The Maturity Structure of Corporate Hedging: The Case of the U.S. Oil and Gas Industry

Mohamed Mnasri
Ph.D. Candidate (Finance), Université du Québec à Montréal
Georges Dionne
Canada Research Chair in Risk Management, HEC Montréal, CIRRELT, and CIRPÉE
Jean-Pierre Gueyie
Associate Professor, Department of Finance, Université du Québec à Montréal

October 22, 2013

ABSTRACT

This paper investigates how firms design the maturity of their hedging programs, and the real effects of maturity choice on firm value and risk. Using a new dataset on hedging activities of 150 U.S. oil and gas producers, we find strong evidence that hedging maturity is influenced by investment programs, market conditions, production specificities, and hedging contract features. We also give empirical evidence of a non-monotonic relationship between hedging maturity and measures of financial distress. We further investigate the motivations of early termination of contracts. Finally, we show that longer hedging maturities could attenuate the impacts of commodity price risk on firm value and risk.

***Keywords**:* Risk management, maturity choice, early termination, economic effects, oil and gas industry.

***JEL classification**:* D8, G32

1. Introduction

We explore a new channel in corporate risk management literature through which firms could create value and reduce risk by considering the following questions: How far ahead do firms hedge? What are the determinants of the maturity structure of firms' hedging programs? What are the economic effects of hedging maturities on firm value and risk? These questions are still largely unexplored because of the lack of empirical analysis due to limitations of the data. Using an extensive and new hand-collected dataset on the risk management activities of 150 U.S. oil and gas producers with quarterly observations over the period 1998-2010, we fill this gap in the literature and answer the above questions. It is important to understand why firms within the same industry and with the same risk exposure differ in terms of their hedging maturity structure.

We contribute to the literature on corporate hedging in several ways. Our first contribution is to provide empirical evidence of the rationales and determinants of the maturity structure of hedging contracts at inception; we also study the rationales for early termination of hedging contracts, and the real implications of maturity choice on firm value and risk. We hence add new significant results to the empirical literature; the scant empirical studies discuss the maturity structure of hedging in a largely descriptive manner.[1] In addition, our data collected from publicly disclosed information avoid

[1] Dolde (1993) surveys the hedging practices of 244 Fortune 500 companies and finds that the common practice is to hedge cash flow exposures within a horizon of two to four quarters. In line with Dolde (1993), Tufano (1996) provides statistics about the percentage of the production hedged for North American gold mining firms for 1991-1993, and finds that they hedge 61.2% of their gold production for the current year (1991) and 10% and 11% for the subsequent two years. In a Wharton survey of financial risk management practices and derivatives of 399 U.S. non-financial firms, Bodnar et al (1998) report that 82% of the questioned firms use foreign currency derivatives with an initial maturity of 91 days or less, and only 12% use foreign currency derivatives with maturities exceeding 3 years. They also find that hedging ratios at longer maturities decreased dramatically during 1998. Adam and Fernando (2006 and 2008) study the cash flow gains from selective hedging for a sample of 92 North American gold producers from 1989 to 1999 and report descriptive statistics of hedging ratios up to five years. They find that gold producers use hedging programs with one-year maturities in 90% of firm-quarters with non-zero hedging with a mean hedging ratio of 54% of expected gold production, hedging programs with three-year maturities in 51% of hedging quarters with an average hedging ratio of 25%, and programs with five-year maturities in 18% with an average hedging ratio of 28%. They also point out that near-term hedging ratios are more volatile than those with longer horizons. Carter, Rogers, and Simkins (2006) investigate the jet fuel hedging activities of U.S. airline firms during 1992-2003 and find that hedging maturities vary significantly between firms (e.g., from one year to six years ahead) and that hedging ratios of the next year's fuel consumption are very disparate (e.g., from 1% to 43%).

the non-response bias associated with questionnaires and provide detailed information about real hedging activities. Finally, we study hedging activities of both commodities (oil and gas) separately, which gives deeper insight into oil and gas producers' hedging dynamics.

Consistent with our predictions, results of our base model (i.e., Dynamic System-GMM Panel Model) show that oil and gas producers, having substantial growth options, use hedging contracts with longer maturities to avoid shortfalls in their future cash flows. We also find that oil and gas producers with a higher positive correlation between their investment expenditures and internal cash flows tend to use short-term hedging contracts because they benefit from a natural hedge. In line with Fehle and Tsyplakov's (2005) prediction, we give strong evidence of the non-monotonic (concave) relationship between measures of the likelihood of financial distress (i.e., leverage) and hedging maturity. This non-monotonic relationship means that hedging maturities increase and then decrease with the likelihood of financial distress.

Results also indicate that distressed oil and gas producers (i.e., with insufficient liquidity) enter long-term put options as a risk-shifting (asset substitution) strategy. Costly put options with long maturities increase rather than eliminate the firm's payoff volatility and decrease assets available for debtholders. Results further show that oil and gas producers with higher cash flow volatility, due to higher production uncertainty and/or higher price-quantity correlation, tend to use farther hedging positions to avoid shortfalls in their future revenues. We also observe strong evidence of the impact of market conditions on hedging maturity choice. Oil and gas price volatilities are significantly positively related to longer maturities hedging, as predicted by Fehle and Tsyplakov (2005). Accordingly, higher price volatility makes firms reluctant to incur costly early termination of their hedging contracts unless spot prices increase significantly. We further verify that when future prices are expected to be higher, firms tend to use short-term hedging and we find empirical evidence of a non-monotonic (concave) relationship between oil and gas spot prices and hedging maturities.

Results show that the hedging contract features (i.e., moneyness, strike price) have an evident impact on maturity choice. As predicted, oil and gas producers keep in-the-money hedging contracts until they mature and terminate out-of-the-money contracts early. Results further imply that a hedging contract initiated at a sufficiently higher strike price is more likely to be kept for longer periods. Consistent with our prediction, tax function convexity motivates the use of long-term contracts and tax loss carry-forwards seem to be a disincentive to hedge longer exposures because they could be used as a caution to reduce firms' future tax liabilities. With respect to asset-liability management, we find that oil and gas producers seek to match the maturities of their hedging and of their oil and gas developed reserves (i.e., assets) and debt.

Results are largely robust to other data collection criteria. Specifically, we use maturity choice at inception of the hedging contracts and find results largely similar to those of our base specification (i.e., Dynamic System-GMM Panel Model). Our results are validated again when we study the determinants of the early termination of hedging contracts. Finally, we give novel evidence of the impact of hedging maturity on firm value and risk, and find that long-term hedging lowers the sensitivity of the stock return to changes in gas prices, in particular. However, we find no significant impact on sensitivity to oil and gas price volatility.

The rest of the paper is organized as follows. In Section 2, we state our hypotheses. In Section 3, we describe our data, and dependent and independent variables. Section 4 presents the retained econometric methodology. Section 5 reports univariate results and Section 6 investigates the empirical evidence of the maturity structure of corporate risk management. In Section 7, we test the robustness of our results by exploring the determinants of maturity choice at the inception of hedging contracts and the determinants of early termination of outstanding hedging contracts. We then investigate the real implications of hedging maturity choice empirically in Section 8, and Section 9 concludes the paper.

2. Hypotheses

The lack of testable theoretical predictions on hedging maturity structure was compensated by Fehle and Tsyplakov (2005). They present an infinite-horizon continuous time model of a firm that can adjust the hedge ratio and maturity of its hedging instruments dynamically in response to fluctuations in firm output price. Their model is calibrated to replicate empirical observations for a gold mining firm and produces a number of new theoretical predictions pertaining to the optimal timing, adjustment, and rollover of hedging contracts and their maturities, which we will describe in depth to develop our hypotheses in this section and test empirically after.

2.1. Financial distress

A large body of the empirical literature has analyzed the positive relationship between financial constraints and firms' hedging activities (e.g., Nance et al (1993), Géczy et al (1997), Tufano (1996), Gay and Nam (1999), Adam (2002, 2009)). In line with this extant literature, Fehle and Tsyplakov (2005) analyzed the implications of financial distress on risk management adjustments. Based on simulations of output (gold) spot prices, they find a non-monotonic relationship between hedging maturity and measures of the probability of financial distress. This non-monotonicity means that hedging maturity first increases and then decreases with the probability of financial distress. To put it another way, firms near distress are often observed with short-run hedging contracts, and may terminate longer contracts at a high cost as a result of risk-shifting behavior. Firms far from distress opt for short-term contracts because of the low marginal benefits of hedging for wealthy firms (e.g., Stulz (1996)).

Fehle and Tsyplakov (2005) also find that financial distress costs are negatively related to hedging maturity. Their simulations show that firms with high distress costs tend to use shorter maturity hedging. Thus, distress costs increase when the firm's cash inflows (i.e., its selling prices) are insufficient to cover production costs and debt payments. Hence we posit:

HYPOTHESIS 1: *Hedging maturity is negatively related to (i) either high or low likelihood of financial distress, and (ii) higher distress costs.*

To verify the empirical relevance of this prediction we use the following two measures of the distress likelihood: (1) the leverage ratio as measured by the book value of long-term debt in current liabilities plus half of long-term debt scaled by book value of total assets as used by Moody's-KMV, and (2) distance-to-default, which is the market-based measure originated from Merton's (1974) approach. This measure gives the number of standard deviations that the firm is away from default (Crosbie and Bohn (2003)). We also use leverage squared and distance-to-default squared to capture non-linearity between financial soundness and hedging maturity. We predict a positive sign for the leverage ratio and distance-to-default and a negative sign for their squared values.

Following Fehle and Tsyplakov's (2005) methodology, we measure firm's incurred distress costs by the following product $I[\, Liquidity - M]\, max[0, -p + c + d]$ where I is an indicator function and Liquidity is the quick ratio (i.e., cash and cash equivalents scaled by the book value of current liabilities). We use the quick ratio because a firm could use this liquidity as a caution to repay future debt requirements (see Dionne and Triki (2013)). M is the median quick ratio of the oil and gas industry. $I[Liquidity - M] = 1 \; if \; Liquidity \; < \; M$ and 0 otherwise. $max[0, -p + c + d]$ means that a firm incurs distress costs that are proportional to the shortfall of its realized selling prices p

compared with its production costs c and debt payments d. These realized prices[2] include the monetary effects of hedging activities, if any. The letter c is for cash cost.[3] Debt payments are measured by the quarterly interest expenses and the outstanding proportion of long-term debt to current liabilities at the end of the quarter, and are represented by d. The variables p, c and d are expressed per Barrel of Oil Equivalent (BOE). Therefore, a firm incurs distress costs when its liquidity is below the industry's median and its actual cash inflows (i.e., realized selling prices net of production costs) are insufficient to meet debt requirements. These distress costs may entail higher future external financing costs.

2.2. Market conditions

The corporate hedging literature shows that market conditions, namely spot prices and their volatilities, play a crucial role in why firms hedge, how much they hedge, and how they hedge (see for instance Bodnar (1998); Stulz (1996); Brown and Toft (2002); Adam (2009)). Fehle and Tsyplakov (2005) investigate the evolution of risk management contracts and the spot price history by simulating the stochastic process of the gold spot price. Basically, they find strong evidence of a non-monotonic relationship between spot price and hedging contract maturity. This means that when spot prices are very high or low, firms choose short maturity hedging. As for Hypothesis 1, when spot prices are very high (low), the likelihood of distress is very low (high). For the range of spot prices between these two extremes, firms tend to adjust their risk management instruments more frequently and then tend to enter into newly initiated contracts with longer maturities.

Moreover, Fehle and Tsyplakov (2005) find that firms with higher price volatility tend to choose longer hedging contracts. In a higher price uncertainty environment, firms tend to refrain from costly early termination of their outstanding contracts unless spot prices increase significantly. These

[2] Firms disclose their realized selling prices for oil and gas, respectively, on an annual basis. For each firm, we repeat the annual observation for each quarter of the same fiscal year. These realized prices include the monetary effects of the firm's hedging activities if any.

[3] Cash costs are disclosed annually. For each firm, we repeat the same observation for each quarter of the same fiscal year.

firms often conclude long-run contracts. In addition, we expect that when future prices are anticipated to be higher, firms tend to terminate their outstanding contracts and initiate new risk management contracts with higher exercise prices. Moreover, the newly initiated contracts will be for short-term maturities to prevent them from being worthless in the future. We therefore propose:

HYPOTHESIS 2: *Hedging maturity is negatively related to (i) either very high or very low spot prices, and (ii) higher anticipated prices. Conversely, firms prefer longer maturity contracts when price volatility is higher.*

We extract the oil and gas spot prices observed at the end of each quarter from the Bloomberg Financial Markets database.[4] We calculate the volatility of oil and gas for each quarter as the standard deviation of daily spot prices within the quarter. As a proxy for the future tendency of oil and gas prices, we calculate an expected return by $E[R_t] = log[F_t/S_t]$ where F_t and S_t are respectively the prices of 12-month Futures[5] contracts and the spot prices observed at the end of quarter *t*. We expect a positive sign for spot prices and volatilities, and a negative sign for spot prices squared and expected returns $E[R_t]$.

2.3. Hedging contract features

Fehle and Tsyplakov (2005) find that features of existing hedging contracts, namely moneyness, remaining maturity and strike price, play an important role in optimal rollover and adjustment decisions. Regarding these features, they derive the following prediction that we will investigate empirically.

---

[4] We use the West Texas Intermediate crude oil (WTI) index as proxy for the oil spot prices. For natural gas spot prices, we use an average index established by Bloomberg Financial Markets database from different location indices (Gulf Coast, Henry Hub, Rocky Mountains, etc.).

[5] For future oil and gas prices, we use (i) Bloomberg NYMEX Crude Oil 12-Month Strip futures price, and (ii) Bloomberg NYMEX Henry Hub Natural Gas 12-Month Strip futures price. These two indices are established by the Bloomberg Financial Markets database as the arithmetic averages of oil (gas) futures contract prices over the next 12 months.

HYPOTHESIS 3: *Hedging contracts initiated at higher strike prices are more likely to be kept until maturity because they are more likely to be in the money for a longer period.*

As proxy for the strike price at initiation of the hedging contracts, we calculate the mean of the spot price during the quarter of the initiation. This proxy will give the information on the level of the strike price of the initiated contract. The moneyness is calculated by the strike price as previously mentioned minus the mean spot price in the current quarter. We predict a positive sign for both strike price and moneyness.

2.4. Underinvestment costs

Froot, Scharfstein, and Stein (1993) argue that firms with future investment expenditures and higher marginal costs of external financing should hedge to reduce the investment financing costs. Subsequent corporate risk management literature shows that hedging is more valuable for firms with substantial investment opportunities and costly external financing. The main argument is that hedging allows firms to reduce their cash flow volatility and hence avoid cutting planned profitable projects. In the same context, Froot, Scharfstein, and Stein (1993) assert that a firm tends to hedge less the more closely correlated its internal cash flows are with its future investment opportunities. We thus explore the impact of the underinvestment argument on hedging contract maturity and we predict:

HYPOTHESIS 4: *Hedging maturity is positively related to firm's growth options and negatively related to a positive correlation between internal cash flows and investment expenditures.*

Investment opportunities are measured by the ratio of the cost incurred over the net property, plant and equipment (net PP&E) at the beginning of the quarter.[6] In the oil and gas industry, the cost incurred includes the total costs of oil and gas property acquisition, exploration and development. We

[6] The cost incurred is given on an annual basis. We suppose that these costs are linearly dispersed over the year and divide the annual amount by four to get a quarterly cost incurred for the fiscal year.

also calculate the correlation coefficient between generated cash flows and costs incurred.[7] It is worth noting that these calculated cash flows are not polluted or contaminated by the monetary effects of hedging because these effects are reported in comprehensive income as suggested by the new derivative accounting standard FASB 133, effective since 1998. The correlation coefficients are calculated, for each firm, in a rolling window by taking all the observations available until the current quarter.

