HEC MONTRÉAL

The Underinvestment Problem and Corporate Hedging Policy – Evidence from the Oil and Gas Industry

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Projet supervisé présenté en vue de l'obtention
du grade de maîtrise ès sciences en gestion
(M. Sc.)

Juillet 2022

ABSTRACT

This research intends to revisit the underinvestment problem and corporate hedging policy using panel data of U.S. oil producers. Contrary to the first hypothesis, I find that the relation between firms' growth opportunities and hedging activities varies based on the proxy used for investment opportunities. Moreover, I observe that firms with higher costs incurred for investments in oil and gas reserves concurrent with low liquidity levels hedge to a greater extent. Firms with a higher correlation between their cash flows and their investment expenses hedge less than the other firms. I also find results contradictory to the overinvestment problem proposed by Morellec and Smith (2007) as a determinant of corporate hedging decisions.

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I. INTRODUCTION

In the basic Modigliani-Miller (1958) model with no imperfections, there would be no incentive for non-financial firms to engage in the use of derivatives. However, some forms of imperfections lead to issues such as agency problems, which can provide such incentive for firms to hedge. Agency problems are conflicts that occur either between the managers of a firm and its shareholders or conflicts between the shareholders of a firm and its debtholders. The role of the manager of a firm is to maximize firm value while minimizing agency costs and other costs related to market imperfections. In this research, I will focus on the agency conflicts between shareholders and debtholders and, more precisely, on the underinvestment problem. The underinvestment problem occurs when firms forego positive NPV projects. The main reason behind this situation is explained by the respective payoff structures of debt and equity holders. In some instances, undertaking positive NPV projects can reduce shareholders' wealth when the gains from that project accrue primarily to the debtholders. For this research, I will be interested in determining the relation between corporate hedging and the investment opportunities of non-financial firms.

Studying non-financial firms is important because their motivations and strategies for using derivatives are not well understood in the financial literature. One of the shortcomings of the existing studies is that the empirical results are inconclusive and often inconsistent with the theoretical framework for using derivatives. While theoretical frameworks provide insight as to why firms should engage in risk management activities, they have not been successfully explaining the empirical findings on the topic in the last few decades (see Morellec and Smith, 2007). We have an idea of potential determinants that managers employ to make risk management decisions. However, for many reasons, it is very difficult for researchers to empirically show the decision-making process of managers in their choice of hedging. Another reason for using non-financial firms is because those firms less frequently make use of derivatives for trading purposes as opposed to financial firms, which may bias the results on the determinants of hedging policy.

The motivation behind this research is to try to understand further the implications and determinants of corporate hedging by testing various hypotheses related to the underinvestment problem on a sample of 95 oil and gas companies. I test 4 hypotheses, 3 of them coming directly from Gay and Nam (1998) on the underinvestment problem while the fourth one is inspired by Morellec and Smith (2007) on the overinvestment problem. The hypotheses are as follows:

Hypothesis 1: Firms with greater investment or growth opportunities will make greater use of derivatives.

Hypothesis 2: Firms with enhanced investment opportunities concurrent with low levels of liquidity will make greater use of derivatives than similar firms with high liquidity.

Hypothesis 3: Firms with a greater correlation between cash flows and investment expenses will hedge less.

Hypothesis 4: Firms with fewer investment opportunities concurrent with high liquidity will make greater use of derivatives than similar firms with low liquidity.

Using six growth opportunity proxies, I test the four hypotheses through univariate tests and probit regressions. For the first hypothesis, results suggest that the relation between growth opportunities and hedging intensity varies based on the proxy used for growth opportunities. For the second hypothesis, I find that firms having high costs incurred for investment in oil and gas reserves relative to their size hedge more if those firms also have low liquidity levels. For the third hypothesis, I find that firms having a higher correlation between their cash flows and investment expenses will not hedge as much as firms that have a low correlation. This result is consistent with what is hypothesized. For the last hypothesis, I find results inconsistent with the overinvestment problem proposed by Morellec and Smith (2007). The results are discussed in detail in the following sections.

The remainder of the research is organized as follows. Section II presents a review of the existing literature on the determinants of corporate hedging policies and more specifically the underinvestment problem. Section III describes the data and the methodology applied to test the four hypotheses. Section IV is a discussion and description of the results found. Finally, Section V concludes the research while Section VI presents the different tables.

II. LITERATURE REVIEW

One issue with the underinvestment problem and corporate derivatives use is that the empirical findings from prior research are not always in line with the theoretical frameworks. Froot,

Scharfstein, and Stein (1993) provide a general framework to analyze corporate risk management policies. The model develops on the concept of the underinvestment problem, which was also introduced as "debt overhang" by Myers (1977). The framework suggests that the underinvestment problem can occur for highly leveraged firms whose shareholders only have a small claim on a firm's assets and for which the benefits of profitable investment projects accrue primarily to bondholders and may not be undertaken by managers. Moreover, when raising external funds is costly, the problem of underinvestment is more prone to be important for firms. Derivatives can be used to increase shareholder value by coordinating the need and availability of internal cash flows to finance positive net present value projects.

Mian (1996) provides empirical evidence on the determinants of corporate hedging decisions. Mian's hypothesis related to contracting costs stipulates that since the underinvestment problem is more pronounced for firms with more discretion in their choice of investment decisions, hedgers are predicted to be firms that derive a relatively higher proportion of their market value from growth options relative to their assets in place. In this case, the use of hedging instruments would be seen as a way to mitigate the contracting costs of the firm, or more precisely, the agency costs related to the conflicts between the stockholders and the bondholders. Mian used 1992 data from 3,022 non-financial firms, including 771 hedgers and 2,251 non-hedgers. As a proxy for the investment opportunities of the firm, he employed the market-to-book ratio. Mian ran a univariate test for each potential determinant of corporate hedging on the hedging level for both hedgers and non-hedgers separately. Second, he ran a logistic regression relating the probability of hedging to the determinants of hedging. Lastly, he made some robustness checks to see whether his results were impacted by the potential presence of speculators in his sample. Mian included in the sample of the last model only firms that explicitly state that they hedge exposures (hedgers) to remove the impact of potential speculators in the sample. Contrary to the hypothesis, the main conclusion is that the probability of hedging is negatively related to the market-to-book ratio and that the results are not biased by the presence of potential speculators in the sample. He also finds that this relationship varies across the type of risk hedged.

Gay and Nam (1998) specifically focus on the underinvestment problem and use univariate tests as well as tobit models to test three hypotheses. Their final sample is composed of 325 derivatives users and 161 non-users at the fiscal year-end of 1995. Their three hypotheses are the

same first three hypotheses that I test in this research and are organized as follows: Firms with more growth opportunities will make greater use of derivatives, firms with more opportunities concurrent with low levels of cash stocks will use derivatives more than similar firms with high cash stocks, and firms with a greater correlation between cash flows and investment expenses will use derivatives less. As proxies for growth opportunities, they consider five variables: normalized research and development expenses, market-to-book ratio, Tobin's Q, the price-to-earnings ratio (P/E), and the cumulative abnormal return (CAR). In their regressions, the dependent variable is equal to each firm's notional dollar amount of derivatives normalized by total assets, and zero for non-users. Additionally, they introduce a dummy variable for the purposes of testing the second hypothesis which splits the data between firms for which the underinvestment problem is considered to be the greatest and the lowest. Thus, the dummy variable is an explanatory variable and takes the value of one for firms that have simultaneously high investment opportunities and low cash levels and zero otherwise. For the first hypothesis, Gay and Nam (1998) find consistent results as all five growth variables have a positive coefficient and are statistically significant at the 1% or 5% levels. This result suggests that firms with higher growth opportunities also have a higher notional amount of hedging scaled by total assets. For the second hypothesis, they also find consistent results. The dummy variable coefficient is positive across all five variables, although statistically significant only across two out of five growth proxies. This result suggests that firms with high growth opportunities and low cash levels will make greater use of derivatives. For the last hypothesis, the variable of interest is the correlation between the firm's cash flows and investment expenses. They find a statistically significant and negative correlation coefficient across all growth proxies. This result confirms the third hypothesis that firms for which cash flows are correlated with their investment opportunities will not hedge as much as firms having a low correlation between cash flows and growth opportunities. Overall, as opposed to Mian (1996), their results are consistent with the general framework provided by Froot et al. (1993).

