} \\ &+ \beta_{14} GasVolatility_{i,t} + \beta_{15-17} ManagerIncentives^1_{i,t} + \omega_{i,t} \qquad (7) \end{aligned}$$

Description of the variables are listed below:

- *LDA*: As a proxy for bankruptcy's role in risk management, we use each firm's ratio of long-term debt to total assets (LDA). The sign of the leverage ratio's coefficient could be both positive and negative, depending on the time-line. Initially, the firm will want to hedge more in order to be able to increase its leverage. After the firm has been able to borrow, the relationship might become negative due to debt overhang.

- *ln(Total Assets)*: As mentioned in section B.2.1 previous research suggests that larger firms are more likely to hedge than smaller firms (e.g. Bodnar et al., 1995; Guay & Kothari, 2003; Haushalter, 2000). We continue to use the log of total assets as a proxy for size, and expected the relation to hedging to be positive. We additionally use the interaction between size and the leverage ratio to test for the combined effect. We expected larger firms with higher leverage ratios to hedge more. A possible explanation for both these positive relationships may be that larger firms have better abilities to make the necessary investments and possess the required human and technological resources required in establishing a risk management program than smaller firms (Arnold et al., 2014).
- *ln(Loss Carryforward)*: The tax liabilities is the hardest variable to find a proxy for. Some previous studies have used the effective marginal tax rate (e.g Haushalter, 2000). However, there are also a large body of research that has utilized the tax-loss carryforward as a proxy (e.g. Aretz & Bartram, 2010; Arnold et al., 2014), which is readily available in the firms' 10-Ks. Since we expect the distribution of tax-loss carryforwards to be skewed to the right, we will use the log of loss carryforwards as a proxy for tax incentives. The reason it works as a proxy is that a company only can deduct taxes in times of positive income, which means that hedging should increase the net present value of tax-loss carryforwards. I.e. we expected the coefficient of this variable to be positive.
- *Price/Book*: When facing risk of bankruptcy, debt overhang might lead to underinvestment. Underinvestment can be defined as firms having many growth opportunities but external financing is costlier than internally generated funds. The underinvestment problem is usually experienced by highly levered companies facing the prospects of default, and in some cases just a downturn in earnings (Stultz, 1996; Froot et al., 1993). As a high price/book ratio indicates growth opportunities, we use this variable as a proxy to test whether firms hedge to decrease the risk of underinvestment (Arnold et al., 2014). We expected there to be a positive relationship between hedging and firms' price/book ratio.
- *Current Ratio*: We use the ratio of current liabilities to cash and marketable securities as a measure of liquidity. Companies with large amounts of cash experience less liquidity risk, a risk that might lead to insolvency

risk through financial distress costs. When the current ratio is high, firms have more current liabilities relative to cash and accordingly a higher liquidity risk. Since hedging can decrease this risk, we expected the relationship between hedging and the current ratio to be positive.

- *Dividend Dummy*: One motivation for hedging can be gaining access to more leverage. If the firm has easy access to capital, this motivation will be weaker. To gauge the market access, we use a dividend dummy as a proxy. The intuition is that firms that pay dividends have easier access to external financing. Hence, we expect the coefficient of this variable to be negative. However, since dividends tend to be sticky, they can also work as a financial constraint on firms. If so, the relationship between hedging and the dividend dummy should be positive (Arnold et al., 2014).
- *ROA*: More profitable firms generate higher cash flows, which means that they have a higher ability to maintain loans, get access to more capital, and have a higher ability to bear poor market conditions in general. Hence, they have less incentives to hedge, and accordingly we expected the relationship to be negative. To measure this effect we use return on assets (ROA).
- *Reserves/Total Assets*: We use the ratio of the book value of reserves to the book value of total assets. We expected a firm's exposure to oil and gas prices to increases with the size of total reserves. Hence, hedging should be positively related to this variable.
- *Production Costs*: We use production cost per barrel of oil equivalent. Firms with higher production costs are more sensitive to decreases in prices of oil and gas. Thus, we expected there to be a positive relationship between production costs and hedging.
- *Oil and Gas Prices*: Consistent with the variables collected from the firms' 10-Ks, we use oil and gas prices at year end. A firms decision to hedge should be independent from current oil and gas prices. Still, we suspect that the price level may prove to have an impact. When oil and gas prices are relatively low, firms may worry about prices decreasing further and accordingly decide to hedge. When oil and gas prices are relatively high, firms have higher revenues and can better tolerate decreases in prices. Accordingly, they may decide not to hedge. We thus expected the coefficient of oil and gas prices to be negative.
- *Oil and Gas Price Volatility*: We use the standard deviation of oil and gas prices during each consecutive year, using daily data, as a measure of volatility. As the volatility in oil and gas prices increase, the value of hedging should also increase (given that the cost of hedging remains the same). Thus, we expected there to be a positive relationship between