2.5. Production characteristics

Several studies,[8] mostly theoretical, have investigated the role of characteristics of production activity on firm's hedging behavior. These studies demonstrate the importance of production uncertainty (i.e., quantity risk) and the correlation between produced quantities and spot prices on firm's hedging programs (i.e., hedging extent and strategy choice). We explore the effects of these characteristics on hedging maturity choice. By deriving the optimal hedge analytically, Brown and Toft (2002) show that firms tend to hedge less for longer exposures because of the difficulty in forecasting their future produced quantities accurately.

These theoretical models also highlight the important impact of the correlation between produced quantities and spot prices on hedging decisions. Brown and Toft (2002) and Gay, Nam, and Turac (2002, 2003) find that firms with a negative price-quantity correlation benefit from a natural hedge with declining quantities and increasing prices, and vice versa. On the contrary, a positive price-quantity correlation leads to higher variations in firm's cash flows because both prices and quantities are moving in the same direction. Hence we propose:

---

[7] Internally generated cash flows are measured by the Free Cash Flow before capital expenditures, as in Lehn and Poulsen (1989). They calculate Free Cash Flow before investment as operating income before depreciation less total income taxes plus changes in the deferred taxes from the previous quarter to the current quarter less gross interest expenses on short- and long-term debt less the total amount of preferred dividends less the total dollar amount of dividends declared on common stock.

[8] These studies include Moschini and Lapan (1995), Brown and Toft (2002), Gay, Nam, and Turac (2002, 2003) and Adam (2009).

HYPOTHESIS 5: *Hedging maturity is negatively related to production uncertainty and positively related to a positive price-quantity correlation.*

For each firm, we measure production uncertainty by the coefficient of variation of daily production[9] for oil and gas respectively by taking all the observations available until the current quarter. We calculate the correlation coefficient between daily oil (gas) production and oil (gas) spot prices by taking all the firm's observations available until the current quarter.

2.6. Other control variables

We include the following control variables largely retained in the corporate risk management literature.

2.6.1. Managerial risk aversion

As proxy for managerial risk aversion, we include the number of options and the market value[10] of the firm's stocks held by the CEO. According to Smith and Stulz (1985), managers should undertake hedging activities more actively if their utility is a concave function of firm value, and they should be reluctant to engage risk management activities if their utility is a convex function of the firm's value. Therefore, we predict that a CEO owning a significant fraction of the firm's common shares tends to use hedging contracts with longer maturities because he would like to insulate the firm value from the underlying risks. Conversely, we expect a CEO with significant option holdings to tolerate more volatility in firm value, and consequently prefer short-term hedging contracts.

[9] Daily production for oil and gas, respectively, are disclosed by firms annually. We repeat the annual observation for each quarter of the same fiscal year.

[10] We use the number of options held by the firm's CEO at the end of each quarter and we measure the CEO's firm-specific wealth by the logarithm of one plus the market value of common shares held by the CEO at the end of each quarter. We use the logarithm specification of the market value of common shares held by CEOs to reflect the fact that the CEOs' risk aversion should decrease as their firm-specific wealth increases (Tufano (1996)).

2.6.2. *Tax incentives*

The tax argument for corporate hedging is accounted for using a simulation procedure proposed by Graham and Smith (1999) to estimate the expected percentage of tax savings arising from a 5% reduction in the volatility of pre-tax income. The tax argument means that hedging increases the firm's after-tax value when its local tax function is convex. A firm will thus hedge more extensively when its taxable income is in the progressive region of the tax structure. We expect firms with higher tax function convexity to use hedging contracts with longer maturities that would increase the tax benefits of hedging. We also use the book value of tax loss carry-forwards scaled by the book value of total assets. Graham and Rogers (2002) argue that tax loss carry-forwards are uncorrelated with tax function convexity, and that this variable might measure other corporate characteristics. Thus, we expect that it represents a disincentive to hedge because firms could use this tax shield to minimize their future tax liabilities. Therefore, we predict that firms with higher tax loss carry-forwards tend to use short-term hedging contracts.

2.6.3. *Asset-Liability Management*

Asset-Liability Management is also accounted for in our analysis. Maturity matching is a common best practice in corporate finance. We use the following two measures: (1) a weighted average maturity of debt. This average maturity is calculated as the book value-weighted average maturities of debt that mature within one, two, three, four and five years[11]; and (2) an expected life duration (in years) of developed reserves for oil and gas separately. This expected life duration is calculated by dividing the current quantity of oil (gas) developed reserves by the current annual oil (gas) production. These two variables allow us to capture any maturity matching between both the

[11] These items are disclosed by COMPUSTAT on an annual basis. We repeat the annual observation for each quarter of the same fiscal year.

hedging strategy and the firm's assets (proven reserves, which are the most important components of an oil and gas producer's assets) and hedging strategy and the firm's future debt commitments.

3. Sample construction and characteristics

3.1. Sample construction

This study is implemented on a sample of 150 US oil and gas producers over the period of 1998 to 2010. The oil and gas industry is an excellent laboratory to test corporate risk management motivations and implications for several reasons. First, firms in this industry share homogenous risk exposures (i.e. fluctuations in crude oil and natural gas prices). Hence, diversity in hedging strategies implemented does not come from differences in risk exposure, but is more likely to result from differences in firm characteristics. Second, the existence of financial derivatives on crude oil and natural gas offer these firms several price hedging methods. Third, improvements in accounting disclosure related to oil and gas producing activities have made operational data available. These data pertain to exploration, production and reserve quantities, cash costs, etc.

A preliminary list of 413 US oil and gas producers with the primary Standard Industrial Classification (SIC) code 1311[12] (Crude Petroleum and Natural Gas) was extracted from Bloomberg. Only firms that met the following criteria were retained: have at least five years of historical data of oil and gas reserves during the period 1998-2010; the 10-K and 10-Q reports are available from the EDGAR website, and the firm is covered by COMPUSTAT. The filtering process produced a final sample of 150 firms with an unbalanced panel of 6,326 firm-quarter observations. To our knowledge,

[12] SIC code 1311 ‘‘Crude Petroleum and Natural Gas,’’ which comprises companies primarily involved in the operation of properties for the recovery of hydrocarbon liquids and natural gas.

this sample is the most recent and the largest in the empirical literature on risk management in the oil and gas industry.

Data on these firms' financial and operational characteristics were gathered from several sources. Data regarding financial characteristics were taken from the COMPUSTAT quarterly dataset held by Wharton Research Data Services (WRDS). Other items related to institutional and managerial share-holding and option-holding were taken from the Thomson Reuters dataset maintained by WRDS. Data related to oil and gas producers' reserves, production quantities, cash costs, exploration, development and property acquisitions were taken from Bloomberg's annual data set and verified and supplemented by hand-collecting data directly from 10-K annual reports. Quarterly data about oil and gas producers' hedging activities were hand-collected from 10-K and 10-Q reports.

Table 1 summarizes the definitions, construction and data sources of the variables.

[Table 1 here]

3.2. Sample characteristics

3.2.1. Descriptive statistics: Dependent variable

Our dependent variable is hedging maturity measured by the average remaining maturity weighted by the hedged notional quantity as follows:

$$HM_{i,j,t} = \sum_{T=k}^{k+5} \frac{N_{T,j} \times T}{\sum_{T=k}^{k+5} N_{T,j}}, \quad (1)$$

where $HM_{i,j,t}$ is the weighted-average remaining maturity for firm i at quarter t and hedging instrument j. The hedging instrument could be swap contracts, put options, costless collars, forward or future contracts and 3-way collars. $N_{T,j}$ is the hedged notional quantity[13] for instrument j and horizon T. T departs from the current fiscal year to five years ahead. We retain a maximum of five years because we rarely find firms with hedging positions exceeding this horizon. k takes the value of 1 at the beginning of the current fiscal year or a fraction of the year otherwise (e.g., 0.75 for nine months).

Table 2 contains descriptive statistics of the weighted-average hedging maturity by hedging instruments for oil and gas hedgers separately. Overall, Table 2 shows that gas hedgers and oil hedgers adopt quite similar hedging horizons for each hedging instrument. For example, the average remaining maturity for swap contracts is 1.286 (1.227) years for gas (oil) hedgers. For put options, the remaining maturity is, on average, 1.023 (1.083) years for gas (oil) hedgers. Moreover, statistics show little variation of average remaining maturities across instruments. Swaps contracts and 3-way collars seem to have the longest average remaining maturity with respectively 1.286 and 1.187 years for gas hedgers, and 1.227 and 1.448 years for oil hedgers. Forward and future contracts appear to have the nearest average remaining maturities with 0.856 (0.818) years for gas (oil) hedgers. We also calculate the average remaining maturity for oil (gas) hedging portfolios that include two or more instruments simultaneously. Hedging portfolios have an average remaining maturity of 1.222 (1.204) years for gas (oil) hedgers. Hedging horizons therefore seem to not differ significantly across oil and gas and across hedging instruments. Statistics related to hedging maturities reported in Table 2 are in line with previous empirical findings that firms tend to hedge near-term positions.

[13] We follow Haushalter (2000) and use notional quantities for put options because we lack detailed information to calculate a delta-percentage for these options. At least, we have three attributes of our sample that could mitigate this shortcoming in our study: (i) put options are used on average in 11% (12%) of firm-quarters with gas (oil) hedging, (ii) put options are used with either swap/or collars most, and (iii) the fraction of the quantity hedged by put options does not exceed 40% (50%) for gas (oil).

[Table 2 here]

Table 2 also shows that gas hedging occurred in 3137 firm-quarters (49.58% of the firm-quarters in the sample) and oil hedging occurred in 2607 firm-quarters (41.21% of the firm-quarters in the sample). Table 2 presents a breakdown of the frequency of use for each hedging instrument. The most common hedging vehicles used in the oil and gas industry are swap contracts, with 45.58% (45.25%) of use in gas (oil) hedging. The second most frequently used instrument is costless collars, with 37.19% (37.11%) for gas (oil) hedging. Next are Put options, with 10.55% for gas hedging and 11.85% for oil hedging. The least used instruments are forward or Futures contracts, with only 3.25% (2.78%) for gas (oil) hedging and 3-way collars, with only 3.42% (3.02%) for gas (oil).

3.2.2. Descriptive statistics: Independent variables

Descriptive statistics are computed on the pooled dataset. Table 3 gives the mean, median, 1st quartile, 3rd quartile and standard deviation for the 150 U.S. oil and gas producers in the sample. Statistics show that oil and gas producers expend, on average, the equivalent of 22.37% of the book value of their net property, plant and equipment in exploration and reserve acquisition and development. The correlation between internal cash flows and investment expenditures has a mean (median) of 0.307 (0.373), with one fourth of the sample having a correlation less than -0.015 and another fourth a correlation greater than 0.70. These two specificities of the firm's investment programs create opposite effects on the hedging needs of oil and gas producers because investment expenditures accentuate these needs and a higher positive correlation attenuates them. The two measures of financial constraints, namely distance-to-default and the leverage ratio, indicate that oil and gas producers have a relatively solid financial situation. Distance-to-default and leverage ratio have, respectively, a mean (median) of 2.234 (2.052) and 15.8% (14.2%), which reflects little variation in the financial solvency of the sample firms.[14] Surprisingly, statistics indicate that oil and gas producers in financial distress (i.e., with liquidity below the industry's median, and realized selling prices insufficient to cover production costs and debt requirements) incurred on average distress costs of 2.3$/BOE. However, 75% of the sample does not incur any distress costs, and only a few producers have insufficient operating income to meet their debt commitments.

[Table 3 here]

Statistics further show higher production uncertainty, as measured by the coefficient of variation in daily production, with a mean (median) of 0.41 (0.31) for oil and 0.41 (0.30) for gas production respectively. Interestingly, the price-quantity correlation is relatively positive with a mean (median) of 0.23 (0.45) for oil and 0.15 (0.23) for gas. The higher level of production uncertainty and the positive price-quantity correlation create additional variability in generated cash flow, and consequently greater hedging needs for oil and gas producers. The tax preference item, measured by the ratio of the book value of tax loss carry-forwards scaled by the book value of total assets, has a mean (median) of 13.42% (0.00%). The expected tax saving benefits of hedging have a mean (median) of 5.24% (4.80%), which are quite similar to the findings of previous studies. The manager's stock and option ownership varies considerably, with a mean (median) of 28.983 MM$ (1.125 MM$) for stockholding and 174,386 (0.000) for options. Debt maturity has a mean and median of 2 years. Oil and gas proven reserves have almost similar expected life durations, with a mean (median) of 9 (7) years.

[14] Drucker and Puri (2009) examine the secondary market for loan sales in the USA over the 1999-2004 period. Using a sample of 7261 loans, they find a mean (median) for Distance-to-Default of 2.304 (1.929). Campello et al (2011) study the implications of hedging for corporate financing and investment. Using a dataset of 1185 firms over the period 1996-2002, they find a mean (median) for the Distance-to-Default of 2.464 (1.861).

4. Econometric methodology

The inspection of the time series characteristics of the remaining hedging maturity by instrument shows a high first-order serial correlation ranging from 0.8 to 0.9. This motivates the modeling of the hedging behavior within a dynamic rather than a static framework. The general model of the data-generating process is as follows:

$$HM_{i,t,j} = \rho_j HM_{i,t-1,j} + \beta_j X_{i,t} + \varphi_j Y_{j,t} + \varepsilon_{i,t,j} + u_{i,j}; \quad |\rho_j| < 1; \ (i = 1, \dots, N: t = 1, \dots, T_i), \qquad (2)$$

where $HM_{i,t,j}$ is the remaining maturity for hedging instrument *j* used by firm *i* at time *t*. Hedging instrument *j* might be swaps contracts, put options, costless collars, forward and future contracts, or 3-way collars. $HM_{i,t-1,j}$ is the observation on the same series for the same firm in the previous period. $X_{i,t}$ is a set of observed exogenous variables related to investment programs, financial distress, taxes, managerial risk aversion, production function characteristics, oil and gas market conditions and asset-liability management, which may be associated with hedging maturity choice for instrument *j* by firm *i* at time *t*. $X_{i,t}$ also includes the Inverse Mills Ratio coming from the first step of the Heckman regression with sample selection. $Y_{j,t}$ contains hedging contract *j* features at time *t*, namely, moneyness and strike price. $u_{i,j}$ is the unobserved firm-instrument specific effects and $\varepsilon_{i,j,t}$ is the disturbance term that is assumed to be independent across firms with $\mathrm{E}(\mathrm{u}_{\mathrm{i,j}}) = \mathrm{E}(\varepsilon_{\mathrm{i,j,t}}) = \mathrm{E}(\mathrm{u}_{\mathrm{i,j}}\ \varepsilon_{\mathrm{i,j,t}}) = 0$.