In their research, Geczy, Minton, and Schrand (1996) focus on understanding why firms make the use of currency derivatives, a tool employed by firms to hedge their risk exposure to exchange rate movements. They hypothesized that hedging can reduce underinvestment costs associated with investment opportunities in the presence of financial constraints. To obtain those results, they constructed a sample of 372 industrial US firms that have a least one source of foreign exchange-rate exposure at the year-end of 1990. As proxies for the growth opportunities available to a firm,

they utilize three different measures which are: the ratio of a firm's research and development (R&D) expenditures to its sales, the ratio of a firm's capital expenditures for property, plant, and equipment (PP&E) to firm and the book value of a firm's common equity scaled by its market value. To test their hypotheses, they performed univariate tests as well as logit regressions. Logit regressions are employed to distinguish among the variables for the use of derivatives. For the independent variable, they employ a dummy variable, equal to one in the case where the firm uses currency derivatives, and zero for firms that do not use currency derivatives. They find results consistent with their hypothesis, such that firms with greater growth options are more likely to employ currency derivatives as a way to mitigate the underinvestment problem. Although impossible to fully remove potential endogeneity problems, they conducted a variety of robustness checks and found results in line with the general risk management framework.

Bartram et al. (2003) argue that there is a lack of data and research on the use of derivatives by non-financial firms outside the United States. Their research intends to bridge that gap by studying the use of derivatives by firms across 48 countries. They also make the hypothesis that the market-to-book ratio variable will be positive, which supports the underinvestment theory that firms with higher investment opportunities will hedge more. Contrary to their hypothesis, the authors find a negative coefficient for the market-to-book ratio, the main proxy for a firm's investment opportunities. This result suggests that when using the sample of international firms, firms with more investment opportunities tend to hedge less, which is the opposite result of the framework proposed by Froot et al. (1993).

Morellec and Smith (2007) further contribute to the literature by incorporating manager-shareholder conflicts as a determinant of corporate hedging policy and develop a hypothesis for the contradictory results found by Bartram et al. (2003). The main idea behind the research is that both the underinvestment and overinvestment problems play a dynamic role in a firm's risk management policy. The overinvestment problem, also referred to as "empire building", occurs when managers of firms derive utility from undertaking investment projects, no matter if they have a positive or negative net present value (NPV). Their analysis confirms Bartram et al. (2003) findings and provides a potential explanation for it. According to the authors, "firms that derive more of their value from assets in place [...], although having lower costs of underinvestment, generally display larger costs of overinvestment" (Morellec and Smith, 2007). This suggests that

firms having lower growth opportunities may hedge more to mitigate the overinvestment problem. This development made by Morellec and Smith (2007) may in part explain why we find contradictory results in the literature on the underinvestment problem. Other reasons such as potential endogeneity issues and reverse causality may also play a part in the inconsistency between the empirical findings and the theory.

Rampini, Sufi, and Viswanathan (2014) challenge the existing literature that the level of financial constraints of a firm should have a positive relation with risk management intensity. Indeed, they develop a dynamic risk management model that predicts that more financially constrained firms should engage less in risk management based on the fact that collateral constraint is the link between a firm's access to external financing and risk management. In other words, there is a trade-off between a firm's financing and its hedging practices since a financially constrained firm needs to have enough collateral to cover both payments on external capital and payments to hedging counterparties. Using a panel data sample of 23 US airlines between 1996 and 2009 to test their dynamic risk management model, they find results that are consistent with their prediction that financially distressed airlines hedge less. They also find that this result becomes even more significant in the case of financial distress. Indeed, distressed airline firms reduce commodity price hedging by as much as 30%.

III. METHODOLOGY

In this section, I will present the four different hypotheses that I test in this research. Subsequently, I describe the sample, the variables, and the methods of estimation to conduct these four hypotheses.

A. HYPOTHESES

To identify the relation between firms' investment opportunities and corporate derivatives policy, I investigate four different hypotheses. The first three hypotheses of the research were developed by Gay (1998) and have the goal of further understanding the real implications of the underinvestment problem. The fourth hypothesis is inspired by the developments made by

Morellec and Smith (2007) and their proposition that the overinvestment problem also has an impact on corporate derivatives use. These four hypotheses are as follows:

Hypothesis 1: Firms with greater investment or growth opportunities will make greater use of derivatives.

Hypothesis 2: Firms with enhanced investment opportunities concurrent with low liquidity ratios will make greater use of derivatives than similar firms with high liquidity ratios.

Hypothesis 3: Firms with a greater correlation between cash flows and investment expenses will hedge less.

Hypothesis 4: Firms with fewer investment opportunities concurrent with high liquidity ratios will make greater use of derivatives than similar firms with low liquidity ratios.

B. SAMPLE DESCRIPTION

The initial sample was composed of 6,326 quarterly observations across 150 oil and gas companies between 1998 and 2010. The sample was collected by Professor Mohamed Mnasri as part of his Ph.D. research. He retained firms that met the three following criteria: "They have at least five years of oil reserve data during the 1998-2010 period, their 10-K and 10-Q reports are available from the EDGAR website, and the firm is covered by Compustat" (Dionne and Mnasri, 2018). Financial data on these companies were also collected and provided by Professor Mohamed Mnasri. He collected most of the data from sources such as WRDS, Thomson Reuters, and Bloomberg while data about hedging activities were hand-collected through the companies' 10-K and 10-Q reports. As for hypothesis testing purposes, the sample was further reduced to 1,294 quarterly observations across 95 oil and gas companies. This reduced sample includes only firm-quarter observations that qualified as either having a high or low hedging intensity. Table 1 presents the summary statistics of oil hedging by horizon of the initial sample. HR0 stands for the oil hedging ratio in the current year while the following five hedge ratio measures are the hedge ratios for one to five years ahead. As we can see, the oil hedging ratio is decreasing significantly as the horizon increases, having only 61 firm-quarter observations hedge for five years ahead.

C. VARIABLE DESCRIPTION

In this subsection, I describe the key variables employed in the research and I divide them as follows: the dependent variables, the growth variables, the dummy variable, and the control variables. Table 2 presents a summary statistic of the variables for the 150 U.S. oil producers. Table 3 presents the pairwise correlations of the variables used in the various regressions. From the correlation matrix, I find that only 6 correlations out of 153 are higher than 0.5 namely, dividend payout and the number of analysts with respect to gas reserve, gas price volatility and oil spot price with respect to the gas spot price, gas geographic diversification with respect to oil geographic diversification, and oil price volatility with respect to oil spot price. Table 4 presents a summary of the construction of the explanatory variables and their predicted coefficient signs.

1. DEPENDENT VARIABLE

In the regressions tested in the next section, the dependent variable is a dummy variable based on the firms' oil hedging ratio. The dummy variable takes the value of one for firm-quarter observations having a high hedging intensity and zero for firm-quarter observations having a low hedging intensity. To qualify as having a high hedging intensity, a firm-quarter observation must have an oil hedging ratio for the current year higher than the third quartile cut-off point. On the other end, to qualify as having a low hedging intensity, a firm-quarter observation must have an oil hedging ratio for the current year lower than the first quartile cut-off point. The cut-off points are calculated from the 2,587 quarterly observations having a non-zero oil hedging ratio in the current year. All firm-quarter observations having a hedging intensity that happened to be between the first and third quartiles were removed, decreasing the sample to 1,294 observations.