volatility in oil and gas prices and the hedging variable.

- *Managerial Motives*: Manager incentives can be separated into ownership of equity and ownership of options. We expected hedging to increase with the amount of equity owned, due to increasing underdiversification for managers. We expected hedging to decrease with the amount of options owned, as the value of options increase with volatility and further since options cap the downside but keep the upside. The number 1 next to manager incentives in the above regressions indicates that we run three iterations of the regression using different proxies for manager incentives: in the first we use insider equity ownership from Bloomberg, in the second we use manager equity ownership and manager option ownership from COMPUSTAT, and in the third we run the regression without any data on manager incentives. We note that insider equity ownership is a broader term than manager equity ownership, as it includes both managers and investors that own more than 10%. Hence, it might be a bad proxy for manager incentives.

C.1.1 Results

Table VI presents the regression results for hypothesis 3. Iteration (1) provides us with most statistically significant variables and the highest R-squared. In this iteration, we use insider ownership collected from Bloomberg as a proxy for manager incentives and the sample includes the time period 2010 to 2015. The reason for a lower R-squared, and less statistically significant variables in the two other equations may be due to the sample utilized. In iteration (2) and (3) the sample includes the entire time period, which may cause noise in the data. Further, in iteration (2), the sample is quite small due to the data constraint on the variables representing manager incentives. In iteration (3), we exclude manager incentives altogether. We do not believe that this exclusion will cause omitted-variable bias, as we do not expect managerial incentives to be correlated with the other independent variables. However, it may still inflate the standard errors of the coefficients because it is correlated with PPH.

In iteration (1), we find a negative relationship between the leverage ratio (LDA) and PPH, statistically significant at the 10% level. As argued in the theoretical background in section III, the relationship between leverage and hedging might be different depending on the time-line. A negative relationship suggest evidence of issues relating to debt overhang. As previously explained, this refers to the conflicts of interest between shareholders and debtholders, were it is beneficial for shareholders of a leveraged firm to substitute highly risky investment project, possibly even negative net present value projects, for safe investment projects (Aretz & Bartram, 2010). Thus, while hedging can give firms easier to access external financing, they may not have incentives to hedge once the debt is in place. These results are in line with Guay and Kothari's (2003) cash flow sensitivity analysis, but contradict Haushalter (2000) who finds a positive relationship between hedging and the leverage ratio.

Further in iteration (1), we get positive and statistically significant results for firm size, the interacted variable between firm size and the leverage ratio, the market access variable, the current ratio and production costs per BOE. With the exception of the market access variable, this is in accordance with what we expected before running the regressions. The positive relationship between size and PPH is widely documented in prevous reserach (e.g. Bodnar et al., 1995; Guay & Kothari, 2003; Haushalter, 2000). One explanation for the positive relationship is that larger firms may have better abilities to make the necessary initial investments and possess the required human and technological resources required in establishing a risk management program than smaller firms (Arnold et. al, 2014). Further, the interacted variable between firm size and the leverage ratio indicate that larger and more leveraged firms hedge more. The combined effect of this interacted variable and the coefficient of the leverage ratio suggest that larger firms are able to utilize hedging premiums in the form of lower financing costs. Smaller firms with high leverage ratios, on the other hand, do not seem to find the same value in lower financing costs and prefer to stay more exposed to oil and gas price fluctuations. Again, this might have something to do with the cost related to implementing a risk management program. The positive coefficient of the current ratio implies that firms with higher current liabilities relative to cash and marketable securities hedge more. This hedging would decrease the firm's liquidity risk and accordingly decrease the insolvency risk through financial distress costs. The positive relationship between production costs and hedging was expected. This indicates that firms with higher production costs are more sensitive to energy price fluctuations, and thus find more value in hedging. Lastly, we did not expect to find a positive relationship between market access, using dividend dummy as a proxy, and hedging. We expected this relationship to be negative, as paying dividends should give firms easier access to external financing. However, due to the stickiness of dividends, dividends may also constrain the firm financially (Aretz & Bartram, 2010). The latter might explain the positive relationship found.