We follow Arellano and Bover (1995) and Blundell and Bond (1998) in estimating the model in equation (2) by a Dynamic System-GMM Panel Model (SYS-GMM hereafter). We choose this special econometric specification because other econometric frameworks (e.g., OLS, 2SLS and Within Group estimates) lead to asymptotically inefficient estimates as mentioned by Bond (2002), especially for small time-series panel data. Moreover, we prefer a SYS-GMM specification over the Difference-

GMM, developed by Arellano and Bond (1991), because the latter model suffers from poor finite sample properties in terms of bias and precision, especially when the series are close to a random-walk, as was subsequently well documented by Blundell and Bond (1998).

A SYS-GMM[15] estimate for dynamic panel data combines moment conditions for the model in first difference with moment conditions for the model in level which improves the estimates even when the series are very persistent. We use two-step estimation, which leads to standard errors that are theoretically robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals, but they are downward biased, as suggested by Roodman (2009a). To control for this bias, we implement the Windmeijer (2005) correction for the potential downward bias in the standard errors produced by two-step estimation. In addition, two-step estimation allows a robust Hansen J-test, which is not available in one-step estimation. Following the good practice guideline suggested by Roodman (2009a, 2009b), we report statistics that allow us to test the validity of the econometric specification of the estimated SYS-GMM Model.

To control for the possibility of sample selection bias, the estimation of all our models was derived in the context of the Two-Step Heckman Regression with Selection. This procedure captures the sequential decisions of oil and gas producers: a first decision to hedge or not and a second decision about the nature of the hedging strategy. In the first step, we follow the literature and model the existence of hedging activity as a function of variables that are conjectured to be determinants of the hedging decision: tax incentives, leverage ratio, liquidity, cash costs, convertible debt, firm market value, sales to capture the market risk exposure of firms, and oil and gas reserves quantities that should be qualified as hedging substitutes. Table A.I reports the estimation results of the first step. We observe that almost all variables are statistically significant and with appropriate signs, as already

[15] We estimate the model in equation (2) with the user-written command *xtabond2* in Stata Software developed by Roodman (2009b).

obtained in the previous literature on the decision to hedge (Tufano (1996); Graham and Rogers (2002); Campello et al (2011); Dionne and Triki (2013)).

5. Univariate results

Table 4 presents our univariate results, comparing oil and gas producers' characteristics and market conditions, based on the remaining maturities of hedging portfolios (i.e., a simultaneous combination of hedging instruments). We then classify the remaining weighted-average maturities as (1) short-term maturities (i.e., below one year ahead), (2) medium-term maturities (i.e., between one and two years ahead), and (3) long-term maturities, exceeding two years ahead. Tests of differences between means and medians of relevant variables contrast short- and medium-terms to long-term maturities and are conducted for gas and oil hedgers separately. Comparison of means is constructed using a *t*-test assuming unequal variances; comparison of medians is constructed using a non-parametric Wilcoxon rank-sum *Z*-test and two-sided *p*-values are computed.

[Table 4 here]

The univariate tests show considerable differences between firm-quarters with long-term maturities and those with short- or medium-term maturities for oil hedgers and gas hedgers separately. Table 4 Panel A reports results pertaining to the subsample of gas hedgers and Panel B presents results for oil hedgers. Results show that oil and gas producers with higher distance-to-default tend to choose longer maturities. Results related to the leverage ratio are mixed. Although the higher leverage ratio is related more to longer maturities for gas hedgers, it seems to be associated more with shorter maturities for oil hedgers. Counter to our predictions, higher distress costs are related more to long-run contracts for gas hedgers. Consistent with our predictions, results further show that oil and gas producers with higher growth opportunities prefer long-run hedging contracts, and that higher correlation between free cash flows and investment expenditures motivates the use of short- and medium-term contracts.

Univariate tests also show that oil and gas producers with higher production uncertainty tend to use long maturity contracts. This is inconsistent with the prediction that higher production uncertainty makes firms reluctant to make a large hedge for more distant exposures. We find that price-quantity correlation is more closely related to medium-term contracts for gas hedgers, and to long-term contracts for oil hedgers. In sum, these findings corroborate our prediction that firms with higher price-quantity correlation tend to use longer maturities because their cash flows are more volatile. Consistent with our prediction, the Wilcoxon test for difference in medians shows that higher CEO stake value in the firm is more related to long maturity contracts. In contrast, higher CEO option-holdings are associated with long-term contracts, which contradicts the prediction that a manager with a convex utility in firm value has a disincentive to undertake corporate hedging.

Univariate tests pertaining to tax incentives indicate that medium-term hedging is related to a higher percentage of tax savings for oil hedgers. Consistent with our prediction, oil and gas producers with higher tax loss carry-forwards tend to use short maturity hedging. In addition, oil and gas producers with remaining longer maturities of debt and proven reserves tend to choose long-run contracts. This corroborates the asset-liability management argument. As predicted, results pertaining to market conditions suggest that higher spot prices and volatilities are associated more with medium-term contracts for gas hedgers and longer contracts for oil hedgers. Conversely, when oil future prices are anticipated to be higher, oil hedgers tend to prefer long maturity contracts.

Table 5 presents our results, comparing the moneyness and strike prices of hedging instruments based on their remaining maturities. Table 5 Panel A reports results pertaining to gas hedgers and Panel B presents results for oil hedgers. For conciseness, we concentrate our analysis on the three major hedging instruments used by oil and producers: swap contracts, put options and costless collars.[16] For oil hedgers, we find that swap contracts with the longest maturities have the lowest moneyness as measured by the strike price minus the spot price. One explanation would be that firms are reluctant to exit out-of-the-money swaps prior to the agreed-upon termination date due to the termination costs. Consistent with our prediction, results also show that higher strike prices are related more to medium-term swaps for gas hedgers and to long-term swaps for oil hedgers. We further find that higher moneyness and strike prices are related more to medium-term put options in the case of gas hedging. As predicted, longer term put options are associated more with higher strike prices for oil hedgers. Consistent with predictions, longer term collars are related to higher moneyness and strike prices for both oil and gas hedgers.

[Table 5 here]

6. Maturity structure of corporate risk management

To investigate the determinants of hedging maturity choice by oil and gas producers, we estimate the dynamic panel regression using a two-step SYS-GMM[17] model as presented previously. In these regressions, the weighted-average remaining maturity is regressed on variables that measure underinvestment costs, financial distress costs, production function characteristics, managerial risk aversion, tax incentives, market conditions, asset-liability management and contract features. Many specifications of the SYS-GMM are estimated for the subset of oil hedgers and gas hedgers separately

[16] We skip the observations related to forward/futures contracts because they contribute to only 3.25% of gas hedging activity and 2.78% of oil hedging activity. We also omit observations related to three-way collars because they are used in only 3.42% of cases for gas hedging activity and 3.02% of cases for oil hedging.

[17] Following the good practice guideline suggested by Roodman (2009a and 2009b), we use all available lags of the dependent variables as instruments to retain more information. We also apply a collapsing technique to avoid instrument proliferation that weakens the Hansen test instrument validity. We further report: (i) the number of instruments generated for the regression, (ii) the Hansen J-test statistics and p-value, and (iii) the Arellano-Bond test for a second-order serial correlation in residuals (e.g., AR (2) test).

and for the following major hedging instruments used: swap contracts, put options and costless collars. We based our analysis on remaining maturity by instrument rather than the whole hedging portfolio to get more insights into the hedging dynamics of oil and gas producers.

[Table 6 and 7 here]

The results in Tables 6 (gas hedgers) and 7 (oil hedgers) are generally consistent with hypotheses pertaining to underinvestment costs. In particular, oil and gas producers with higher future investment opportunities (*INV_OPP*) tend to use longer term swap contracts, put options and costless collars. Oil and gas producers with substantial growth opportunities employ hedging contracts with longer maturities to reduce any shortfall in their future cash flows and hence avoid both cutting planned investment programs and costly external financing. We also find a significant negative effect of a positive correlation between investment expenditures and internally generated cash flows (*COR_CI_CF*) and hedging contract horizon because firms benefit from a natural hedge. We find that the remaining maturities of put options and swap contracts decline with this positive correlation for gas hedgers and oil hedgers respectively. The impacts on costless collars' maturities are mixed and insignificant. Interestingly, results reveal opposite effects of firm's investment specificities on hedging maturity structure: growth options accentuate future funding needs and a positive correlation dampens this need. These opposite effects are essentially driven by the simultaneous positive impacts of current oil and gas prices on future investment opportunities and present cash inflows.

The results pertaining to financial distress give strong evidence of the non-monotonic relationship between hedging horizons and the likelihood of financial distress. In line with Fehle and Tsyplakov's (2005) prediction, we find that the leverage ratio (*LEV*) and the leverage squared (*LEV_SQUARE*) have highly significant positive and negative coefficients respectively for both subsets of gas hedgers and oil hedgers, for the three hedging instruments.[18] These non-monotonic (concave) relationships mean that hedging maturities should first increase and then decrease with the likelihood of financial distress. To further investigate this non-monotonic relationship empirically, we use an alternative robust measure of the likelihood of financial distress, namely, distance-to-default. Interestingly, results show that remaining maturity should increase and decrease with the distance to default. Generally, we find that Distance-to-Default (*DTD*) and its squared value (*DTD_SQUARE*) are respectively significantly positively and negatively related to hedging instrument maturity. The non-monotonic relationship between hedging maturity and leverage ratio is shown, for each hedging instrument, in Figure 1 for gas hedgers and in Figure 2 for oil hedgers. These figures suggest show that this non-monotonic relationship is more pronounced for put options for gas hedgers and for costless collars for oil hedgers.

[Figure 1 and 2 here]

In contrast with our hypotheses, we find that distressed oil and gas producers incurring a higher dollar loss per Barrel of Oil Equivalent (*DIS_COSTS*) tend to use put options with longer maturities. This empirical finding contradicts the simulation results of Fehle and Tsyplakov (2005), who find that firms incurring higher distress costs tend to use short-term hedging contracts. A possible explanation comes from Jensen and Meckling's (1976) risk shifting (or asset substitution) approach. By entering costly long-term put options, distressed oil and gas producers increase rather than eliminate the firm's payoff volatility, decrease assets available for debtholders and preserve any upside potential for shareholders.

[18] As robustness checks, we measure the leverage ratio by: (i) long-term debt in current liabilities plus long-term debt scaled by total assets, (ii) long-term debt scaled by total assets. Results are the same.

Results further indicate that oil and gas producers with higher production uncertainty (*PROD_CV_OIL* and *PROD_CV_GAS*) tend to use long-term swap contracts and costless collars. The impact on put options' maturities is also positive but not significant. This finding contradicts Brown and Toft (2002), who assert that higher production uncertainty makes firms reluctant to hedge farther exposures. As predicted, we find that higher price-quantity correlations (*COR_PQ_OIL* and *COR_PQ_GAS*) motivate oil and gas hedgers to use more distant costless collar positions. A higher price-quantity correlation induces higher firm cash flow volatility because both prices and quantities are moving in the same direction. Altogether, we find that oil and gas producers with higher cash flow volatility, due to higher production uncertainty and/or higher price-quantity correlation, tend to use longer hedging positions to avoid shortfalls in their future revenues.

The results for the variables pertaining to market conditions are highly consistent with our predictions. We find that oil and gas price volatilities (*OIL_VOL* and *GAS_VOL*) are significantly positively related to longer maturities for the three hedging instruments. This corroborates the simulation results of Fehle and Tsyplakov (2005), namely that in a higher price fluctuation environment, firms tend to refrain from costly early termination of their outstanding contracts unless spot prices increase significantly. We further find that when future gas prices are expected to be higher, as measured by *GAS_RET*, gas hedgers tend to use short-term hedging. This is consistent with the prediction that when future prices are expected to be higher, firms tend to terminate their outstanding contracts and initiate new hedging contracts with higher exercise prices. In addition, these newly initiated contracts have short maturities to prevent them from being worthless in the future.

Surprisingly, expected tendency in future oil prices, as measured by *OIL_RET*, has the predicted negative sign but no significant impact.[19]

Our results also provide strong evidence of a non-monotonic relationship between spot prices and hedging maturities, as conjectured by Fehle and Tsyplakov (2005). We find that oil and gas spot prices (*OIL_SPOT* and *GAS_SPOT*) and the spot prices squared (*OIL_SPOT_SQUARE* and *GAS_SPOT_SQUARE*) have highly significant positive and negative coefficients respectively, yielding a non-monotonic relationship. Accordingly, when spot prices are either very high or very low, firms are more likely to choose short-term hedging contracts. This corroborates the non-monotonic relationship between financial distress likelihood measures (i.e., leverage ratio and distance-to-default) and hedging maturity. When spot prices are very high or low, firms are more likely to be far from or deep in financial distress respectively. Figures 3 and 4 show the non-monotonic relationship between hedging maturity and spot prices for gas hedgers and oil hedgers separately. The non-monotonic relationship is more evident for swap contracts for oil hedgers.

[Figure 3 and 4 here]

Hedging contract features appear to have an evident impact on hedging maturity choice. Results show that swap contracts and costless collars with higher *MONEYNESS* (e.g., strike prices higher than current spot prices) tend to have longer maturities. For put options, moneyness has the predicted sign but no significant impact. As predicted, oil and gas producers keep in-the-money hedging contracts until they mature and early terminate out-of-the-money contracts. Results also indicate that when hedging contracts are initiated at sufficiently higher prices (*STRIKE*) they are more likely to be kept for longer periods.

---

[19] We further investigate the effects of anticipated oil and gas prices, as observed in the future contracts market, on hedging maturity choice by using the following Futures terms: three, six, fifteen, eighteen and twenty four months ahead. Our results are unchanged with 12-month future contracts.

Consistent with our expectations, we find that oil and gas producers with higher tax loss carry-forwards (*TLCF*) choose short-term hedging maturities. Tax loss carry-forwards thus seem to be a disincentive to hedge longer exposures because they reduce firms' future tax liabilities. This corroborates the argument of Graham and Rogers (2002) that tax loss carry-forwards are uncorrelated with tax function convexity. As predicted, results further show a significant positive association between tax function convexity (*TAX_SAVE*) and put option and costless collar maturities for gas hedgers, in particular. For oil hedgers, the tax function convexity measure has the predicted sign but no significant impact.

Results for variables pertaining to asset-liability management are as predicted. We find that oil and gas producers with longer average debt maturity (*DEBT_MAT*) tend to use more distant swap and collar positions.[20] Average debt maturity appears to have no significant impact on put option maturity. We document strong evidence of a positive impact of the expected life duration of proven oil and gas reserves (*RES_MAT_OIL* and *RES_MAT_GAS*) on maturities of the three hedging instruments. These results suggest that oil and gas producers seek to match the maturities of their hedging and the maturities of their assets and debt. The CEO's stake value in the firm (*CEO_CS*) seems to have no impact on hedging maturity choice. CEO option-holding has a mixed impact. Although CEO option-holding (*CEO_OPT*) is negatively related to collar maturities for gas hedgers, it is positively related to swap maturities for oil hedgers.

[20] We use an alternative measure of average debt maturity as described by Eisdorfer (2008). The firm's average debt maturity is estimated by: $\hat{T} = \frac{1}{TD}\,(0.5\,STD + 5\,LTD)$ where *TD*, *STD*, and *LTD* are the book values of total, short-term, and long-term debt. Our results are the same.