2. GROWTH VARIABLES

As the theory suggests that greater investment opportunities lead to a greater underinvestment problem, investment opportunity proxies are needed for regression testing purposes. I choose six investment opportunity proxies based on the existing literature. In his research, Gay (1998) utilized normalized research and development expenses, market-to-book ratio, Tobin's Q, P/E ratio, and the cumulative abnormal return. In this research, the first growth variable is the market-to-book

ratio, calculated as the market value of a firm's equity by the book value of the firm's equity at quarter-end.

As a second growth variable, I employ Tobin's Q, calculated as the book value of debt plus the book value of preferred shares plus the market value of equity divided by the book value of total assets. In their research on proxy variables for investment opportunities, Adam and Goyal (2008) find that Tobin's Q and the market-to-book assets ratio (MBA) are highly correlated and can be employed interchangeably. They also find that the market-to-book assets ratio has the highest information content as a proxy for investment opportunities and the most relevant proxy. In this research, Tobin's Q is thus a potential improvement for the market-to-book ratio proxy.

As the normalized research and development expenses calculated by Gay (1998) may not be as suitable for research on oil and gas companies, the third variable in this research is calculated as a firm's costs incurred for investment in oil and gas reserves divided by the firm's size[1]. The investment costs include costs related to the acquisition, exploration, and development of oil and gas reserves. This variable is referred to as "R&D" in the various tables that appear in this research.

A widely accepted concept is that growth firms tend to have higher P/E ratios. Based on this belief, the P/E ratio is the fourth growth variable of this research. The P/E ratio of a firm is calculated as its stock price at quarter-end divided by its earnings per share.

The variable named "investment opportunities" in Dionne and Mnasri (2018) is the fifth growth variable of this research. This variable is calculated as a firm's quarterly capital expenditures scaled by the property, plant, and equipment at the beginning of the quarter. This variable is referred to as "investment opportunities" in the various tables of this research.

Reserves and resources are two measures that can be utilized as proxies for investment opportunities for firms in the oil and gas or mining industries. Adam and Goyal (2008) find that reserves contribute significantly more to the value of investment opportunities than do resources. Based on these findings, the last growth variable is the oil reserves, calculated as the sum of

[1] Firm size is calculated as the log of the sum of the market value of equity plus the book value of debt plus the book value of preferred shares.

developed and undeveloped oil reserves. This variable is measured annually, thus the same oil reserve measure appears across the quarters of the same fiscal year.

Due to their respective distributions, the log of the market-to-book ratio, Tobin's Q, the P/E ratio, and oil reserves are employed.

3. DUMMY VARIABLE

Similar to Gay (1998), I introduce a dummy variable as an explanatory variable to test the second and fourth hypotheses on the risk management practices of firms based on their investment opportunities concurrent with their level of cash. The rationale behind this dummy variable is to separate firms that are more prone to have an important underinvestment or overinvestment problem from the rest and see if there are any differences in their hedging practices. To do so, I construct the cash stock ratio, calculated as a firm's cash and short-term investments divided by its total assets. Next, I separate the sample into two groups. Firms having a cash stock ratio greater than the mean are considered high-cash firms while firms having a cash stock ratio lower than the mean are considered low-cash firms. Similarly, for each growth variable, we divide the sample between high-growth and low-growth firms if observations are above or below the mean of their respective growth proxy. Thus, for both hypotheses, each growth variable has its unique dummy variable. For the second hypothesis, the dummy variable is equal to one for firms having simultaneously high growth and low cash and zero otherwise. For the fourth hypothesis, the dummy variable is equal to one for firms having simultaneously low growth and high cash and zero otherwise. Like Gay (1998), the dummy variable is a standalone variable or in conjunction with each growth variable in the regressions of the second and fourth hypotheses.

4. CONTROL VARIABLES

In addition to the growth and dummy variables, I introduce control variables in the regressions to control for factors other than the underinvestment problem that may drive managers to undertake risk management practices.

Hedging may be driven by the reduction in expected taxes. In the model developed by Smith and Stulz (1985), they find that when the taxation function of a firm is convex, hedging policy can reduce expected tax payments with hedging. A convex tax function occurs in the presence of items

such as foreign tax credits, tax loss carry forwards, tax-related progressivity, and others. To control for a tax function that may incentivize managers to use risk management, I introduce the "tax save" control variable. This variable is constructed based on Graham and Smith (1999).

Previous research has suggested that convertible debt and preferred stock could be employed by firms as alternatives to derivatives as risk management tools. Theory suggests that convertible debt can mitigate the bondholder-shareholder agency conflicts. In the past, authors have made some contradictory arguments about the use of convertible debt and preferred stock as a substitute for hedging. For example, Nance, Smith, and Smithson (1993) argue that firms may employ convertible debt and preferred stock to mitigate the agency costs and costs related to financial distress, and thus it may be used by managers as a substitute for hedging instruments. On the other end, although finding non-significant results in their empirical tests, Bartram et al. (2003) argue that these securities act as complements rather than substitutes. To control for potential hedging alternatives, I introduce both preferred stock and convertible debt as control variables in the regressions. The preferred stock control variable is calculated as the ratio of a firm's preferred stock over its market value of equity. Similarly, the convertible debt control variable is calculated as the ratio of a firm's convertible debt over its market value of equity.

Managerial risk aversion may also play a role in corporate hedging policy. Managers who have concave compensation functions with respect to firm value have a monetary incentive to reduce the firm's volatility of cash flows and thus undertake risk management practices (see Smith and Stulz, 1985). As a proxy for managerial risk aversion, I introduce the control variable "CEO number of options" in the various regressions. It is calculated as the number of stock options held by the firm's CEO (times 10,000) at the end of the quarter (see Dionne and Mnasri, 2018).

Problems associated with information asymmetry, transparency, and governance may push managers to undertake hedging practices that will reduce the risk related to a firm's cash flows. I apply two proxies to control for potential information asymmetry problems, institutional ownership, and the number of analysts following a firm. Firms whose ownership is composed of a greater proportion of institutional investors and who are followed by a greater number of analysts are expected to have less information asymmetry. Institutional ownership is simply calculated as the percentage of a firm's shares that are held by institutional investors. The number of analysts

variable is the number of analysts who follow the firm and have issued a forecast of the firm's earnings.

There are also numerous other motivations for risk management such as the lack of liquidity or dividend payments. To control for such motivations, I introduce the liquidity ratio and the dividend payout control variables. The liquidity ratio variable is constructed as a firm's book value of cash and cash equivalents divided by the book value of its current liabilities. On the other end, the dividend payout variable is a dummy variable, equaling one if the firm declared dividends during the quarter and zero otherwise.

The remaining control variables are a set of oil and gas-related controls that are included to account for other differences in firm characteristics or market-related factors that may drive hedging decisions. These variables include oil and gas geographic diversification, gas reserve (in log), oil and gas price volatility, oil and gas spot price, and oil and gas production risk. These variables' constructions are further detailed and explained by Dionne and Mnasri (2018) and in Table 4.

D. METHODS OF ESTIMATION

As for the methodology, I apply both univariate and multivariate analyses to test the various hypotheses. For hypotheses 2 and 4, I apply the univariate test of the difference between two means of two different samples. To push further the analysis, a probit model estimates the various coefficients of the four hypotheses. Robust standard errors are computed across all regressions. Moreover, all explanatory variables are lagged by one period at the firm-specific level. Further details about the construction of the regression equations are presented in the next section.

IV. EMPIRICAL RESULTS

This section presents the results of the tests for the four hypotheses. As mentioned earlier, these hypotheses are tested through univariate and multivariate analyses.