In iteration (2) we only find statistically significant results for manager equity ownership and firm size. In iteration (3) we only find statistically significant results for firm size. Thus, firm size is the only variable statistically significant across all equations. The positive coefficient of manager equity ownership in iteration (2) support the theories on undiversified managers hedging for personal utility maximization. In iteration (1), while not statistically significant, we find a negative relationship between insider equity ownership. Insiders are a broader term than managers, as it captures both managers as well as investors that own more than 10% of a firms' shares. Hence, it might be a bad proxy to test for managers incentives in hedging. Further, while not statistically significant at any conventional level, we get a negative coefficient for manager ownership of options. This is also in accordance with theory, as the value of the managers' options increase with the risk undertaken by the firm.

There are several variables that are not statistically significant in any of the three equations. We suspect that this is partly due to bad proxies. For example, our proxy for tax incentives is the log of tax-loss carryforward. This proxy has been criticized in several previous studies and is rarely found to be statistically significant (e.g. Aretz & Bartram, 2010; Arnold et al., 2014). Due to lack of available data on more suitable proxies for tax incentives, like marginal tax rate proxies, tax code progressivity dummies or tax credits, we still chose to conduct the test using the log of tax loss carryforward. Thus, we are not able to clearly confirm nor reject the tax incentives hypothesis.

Table VI. : Determinants of Hedging

This table presents the regression results for hypothesis 3. Due to lack of data on manager incentives we run three iterations of the below regression containing different data on $MangerIncentives$. The model used is:

$$PPH_{i,t} = \alpha + \beta_1 LDA_{i,t} + \beta_2 ln(TotalAssets)_{i,t} + \beta_3 ln(TotalAssets)_{i,t} * LDA_{i,t} + \beta_4 ln(LossCarryforward)_{i,t} + \beta_5 Price/Book_{i,t} + \beta_6 CurrentRatio_{i,t} + \beta_7 DividendDummy_{i,t} + \beta_8 ROA_{i,t} + \beta_9 Reserves/TotalAssets_{i,t} + \beta_{10} ProductionCosts_{i,t} + \beta_{11} Oil_{i,t} + \beta_{12} Gas_{i,t} + \beta_{13} OilVolatility_{i,t} + \beta_{14} GasVolatility_{i,t} + \beta_{15-17} ManagerIncentives^1_{i,t} + \omega_{i,t}$$

The variables are explained in section VI.C. The first iteration contains insider equity ownership information on all companies in our sample in the period 2010 to 2015. The second contains information on manager ownership of both equity and options for 34 companies in the period 2004 to 2015. The third does not contain any information on manager incentives. Hence, it contains all companies across the entire time-period. The T-stats are listed below each variable in parenthesis. The variables which are statistically significant at or below a 10%-level are written in bold.

	(1) PPH	(2) PPH	(3) PPH
LDA	**-0.258**	-0.111	-0.045
	(-1.79)	(-0.49)	(-0.46)
ln(total assets)	**0.059**	**0.027**	**0.081**
	(2.06)	(2.9)	(4.82)
ln(total assets)*LDA	**0.085**	0.019	0.014
	(3.16)	(0.51)	(0.84)
ln(loss carryforward)	-0.013	-0.018	-0.004
	(-0.89)	(-1.62)	(-0.46)
Price/Book	0.00003	-0.0001	2.96E-05
	(0.76)	(-1.41)	(0.8)
Current Ratio	**0.012**	0.014	-0.0007
	(2.07)	(0.62)	(-0.24)
Dividend Dummy	**0.121**	0.078	0.048
	(2.56)	(1.08)	(1.51)

Table VI continues on the next page.