7. Robustness checks

In this section, we investigate the empirical relevance of our predictions and our previous findings by: (i) studying maturity choice at hedging contract inception, (ii) and investigating the determinants of the early termination of outstanding hedging contracts.

7.1. Maturity choice at the inception of the hedging contract

We skim the time series of the weighted-average maturity by hedging instrument and detect initiation dates by choosing observations where the observed maturity at time *T* is superior to the one at time *T-1*. We run a pooled cross-sectional time-series regression of the weighted-average maturities at the inception dates on firm's fundamentals, production function characteristics and oil and gas market conditions. Table 8 and 9 report the regression results for gas hedgers and oil hedgers separately.

[Table 8 and 9 here]

In line with the baseline model (i.e., SYS-GMM), results illustrate the opposite effects of investment program specificities and the non-monotonic relationship between new contracts' maturities and measures of likelihood of financial distress (*LEV* and *DTD*). Distress costs and production uncertainty have the same positive impact on hedging maturities of newly initiated contracts. Results also indicate that the maturities of newly initiated hedging contracts are increasing with strike prices and reserves' expected life duration, and decreasing with tax loss carry-forwards. The coordination between debt maturity and newly initiated collars is again confirmed but it disappears for initiated swaps. Results further show, for gas hedgers, that managers with a higher stake value in the firm prefer long-term collars, as predicted.

However, impacts of leverage ratio and gas price-quantity correlation on maturities of newly initiated swaps contradict our previous findings. Surprisingly, oil and gas market conditions largely lose their effect on hedging contract maturity at initiation. The non-monotonic relationship with spot prices appears to exist only for newly initiated swaps' maturities for oil hedgers. Dissimilar to baseline model results, oil hedgers tend to initiate longer maturity swaps and collars when anticipated oil prices are increasing. One possible explanation for this finding could be that, when oil prices are anticipated to be high in the near term (e.g., we use 12-month future contracts), firms believe that they are more likely to decline in the long run (i.e., mean reversion); hence they tend to initiate long-term hedging contracts to lock-in higher strike prices.[21] Managerial option-holding appears to have no significant impact on maturity choice at the inception of hedging contracts.

7.2. Determinants of the early termination decision of hedging contracts

Termination of a hedging contract is considered as an early termination when the outstanding hedging contract has a remaining weighted-average maturity equal to or above six months. For each instrument, we create a dummy variable that takes the value of one when we pick up observations of no-hedging preceded by an outstanding hedging with remaining maturity equal to or above six months and zero otherwise. We run pooled cross-sectional time-series probit regressions of these dummy variables on firm fundamentals, production characteristics and oil and gas market conditions. Tables 10 and 11 report the regression results for gas hedgers and oil hedgers separately.

[Tables 10 and 11 here]

[21] We use the following Futures' terms for anticipated oil and gas prices, as observed in the future contracts market: three, six, fifteen, eighteen and twenty-four months ahead. We observe changes only for put option maturities, which become significantly negatively affected by three- and six-month gas future prices, as predicted.

We find strong evidence of a non-monotonic (convex) relationship between early termination of swap contracts and leverage ratio, in particular.[22] This finding means that early termination of swap contracts decreases then increases with the probability of financial distress. Put options and costless collars also exhibit a non-monotonic (convex) relationship with financial leverage but with lower statistical significance. This empirical evidence corroborates our previous findings. Price-quantity correlations are negatively related to early termination. This is in line with predictions and previous findings that firms with positive price-quantity correlation tend to use longer hedging positions because their generated cash flows are more volatile.

Consistent with our previous findings, higher oil and gas price volatilities prevent the early termination of hedging positions. Results further indicate that when future oil prices are anticipated to be higher, firms tend to early terminate their outstanding swap contracts to profit from the rising prices or to lock in higher strike prices for new contracts. Results again show an evident non-monotonic (convex) relationship between early termination and oil and gas spot prices. When oil and gas prices attain higher levels, outstanding hedging contracts are actively terminated and might be replaced by new contracts with higher strike prices.

Results also show that in-the-money swap contracts are less likely to be prematurely terminated by oil hedgers. The remaining maturity of hedging contracts is statistically negatively related to early termination, namely contracts with longer remaining maturity are less likely to be prematurely terminated. Possible explanations could be that the early termination of longer contracts generates higher termination costs, and/or for longer maturities market conditions could improve over the remaining life of the contract, which becomes more beneficial for hedgers. The impact of debt maturity on early termination is negative as predicted but significant only in cases of swap contracts

[22] We also use distance-to-default and find similar results.

for gas hedgers and put options for oil hedgers. Unexpectedly, higher percentages of tax save motivates the early termination of put options by oil hedgers, and longer gas reserves duration motivates the early termination of collar positions. As predicted, managers with higher stockholding tend to maintain their outstanding hedging contracts, in particular put options and collars.

8. Real implications of hedging maturity choice

In this section, we extend the controversial existing literature that focuses on the relationship between corporate hedging and firm risk and value. One strand of this empirical literature finds no support for the risk reduction argument and firm value maximization theory (see for instance Hentschel and Kothari (2001); Guay and Kothari (2003); Jin and Jorion (2006); Fauver and Naranjo (2010)). In contrast, another strand of the literature shows that firm's derivative transactions translate into increases in shareholder value (Allayannis and Weston (2001); Graham and Rogers (2002); Carter, Rogers, and Simkins (2006); Adam and Fernando (2006); Bartram, Brown, and Conrad (2011)). Other studies give empirical evidence of risk reduction associated with derivative usage (e.g., Guay (1999); Allayannis and Ofek (2001); Bartram, Brown, and Conrad (2011)). Aretz and Bartram (2010) review the existing empirical literature on corporate hedging and firm value and risk.

We complement the empirical literature by going into further detail and investigating the real implications of the maturity structure of corporate risk management on: (1) firms' stock return sensitivity to changes in oil and gas prices; (2) firms' stock volatility sensitivity to oil and gas price volatilities. In addition, our study does not suffer from the endogeneity concern related to derivatives use as advanced by Jin and Jorion (2006) to explain the controversial results in the literature. This is because we select firms within the same industry; they have the same exposure to commodity risks and they differ vastly in terms of their hedging behaviors. To our knowledge, no empirical study to date gives direct evidence of the effects of maturity structure of corporate hedging on firm value and risk.

8.1. Effects of hedging maturity on stock return sensitivity

Our tests expand on that of Jorion and Jin (2006), who run pooled cross-sectional time-series regressions of firms' stock returns on the market and oil and gas price changes, and control for commodity risk hedging and proven oil and gas reserves. We estimate the following models with interaction variables reflecting the impact of hedging maturity in oil beta:

$$R_{i,t} = \alpha_1 + \beta_m \times R_{m,t} + \left(\gamma_{oil} + \sum_{j=1}^{3} \gamma_j \times HM_{i,j,t-1} + \gamma_4 \times \frac{oil\ reserve_{i,t-1}}{MVE_{i,t-1}}\right) \times R_{oil,t} + \beta_{gas} \times R_{gas,t} + \varepsilon_{i,t} \quad (3)$$

and a symmetric equation for gas beta. $R_{i,t}$ is the total stock rate of return for firm *i* in month *t*, $R_{m,t}$ is the monthly return of the S&P 500 index, $R_{oil,t}$ is the monthly rate of change in the price of the NYMEX WTI crude oil near-month futures contract, $R_{gas,t}$ is the monthly rate of change in the price of the NYMEX Henry Hub natural gas near-month futures contract. $HM_{i,j,t-1}$ are three variables reflecting outstanding maturities for swap contracts, put options and costless collars at the end of the previous month for oil (gas) hedgers.[23] Oil reserve/MVE (gas reserve/MVE) are the discounted dollar values of oil (gas) developed reserves divided by the market value of equity.[24] The model in (3) allows us to detect the impact of the maturity structure on the sensitivity of firm's stock return to changes in oil and gas prices. We then predict negative signs on the maturities of the three hedging strategies (i.e.,

[23] We collect hedging strategy observations on a quarterly basis. For the first two months of each fiscal quarter, we repeat the observations at the end of the previous fiscal quarter. We then suppose that hedging strategies outstanding at the end of the previous fiscal quarter are effective until the end of the current fiscal quarter when we update the observations with the new information reported by firms.

[24] We calculate developed oil and gas reserve quantities on a quarterly basis by considering production, development, and acquisition and exploration activities. For the first two months of each fiscal quarter, we repeat the observations at the end of the previous fiscal quarter. Following SFAS No. 69 and SEC regulations, we calculate a standardized measure of discounted future net cash flows from developed reserves by considering current oil and gas prices, current production quantities and costs, and a discounting rate of 10%. The ratio of reserve/MVE is updated monthly by considering the firm's new stock, oil and gas prices.

swaps, put, and collars). Oil and gas reserves should have positive signs because a greater ratio of reserve/MVE induces greater exposure to oil and gas price fluctuations. We include firm fixed effects and correct standard errors for within-firm correlation (clustering) and heteroskedasticity using the Huber-White-Sandwich estimator. We further include the inverse Mills ratios coming from the Heckman first-step for both subsets of oil hedgers and gas hedgers.

Panel A of Table 12 reports the estimations of the model in (3). Columns (1) and (2) of Panel A display the estimation of models with interaction variables between the remaining maturity of the hedging portfolio (i.e., weighted-average maturity of all outstanding hedging instruments) at the end of the previous month and the monthly rate of change in the prices of the NYMEX oil and gas futures contracts for subsets of gas hedging and oil hedging separately. Results show that these interaction variables have the predicted negative sign. However, this negative relationship is statistically significant only for gas hedgers. Longer hedging maturities could lower the sensitivity of stock return to changes in gas prices. Going further in detail, Column (3) of Panel A indicates that swap contracts and costless collars positions with the longest maturities could achieve the lowest sensitivity of stock return to changes in gas prices. Put options have the predicted negative sign but no significant impact. For oil hedgers, the three hedging instruments have no significant impact on the sensitivity of stock return to changes in oil prices as observed for the oil hedging portfolio (Column 4).

Consistent with Rajgopal (1999), and Jin and Jorion (2006), results show that greater oil and gas reserves accentuate a stock's exposure to oil and gas price fluctuations. We repeat our regressions and replace the ratio of reserve/MVE by the production mix, namely the ratio of the daily gas or oil production quantity divided by the total daily oil and gas production, and find similar results. The coefficients of the production mix ratios are positive, as predicted, and have higher economic significance.

[Table 12 here]

8.2. *Effects of hedging maturity on stock volatility sensitivity*

This sub-section provides detailed evidence of the relation of firms' total risk measured by the annualized stock return volatility, and firms' hedging strategies. Our aim is to examine which hedging maturity better mitigates the effects of the exposure to oil (gas) price volatilities on firms' total risk. Following Guay (1999), we partition the total stock return volatility into market risk, oil and gas risks and firm-specific risk. We then estimate the following model with interaction variables for oil hedgers:

$$\sigma_{i,t} = \omega_0 + \omega_m \times \sigma_{m,t} + \left(\omega_{oil} + \sum_{j=1}^{3} \omega_j \times HM_{i,j,t-1}\right) \times \sigma_{oil,t} + \omega_{gas} \times \sigma_{gas,t} + \sum_{j=4}^{8} \omega_j \times Control_{i,t} + \delta_{i,t} \quad (4)$$

and a symmetric equation for gas hedgers where $\sigma_{i,t}$ is the annualized standard deviation of daily stock returns for firm *i* during month *t* to capture the aggregate firm risk, $\sigma_{m,t}$ is the annualized standard deviation of daily S&P 500 index returns during month *t*, $\sigma_{oil,t}$ are $\sigma_{gas,t}$ are the annualized standard deviations of daily returns of the NYMEX WTI crude oil and Henry Hub natural gas near-month futures contracts during month *t*. $HM_{i,j,t-1}$ are outstanding remaining maturities as previously defined. $Control_{i,t}$ are a set of exogenous variables related to firms' characteristics. We retain firm size, leverage and liquidity, which Bartram, Brown and Stulz (2012) find to be important determinants of both firm total risk and systematic risk. We also use Distance-to-Default, defined above, and the inverse Mills ratios coming from the Heckman first-step for both subsets of oil hedgers and gas hedgers respectively. This specification partitions total stock return volatility into firm-specific exposures to oil and gas volatilities, global market index risk and firm-specific characteristics. We include firm fixed effects and correct standard errors for within-firm correlation (clustering) and heteroskedasticity using the Huber-White-Sandwich estimator.

Panel B of Table 12 reports the estimations of the model in (4). Panel B also shows the estimation of models with interaction variables between the remaining maturity of the hedging portfolio at the end of the previous month and annualized standard deviations for oil and gas NYMEX contracts respectively (Column 5 and 6). Overall, results show that these interaction variables, in all the specifications, have no statistically significant effects on the sensitivity of stock volatility to commodity price risk. Results also suggest that larger firms with higher financial leverage have higher return volatility, and firms with higher Distance-to-Default and carrying higher cash balances have lower stock return volatility.

9. Concluding Remarks

A substantial body of the corporate risk management literature has increased our understanding of the motivations, virtues and value implications of hedging. This literature derives its theoretical or empirical predictions based on hedging extent or hedging activity participation. Due to the lack of data, the empirical maturity structure of corporate risk management is discussed in a largely descriptive manner. In this study, we go beyond the classical questions in the corporate hedging literature and investigate the following empirical questions: How far ahead do firms hedge? What are the determinants of the maturity structure of firms' hedging programs? and What are the economic effects of hedging maturities on firm value and risk?

Using an extensive and new hand-collected dataset on the risk management activities of 150 U.S. oil and gas producers and the empirical predictions of Fehle and Tsyplakov (2005), we find that the maturity structure of corporate hedging is positively influenced by firms' investment opportunities.

Results also show that a positive correlation between investment expenditure and generated cash flows gives firms a natural hedge and motivates the use of short-term contracts. We provide strong evidence that hedging maturities should increase and then decrease with the likelihood of financial distress, as conjectured by Fehle and Tsyplakov (2005). Highly distressed oil and gas producers should enter long-term put options as a risk-shifting strategy. Results indicate that oil and gas producers with higher cash flow volatility tend to use longer maturity hedging to avoid shortfalls in their future cash flows.

Interestingly, we observe strong evidence of the impact of market conditions on hedging maturity choice. We give empirical evidence of a non-monotonic relationship between oil and gas spot prices and hedging maturities, as suggested by Fehle and Tsyplakov (2005). In addition, hedging contract features (i.e., moneyness, strike price) have an evident impact on maturity choice. Regarding asset-liability management, oil and gas producers appear to match the maturities of their hedging positions and the maturities of their assets and debt. Tax function convexity seems to influence the maturity structure of firm's hedging. We also give the first direct evidence of the motivations for early termination of hedging contracts, which appears to be strongly influenced by the likelihood of financial distress, spot prices and their volatilities, price-quantity correlation, and the remaining maturities of contracts. We also find evidence of a non-monotonic (convex) relationship between early termination and financial leverage and spot prices. Table 13 summarizes our predictions and findings arising from the baseline model (i.e., SYS-GMM), maturity choice at inception of the hedging contract, and early termination of contracts. Overall, this table shows that our findings are stable and consistent across these tests. Finally, we explore the real effects of hedging maturity on firm value and risk, and provide empirical evidence that long-term hedging lowers the sensitivity of the stock return to changes in gas prices in particular.