A. UNIVARIATE ANALYSIS

Before looking at the results of the four hypotheses, I first conduct a univariate analysis of the difference between two means of oil producers' characteristics by their oil hedging intensity. The results are presented in Table 5 in section VI. The data contains only firms whose hedge ratios for the current year (HR0) are non-zero. The data is then split between firms having hedge ratios for the current year lower than the 1st quartile (1) and those having hedge ratios for the current year higher than the 3rd quartile (2).

The univariate analysis shows significant differences in firm characteristics based on their hedging intensities. The results suggest that the relation between a firm hedging intensity and its growth opportunities varies based on the growth proxy used. As initially predicted, the tax save mean is significantly higher for the high hedging group than for the low hedging group. This result suggests that firms hedge to reduce their expected tax liabilities. I find that firms in the low hedging intensity group have a higher convertible debt mean, suggesting that those firms employ convertible debt as an alternative for hedging. Moreover, the results show that the hedging intensity of a firm is positively related to its level of financial constraints. Indeed, the high hedging group has significantly higher leverage, a lower liquidity ratio, and a lower dividend payout than the low hedging group, which is in line with the literature.

In terms of management risk aversion, I find that firms having a CEO with a greater number of options engage further in risk management practices. This result is inconsistent with what is predicted as we would expect out-of-the-money option holders to increase the risk associated with the firm's cash flows to increase the expected value of the options. However, the moneyness of the options may also play an important role in the managers' decision to hedge. Related to the information asymmetry of a firm, I find that a firm's hedging intensity is negatively correlated to its institutional ownership and to the number of analysts following the firm. This result is consistent with the conjecture that firms with lower information asymmetry do not hedge as much as firms with high information asymmetry. In terms of operational constraints, I find that firms with lower gas reserves, lower geographic diversification, and higher production risk hedge to a higher extent.

B. MULTIVARIATE ANALYSIS

The following subsections present the results of the four hypotheses, tested with probit models. Compared to Table 5, the sample size is reduced to 803 observations for the following tables due to manipulations necessary to lag the explanatory variables and the use of different growth measures.

1. TEST OF HYPOTHESIS 1

The first hypothesis states that firms with greater investment opportunities will make greater use of derivatives. As mentioned earlier, the dependent variable (Y_t) in the probit models is a dummy variable that takes the value of one for firms having hedging ratios (HR0) higher than the 3rd quartile and zero for firms having hedging ratios (HR0) lower than the 1st quartile. The relation between a firm's hedging ratio and the set of growth and control variables is estimated with the following regression equation: $Y_t = \beta_0 + \beta_1 \text{Growth}_{i,t-1} + \beta_{2,\dots,19} \text{Control}_{t-1} + u_t \;\; i = 1, \dots, 6$

I repeat this equation six times for each of the six growth variables ($i = 1, \dots, 6$) that were described in the methodology section.

Table 6 presents the results of this first hypothesis. I find that four growth variables out of six have a negative coefficient, while only two of those (market-to-book ratio and Tobin's Q) are statistically significant at the 5% level. This suggests that a firm hedges more when it has a lower market-to-book ratio and lower Tobin's Q, which is contrary to the initial hypothesis. It is not surprising that the market-to-book ratio and Tobin's Q variables provide similar results as Tobin's Q is a potential proxy improvement for the market-to-book ratio in this regression. On the other end, the oil reserve variable is positive and statistically significant at the 1% level, suggesting that a firm having a higher oil reserve tends to hedge more. These results suggest that the relation between risk management and a firm's investment opportunities varies based on the growth proxy that is used. As for the control variables, leverage, liquidity, dividend payout, oil and gas geographic diversification, and oil spot price are statistically significant across all six regression columns.

In their research, Mian (1996) and Gay (1998) ran a similar regression but with hedgers and non-hedgers. Since I removed non-hedgers for the purpose of this test, I also tested the same

regression using non-hedgers instead of the low quartile hedgers to be able to compare with the results obtained by Mian (1996) and Gay (1998). To conduct this alternative test, I replaced the low quartile hedgers with firms whose hedge ratios are zero across the entire time period. The sample for this regression included 1188 firm-quarter observations, 854 of which were non-hedgers. Like the previous regression, four out of six variables have negative coefficient signs while the oil reserve coefficient is still positive and statistically significant at the 1% level. However, the market-to-book ratio and Tobin's Q variables are not statistically significant using this alternative method of testing.

2. TEST OF HYPOTHESIS 2

The second hypothesis states that firms having simultaneously high growth opportunities and low liquidity levels tend to hedge more. The rationale behind this hypothesis is to isolate firms for which the underinvestment problem is prone to be most important and see if there are any differences in those firms' hedging practices. To test this hypothesis, I apply both univariate analysis and a probit regression model.

For the univariate test, the sample is divided into two groups. The first group is composed of firms having growth opportunities higher than the sample average and a liquidity ratio lower than the sample average, simultaneously. Similarly, the second group is composed of firms having growth opportunities higher than the sample average and a liquidity ratio higher than the sample average, simultaneously. The results of the mean differences are reported in Table 7. While five out of six growth variables report higher hedging ratios for the high growth, high liquidity group, none of the six mean differences is statistically significant.

For the multivariate analysis of the second hypothesis, I introduce a dummy variable (D1) for each growth variable that takes the value of one for firm-quarter observations having simultaneously high growth opportunities and a low liquidity ratio and zero otherwise. Like Gay (1998), I also introduce the dummy variable multiplied by its respective growth variable as an explanatory variable. The model equation is the following:

$$Y_t = \beta_0 + \beta_1 \text{Growth}_{i,t-1} + \beta_2 D_{j,t-1} + \beta_3 D_{j,t-1} * \text{Growth}_{i,t-1} + \beta_{4,\dots,21} \text{Control}_{t-1} + u_t \; j = 1, \dots, 6$$

The results of this regression are presented in Table 8. The main variable of interest in the table is the dummy variable (D1). A positive dummy variable coefficient would suggest that firms

having simultaneously high growth opportunities and a low liquidity ratio tend to hedge their risk exposures more. The results obtained in Table 8 are somewhat inconclusive. Three of the six dummy variable coefficients are positive while the other three are negative. However, the dummy variable coefficient of the R&D growth variable (column 3) is positive and statistically significant at the 1% level. This suggests that firms having high costs incurred for investment in oil and gas reserves relative to their size concurrent with low liquidity levels tend to hedge more. The dummy variable multiplied by its respective growth variable coefficient is measuring the level of sensitivity between derivatives use and growth opportunities. I find that none of those variables are statistically significant.

3. TEST OF HYPOTHESIS 3

The third hypothesis stipulates that firms with a greater correlation between cash flows and investment expenses will employ derivatives less. To test this hypothesis, I apply a probit model in which I introduce two different measures of correlation. The first one is the correlation between capital expenditures and free cash flows. The results of the regressions are presented in Table 9. The second one is the correlation between the costs incurred for investments in oil and gas reserves and free cash flows. Those results are presented in Table 10. The relation is tested by applying the following equation:

$$Y_t = \beta_0 + \beta_1 \text{Growth}_{i,t-1} + \beta_2 \text{Correlation}_{t-1} + \beta_{3,\dots,20} \text{Control}_{t-1} + u_t$$

$$i = 1, \dots, 6$$

The variable of interest in Tables 9 and 10 is the correlation variable. A positive correlation would suggest that firms having a greater correlation between their cash flows and their investment opportunities hedge more, which is against the third hypothesis.

In Table 9, I find that the correlation between capital expenditures and cash flow coefficients is negative across all six growth proxies. Although not statistically significant, these results are in line with the third hypothesis. Similarly, in Table 10, I find that the correlation between costs incurred, and cash flow coefficients are negative and statistically significant across each growth variable. Since those results are statistically significant, it confirms the third hypothesis that firms having a higher correlation between cash flows and investment expenses hedge less than the other firms.