Table VI continued.

ROA	0.001	-0.0004	2.93E-05
	(1.59)	(-0.39)	(0.05)
Reserves/	0.008	0.032	0.023
Total Assets	(0.34)	(1.23)	(1.6)
Production Costs	**0.007**	0.006	0.0002
	(2.14)	(1.49)	(0.32)
Oil Price	-0.0004	-0.0005	0.0004
	(-0.57))	(-0.71)	(0.94)
Gas Price	0.025	-0.009	-0.009
	(1.08)	(-0.79)	(-1.22)
Oil volatility	0.002	-0.0005	0.0006
	(0.39)	(-0.23)	(0.36)
Gas volatility	0.207	-0.0006	0.029
	(1.44)	(-0.02)	(1.19)
Insider equity	-0.0001	-	-
ownership	(-0.03)		
Manager equity	-	**3.074**	-
ownership		(2.18)	
Manager option	-	-1.464	-
ownership		(-0.25)	
R-squared	0.0708	0.0008	0.0536
Fixed/Random	Fixed	Fixed	Fixed
Sample Size	347	268	641

VII. Conclusion

In this paper, we present an empirical analysis on hedging in 98 U.S. oil and gas exploration firms from 2004 to 2015. We investigate the effects of hedging on the firms' stock price exposure towards fluctuations in oil and gas prices, the value implications of hedging and the determinants of hedging.

We find that investors recognize the effects of hedging on stock price exposure towards fluctuations in oil and gas prices in periods of negative shocks in these prices, specifically during the financial crisis of 2008 and during the recent turmoil in oil and gas prices during 2014 and 2015. Further, these periods are the only periods where hedging proves to be value adding. Outside these periods, we find a hedging discount on firm value. We explain this with investor loss aversion, i.e. investors being more sensitive to negative surprises than to positive. Hence, we claim that hedging is value adding only in the presence of greater downside risk, when underinvestment and financial distress risk are more substantial.

With regards to hedging determinants, our findings indicate that more leveraged firms in general hedge less, indicating evidence of issues related to debt overhang. However, larger leveraged firms seem to recognize the benefits of hedging in reducing financing costs, and hedge more than smaller levered firms. Further, larger firms and firms with a higher current ratio and production costs per BOE hedge more. We also find some evidence of undiversified managers hedging for personal utility maximization, and that manager ownership of options lead to less hedging. Lastly, our results indicate that firms that pay dividends hedge more. We have used dividends as a proxy for market access, and thus expected this relationship to be negative. However, we suspect that dividends are a bad proxy for market access and that the positive relationship found can be explained by dividends being sticky and accordingly constraining the firm financially. While there are several important implications from these findings, we suspect our results are sensitive to the proxies utilized.

The main contribution in this paper relates to the finding that the value implications of hedging at the firm level depends on patterns, and specifically negative shocks, in oil and gas prices. While we find that investors recognize the effects of hedging and reward firms that hedge in crisis periods, investors do not recognize the effects of hedging outside crisis periods and accordingly do not reward firms that hedge in these periods. This finding helps explain the variation in results in previous empirical research on this subject. We explain Jin and Jorion's (2006) finding of no relationship between hedging and firm value to be due to a low volatility regime during their sample period. Further, we explain Phan et al.'s (2014) finding of a hedging discount by the, in general, increasing price pattern during their sample period. Our sample includes two sharp oil price drops and has a longer time frame than both these studies, and accordingly gives our results higher credibility.

However, we note that there might be some endogeneity issues in our results. There are several factors we have chosen to leave out, like, e.g., basis risk. Further, our analysis is conducted on U.S. oil and gas exploration firms, and we have no knowledge of whether our results are transferable to other industries and geographical areas. Future research looking at similar price patterns in other industries and focusing on firms located in other geographical areas might shed more light on the implications of our results. As for the determinants of hedging, we suspect that our results might be biased from utilizing bad proxies. Future research using more comprehensive data on, among others, managerial and tax incentives, might provide more insights on the determinants of hedging at the firm level.