Table 13: Summary of our predictions and findings

This table presents a summary of our predictions and findings pertaining to the hypotheses tested. The superscripts ***, **, and * mean that the sign is significant at the 1%, 5%, and 10% levels, respectively; -/+ means that the given variable takes the minus sign in some specifications and the plus sign in others, but with no significant effects; n/a stands for non-available and means that the given variable is not included in the regression.

		Hedging maturity structure Baseline model: SYS-GMM			Maturity choice at the inception of the contract			Early termination of the contract		
Hedging strategies		**Swap contracts**	**Put options**	**Costless Collars**	**Swap contracts**	**Put options**	**Costless collars**	**Swaps contracts**	**Put options**	**Costless collars**
Investment programs and real options										
Investment opportunities	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+	+	-	+**	+	-	+
	Oil Hedgers	+**	+**	+*	+	+***	+***	-	+	+
Correlation between internal funds and Investment programs	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-	-**	-/+	-***	-***	-	-	+	-
	Oil Hedgers	-***	+	+	-***	-	-	-	+	+
Oil and gas market conditions										
Spot price	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+****	-	+	+**	-***	-***	-***
	Oil Hedgers	+***	+	+***	+***	+	+**	-***	-***	-***
Spot price squared	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-***	-***	-***	+	-	-	+	+***	+***
	Oil Hedgers	-***	-	-**	-***	-	-	+***	+**	+***
Return	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-**	-***	-***	-/+	-	-	+	-	+
	Oil Hedgers	-/+	-	-	+***	-/+	+***	+***	+	+
Price volatility	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+**	-	-/+	+	-***	-	-**
	Oil Hedgers	+***	+**	+***	+**	+**	+	-**	-	-**
Oil and gas production function characteristics										
Production uncertainty	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	+**	+	+***	+	+**	+***	+	-	-
	Oil Hedgers	+*	+	-	+***	-	-*	+	-	-
Price–quantity correlation	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+	-/+	+**	-**	-*	+	-	-	-*
	Oil Hedgers	+	-/+	+**	-/+	-	+***	-**	-*	-***
Financial distress										
Leverage	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+***	-**	+**	+**	-***	-*	-
	Oil Hedgers	+***	+**	+***	-***	-	-	-***	-	-**
Leverage squared	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-***	-***	-***	+***	-**	-*	+***	+	+
	Oil Hedgers	-**	-	-***	+***	+	+	+***	+	+
Distance to default	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+	+***	-	-	+	n/a	n/a	n/a
	Oil Hedgers	+**	+***	+***	+***	+***	+**	n/a	n/a	n/a

Continued

Table 13-*Contunied*

Hedging strategies		Baseline model: SYS-GMM Maturity choice			Maturity choice at the inception of the contract			Early termination of the contract		
		Swap contracts	Put options	Costless Collars	Swap contracts	Put options	Costless collars	Swaps contracts	Put options	Costless collars
Distance to default squared	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-*	+	-***	+	+	-	n/a	n/a	n/a
	Oil Hedgers	-	-***	-**	-***	-***	-*	n/a	n/a	n/a
Distress costs	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	+	+*	+	+**	+**	+	-	-	+
	Oil Hedgers	-/+	+***	+	+*	+***	-/+	-	-	+
Contract features										
Moneyness	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+	+*	n/a	n/a	n/a	-	-	+
	Oil Hedgers	+***	+	+***	n/a	n/a	n/a	-***	-	-
Strike price	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+***	-	+**	+***	n/a	n/a	n/a
	Oil Hedgers	+***	+***	+***	+***	+**	+***	n/a	n/a	n/a
Remaining maturity	Predicted							-	-	-
	Gas Hedgers							-*	-***	-***
	Oil Hedgers							-***	-**	-***
Tax incentives										
Tax loss carry-forwards	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-***	-***	-**	-***	-***	-	n/a	n/a	n/a
	Oil Hedgers	-***	-***	-	-***	-***	-***	n/a	n/a	n/a
Tax save	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	-/+	+**	+**	-*	-	+	-	-	-
	Oil Hedgers	+	+	+	-/+	+	-	+	+*	+
Asset-liability management										
Debt maturity	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	-/+	+***	+	-/+	+**	-*	-	-
	Oil Hedgers	+***	-/+	+***	+	+	+**	-	-***	-
Reserve expected life	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+***	+***	+***	+**	+	-	+*
	Oil Hedgers	+***	+**	+***	+***	+**	+	+	-	-
Managerial compensation policy										
Managerial shareholding	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+	-/+	+	+	-/+	+**	-	-*	-*
	Oil Hedgers	-	-	-	-	-/+	+	-	-	-
Managerial option holding	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	+	-/+	-***	+	-/+	+	-	+	-*
	Oil Hedgers	+*	-/+	-	+	+	+	-	+	-

REFERENCES

Adam, T., 2002, Risk management and the credit risk premium, *Journal of Banking and Finance* 26, 243–269.

Adam, T., 2009, Capital expenditures, financial constraints, and the use of options, *Journal of Financial Economics* 92, 238–251.

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

Allayannis, G., Ofek, E., 2001, Exchange rate exposure, hedging, and the use of foreign currency derivatives. *Journal of International Money and Finance* 20, 273–296.

Allayannis, G., Weston, J.P., 2001. The use of foreign currency derivatives and firm market value. *Review of Financial Studies* 14, 243-276.

Arellano, M. and S. Bond (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies* 58, 277–98.

Arellano, M. and O. Bover (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics* 68, 29–51.

Aretz, K., Bartram, S.M., 2010. Corporate hedging and shareholder value. *Journal of Financial Research* 33, 317–371.

Bartram, S.M., Brown, G.W., Stulz, R.M., 2012. Why are U.S. stocks more volatile? *Journal of Finance* 67 (4), 1329–1370.

Bartram, S.M., Brown, G.W., Conrad, J., 2011. The effects of derivatives on firm risk and value. *Journal of Financial and Quantitative Analysis* 46 (4), 967–999.

Bartram, S.M., Brown, W.G., Fehle, F.R., 2009. International evidence on financial derivative usage. *Financial Management* 38, 185–206.

Bodnar, G.M., Hayt, G.S., Marston, R.C., 1998. 1998 Survey of financial risk management by US nonfinancial firms. *Financial Management* 27, 70–91.

Bond, S. R., 2002, Dynamic panel data models: a guide to micro data methods and practice. *Portuguese Economic Journal* 1, 141–162.

Brown, G.W., Toft, K.B., 2002, How firms should hedge. *Review of Financial Studies* 15, 1283–1324.

Blundell, R., Bond, S., 1998, Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics* 87, 115–43.

Carter, D.A., Rogers, D., Simkins, B.J., 2006, Does hedging affect firm value? Evidence from the US airline industry, *Financial Management* 35, 53–87.

Campello, M., Lin, C., Ma, Y., Zou, H., 2011, The Real and Financial Implications of Corporate Hedging, *Journal of Finance* 66 (5), 1615-1647.

Crosbie, P.J., Bohn, R.J., 2003, Modeling Default Risk (KMV, LLC, San Francisco, CA).

Dionne, G., Triki, T., 2013, On risk management determinants: What really matters? *European Journal of Finance* 19, 145–164.

Dolde, W., 1993, The trajectory of corporate financial risk management. *Journal of Applied Corporate Finance* 6 (3), 33–41.

Drucker, S., Puri, M., 2009, On loan sales, loan contracting, and lending relationships. *Review of Financial Studies* 22, 2835–2872.

Fauver, L., Naranjo, A., 2010, Derivative usage and firm value: The influence of agency costs and monitoring problems. *Journal of Corporate Finance* 16, 719-735.

Froot, K.A., Scharfstein, D.S., Stein, J.C., 1993, Risk management: coordinating corporate investment and financing policies. *Journal of Finance* 48, 1629–1658.

Gay, G.D., and J. Nam, 1998, The underinvestment problem and corporate derivatives use, *Financial Management* 27, 53–69.

Gay, G.D., J. Nam, and M. Turac, 2002, How firms manage risk: The optimal mix of linear and non-linear derivatives, *Journal of Applied Corporate Finance* 14, 82–93.

Gay, G.D., J. Nam, and M. Turac, 2003, On the optimal mix of corporate hedging instruments: Linear versus non-linear derivatives, *Journal of Futures Markets* 23, 217–239.

Géczy, C., Minton, B.A., Schrand, C., 1997, Why firms use currency derivatives. *Journal of Finance* 52, 132–154.

Graham, J.R., Rogers, D.A., 2002, Do firms hedge in response to tax incentives? *Journal of Finance* 57 (2), 815–839.

Graham, J., Smith. C.W., 1999, Tax incentives to hedge. *Journal of Finance* 54, 2241–2262.

Guay, W.R., 1999, The impact of derivatives on firm risk: An empirical examination of new derivatives users. *Journal of Accounting and Economics* 26, 319–351.

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

Haushalter, D., Heron, R.A., Lie, E., 2002, Price Uncertainty and Corporate Value. *Journal of Corporate Finance* 8 (3), 271-286.

Haushalter, D., 2000, Financing policy, basis risk, and corporate hedging: Evidence from oil and gas producers. *Journal of Finance* 55 (1), 107–152.

Hentschel, L., Kothari, S.P., 2001. Are corporations reducing or taking risks with derivatives? *Journal of Financial and Quantitative Analysis* 36, 93–118.

Jin, Y., Jorion, P., 2006. Firm value and Hedging: evidence from U.S. oil and gas producers. *Journal of Finance* 61 (2), 893-919.

Lehn, K., Poulsen, A., 1989. Free cash flow and stockholder gains in going private Transactions. *Journal of Finance* 44, 771-788.

Merton, R.C., 1974, On the pricing of corporate debt: The risk structure of interest rates, *Journal of Finance* 29, 449-470.

Moschini, G., and H. Lapan, 1995, The hedging role of options and futures under joint price, basis, and production risk, *International Economic Review* 36, 1025–1049.

Nance, D.R., Smith, C.W. & Smithson, C.W., 1993, On the determinants of corporate hedging. *Journal of Finance* 48 (1), 267–284.

Rajgopal, S., 1999. Early evidence on the informativeness of the SEC's market risk disclosures: The case of commodity price risk exposure of oil and gas producers, *Accounting Review* 74, 251–280.

Roodman, D., 2009a, How to do xtabond2: an introduction to difference and system GMM in Stata. *Stata Journal* 9, 86–136.

Roodman, D., 2009b, A note on the theme of too many instruments. *Oxford Bulletin of Economics and Statistics* 71, 135–158.

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

Stulz, R.M., 1996. Rethinking risk management. *Journal of Applied Corporate Finance* 9, 8–24.

Stulz, R. M., 1984. Optimal hedging policies. *Journal of Financial and Quantitative Analysis* 19 (2), 391–405.

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

Windmeijer, F., 2005, A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics* 126, 25–51.

Table 1
Variable definitions and construction, and data sources

Variable definition	Variable name	Construction	Data source
Variables that proxy for tax advantage of hedging			
Tax loss carry-forwards	*TLCF*	Book value of the TLCF scaled by the book value of total assets	Compustat
Tax save	*TAX_SAVE*	Tax liability saving arising from a 5% reduction in taxable income (Graham and Smith (1999)).	Compustat
Variables that proxy for financial distress costs			
Leverage	*LEV*	Book value of long-term debt in current liabilities + one-half of long-term debt scaled by the book value of total assets.	Compustat
Distance-to-default	*DTD*	Market-based measure of default risk based on Merton's (1974) approach and used by Moody's KMV. The DTD is equal to $\frac{V_a - D}{V_a \sigma_a}$, where D is defined as long-term debt in current liabilities plus one-half of long-term debt, V_a is the market value of assets, and σ_a is one-year asset volatility. The quantities V_a and σ_a are unobservable and are approximated from Merton's (1974) model by using the market value and volatility of equity, the three-month Treasury bill rate, and debt (D). See Crosbie and Bohn (2003) for more details on the construction of the DTD.	Manually constructed
Financial distress costs	*DIST_COSTS*	Measured by $I[\,Liquidity - M]\; max[0, -p + c + d]$ where Liquidity is the quick ratio, M is the median quick ratio of the oil and gas industry, p are the realized selling prices, c are production costs, and d debt payments. p, c and d are expressed per Barrel of Oil Equivalent. $I[Liquidity - M] = 1\; if\; Liquidity < M$ and 0 otherwise.	Manually constructed
Cash cost	*CASH_COST*	Production cost of a BOE	Bloomberg and 10-K reports
Variables that proxy for underinvestment costs			
Investment opportunities (IOs)	*INV_OPP*	Total costs incurred in oil and gas property acquisition, exploration, and development, scaled by net property, plant, and equipment at the beginning of the quarter.	Manually constructed
Correlation between investment expenditures and free cash flows.	*COR_CI_CF*	Correlation coefficient between free cash flow and costs incurred. This coefficient is calculated for each firm by using all the observations until the current quarter.	Manually constructed
Variables that proxy for production characteristics			
Oil production uncertainty	*PROD_CV_OIL*	Coefficient of variation of daily oil production. This coefficient is calculated for each firm by using all the observations of daily oil production until the current quarter.	Manually constructed
Gas production uncertainty	*PROD_CV_GAS*	Coefficient of variation of daily gas production. This coefficient is calculated for each firm by using all the observations of daily gas production until the current quarter.	Manually constructed
Price–quantity correlation (oil)	*COR_PQ_OIL*	Correlation coefficient between daily oil production and oil spot prices.	Manually constructed
Price–quantity correlation (gas)	*COR_PQ_GAS*	Correlation coefficient between daily gas production and gas spot prices.	Manually constructed
Variables that proxy for firm size			
Sales	*SALES*	Total revenues from oil and gas sales (in millions of dollars)	Compustat
Market value	*MKT_VALUE*	Number of common shares outstanding * end-of-quarter per share price (in millions of dollars).	Compustat
Oil reserves	*RES_OIL*	Quantity of the total proven developed and undeveloped oil reserves (in millions of barrels).	Bloomberg and 10-K reports
Gas reserves	*RES_GAS*	Quantity of the total proven developed and undeveloped gas reserves (in billions of cubic feet).	Bloomberg and 10-K reports
Variables that proxy for managerial risk aversion			
Market value of CEO shareholding	*CEO_CS*	Measured by the logarithm of 1 plus the market value of common shares held by the CEO at the end of each quarter.	Thomson Reuters