4. TEST OF HYPOTHESIS 4

The last hypothesis states that firms with fewer investment opportunities concurrent with high liquidity ratios will make greater use of derivatives than similar firms with low liquidity ratios. The rationale for this hypothesis is to see if the overinvestment problem may also explain firms' corporate hedging policies by looking at the hedging practices of firms for whom the overinvestment problem is most important.

To test this hypothesis, I apply a similar process as the second hypothesis. I first start with a univariate analysis in which I divide the sample into two different groups. The first group is composed of firm-quarter observations having growth opportunities lower than the sample mean concurrent with a liquidity ratio higher than the sample mean. On the other end, the second group includes firm-quarter observations having both growth opportunities and liquidity lower than the sample mean. The test of the mean differences is presented in Table 11. I find that four out of six variables have a higher hedging ratio for the low growth, low liquidity group. Just like the second hypothesis, this result is inconclusive as none of the mean differences are statistically significant.

For the multivariate analysis of the fourth hypothesis, I introduce a dummy variable (D1) for each growth variable that takes the value of one for firm-quarter observations having simultaneously low growth opportunities and a high liquidity ratio and zero otherwise. Just like the second hypothesis, I also include the dummy variable in conjunction with its respective growth variable as an explanatory variable. The model equation is the following:

$$Y_t = \beta_0 + \beta_1 \text{Growth}_{i,t-1} + \beta_2 D_{q,t-1} + \beta_3 D_{q,t-1} * \text{Growth}_{i,t-1} + \beta_{4,\dots,21} \text{Control}_{t-1} + u_t \; q = 1, \dots, 6$$

The results are presented in Table 12. Just like in Table 8, the main variable of interest is the dummy variable (D1). I find that five out of six dummy variable coefficients are negative. However, only the Tobin's Q variable is statistically significant at the 5% level. This result suggests that there is a negative relation between firms having a low Tobin's Q concurrent with high liquidity and hedging intensity. Indeed, a negative dummy variable coefficient means that firms that are more prone to the overinvestment problem tend to hedge less than the other firms. As for the dummy variables multiplied by their respective growth proxy, the coefficient of the conjunction between the dummy variable and the P/E ratio is negative and statistically significant

at the 5% level. This result suggests that for firms that have a low P/E and high liquidity, there is a lower level of sensitivity between risk management and growth opportunities. Overall, the findings do not support the fourth hypothesis on the overinvestment problem.

V. CONCLUSION

Using a sample of U.S. oil producers, this research revisits the underinvestment problem, as a determinant of corporate hedging policy. I test the three hypotheses developed by Gay (1998) and an additional hypothesis inspired by the proposition made by Morellec and Smith (2007) that the overinvestment problem is also a determinant of firms' hedging decisions. Using six different proxies for investment opportunities, I find that the relation between a firm's hedging intensity and its investment opportunities varies based on the proxy used. Firms that have high investments in oil and gas reserves hedge more when they also have low liquidity levels. I also find that firms having a higher correlation between cash flows and investment expenses hedge less than the other firms, which is consistent with the literature. Finally, I find results that are contradictory to the overinvestment problem proposed by Morellec and Smith (2007). Further developments on the subject could help to get a clearer understanding of the real implications of the underinvestment problem with regard to hedging policy. Indeed, more robust regressions with the use of an instrumental variable could help reduce potential endogeneity problems such as reverse causation. Dionne and Mnasri (2018) have revisited the real implications of risk management by using the instrumental variable approach to correct potential endogeneity issues present in the existing literature. While finding the right instrument for growth opportunities remains a challenge, a similar method could be developed in the case of the underinvestment problem.

VI. TABLES

TABLE 1

SUMMARY STATISTICS FOR OIL HEDGING BY HORIZON

Variables	Obs.	Mean	Median	1st quartile	3rd quartile	STD
HR0	2587	46.070%	44.564%	24.355%	63.881%	27.876%
HR1	1723	38.328%	36.043%	16.469%	54.690%	27.338%
HR2	907	30.848%	26.798%	9.614%	46.316%	25.680%
HR3	431	27.352%	19.946%	7.340%	43.601%	25.777%
HR4	185	23.254%	14.686%	7.215%	33.860%	24.589%
HR5	61	21.887%	19.685%	4.563%	38.933%	18.171%

TABLE 2

VARIABLE CHARACTERISTICS

Variables	Obs.	Mean	Median	1st quartile	3rd quartile	STD
Market-to-book (in log)	5656	0.736	0.717	0.302	1.131	0.811
Tobin's Q (in log)	5909	0.252	0.175	-0.093	0.529	0.613
R&D	5793	92.886	13.540	2.582	69.687	278.062
P/E ratio (in log)	3915	4.080	4.002	3.493	4.603	1.158
Investment opportunities	6295	0.129	0.062	0.035	0.107	2.333
Oil reserve (in log)	6180	2.135	2.158	0.151	4.041	2.882
Tax save	6160	0.053	0.048	0.029	0.070	0.051
Convertible debt	5848	0.038	0.000	0.000	0.000	0.160
Preferred stock	5913	0.133	0.000	0.000	0.000	3.828
Leverage	6044	0.516	0.523	0.342	0.659	0.285
Liquidity	6069	1.555	0.275	0.080	0.850	5.335
Dividend payout	6326	0.265	0.000	0.000	1.000	0.442
CEO number of options	6326	17.439	0.000	0.000	12.000	68.176
Institutional ownership	6326	0.337	0.216	0.000	0.687	0.346
Number of analysts	6326	5.108	2.000	0.000	8.000	6.914
Geographic diversification (oil)	6178	0.101	0.000	0.000	0.000	0.233
Geographic diversification (gas)	6180	0.063	0.000	0.000	0.000	0.183
Gas reserve (in log)	6196	4.503	4.664	2.765	6.396	2.836
Oil price volatility	6318	3.280	2.371	1.608	3.655	2.829
Gas price volatility	6318	0.733	0.500	0.290	1.111	0.560
Oil spot price	6318	49.265	43.450	26.800	69.890	28.044
Gas spot price	6318	5.139	4.830	3.070	6.217	2.617
Oil production risk	6246	0.272	0.169	0.080	0.344	0.302
Gas production risk	6222	0.273	0.181	0.092	0.360	0.281

TABLE 3

CORRELATION MATRIX

	Tax save	Convertible debt	Preferred stock	Leverage	Liquidity	Dividend payout	CEO number of options	Institutional ownership	Number of analysts
Tax save	1								
Convertible debt	0.15***	1							
Preferred stock	0.15***	0.29***	1						
Leverage	0.2***	0.2***	0.18***	1					
Liquidity	-0.08**	0.01	-0.02	-0.34***	1				
Dividend payout	-0.31***	-0.12***	-0.07**	-0.06	-0.13***	1			
CEO number of options	0.07**	0.03	0.07**	-0.01	-0.03	0.0	1		
Institutional ownership	-0.31***	-0.14***	-0.09***	-0.05	-0.14***	0.28***	-0.16***	1	
Number of analysts	-0.24***	-0.13***	-0.12***	-0.05	-0.14***	0.48***	-0.04	0.47***	1
Geographic diversification (oil)	-0.2***	-0.03	-0.09**	-0.15***	-0.04	0.4***	-0.05	0.18***	0.45***
Geographic diversification (gas)	-0.15***	-0.05	-0.07*	-0.02	-0.06*	0.33***	-0.01	0.15***	0.3***
Gas reserve (in log)	-0.28***	-0.09**	-0.08**	0.14***	-0.26***	0.65***	-0.02	0.44***	0.79***
Oil price volatility	0.03	-0.04	-0.06	-0.06*	0.03	0.04	-0.07**	0.15***	0.13***
Gas price volatility	0.00	-0.01	-0.04	-0.04	-0.01	-0.04	-0.02	0.08**	0.03
Oil spot price	-0.11***	-0.07*	-0.08**	-0.06*	-0.02	0.04	-0.04	0.25***	0.2***
Gas spot price	-0.06*	-0.08**	-0.09**	-0.02	-0.0	-0.01	-0.05	0.16***	0.12***
Oil production risk	0.2***	0.02	0.01	-0.05	0.11***	-0.21***	0.1***	-0.21***	-0.26***
Gas production risk	0.19***	0.04	0.01	0.04	0.09**	-0.27***	0.18***	-0.25***	-0.27***