Appendix A. Extracting Hedging Information from 10Ks

In this section we go through an example of how information about the companies' 10-Ks are extracted from EDGAR to create the PPH variable. We use Anadarko Petroleum Corporation's (APC) 2015 10-K as an example. From Figure 2, on the next page, it is clear that APC does hedge with the aim to reduce cash flow variability. However, as we can see from the table in Figure 2, they are only hedging their exposure towards Natural gas. They are hedging 635,000 million British thermal units (MMBtu) per day using three-way collars and 170,000 MMBtu per day using fixed-price contracts. Since our production numbers from Bloomberg are stated in million cubic feet (MMcf) we had to convert MMtu to MMcf in order to get PPH. This was done using the following conversion:

$$1\ MMcf = MMBtu * \frac{0.9756}{1000} \tag{A1}$$

In order to calculate the percentage of total production hedged we convert MMcf into barrels of oil equivalents (BOE) as follows:

$$1\ BOE = 0.00019 * MMcf \tag{A2}$$

Once we had everything measured in BOE, we were able to calculate the actual percentage of production hedged:

$$\begin{aligned} PPH = & \frac{Gas\ hedged}{Gas\ production}\ \frac{Gas\ production}{Total\ production} \\ & + \frac{Oil\ hedged}{Oil\ production}\ \frac{Oil\ production}{Total\ production} \end{aligned} \tag{A3}$$

In APC's case the PPH for 2015 was:

$$\begin{aligned} PPH_{APC,2015} = & \frac{(635,000 + 107,000) * 365 * 0.9756/1000}{2334 * 365} \\ & * \frac{2334 * 365 * 0.00019 * 1000}{(2334 * 365 * 0.00019 * 1000) + (317 * 365)} + 0 \\ & = 19.62\% \end{aligned}$$

11. Derivative Instruments

Objective and Strategy The Company uses derivative instruments to manage its exposure to cash-flow variability from commodity-price and interest-rate risks. Futures, swaps, and options are used to manage exposure to commodity-price risk inherent in the Company's oil and natural-gas production and natural-gas processing operations (Oil and Natural-Gas Production/Processing Derivative Activities). Futures contracts and commodity-price swap agreements are used to fix the price of expected future oil and natural-gas sales at major industry trading locations, such as Henry Hub, Louisiana for natural gas and Cushing, Oklahoma or Sullom Voe, Scotland for oil. Basis swaps are periodically used to fix or float the price differential between product prices at one market location versus another. Options are used to establish a floor price, a ceiling price, or a floor and a ceiling price (collar) for expected future oil and natural-gas sales. Derivative instruments are also used to manage commodity-price risk inherent in customer price requirements and to fix margins on the future sale of natural gas and NGLs from the Company's leased storage facilities (Marketing and Trading Derivative Activities).

Interest-rate swaps are used to fix or float interest rates on existing or anticipated indebtedness. The purpose of these instruments is to manage the Company's existing or anticipated exposure to interest-rate changes. The fair value of the Company's current interest-rate swap portfolio increases (decreases) when interest rates increase (decrease).

The Company does not apply hedge accounting to any of its derivative instruments. As a result, gains and losses associated with derivative instruments are recognized currently in earnings. Net derivative losses attributable to derivatives previously subject to hedge accounting reside in accumulated other comprehensive income (loss) and are reclassified to earnings as the transactions to which the derivatives relate are recognized in earnings. See *Note 14—Accumulated Other Comprehensive Income (Loss)*.

Oil and Natural-Gas Production/Processing Derivative Activities The natural-gas prices listed below are New York Mercantile Exchange (NYMEX) Henry Hub prices. The following is a summary of the Company's derivative instruments related to natural-gas production/processing derivative activities at December 31, 2014:

		2015 Settlement
Natural Gas		
Three-Way Collars (thousand MMBtu/d)		635
Average price per MMBtu		
Ceiling sold price (call)	$	4.76
Floor purchased price (put)	$	3.75
Floor sold price (put)	$	2.75
Extendable Fixed-Price Contracts (thousand MMBtu/d) [1]		170
Average price per MMBtu	$	4.17

Figure 2. Excerpt from APC's 2015 10-K

Appendix B. Companies in Sample

Table VII. : Company Names

The list below contains the names of the 98 companies included in our sample in alphabetical order.