Table 1-*Continued*

Variable definition	Variable name	Construction	Data source
# CEOs stock options	*CEO_OPT*	Number of CEO stock options (in thousands).	Thomson Reuters
Variables that proxy for Market conditions			
Oil expected return	*OIL_RET*	Measured by $E[R_t] = \log[F_t/S_t]$ where F_t and S_t are respectively the oil prices of 12-month Futures contracts and the oil spot prices observed at the end of quarter t.	Manually constructed
Oil spot price	*OIL_SPOT*	Oil spot price represented by the WTI in the NYMEX.	Bloomberg
Gas expected return	*GAS_RET*	Measured by $E[R_t] = \log[F_t/S_t]$ where F_t and S_t are respectively the gas prices of 12-month Futures contracts and the gas spot prices observed at the end of quarter t.	Manually constructed
Gas spot price	*GAS_SPOT*	Constructed as an average index established from principal locations' indices in the United States (Gulf Coast, Henry Hub, etc.)	Bloomberg
Oil price volatility	*OIL_VOL*	Historical volatility (standard deviation) using the spot price of the previous 60 days.	Manually constructed
Gas price volatility	*GAS_VOL*	Historical volatility (standard deviation) using the spot price of the previous 60 days.	Manually constructed
Variables that proxy for the asset-liability management			
Weighted-average maturity of debt (in years)	*DEBT_MAT*	Calculated as the book value-weighted average maturities of debt that mature within one, two, three, four and five years.	Manually constructed
Expected life duration of oil and gas reserves (in years)	*RES_MAT_(OIL/GAS)*	Calculated by dividing the current quantity of oil (gas) developed reserves by the current annual oil (gas) production.	Manually constructed
Variables that proxy for hedging contract features			
Contract strike price	*STRIKE*	Measured by the average spot price during the quarter of the initiation of the hedging contract	
Contract moneyness	*MONEYNESS*	Calculated as the contract strike price minus the average spot price during the current quarter	
Variables that proxy for hedging substitutes			
Quick ratio	*Q_RATIO*	Cash and cash equivalents scaled by current liabilities.	Compustat
Book value of convertible debt	*BVCD*	Book value of convertible debt scaled by the book value of total assets.	Compustat

Table 2
Weighted-average maturity by hedging instrument (in years)

Hedging Instrument	Obs	% of use	Mean	Median	1st quartile	3rd quartile	Min	Max	Std Dev
Panel A: Gas hedgers									
Swap contracts	2255	45.58%	1.286	1.161	0.894	1.582	0.250	5	0.651
Costless Collars	1840	37.19%	1.156	1.032	0.822	1.404	0.250	4.190	0.539
Put options	522	10.55%	1.023	1	0.750	1.273	0.250	3.220	0.538
Forwards or Futures	161	3.25%	0.856	0.914	0.616	1.002	0.250	1.942	0.330
3-way Collars	169	3.42%	1.187	1.096	0.881	1.427	0.250	3.101	0.511
Gas hedging portfolio maturity	**3137**		**1.222**	**1.111**	**0.906**	**1.478**	**0.250**	**5**	**0.559**
Panel B: Oil hedgers									
Swap contracts	1711	45.25%	1.227	1.061	0.750	1.530	0.250	3.758	0.644
Costless Collars	1403	37.11%	1.221	1.050	0.799	1.500	0.250	4.439	0.621
Put options	448	11.85%	1.083	1	0.750	1.416	0.250	2.970	0.548
Forwards or Futures	105	2.78%	0.818	0.750	0.500	1	0.250	1.750	0.332
3-way Collars	114	3.02%	1.448	1.230	0.855	1.840	0.250	4.212	0.878
Oil hedging portfolio maturity	**2607**		**1.204**	**1.061**	**0.820**	**1.489**	**0.250**	**3.935**	**0.575**

Table 3

Summary statistics for sample firms financial and operational characteristics

This table provides financial and operational statistics for the 150 US oil and gas producers for the period 1998-2010. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *DTD* for distance-to-default; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *DIS_COSTS* for distress costs (in $); *PROD_CV_OIL* and *PROD_CV_GAS* measure the production uncertainty for oil and gas respectively; *COR_PQ_OIL* and *COR_PQ_GAS* measure the quantity-price correlation for oil and gas respectively; *CEO_CS* for the market value of common shares held by firm's CEO (in MM$); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* and *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years).

Variable	Obs	Mean	Median	1st quartile	3rd quartile	Std Dev
Variables that proxy for underinvestment costs						
INV_OPP	6,006	0.224	0.075	0.041	0.129	3.619
COR_CI_CF	6196	0.307	0.373	-0.015	0.693	0.452
Variables that proxy for financial distress costs						
DTD	5,686	2.234	2.052	1.323	2.862	1.361
LEV	6,063	0.158	0.142	0.053	0.220	0.153
DIS_COSTS	6298	2.347	0	0	0	16.957
Variables that proxy for production characteristics						
PROD_CV_OIL	6,058	0.416	0.313	0.141	0.587	0.388
COR_PQ_OIL	6,119	0.229	0.455	-0.287	0.723	0.587
PROD_CV_GAS	6,078	0.408	0.303	0.146	0.582	0.359
COR_PQ_GAS	6,112	0.154	0.230	-0.174	0.504	0.419
Variables that proxy for managerial risk aversion						
CEO_CS	6,326	28.983	1.125	0.000	11.563	152.159
CEO_OPT	6,326	174.386	0.000	0.000	120.000	681.760
Variables that proxy for tax advantage						
TLCF	6,066	0.134	0.000	0.000	0.064	0.438
TAX_SAVE	6,160	0.052	0.048	0.029	0.070	0.051
Variables that proxy for the asset-liability management						
DEBT_MAT	6326	2	2	0	3.349	1.640
RES_MAT_OIL	6157	9.055	7.542	5.050	10.639	10.846
RES_MAT_GAS	6180	9.506	7.476	5.206	10.439	10.657

Table 4

Characteristics of oil and gas producers and market conditions by hedging maturity

This table provides the mean and median values of firms' financial and operational characteristics and market conditions according to the weighted-average maturity of the hedging portfolio. For each firm-quarter with hedging activity, a hedging portfolio maturity is classified as short-term maturity if it is below one year ahead, a medium-term maturity if it is between one and two years ahead, and a long-term maturity if it exceeds two years ahead. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *DTD* for distance-to-default; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *DIS_COSTS* for distress costs (in $); *PROD_CV_OIL* and *PROD_CV_GAS* measure production uncertainty for oil and gas respectively; *COR_PQ_OIL* and *COR_PQ_GAS* measure the quantity-price correlation for oil and gas respectively; *CEO_CS* for the market value of common shares held by firm's CEO (in MM$); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* and *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years); *GAS_SPOT* and *OIL_SPOT* are spot prices; *GAS_VOL* and *OIL_VOL* are historical volatilities of spot prices over the current quarter; *GAS_RET* and *OIL_RET* are oil and gas returns measured by log(12-month future price/spot price). Comparison of means is constructed using a *t*-test assuming unequal variances; comparison of medians is constructed by using the non-parametric Wilcoxon rank sum *Z*-score. Two sided *p*-values are reported.

Characteristics of oil and gas producers and market conditions by hedging maturity

	Short Maturity			Medium Maturity			Long Maturity			Short vs. Long		Medium vs. Long	
Variable	**Obs**	**Mean**	**Median**	**Obs**	**Mean**	**Median**	**Obs**	**Mean**	**Median**	***p*-Value (Mean)**	***p*-Value (Median)**	***p*-Value (Mean)**	***p*-Value (Median)**
Panel A: Gas hedgers													
Financial distress													
LEV	1287	0.183	0.160	1555	0.198	0.176	267	0.231	0.183	0.000	0.000	0.006	0.024
DTD	1271	2.305	2.237	1516	2.402	2.312	250	2.615	2.379	0.002	0.019	0.036	0.173
DIS_COSTS	1299	1.612	0	1569	1.339	0	269	2.586	0	0.129	0.000	0.045	0.000
Underinvestment costs													
INV_OPP	1284	0.098	0.078	1533	0.111	0.078	268	0.134	0.068	0.016	0.101	0.131	0.071
COR_CI_CF	1299	0.418	0.502	1569	0.427	0.529	269	0.282	0.369	0.000	0.000	0.000	0.000
Production characteristics													
PROD_CV_GAS	1299	0.346	0.266	1569	0.474	0.369	269	0.528	0.439	0.000	0.000	0.083	0.497
COR_PQ_GAS	1299	0.207	0.306	1569	0.306	0.391	269	0.201	0.306	0.811	0.807	0.000	0.002
Managerial risk aversion													
CEO_CS	1299	33.373	3.682	1569	52.285	6.381	269	46.969	12.917	0.146	0.000	0.565	0.000
CEO_OPT	1299	203,532	20,000	1569	210,316	18,655	269	421,252	6,000	0.034	0.425	0.043	0.814
Tax incentives													
TAX_SAVE	1287	0.048	0.046	1563	0.050	0.047	269	0.049	0.046	0.686	0.172	0.492	0.634
TLCF	1287	0.069	0	1554	0.054	0	268	0.037	0	0.000	0.018	0.033	0.007
Asset-liability management													
RES_MAT_GAS	1299	7.407	6.642	1569	8.609	7.728	269	10.872	8.826	0.000	0.000	0.000	0.000
DEBT_MAT	1299	2.147	2.200	1569	2.709	3	269	2.666	3	0.000	0.000	0.664	0.495
Market conditions													
GAS_SPOT	1298	5.049	4.830	1566	5.598	5.530	269	5.357	5.050	0.084	0.070	0.171	0.075
GAS_VOL	1298	0.714	0.468	1566	0.816	0.622	269	0.788	0.549	0.036	0.002	0.437	0.534
GAS_RET	1298	0.121	0.100	1566	0.145	0.110	269	0.137	0.100	0.227	0.387	0.525	0.601
Panel B: Oil hedgers													
Financial distress													
LEV	1172	0.198	0.173	1169	0.189	0.169	250	0.175	0.163	0.003	0.042	0.046	0.045
DTD	1151	2.341	2.240	1145	2.379	2.308	240	2.669	2.707	0.000	0.000	0.000	0.000
DIS_COSTS	1177	1.256	0	1173	1.661	0	250	0.899	0	0.451	0.913	0.139	0.585
Underinvestment costs													
INV_OPP	1161	0.093	0.068	1158	0.130	0.079	250	0.180	0.089	0.000	0.000	0.016	0.038
COR_CI_CF	1180	0.405	0.486	1177	0.457	0.559	250	0.359	0.378	0.110	0.073	0.000	0.000
Production characteristics													
PROD_CV_OIL	1176	0.374	0.282	1175	0.464	0.384	234	0.490	0.376	0.000	0.000	0.325	0.808
COR_PQ_OIL	1180	0.281	0.509	1175	0.446	0.639	234	0.456	0.574	0.000	0.000	0.748	0.916
Managerial risk aversion													
CEO_CS	1180	57.791	3.951	1177	52.202	7.002	250	76.033	15.016	0.150	0.000	0.037	0.000
CEO_OPT	1180	182,748	50,000	1177	194,666	7	250	448,562	3,212	0.024	0.055	0.035	0.445
Tax Incentives													
TAX_SAVE	1173	0.048	0.047	1174	0.052	0.048	250	0.047	0.046	0.478	0.429	0.011	0.071
TLCF	1172	0.091	0	1169	0.067	0	250	0.034	0	0.000	0.000	0.000	0.000
Asset-liability management													
RES_MAT_OIL	1180	7.883	6.971	1177	8.599	8.149	250	11.078	9.972	0.000	0.000	0.000	0.000
DEBT_MAT	1180	2.331	2.636	1177	2.715	3	250	2.870	3.037	0.000	0.000	0.148	0.233
Market conditions													
OIL_SPOT	1179	46.648	32.500	1177	62.638	65.870	250	73.421	70.610	0.000	0.000	0.000	0.000
OIL_VOL	1179	3.168	2.233	1177	4.189	3.306	250	4.930	3.654	0.000	0.000	0.002	0.000
OIL_RET	1179	-0.024	-0.023	1177	0.006	0.016	250	0.019	0.025	0.000	0.000	0.000	0.003

Table 5

Contract features by hedging maturity

This table provides the mean and median values of the hedging instruments features (i.e., moneyness and strike price) according to its weighted-average maturity. Hedging instruments are swap contracts, put options, and costless collars. Strike price is measured by the average spot price during the quarter of initiation of the hedging contract. Moneyness is calculated as the contract strike price minus the average spot price during the current quarter. For each instrument, a hedging maturity is classified as short-term maturity if it is below one year ahead, a medium-term maturity if it is between one and two years ahead, and a long-term maturity if it exceeds two years ahead. Comparison of means is constructed using a *t*-test assuming unequal variances; comparison of medians is constructed by using the non-parametric Wilcoxon rank sum *Z*-score. Two sided *p*-values are reported.

Contract features by hedging maturity

	Short Maturity			Medium Maturity			Long Maturity			Short vs. Long		Medium vs. Long	
Variable	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	*p*-value (Mean)	*p*-value (Median)	*p*-value (Mean)	*p*-value (Median)
Panel A: Gas hedgers													
Swap contracts													
MONEYNESS	903	-0.187	0	1069	-0.029	0	282	-0.127	0	0.580	0.171	0.344	0.176
STRIKE	903	5.054	5.261	1069	5.506	5.511	282	5.108	5.261	0.744	0.532	0.012	0.011
Put options													
MONEYNESS	306	-0.005	0	184	0.121	0	27	-0.480	0	0.108	0.395	0.043	0.018
STRIKE	306	5.263	5.407	184	5.849	6.114	27	4.865	4.706	0.273	0.369	0.011	0.028
Costless collars													
MONEYNESS	869	0.040	0	859	0.052	0	111	0.777	0	0.002	0.000	0.003	0.000
STRIKE	869	5.491	5.484	859	6.203	6.164	111	7.457	7.161	0.000	0.000	0.000	0.000
Panel B: Oil hedgers													
Swap contracts													
MONEYNESS	794	-2.689	-0.622	706	-2.681	0	211	-5.186	0	0.019	0.300	0.031	0.103
STRIKE	794	41.656	31.155	706	56.059	58.095	211	65.592	64.952	0.000	0.000	0.000	0.000
Put options													
MONEYNESS	230	-1.428	0	188	0.760	0	27	2.043	0	0.389	0.143	0.751	0.514
STRIKE	230	49.356	38.314	188	63.068	60.048	27	66.512	59.956	0.011	0.013	0.599	0.675
Costless collars													
MONEYNESS	663	-2.676	-0.263	589	-3.016	0	151	5.298	0	0.000	0.004	0.000	0.015
STRIKE	663	50.717	48.305	589	60.551	60.048	151	77.451	63.335	0.000	0.000	0.000	0.000