TABLE 3 (continued)

CORRELATION MATRIX

	Geographic diversification (oil)	Geographic diversification (gas)	Gas reserve (in log)	Oil price volatility	Gas price volatility	Oil spot price	Gas spot price	Oil production risk	Gas production risk
Tax save									
Convertible debt									
Preferred stock									
Leverage									
Liquidity									
Dividend payout									
CEO number of options									
Institutional ownership									
Number of analysts									
Geographic diversification (oil)	1								
Geographic diversification (gas)	0.68***	1							
Gas reserve (in log)	0.42***	0.37***	1						
Oil price volatility	0.05	0.08**	0.01	1					
Gas price volatility	0.01	-0.02	-0.03	0.23***	1				
Oil spot price	0.07**	0.11***	0.06*	0.6***	0.29***	1			
Gas spot price	0.04	0.0	-0.02	0.37***	0.57***	0.63***	1		
Oil production risk	-0.27***	-0.19***	-0.34***	0.02	0.02	0.02	0.04	1	
Gas production risk	-0.19***	-0.19***	-0.37***	0.13***	0.07**	0.12***	0.1***	0.4***	1

N = 803

*** Significant at the 0.01 level.

** Significicant at the 0.05 level.

* Significant at the 0.10 level.

TABLE 4

VARIABLE CONSTRUCTION AND PREDICTED COEFFICIENT SIGN

Variables	**Construction**	**Predicted sign**
Market-to-book (in log)	The market value of equity divided by the book value of equity (in log)	+
Tobin's Q (in log)	The market value of equity plus the book value of debt plus the book value of preferred shares divided by total assets (in log)	+
R&D	Investments in oil and gas reserves (acquistion, exploration, and development) divided by firm size	+
P/E ratio (in log)	The closing stock price at quarter-end divided by the earnings per share (in log)	+
Investment opportunities	Quarterly capital expenditures divided by property plant and equipment at the beginning of the quarter	+
Oil reserve (in log)	Annual quantity (in millions of barrel) of the total proved developed and undeveloped oil reserves (in log)	+
Tax save	Constructed based on Graham and Smith (1999). Taxable income, income volatility, first order serial correlation in income, investment tax credits, net operating loss carrybacks and carryforwards and some interaction terms are used to calculate the tax save variable.	+
Convertible debt	Book value of convertible debt divided by market value of equity	-
Preferred stock	Book value of preferred shares divided by market value of equity	-
Leverage	Book value of total debt divided the book value of total assets	+
Liquidity	Book value of cash and cash equivalents divided by the book value of current liabilities	-
Dividend payout	Dummy variable equaling if dividends were declared during the quarter and zero otherwise	-
CEO number of options	Number of stock options held by the CEO at quarter-end (x 10,000)	-
Institutional ownership	Percentage of the shares held by institutional investors	-
Number of analysts	Number of analysts following the firm and issued a forecast of the firm's quarterly earnings	-

TABLE 4 (continued)

VARIABLE CONSTRUCTION AND PREDICTED COEFFICIENT SIGN

Variables	**Construction**	**Predicted sign**
Geographic diversification in oil (gas)	Equals to $1 - \sum_{i=1}^{N} (\frac{q}{q_i})^2$, where qi is the daily oil (gas) production in region i (Africa, Latin America, North America, Europe and the Middle East) and q is the firm's total daily oil (gas) production	-
Gas reserve (in log)	Annual quantity (in millions of barrel) of the total proved developed and undeveloped gas reserves (in log)	+
Oil (gas) price volatility	Historical standard deviation of the daily oil (gas) spot prices during the quarter	?
Oil spot price	Oil spot price represented by the WTI index on the NYMEX at the end of the current quarter	?
Gas spot price	Average index established from principal locations' indices in the United States	?
Oil (gas) production risk	Coefficient of variation of daily oil (gas) production, calculated for each firm by using rolling windows of 12 quarterly observations	+
Correlation capex/cash flows	12-quarter moving average of the correlation between capital expenditures and free cash flows	-
Correlation costs/cash flows	12-quarter moving average of the correlation between costs incurred for investments in oil and gas reserves and free cash flows	-

TABLE 5

OIL PRODUCERS' CHARACTERISTICS BY OIL HEDGING INTENSITY

	(1)			(2)			(1) vs. (2)
	High Quartile			Low Quartile			
Variables	**Obs.**	**Mean**	**Median**	**Obs.**	**Mean**	**Median**	**t-stat**
Market-to-book (in log)	578	0.7513	0.7093	616	0.6959	0.7358	-1.3126***
Tobin's Q (in Log)	620	0.1666	0.1253	638	0.1922	0.1727	1.1889
R&D	611	102.1186	31.0624	632	165.9066	73.0360	4.8008
P/E ratio (in log)	413	3.8493	3.9092	506	4.0536	3.9566	2.7193***
Investment opportunities	635	0.0990	0.0624	647	0.0792	0.0595	-2.2643***
Oil reserve (in log)	647	3.4884	3.4572	647	4.1064	4.2873	6.1976**
Tax save	641	0.0560	0.0536	647	0.0437	0.0428	-5.3658***
Convertible debt	612	0.0311	0.0000	638	0.0402	0.0000	1.0582***
Preferred stock	620	0.0505	0.0000	638	0.0284	0.0000	-2.2224
Leverage	633	0.6545	0.6207	647	0.5471	0.5300	-8.593**
Liquidity	637	0.3342	0.1040	647	0.4857	0.2126	2.2956***
Dividend payout	647	0.2798	0.0000	647	0.5178	1.0000	9.0066**
CEO number of options	647	29.9093	0.0000	647	20.5242	6.0000	-1.5528***
Institutional ownership	647	0.4750	0.5172	647	0.5783	0.7240	5.7173***
Number of analysts	647	6.5997	4.0000	647	10.6291	9.0000	9.2979***
Geographic diversification (oil)	647	0.0479	0.0000	647	0.2247	0.0000	13.7703***
Geographic diversification (gas)	641	0.0281	0.0000	647	0.1329	0.0000	10.843***
Gas reserve (in log)	638	5.6190	5.5865	645	6.3357	6.3732	7.0578***
Oil production risk	647	0.2585	0.1671	647	0.1971	0.1376	-4.6906***
Gas production risk	647	0.2673	0.1931	647	0.1944	0.1422	-6.0289***

*** Significant at the 0.01 level.

** Significicant at the 0.05 level.

* Significant at the 0.10 level.