ABRAXAS PETROLEUM CORP	HOUSTON EXPLORATION CO
ANADARKO PETROLEUM CORP	ISRAMCO INC
ANTERO RESOURCES CORP	JONES ENERGY INC - A
APACHE CORP	LAREDO PETROLEUM INC
APCO OIL AND GAS INTL INC	MAGNUM HUNTER RESOURCES CORP
APPROACH RESOURCES INC	MARINER ENERGY INC
ARENA RESOURCES INC	MATADOR RESOURCES CO
ATP OIL & GAS CORPORATION	MCMORAN EXPLORATION CO
AURORA OIL & GAS CORP	MERIDIAN RESOURCE CORP
BERRY PETROLEUM CO LLC	MIDSTATES PETROLEUM CO INC
BILL BARRETT CORP	MURPHY OIL CORP
BOIS D' ARC ENERGY INC	NEWFIELD EXPLORATION CO
BONANZA CREEK ENERGY INC	NOBLE ENERGY IN
BRIGHAM EXPLORATION CO	NORTHERN OIL & GAS INC
BURLINGTON RESOURCES INC	OASIS PETROLEUM INC
CABOT OIL & GAS CORP	OCCIDENTAL PETROLEUM CORP
CALIFORNIA RESOURCES CORP	PANHANDLE OIL AND GAS INC-A
CALLON PETROLEUM CO	PANHANDLE OIL AND GAS INC-A
CARRIZO OIL & GAS INC	PDC ENERGY INC
CHESAPEAKE ENERGY CORP	PENN VIRGINIA CORP
CIMAREX ENERGY CO	PETROHAWK ENERGY CORP
CLAYTON WILLIAMS ENERGY INC	PIONEER NATURAL RESOURCES CO
CNX GAS CORP	PLAINS EXPLORATION & PRODUCT
COMSTOCK RESOURCES INC	POSTROCK ENERGY CORP
CONCHO RESOURCES INC	PRIMEENERGY CORP
CONTINENTAL RESOURCES INC	PXP PRODUCING CO LLC
DENBURY RESOURCES INC	QEP RESOURCES INC
EDGE PETROLEUM CORP	QUICKSILVER RESOURCES INC
ENCORE ACQUISITION CO	RANGE RESOURCES CORP
ENERGEN CORP	REMINGTON OIL & GAS CORP
ENERGY PARTNERS LTD-OLD	RESOLUTE ENERGY CORP
EOG RESOURCES INC	REX ENERGY CORP
EP ENERGY CORP-CL A	RING ENERGY INC
EPL OIL & GAS INC	ROSETTA RESOURCES INC
EQT CORP	SANCHEZ ENERGY CORP
ESCALERA RESOURCES CO	SOUTHWESTERN ENERGY CO
EVOLUTION PETROLEUM CORP	STONE ENERGY CORP
EXCO RESOURCES INC	SYNERGY RESOURCES CORP
FORESTAR PETROLEUM CORP	TRANSMERIDIAN EXPLORATION
FX ENERGY INC	TRI-VALLEY CORP
GASCO ENERGY INC	TXCO RESOURCES INC
GASTAR EXPLORATION LTD	ULTRA PETROLEUM CORP
GEOMET INC	UNIT CORP
GEORESOURCES INC	VAALCO ENERGY INC
GOODRICH PETROLEUM CORP	W&T OFFSHORE INC
GRAN TIERRA ENERGY INC	WHITING CANADIAN HOLDING COM
GULFPORT ENERGY CORP	WHITING PETROLEUM CORP
HALCON RESOURCES CORP	WPX ENERGY INC
HARVEST NATURAL RESOURCES	XTO ENERGY INC
HOUSTON AMERICAN ENERGY CORP	

Appendix C. Panel Data and Model Estimation Techniques

Since our data compromises both time series and cross-sectional elements it is known as a panel of data. In panel data, we differentiate between balanced and unbalanced panels. As explained in the data description, we have an unequal number of time series observations for each cross-sectional unit. Thus, our model can be characterized as an unbalanced panel (Brooks, 2004, p. 526-529).