Table 6

Maturity structure by gas hedgers

This table provides the two-step SYS-GMM results for the determinants of the weighted-average remaining maturity for swap contracts, put options and costless collars respectively. The results are for the subsample of gas hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DTD* for distance-to-default; *DTD_SQUARED* for the distance to default squared; *DIS_COSTS* for distress costs (in \$/BOE); *PROD_CV_GAS* measures gas production uncertainty; *COR_PQ_GAS* measures the gas quantity-price correlation; *GAS_VOL* for gas price volatility; *GAS_RET* for gas return as measured by log(gas 12-month future price/gas sport price); *GAS_SPOT* and *GAS_SPOT_SQUARED* are for gas spot price and gas price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *IMR* is the inverse Mills Ratio (Appendix A); *LAG_1* is the dependent variable first lag; *LAG_2* is the dependent variable second lag (used when there is second-order serial correlation in the error term). Standard errors are clustered by firm and incorporate the Windmeijer (2005) correction, in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Variables	(1) Swap	(2) Swap	(3) Swap	(4) Swap	(5) Put	(6) Put	(7) Put	(8) Put	(9) Collar	(10) Collar	(11) Collar	(12) Collar
INV_OPP	0.3292***		0.3468***		0.2735**		0.3192***		0.0695		0.0634	
	(0.089)		(0.082)		(0.114)		(0.108)		(0.086)		(0.079)	
COR_CI_CF		-0.0437		-0.0026		-0.1851**		-0.2055**		-0.0028		0.0599
		(0.042)		(0.048)		(0.081)		(0.099)		(0.044)		(0.043)
LEV	1.3438***			1.4572***	1.3907***			3.2410***	0.8867***			1.0542***
	(0.280)			(0.281)	(0.424)			(0.600)	(0.184)			(0.175)
LEV_SQUARE	-0.9482***			-1.1349***	-1.3725			-5.4469***	-0.5349***			-0.6324***
	(0.360)			(0.402)	(0.866)			(1.456)	(0.130)			(0.170)
DTD			0.0994***				0.0115				0.1499***	
			(0.029)				(0.050)				(0.032)	
DTD_SQUARE			-0.0087*				0.0062				-0.0237***	
			(0.005)				(0.008)				(0.006)	
DIS_COSTS		0.0041		0.0028		0.0069		0.0081*		0.0014		0.0001
		(0.003)		(0.004)		(0.005)		(0.005)		(0.001)		(0.002)
PROD_CV_GAS	0.0734		0.1487**		0.0923		0.0765		0.1273***		0.1439***	
	(0.051)		(0.057)		(0.101)		(0.102)		(0.047)		(0.052)	
COR_PQ_GAS	0.0550		-0.0073		0.0071		0.0110		0.0940**		0.0031	
	(0.051)		(0.045)		(0.083)		(0.078)		(0.042)		(0.039)	
GAS_VOL	0.0555***		0.0541***		0.1128***		0.1287***		0.0482**		0.0425**	
	(0.019)		(0.020)		(0.029)		(0.030)		(0.019)		(0.019)	
GAS_RET	-0.1307*		-0.1572**		-0.4896***		-0.4689***		-0.2587***		-0.2710***	
	(0.070)		(0.069)		(0.142)		(0.130)		(0.070)		(0.076)	
GAS_SPOT		0.1309***				0.1457***				0.0997***		
		(0.016)				(0.029)				(0.017)		
GAS_SPOT_SQUARE		-0.0080***				-0.0074***				-0.0047***		
		(0.001)				(0.002)				(0.001)		
MONEYNESS	0.0144*		0.0209***		0.0158		0.0161		0.0109		0.0142*	
	(0.008)		(0.008)		(0.017)		(0.015)		(0.008)		(0.008)	
STRIKE				0.0299***				0.0384***				0.0222***
				(0.007)				(0.011)				(0.007)
TLCF		-0.3411***		-0.3849***		-0.3462***		-0.4941***		-0.0611*		-0.1061**
		(0.062)		(0.142)		(0.050)		(0.178)		(0.036)		(0.041)
TAX_SAVE	-0.0491		0.2914		0.0389		1.9730**		0.4577		0.7561**	
	(0.140)		(0.235)		(0.848)		(0.764)		(0.409)		(0.340)	
DEBT_MAT		0.0396***		0.0368***		0.0082		-0.0146		0.0307***		0.0337***
		(0.012)		(0.012)		(0.016)		(0.018)		(0.010)		(0.010)
RES_MAT_GAS	0.0184***		0.0188***		0.0212***		0.0208***		0.0228***		0.0200***	
	(0.004)		(0.005)		(0.006)		(0.006)		(0.004)		(0.005)	
CEO_CS		0.1218		0.1756		-0.2095		0.2573		0.1841		0.1322
		(0.114)		(0.154)		(0.330)		(0.326)		(0.148)		(0.121)
CEO_OPT		0.0001		0.0001		-0.0002		0.0001		-0.0002***		-0.0001**
		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)
IMR	0.1829***	0.1002**	0.1202**	0.2569***	0.1225*	0.0851	0.1181*	0.2251***	0.1288***	0.0583	0.0597	0.1734***
	(0.047)	(0.047)	(0.057)	(0.063)	(0.065)	(0.083)	(0.061)	(0.082)	(0.047)	(0.046)	(0.049)	(0.051)
LAG_1	0.5597***	0.5836***	0.5834***	0.5742***	0.4892***	0.5592***	0.5120***	0.4766***	0.5816***	0.6043***	0.5918***	0.6044***
	(0.053)	(0.044)	(0.051)	(0.050)	(0.080)	(0.094)	(0.074)	(0.081)	(0.049)	(0.051)	(0.053)	(0.047)
LAG_2				-0.0289								
				(0.022)								
Observations	2,123	2,129	2,096	2,108	480	485	478	480	1,726	1,746	1,699	1,745
Number of firms	99	100	99	99	44	49	43	44	93	95	93	94
Number of instruments	63	61	63	62	63	61	63	62	63	61	63	62
F statistic	409.4175	705.0217	428.2656	433.7338	173.8287	182.3584	227.4729	200.8200	412.9824	570.3112	601.2629	575.2583
p value F statistic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hansen J statistic	63.8114	53.8975	62.5987	59.8964	36.6077	30.6516	36.9887	33.0220	60.9116	52.6989	56.9287	60.2093
p value of Hansen statistic	0.1074	0.3641	0.1279	0.1595	0.9356	0.9893	0.9295	0.9761	0.1613	0.4082	0.2640	0.1769
AR(2) test statistic	-1.4614	-1.3744	-1.6156	-0.7854	-0.6087	-0.9605	-0.3671	-1.4434	-1.3989	-0.8421	-1.3168	-1.5502
p value of AR(2) statistic	0.1439	0.1693	0.1062	0.4322	0.5427	0.3368	0.7136	0.1489	0.1618	0.3997	0.1879	0.1211
Sigma_e	0.3393	0.4425	0.3471	0.3459	0.3049	0.4605	0.3100	0.3164	0.3175	0.4135	0.3194	0.3277

Table 7

Maturity structure by oil hedgers

This table provides the two-step SYS-GMM results for the determinants of the weighted-average remaining maturity for swap contracts, put options and costless collars respectively. The results are for the subsample of oil hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DTD* for distance-to-default; *DTD_SQUARED* for distance-to-default squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_OIL* measures oil production uncertainty; *COR_PQ_OIL* measures the oil quantity-price correlation, *OIL_VOL* for oil price volatility; *OIL_RET* for oil return as measured by log(oil 12-month future price/oil sport price); *OIL_SPOT* and *OIL_SPOT_SQUARED* are for oil spot price and oil price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *IMR* is the inverse Mills Ratio (Appendix A); *LAG_1* is the dependent variable first lag; *LAG_2* is the dependent variable second lag (used when there are second order serial correlation in the error term). Standard errors are clustered by firm and incorporate the Windmeijer (2005) correction, in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Variables	(1) Swap	(2) Swap	(3) Swap	(4) Swap	(5) Put	(6) Put	(7) Put	(8) Put	(9) Collar	(10) Collar	(11) Collar	(12) Collar
INV_OPP	0.2623**		0.2200**		0.5839**		0.5923**		0.1001*		0.0916*	
	(0.129)		(0.110)		(0.222)		(0.235)		(0.052)		(0.052)	
COR_CI_CF		-0.1294***		-0.0818*		0.0487		0.0533		0.0213		0.0302
		(0.048)		(0.048)		(0.076)		(0.094)		(0.052)		(0.059)
LEV	0.5090*			0.8594***	1.5182*			1.6283**	1.1577***			0.8237***
	(0.265)			(0.256)	(0.803)			(0.760)	(0.348)			(0.208)
LEV_SQUARE	-0.2940			-0.7017**	-1.5120			-1.3516	-1.4545***			-0.9989***
	(0.402)			(0.349)	(2.053)			(1.702)	(0.522)			(0.292)
DTD			0.0729**				0.2709***				0.1614***	
			(0.029)				(0.075)				(0.055)	
DTD_SQUARE			-0.0049				-0.0474***				-0.0230**	
			(0.003)				(0.015)				(0.010)	
DIS_COSTS		0.0011		-0.0006		0.0146***		0.0103***		0.0003		0.0005
		(0.002)		(0.003)		(0.003)		(0.003)		(0.003)		(0.003)
PROD_CV_OIL	0.1090*		0.1260*		0.0089		0.0109		-0.0404		-0.0797	
	(0.065)		(0.065)		(0.119)		(0.104)		(0.062)		(0.059)	
COR_PQ_OIL	0.0590		0.0001		0.0217		-0.0442		0.0983**		0.0427	
	(0.037)		(0.038)		(0.084)		(0.084)		(0.048)		(0.046)	
OIL_VOL	0.0189***		0.0206***		0.0159**		0.0205**		0.0133**		0.0170***	
	(0.005)		(0.005)		(0.007)		(0.008)		(0.005)		(0.006)	
OIL_RET	-0.0313		0.0165		-0.3799		-0.3938		-0.2188		-0.0051	
	(0.195)		(0.209)		(0.495)		(0.504)		(0.230)		(0.215)	
OIL_SPOT		0.0149***				0.0043				0.0080***		
		(0.002)				(0.003)				(0.002)		
OIL_SPOT_SQUARE		-0.0001***				-0.0000				-0.0000**		
		(0.000)				(0.000)				(0.000)		
MONEYNESS	0.0028**		0.0033***		0.0015		0.0031		0.0037***		0.0044***	
	(0.001)		(0.001)		(0.002)		(0.002)		(0.001)		(0.001)	
STRIKE				0.0057***				0.0037***				0.0033***
				(0.001)				(0.001)				(0.001)
TLCF		-0.3940***		-0.5680***		-0.2640***		-0.4791***		-0.0531		-0.0813
		(0.082)		(0.134)		(0.062)		(0.163)		(0.059)		(0.052)
TAX_SAVE	0.1945		0.1802		0.1319		0.9001		0.1094		0.0787	
	(0.154)		(0.140)		(0.612)		(0.583)		(0.286)		(0.273)	
DEBT_MAT		0.0416***		0.0420***		0.0280		-0.0006		0.0310***		0.0260**
		(0.013)		(0.013)		(0.019)		(0.020)		(0.011)		(0.010)
RES_MAT_OIL	0.0311***		0.0272***		0.0119**		0.0052		0.0182***		0.0161***	
	(0.004)		(0.004)		(0.006)		(0.007)		(0.005)		(0.004)	
CEO_CS		-0.1633		-0.0628		-0.3542		-0.3388		-0.0665		-0.1324
		(0.137)		(0.139)		(0.318)		(0.343)		(0.140)		(0.146)
CEO_OPT		0.0002*		0.0002		-0.0001		0.0001		-0.0001		-0.0001
		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)
IMR	0.1311**	0.1470**	0.1049*	0.2848***	0.1382**	0.2096***	0.0121	0.1800***	0.2054***	0.1265**	0.1797**	0.1946***
	(0.059)	(0.071)	(0.060)	(0.062)	(0.059)	(0.066)	(0.052)	(0.052)	(0.068)	(0.049)	(0.068)	(0.044)
LAG_1	0.5630***	0.5548***	0.5728***	0.5490***	0.4645***	0.5872***	0.4760***	0.5211***	0.5858***	0.6228***	0.5745***	0.6256***
	(0.039)	(0.046)	(0.042)	(0.046)	(0.063)	(0.062)	(0.084)	(0.076)	(0.040)	(0.041)	(0.039)	(0.035)
LAG_2	-0.0496**	-0.0696***	-0.0432**	-0.0529**								
	(0.020)	(0.023)	(0.020)	(0.020)								
Observations	1,593	1,608	1,572	1,608	402	417	393	414	1,331	1,351	1,311	1,351
Number of firms	88	89	88	89	36	40	35	37	81	81	81	81
Number of instruments	63	61	63	62	57	57	57	56	63	61	63	62
F statistic	293.9642	413.6701	255.7297	280.9298	128.4730	176.0464	102.0687	336.8433	280.2979	444.6558	275.8100	318.6617
p value F statistic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hansen J statistic	51.8717	51.3504	55.6423	54.2101	29.0451	28.2022	27.3456	35.4909	59.4069	46.4226	56.9199	53.5233
p value of Hansen statistic	0.4007	0.4206	0.2708	0.3170	0.9688	0.9865	0.9825	0.8441	0.1960	0.6558	0.2642	0.3777
AR(2) test statistic	-1.0896	0.1353	-1.2967	-0.7639	0.5991	1.4030	1.0248	1.2104	0.8288	0.2945	0.9272	1.0881
p value of AR(2) statistic	0.2759	0.8923	0.1947	0.4449	0.5491	0.1606	0.3055	0.2261	0.4072	0.7684	0.3538	0.2766
Sigma_e	0.3144	0.4310	0.3160	0.3163	0.3038	0.4969	0.3079	0.3177	0.3374	0.4834	0.3324	0.3533