TABLE 6

MULTIVARIATE TEST OF HYPOTHESIS 1

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Market-to-book (in log)	-0.059**					
Tobin's Q (in log)		-0.122**				
R&D			0.0001			
P/E ratio (in log)				-0.0221		
Investment opportunities					-0.0563	
Oil reserve (in log)						0.0395***
Constant	-0.0546	0.0025	-0.0341	0.0402	-0.0626	-0.0903
Tax save	0.2537	0.1609	0.2793	0.3805	0.3425	0.3754
Convertible debt	-0.341**	-0.34*	-0.34*	-0.354*	-0.340*	-0.2764
Preferred stock	0.4728	0.3778	0.4209	0.4309	0.4422	0.3960
Leverage	0.8817***	0.7936***	0.8561***	0.803***	0.8169***	0.7887***
Liquidity	-0.0865***	-0.0855***	-0.0905***	-0.0908***	-0.0902***	-0.0886***
Dividend payout	-0.1665***	-0.1722***	-0.1723***	-0.1749***	-0.1737***	-0.1692***
CEO number of options	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
Institutional ownership	0.0843	0.0763	0.0743	0.0802	0.0700	0.0507
Number of analysts	-0.0040	-0.0032	-0.0048	-0.0043	-0.0044	-0.006*
Geographic diversification (oil)	-0.2429***	-0.2552***	-0.2462***	-0.2375***	-0.2398***	-0.2712***
Geographic diversification (gas)	-0.3965***	-0.4069***	-0.3838***	-0.391***	-0.3835***	-0.4794***
Gas reserve (in log)	0.0162	0.0137	0.0113	0.0188	0.0190	0.0066
Oil price volatility	0.0077	0.0072	0.011*	0.0095	0.0099	0.0097
Gas price volatility	-0.0144	-0.0172	-0.0164	-0.0146	-0.0139	-0.0097
Oil spot price	0.0018**	0.0017**	0.0014*	0.0017**	0.0017**	0.0017**
Gas spot price	-0.0066	-0.0061	-0.0089	-0.0111	-0.0088	-0.0086
Oil production risk	0.1149	0.0997	0.1051	0.1055	0.1005	0.1447
Gas production risk	-0.0031	0.0097	0.0091	0.0194	0.0230	-0.0456

N = 803

*** Significant at the 0.01 level.

** Significicant at the 0.05 level.

* Significant at the 0.10 level.

TABLE 7

UNIVARIATE TEST OF HYPOTHESIS 2

Variables	Low liquidity, High growth Hedging intensity	High liquidity, High growth Hedging intensity	t-statistic
Market-to-book (in log)	0.117	0.114	0.255
	(N = 200)	(N = 79)	
Tobin's Q (in log)	0.112	0.119	-0.733
	(N = 179)	(N = 84)	
R&D	0.104	0.110	-0.6335
	(N = 161)	(N = 59)	
P/E (in log)	0.116	0.124	-0.789
	(N = 163)	(N = 67)	
Investment opportunities	0.131	0.135	-0.3527
	(N = 88)	(N = 34)	
Oil reserve (in log)	0.110	0.117	-0.8797
	(N = 226)	(N = 89)	

*** Significant at the 0.01 level.
** Significicant at the 0.05 level.
* Significant at the 0.10 level.

TABLE 8

MULTIVARIATE TEST OF HYPOTHESIS 2

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Market-to-book (in log)	-0.0984***					
Tobin's Q (in log)		-0.2558***				
R&D			0.0001*			
P/E (in log)				-0.047**		
Investment opportunities					0.2701	
Oil reserve (in log)						0.0198
D1	-0.0532	0.0654	0.2081***	-0.1506	-0.0078	0.0974
D1*MKT/BK	0.0892					
D1*Q		0.1395				
D1*R&D			-0.0001			
D1*P/E				0.0433		
D1*Investment Opportunties					-0.3327	
D1*Oil Reserve						0.0024
Constant	-0.0594	-0.0679	0.0639	0.1256	-0.0681	-0.0698
Tax save	0.2648	0.1895	0.3154	0.4260	0.3155	0.4677
Convertible debt	-0.358**	-0.349*	-0.3060	-0.355*	-0.335*	-0.2506
Preferred stock	0.4538	0.3683	0.3468	0.4251	0.4333	0.3456*
Leverage	0.8619***	0.8403***	0.8943***	0.773***	0.8147***	0.8065***
Liquidity	-0.0765***	-0.047**	-0.076***	-0.081***	-0.0978***	-0.0691***
Dividend payout	-0.1689***	-0.171***	-0.1569***	-0.172***	-0.1723***	-0.1573***
CEO number of options	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
Institutional ownership	0.0855	0.0855	0.0554	0.0891	0.0641	0.0455
Number of analysts	-0.0039	-0.0025	-0.005*	-0.0041	-0.0044	-0.0057
Geographic diversification (oil)	-0.246***	-0.2699***	-0.2979***	-0.2499***	-0.242***	-0.2767***
Geographic diversification (gas)	-0.3833***	-0.3904***	-0.4147***	-0.3674***	-0.3903***	-0.4561***
Gas reserve (in log)	0.0190	0.0119	-0.0090	0.0186	0.0193	0.0017
Oil price volatility	0.0069	0.0055	0.0121*	0.0088	0.0101*	0.0105
Gas price volatility	-0.0146	-0.0155	-0.0283	-0.0126	-0.0132	-0.0097
Oil spot price	0.0018**	0.0018**	0.0012	0.0017**	0.0017**	0.0017**
Gas spot price	-0.0064	-0.0059	-0.0090	-0.0105	-0.0089	-0.0077
Oil production risk	0.1314	0.1174	0.1120	0.1189	0.0955	0.1425
Gas production risk	0.0015	0.0239	-0.0445	0.0172	0.0252	-0.0425

N = 803

*** Significant at the 0.01 level.

** Significicant at the 0.05 level.

* Significant at the 0.10 level.

TABLE 9

MULTIVARIATE TEST OF HYPOTHESIS 3

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Market-to-book (in log)	-0.059**					
Tobin's Q (in log)		-0.121**				
R&D			0.0001			
P/E ratio (in log)				-0.0218		
Investment opportunities					-0.0587	
Oil reserve (in log)						0.0395***
Correlation capex/cash flows	-0.0018	-0.0041	-0.0108	-0.0098	-0.0132	-0.0001
Constant	-0.0543	0.0029	-0.0322	0.0407	-0.0598	-0.0903
Tax save	0.2535	0.1605	0.2768	0.3773	0.3393	0.3753
Convertible debt	-0.341**	-0.341*	-0.342*	-0.356*	-0.343*	-0.2765
Preferred stock	0.4727	0.3782	0.4214	0.4314	0.4426	0.3960
Leverage	0.8809***	0.7925***	0.8525***	0.8001***	0.8123***	0.7886***
Liquidity	-0.0867***	-0.086***	-0.0919***	-0.092***	-0.0919***	-0.0887***
Dividend payout	-0.1666***	-0.1723***	-0.1725***	-0.1751***	-0.1741***	-0.1692***
CEO number of options	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
Institutional ownership	0.0845	0.0769	0.0760	0.0816	0.0720	0.0507
Number of analysts	-0.0040	-0.0032	-0.0047	-0.0043	-0.0043	-0.006*
Geographic diversification (oil)	-0.2432***	-0.256***	-0.2483***	-0.2395***	-0.2425***	-0.2712***
Geographic diversification (gas)	-0.3959***	-0.4055***	-0.3806***	-0.388***	-0.3795***	-0.4793***
Gas reserve (in log)	0.0162	0.0137	0.0113	0.0188	0.0190	0.0066
Oil price volatility	0.0077	0.0071	0.0108*	0.0094	0.0097	0.0097
Gas price volatility	-0.0143	-0.0169	-0.0156	-0.0139	-0.0130	-0.0096
Oil spot price	0.0018**	0.0017**	0.0014*	0.0017**	0.0017**	0.0017**
Gas spot price	-0.0066	-0.0060	-0.0086	-0.0109	-0.0085	-0.0086
Oil production risk	0.1152	0.1005	0.1071	0.1073	0.1032	0.1447
Gas production risk	-0.0022	0.0116	0.0141	0.0239	0.0291	-0.0456

N = 803

*** Significant at the 0.01 level.

** Significicant at the 0.05 level.

* Significant at the 0.10 level.