A panel data approach to financial modelling offers several advantages. Most importantly, we are able to address a broader range of issues and tackle more complex problems with panel data than would be possible with pure time series or pure cross-sectional data alone. Conducting the same meaningful hypothesis with, e.g., a time series approach would require a much larger number of observations. In a panel, we can increase the number of degrees of freedom, and thus the power of the test, by employing information on the dynamic behaviour of a large number of entities at the same time. Further, combining data this way can also help to mitigate problems of multicollinearity that may arise if time series were modeled individually. Lastly, by structuring our model in an appropriate way we can remove the impact of certain forms of omitted variable bias in regression results (Brooks, 2004, p. 527).

Thus, the question is how to model panel data most appropriately and accordingly utilize its advantages. The simplest would be to estimate a pooled regression, which would involve estimating a single equation on all the data together. The data on the dependent variable and all explanatory variables would then be stacked up into a single column containing all cross-sectional and time series observations, and the equation could be estimated using OLS. This approach to estimating panel data is utilized in both Jin and Jorion (2006) and Phan et al.'s (2014) studies. However, pooled regression has severe limitations. Most importantly, it assumes that the average values of the variables and the relationships between them are constant over time and across all cross-sectional units. Thus, while this approach gains points for its simplicity, financial research give more support to two other broad classes of theories, fixed effects models and random effects models, that are able to bypass the limitations inherent in most other panel estimator approaches, like pooled regression (Brooks, 2004, p. 528-529).

In the fixed effects model, omitted variables can be controlled for if the omitted variables vary across entities but not across time. Fixed effects models can be estimated using OLS, but the OLS assumptions must be extended to include that the errors for a given entity are uncorrelated over time, conditional on the regressors. Further, in order to be able to run OLS-estimation we must first transform the regression by subtracting the time-mean of each entity away from the values of the variable. This is known as *within trasformation* and is automatically implemented in most software packages, for example Stata. The random effects model differs from the fixed effects model in that the intercepts for each cross-sectional unit are assumed to arise from a common intercept α, which is the same for all cross-sectional units and over time, plus a random variable ϵ_i that varies cross-sectionally but is constant over time. ϵ_i measures the random deviation of each entity's intercept term from the random deviation of each entity's intercept term from the "global" intercept term α. This new framework requires the assumptions that ϵ_i has zero mean, is independent of the individual observation error term ν_i, has constant variance and is independent of all explanatory variables. The parameters of the model would be consistently but inefficiently estimated by OLS. Thus, one must utilize a generalized least squared (GLS) procedure. The transformation involved in GLS is to subtract a weighted mean of the dependent variable over time, i.e. a part of the mean rather than the whole mean as is the case for fixed effects estimation. This transformation is also automatically implemented by most software packages (Brooks, 2004, p. 529-537).

We have now narrowed it down to two estimation techniques for modelling panel data, but which will be the most appropriate to utilize? The transformation involved in the GLS procedure under the random effects approach will not remove explanatory variables that do not vary over time, hence their impact on the dependent variable can be found. Additionally, as there are fewer parameters to be estimated with the random effects model, degrees of freedom are saved and the random effects model should accordingly produce more efficient estimators than the fixed effects model. However, the random effects model has a major drawback in that it is only valid if the composite error term, $\omega_{i,t} = \epsilon_i + \nu_{i,t}$, is uncorrelated with all explanatory variables. If $\omega_{i,t}$ is correlated with one or more explanatory variables, the random effects model will in fact provide biased and inconsistent estimators. To decide between the fixed and random effects model we, as researchers frequently do, apply the Hauseman test. Essentially, the Hauseman test tests whether the regression coefficients under the fixed effects and random effects models are statistically different from each other. If they are different, the fixed effects model is preferred even though it uses more degrees of freedom. If the coefficients are not different, the random effects model is preferred since it provides more efficient estimates of the regressors than the fixed effects model (Brooks, 2004, p. 537).

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Preliminary is attached as a separate file upon submission.