TABLE 10

MULTIVARIATE TEST OF HYPOTHESIS 3

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Market-to-book (in log)	-0.048*					
Tobin's Q (in log)		-0.104**				
R&D			0.0001			
P/E ratio (in log)				-0.0180		
Investment opportunities					-0.0449	
Oil reserve (in log)						0.0355**
Correlation costs/cash flows	-0.076**	-0.071*	-0.089**	-0.084**	-0.088**	-0.075*
Constant	-0.0388	0.0089	-0.0128	0.0404	-0.0425	-0.0702
Tax save	0.1766	0.1007	0.1716	0.2702	0.2341	0.2809
Convertible debt	-0.348**	-0.346**	-0.348*	-0.359**	-0.348*	-0.2899
Preferred stock	0.4551	0.3761	0.4065	0.4195	0.4281	0.3887
Leverage	0.8433***	0.7719***	0.8232***	0.7759***	0.7858***	0.7647***
Liquidity	-0.0933***	-0.092***	-0.0978***	-0.0975***	-0.0974***	-0.0949***
Dividend payout	-0.1697***	-0.1742***	-0.1747***	-0.1768***	-0.1759***	-0.1716***
CEO number of options	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
Institutional ownership	0.0960	0.0888	0.0910	0.0941	0.0866	0.0667
Number of analysts	-0.0038	-0.0032	-0.0045	-0.0041	-0.0041	-0.006*
Geographic diversification (oil)	-0.263***	-0.2724***	-0.2707***	-0.2609***	-0.2639***	-0.2885***
Geographic diversification (gas)	-0.3759***	-0.3861***	-0.3626***	-0.3693***	-0.3622***	-0.4517***
Gas reserve (in log)	0.0180	0.0158	0.0129	0.0203	0.0205	0.0092
Oil price volatility	0.0083	0.0077	0.0111*	0.0098	0.0101*	0.0099
Gas price volatility	-0.0139	-0.0163	-0.0158	-0.0140	-0.0134	-0.0096
Oil spot price	0.0017**	0.0016**	0.0013*	0.0017**	0.0016**	0.0017**
Gas spot price	-0.0042	-0.0039	-0.0056	-0.0076	-0.0056	-0.0059
Oil production risk	0.1145	0.1020	0.1080	0.1071	0.1031	0.1425
Gas production risk	0.0250	0.0338	0.0370	0.0461	0.0503	-0.0154

N = 803

*** Significant at the 0.01 level.

** Significicant at the 0.05 level.

* Significant at the 0.10 level.

TABLE 11

UNIVARIATE TEST OF HYPOTHESIS 4

Variables	Low liquidity, Low growth Hedging intensity	High liquidity, Low growth Hedging intensity	t-statistic
Market-to-book (in log)	0.131	0.135	-0.337
	(N = 127)	(N = 72)	
Tobin's Q (in log)	0.134	0.130	0.364
	(N = 148)	(N = 67)	
R&D	0.140	0.133	0.8762
	(N = 166)	(N = 92)	
P/E (in log)	0.128	0.124	0.5007
	(N = 164)	(N = 84)	
Investment opportunities	0.119	0.121	-0.1996
	(N = 239)	(N = 117)	
Oil reserve (in log)	0.150	0.134	1.5492
	(N = 101)	(N = 62)	

*** Significant at the 0.01 level.

** Significicant at the 0.05 level.

* Significant at the 0.10 level.

TABLE 12

MULTIVARIATE TEST OF HYPOTHESIS 4

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Market-to-book (in log)	-0.076**					
Tobin's Q (in log)		-0.156***				
R&D			0.0001			
P/E (in log)				-0.0274		
Investment opportunities					-0.1105	
Oil reserve (in log)						0.0483***
D1	-0.0669	-0.114**	-0.0730	0.2267	-0.1485	-0.1878
D1*MKT/BK	0.0322					
D1*Q		-0.0247				
D1*R&D			-0.0012			
D1*P/E				-0.113**		
D1*Investment opportunties					-0.6729	
D1*Oil reserve						-0.0016
Constant	-0.0364	0.0273	-0.0087	0.0785	-0.0233	-0.1427
Tax save	0.2872	0.2428	0.3575	0.5529	0.5216	0.6688
Convertible debt	-0.331**	-0.311*	-0.3128	-0.3100	-0.2907	-0.2781
Preferred stock	0.4952	0.3773	0.4343	0.4239	0.4214	0.3845
Leverage	0.8956***	0.7969***	0.8506***	0.8028***	0.8315***	0.8415***
Liquidity	-0.0773***	-0.0699***	-0.061**	-0.0569***	-0.043**	-0.050**
Dividend payout	-0.1601***	-0.1584***	-0.167***	-0.1562***	-0.138***	-0.1355***
CEO number of options	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
Institutional ownership	0.0857	0.0754	0.0794	0.0839	0.0755	0.0686
Number of analysts	-0.0037	-0.0026	-0.0047	-0.0026	-0.0026	-0.0048
Geographic diversification (oil)	-0.2402***	-0.2571***	-0.2583***	-0.2663***	-0.242***	-0.3003***
Geographic diversification (gas)	-0.3978***	-0.4086***	-0.3626***	-0.3686***	-0.3777***	-0.4553***
Gas reserve (in log)	0.0130	0.0088	0.0064	0.0123	0.0073	-0.0038
Oil price volatility	0.0077	0.0073	0.0102*	0.0086	0.0101*	0.0101*
Gas price volatility	-0.0144	-0.0175	-0.0121	-0.0170	-0.0120	-0.008
Oil spot price	0.0018**	0.0017**	0.0015*	0.0015**	0.0016**	0.0017**
Gas spot price	-0.0067	-0.0061	-0.0090	-0.0083	-0.0098	-0.0082
Oil production risk	0.1200	0.1094	0.1225	0.1002	0.1005	0.139
Gas production risk	0.0040	0.0178	0.0134	0.0058	0.0525	-0.0248

N = 803

*** Significant at the 0.01 level.

** Significicant at the 0.05 level.

* Significant at the 0.10 level.

BIBLIOGRAPHY

Adam, T. R., Goyal, V. K. (2002). The investment opportunity set and its proxy variables: Theory and evidence. *SSRN Electronic Journal.*

Bartram, S. M., Brown, G., Fehle, F. R. (2003). International evidence on financial derivatives usage. *SSRN Electronic Journal.*

Dionne, G., Mnasri, M. (2018). Real implications of corporate risk management: Review of main results and new evidence from a different methodology. *SSRN Electronic Journal.*

Ferriani, F., Veronese, G. (2022). Hedging and investment trade-offs in the U.S. Oil Industry. *Energy Economics, 106,* 105736.

Froot, K. A., Scharfstein, D. S., & Stein, J. C. (1993). Risk Management: Coordinating Corporate Investment and Financing Policies. *The Journal of Finance, 48*(5), 1629–1658.

Gay, G. D., Nam, J. (1998). The underinvestment problem and corporate derivatives use. *Financial Management, 27*(4), 53.

Geczy, C. C., Minton, B. A., Schrand, C. M. (1996). Why firms use currency derivatives. *SSRN Electronic Journal.*

Graham, J. R., & Rogers, D. A. (2002). Do Firms Hedge in Response to Tax Incentives? *The Journal of Finance, 57*(2), 815–839.

Graham, J. R., & Smith, C. W. (1999). Tax Incentives to Hedge. *The Journal of Finance, 54*(6), 2241–2262.

Mian, S. L. (1996). Evidence on corporate hedging policy. *The Journal of Financial and Quantitative Analysis, 31*(3), 419.

Morellec, E., Smith, C. W. (2007). Agency conflicts and risk management. *Review of Finance, 11*(1), 1–23.

Myers, S. C. (1977). Determinants of corporate borrowing. *Journal of Financial Economics, 5*(2), 147–175.

Nance, D. R., Smith, C. W., & Smithson, C. W. (1993). On the Determinants of Corporate Hedging. *The Journal of Finance, 48*(1), 267–284.

Rampini, A. A., Sufi, A., Viswanathan, S. (2014). Dynamic Risk Management. *Journal of Financial Economics, 111*(2), 271–296.

Smith, C. W., & Stulz, R. M. (1985). The Determinants of Firms' Hedging Policies. *The Journal of Financial and Quantitative Analysis, 20*(4), 391–405.