Table 8

Maturity choice at the inception of hedging contracts by gas hedgers

This table provides pooled cross-sectional time-series regressions of the determinants of the weighted-average remaining maturity for swap contracts, put options and costless collars respectively. The results are for the subsample of gas hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DTD* for distance-to-default; *DTD_SQUARED* for distance-to-default squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_GAS* measures gas production uncertainty; *COR_PQ_GAS* measures the gas quantity-price correlation; *GAS_VOL* for gas price volatility; *GAS_RET* for gas return as measured by log(gas 12-month future price/gas sport price); *GAS_SPOT* and *GAS_SPOT_SQUARED* are for gas spot price and gas price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *IMR* is the inverse Mills Ratio (Appendix A). Robust standard errors using Huber-White-Sandwich estimator are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Variables	(1) Swap	(2) Swap	(3) Swap	(4) Swap	(5) Put	(6) Put	(7) Put	(8) Put	(9) Collar	(10) Collar	(11) Collar	(12) Collar
INV_OPP	0.0026		0.0146		-0.0512		-0.0371		0.1862**		0.1876**	
	(0.109)		(0.111)		(0.140)		(0.151)		(0.082)		(0.079)	
COR_CI_CF		-0.2297***		-0.2398***		-0.4763***		-0.4721***		-0.0388		-0.0025
		(0.063)		(0.071)		(0.120)		(0.137)		(0.055)		(0.058)
LEV	-0.5737*			-0.9896**	1.9823**			1.5209	0.4274			0.7591**
	(0.343)			(0.408)	(0.784)			(1.168)	(0.329)			(0.357)
LEV_SQUARE	1.0634***			1.1176***	-2.5490**			-2.8874	-0.3952			-0.6584*
	(0.306)			(0.333)	(1.280)			(2.469)	(0.320)			(0.359)
DTD			-0.0023				-0.1624				0.0425	
			(0.040)				(0.119)				(0.064)	
DTD_SQUARE			0.0025				0.0253				-0.0085	
			(0.006)				(0.021)				(0.010)	
DIS_COSTS		0.0057**		0.0055**		0.0036		0.0056		0.0015		0.0010
		(0.003)		(0.002)		(0.005)		(0.005)		(0.002)		(0.002)
PROD_CV_GAS	0.0294		0.0257		0.2925**		0.2413**		0.2699***		0.2538***	
	(0.054)		(0.057)		(0.114)		(0.121)		(0.057)		(0.060)	
COR_PQ_GAS	-0.1624**		-0.1725**		-0.1216		-0.1775*		0.0628		0.0392	
	(0.072)		(0.067)		(0.092)		(0.091)		(0.053)		(0.052)	
GAS_VOL	-0.0259		-0.0364		0.0072		-0.0135		0.0377		0.0317	
	(0.041)		(0.039)		(0.055)		(0.053)		(0.038)		(0.038)	
GAS_RET	0.0015		-0.0392		-0.1774		-0.1942		-0.0055		-0.0033	
	(0.132)		(0.126)		(0.170)		(0.163)		(0.100)		(0.099)	
GAS_SPOT		-0.0159				0.0524				0.0654**		
		(0.035)				(0.040)				(0.027)		
GAS_SPOT_SQUARE		0.0010				-0.0028				-0.0032		
		(0.003)				(0.003)				(0.002)		
STRIKE				-0.0141				0.0260**				0.0278***
				(0.010)				(0.012)				(0.009)
TLCF		-0.5876***		-0.5165***		-0.7963***		-0.6928***		-0.0835		-0.1434
		(0.142)		(0.147)		(0.198)		(0.208)		(0.152)		(0.152)
TAX_SAVE	-1.4783*		-1.5711*		-0.1894		-0.3458		0.2650		0.2519	
	(0.873)		(0.841)		(0.878)		(0.831)		(0.201)		(0.214)	
DEBT_MAT		0.0152		0.0188		0.0068		-0.0029		0.0242**		0.0229**
		(0.013)		(0.013)		(0.020)		(0.020)		(0.011)		(0.012)
RES_MAT_GAS	0.0142***		0.0120***		0.0320***		0.0281***		0.0128**		0.0122**	
	(0.005)		(0.004)		(0.007)		(0.007)		(0.005)		(0.005)	
CEO_CS		0.2019		0.1969		-0.0600		0.1344		0.4796**		0.4417**
		(0.258)		(0.269)		(0.297)		(0.360)		(0.205)		(0.205)
CEO_OPT		0.0007		0.0008		-0.0001		0.0004		0.0001		0.0001
		(0.001)		(0.001)		(0.002)		(0.002)		(0.000)		(0.000)
IMR	-0.3736***	-0.2885***	-0.3237***	-0.3941***	-0.0970	-0.3959***	-0.3236***	-0.2614	-0.3176***	-0.2978***	-0.3778***	-0.2299***
	(0.060)	(0.057)	(0.060)	(0.071)	(0.112)	(0.108)	(0.095)	(0.158)	(0.070)	(0.073)	(0.065)	(0.080)
CONSTANT	1.6506***	1.6762***	1.5977***	1.8711***	0.6523***	1.4443***	1.3201***	1.2623***	1.0725***	1.1194***	1.1399***	1.0577***
	(0.112)	(0.124)	(0.115)	(0.147)	(0.194)	(0.181)	(0.212)	(0.261)	(0.098)	(0.096)	(0.109)	(0.121)
Observations	733	735	726	735	168	168	167	163	603	608	597	607
R-squared	0.0799	0.0825	0.0649	0.0948	0.2083	0.2047	0.1947	0.1898	0.1236	0.0872	0.1220	0.0888

Table 9

Maturity choice at the inception of hedging contracts by oil hedgers

This table provides pooled cross-sectional time-series regressions of the determinants of the weighted-average remaining maturity for swap contracts, put options and costless collars respectively. The results are for the subsample of oil hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DTD* for distance-to-default; *DTD_SQUARED* for distance-to-default squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_OIL* measures oil production uncertainty; *COR_PQ_OIL* measures the oil quantity-price correlation; *OIL_VOL* for oil price volatility; *OIL_RET* for oil return as measured by log(oil 12-month future price/oil sport price); *OIL_SPOT* and *OIL_SPOT_SQUARED* are for oil spot price and oil price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *IMR* is the inverse Mills Ratio (Appendix A). Robust standard errors using Huber-White-Sandwich estimator are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Variables	(1) swap	(2) swap	(3) swap	(4) swap	(5) put	(6) put	(7) put	(8) put	(9) collar	(10) collar	(11) collar	(12) collar
INV_OPP	0.1860		0.2165		0.3426**		0.3949***		0.2728***		0.2879***	
	(0.154)		(0.142)		(0.157)		(0.145)		(0.104)		(0.104)	
COR_CI_CF		-0.2169***		-0.2177***		-0.1492		-0.1486		-0.0184		-0.0360
		(0.063)		(0.065)		(0.124)		(0.125)		(0.075)		(0.086)
LEV	-1.3732***			-0.2853	-1.8256			-0.2747	-0.3317			-0.3262
	(0.403)			(0.378)	(1.277)			(1.569)	(0.425)			(0.478)
LEV_SQUARE	1.0744***			-0.0052	3.5507			1.2990	0.0682			0.1122
	(0.377)			(0.342)	(3.041)			(3.217)	(0.500)			(0.543)
DTD			0.1393***				0.2988***				0.1412**	
			(0.035)				(0.101)				(0.065)	
DTD_SQUARE			-0.0098***				-0.0515***				-0.0200*	
			(0.003)				(0.015)				(0.010)	
DIS_COSTS		0.0018		0.0029*		0.0085*		0.0119***		-0.0003		0.0007
		(0.002)		(0.002)		(0.005)		(0.004)		(0.001)		(0.001)
PROD_CV_OIL	0.3939***		0.3406***		-0.1638		-0.1586		-0.1665*		-0.1750*	
	(0.089)		(0.087)		(0.125)		(0.112)		(0.095)		(0.094)	
COR_PQ_OIL	-0.0259		0.0060		-0.0359		-0.0879		0.1208***		0.1039**	
	(0.042)		(0.037)		(0.088)		(0.079)		(0.047)		(0.048)	
OIL_VOL	0.0126		0.0279**		0.0155		0.0294**		0.0032		0.0094	
	(0.011)		(0.011)		(0.013)		(0.013)		(0.013)		(0.013)	
OIL_RET	1.0026***		0.9922***		-0.1797		0.1297		1.3909***		1.5355***	
	(0.359)		(0.348)		(0.562)		(0.589)		(0.419)		(0.424)	
OIL_SPOT		0.0222***				0.0058				0.0105**		
		(0.003)				(0.005)				(0.004)		
OIL_SPOT_SQUARE		-0.0001***				-0.0000				-0.0000		
		(0.000)				(0.000)				(0.000)		
STRIKE				0.0100***				0.0039**				0.0049***
				(0.001)				(0.002)				(0.001)
TLCF		-0.4943***		-0.4607***		-0.6377***		-0.6094**		-0.2474***		-0.2038***
		(0.133)		(0.136)		(0.215)		(0.261)		(0.079)		(0.077)
TAX_SAVE	0.0044		-0.0476		0.8006		0.6848		-0.1129		-0.7660	
	(0.208)		(0.211)		(1.408)		(1.555)		(1.037)		(1.001)	
DEBT_MAT		0.0212		0.0196		0.0128		0.0093		0.0296*		0.0328**
		(0.014)		(0.014)		(0.025)		(0.026)		(0.015)		(0.016)
RES_MAT_OIL	0.0272***		0.0234***		0.0132**		0.0108**		0.0051		0.0039	
	(0.004)		(0.004)		(0.006)		(0.005)		(0.005)		(0.005)	
CEO_CS		-0.1867		-0.1990		0.0916		-0.0315		0.0717		0.1074
		(0.229)		(0.230)		(0.673)		(0.696)		(0.321)		(0.323)
CEO_OPT		0.0006		0.0007		0.0002		0.0002		0.0004		0.0004
		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)
IMR	-0.2008**	0.0349	-0.0675	0.0230	-0.4435***	-0.3672***	-0.3348***	-0.3689**	-0.2096***	-0.0748	-0.1387*	-0.1324
	(0.091)	(0.087)	(0.083)	(0.094)	(0.121)	(0.105)	(0.086)	(0.147)	(0.077)	(0.080)	(0.081)	(0.083)
CONSTANT	1.2574***	0.6425***	0.6798***	0.9784***	1.5144***	1.3262***	0.9009***	1.3511***	1.4490***	0.8816***	1.1732***	1.1215***
	(0.117)	(0.115)	(0.121)	(0.133)	(0.241)	(0.198)	(0.215)	(0.322)	(0.123)	(0.127)	(0.143)	(0.144)
Observations	562	570	557	570	128	132	126	129	433	436	430	436
R-squared	0.1874	0.2042	0.1950	0.2045	0.2062	0.2111	0.2643	0.2148	0.0952	0.1078	0.1129	0.1046

Table 10

Determinants of early termination of hedging contracts by gas hedgers

This table provides pooled cross-sectional time-series *PROBIT* regressions of the determinants of the early termination of swap contracts, put options and costless collars respectively. The results are for the subsample of gas hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_GAS* measures gas production uncertainty; *COR_PQ_GAS* measures the gas quantity-price correlation; *GAS_VOL* for gas price volatility; *GAS_RET* for gas return as measured by log(gas 12-month future price/gas sport price); *GAS_SPOT* and *GAS_SPOT_SQUARED* are for gas spot price and gas price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *REMAINING_MAT* is the remaining maturity at the termination date (in years); *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); Robust standard errors using Huber-White-Sandwich are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Variables	(1) Swap	(2) Swap	(3) Put	(4) Put	(5) Collar	(6) Collar
OPP_INV	0.2358		-0.3690		0.0856	
	(0.284)		(0.790)		(0.273)	
COR_CI_CF		-0.0556		0.1147		-0.1326
		(0.115)		(0.221)		(0.138)
LEV	-2.9846***		-4.1255*		-0.5718	
	(0.795)		(2.176)		(0.863)	
LEV_SQUARE	1.8096***		4.4556		0.5257	
	(0.664)		(3.985)		(0.628)	
DIS_COSTS		-0.0083		-0.0161		0.0040
		(0.007)		(0.016)		(0.004)
PROD_CV_GAS	0.0479		-0.4728		-0.1927	
	(0.144)		(0.291)		(0.154)	
COR_PQ_GAS	-0.1553		-0.2885		-0.2564*	
	(0.144)		(0.182)		(0.145)	
GAS_VOL	-0.5007***		-0.1973		-0.2868**	
	(0.144)		(0.204)		(0.137)	
GAS_RET	0.1737		-0.1456		0.2358	
	(0.328)		(0.388)		(0.315)	
GAS_SPOT		-0.1848***		-0.3378***		-0.3630***
		(0.068)		(0.108)		(0.081)
GAS_SPOT_SQUARE		0.0061		0.0223***		0.0195***
		(0.005)		(0.007)		(0.006)
MONYNESS		-0.1084		-0.2623		0.2060
		(0.185)		(0.404)		(0.164)
REMAINING_MAT	-0.4496*		-1.2286***		-1.1152***	
	(0.261)		(0.396)		(0.299)	
TAX_SAVE		-0.4619		-0.4984		-0.3618
		(1.036)		(4.009)		(0.834)
DEBT_MAT		-0.0580*		-0.0016		-0.0345
		(0.030)		(0.051)		(0.033)
RES_MAT_GAS	0.0106		-0.0073		0.0146*	
	(0.007)		(0.021)		(0.009)	
CEO_CS		-1.7609		-13.9335*		-3.0740*
		(1.456)		(7.343)		(1.864)
CEO_OPT		-0.0007		0.0009		-0.0039*
		(0.001)		(0.001)		(0.002)
CONSTANT	-1.1494***	-0.7850***	-0.5415	-0.3609	-1.5494***	-0.2803
	(0.167)	(0.210)	(0.354)	(0.385)	(0.232)	(0.251)
Observations	2,312	2,342	559	564	1,865	1,905
Pseudo-R squared	0.0762	0.0569	0.2174	0.0883	0.1527	0.1002
Chi-squared	34.5827	45.6079	44.9633	16.3846	32.6056	45.0865
Significance	0.0001	0.0000	0.0000	0.0593	0.0002	0.0000

Table 11

Determinants of early termination of hedging contracts by oil hedgers

This table provides pooled cross-sectional time-series *PROBIT* regressions of the determinants of the early termination of swap contracts, put options and costless collars respectively. The results are for the subsample of oil hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_OIL* measures oil production uncertainty; *COR_PQ_OIL* measures the oil quantity-price correlation; *OIL_VOL* for oil price volatility; *OIL_RET* for oil return as measured by log(oil 12-month futures price/oil sport price); *OIL_SPOT* and *OIL_SPOT_SQUARED* are for oil spot price and oil price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *REMAINING_MAT* is the remaining maturity at the termination date (in years); *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* is the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); Robust standard errors using Huber-White-Sandwich are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Variables	(1) Swap	(2) Swap	(3) Put	(4) Put	(5) Collar	(6) Collar
OPP_INV	-0.3025		0.1810		0.2939	
	(0.446)		(0.424)		(0.241)	
COR_CI_CF		-0.0697		0.3345		0.0397
		(0.147)		(0.259)		(0.138)
LEV	-3.2636***		-3.2577		-2.3780**	
	(1.109)		(3.305)		(1.043)	
LEV_SQUARE	2.6593***		2.4391		1.9671	
	(0.931)		(7.625)		(1.219)	
DIS_COSTS		-0.0302		-0.0131		0.0029
		(0.027)		(0.013)		(0.005)
PROD_CV_OIL	0.0381		-0.0322		-0.3278	
	(0.206)		(0.414)		(0.208)	
COR_PQ_OIL	-0.2531**		-0.3286*		-0.3523***	
	(0.127)		(0.183)		(0.116)	
OIL_VOL	-0.1040**		-0.0170		-0.1482**	
	(0.053)		(0.040)		(0.059)	
OIL_RET	3.0460***		1.3630		1.9779	
	(0.921)		(1.426)		(1.214)	
OIL_SPOT		-0.0441***		-0.0290***		-0.0463***
		(0.009)		(0.010)		(0.007)
OIL_SPOT_SQUARE		0.0002***		0.0002**		0.0002***
		(0.000)		(0.000)		(0.000)
MONYNESS		-0.4600***		-0.0167		-0.0452
		(0.097)		(0.027)		(0.030)
REMAINING_MAT	-0.8982***		-1.0269**		-0.8855***	
	(0.285)		(0.456)		(0.282)	
TAX_SAVE		0.9225		6.3143*		1.1954
		(0.890)		(3.477)		(1.130)
DEBT_MAT		-0.0075		-0.2048***		-0.0156
		(0.039)		(0.062)		(0.034)
RES_MAT_OIL	0.0186		-0.0957		-0.0152	
	(0.012)		(0.064)		(0.015)	
CEO_CS		-1.2290		-1.0270		-1.0966
		(1.137)		(2.493)		(0.709)
CEO_OPT		-0.0008		0.0006		-0.0025
		(0.002)		(0.001)		(0.003)
CONSTANT	-1.0042***	-0.4612*	-0.2718	-0.6973*	-0.5360*	-0.1093
	(0.256)	(0.264)	(0.686)	(0.382)	(0.275)	(0.239)
Observations	1,747	1,792	446	471	1,435	1,471
Pseudo-R squared	0.1385	0.3535	0.2079	0.1282	0.1570	0.1770
Chi-squared	37.2153	108.8693	20.0476	25.2569	34.1545	73.2886
Significance	0.0000	0.0000	0.0176	0.0027	0.0001	0.0000

Table 12

Effect of hedging maturity on stock return and volatility sensitivity

This table reports the coefficient estimates of the fixed effects regressions of the effect of hedging strategy choice on firm's return and risk. The dependent variables are (i) the total stock rate of return for firm *i* in month *t* (Panel A), and (ii) the total stock risk measured by the annualized standard deviation of stock daily returns for firm *i* during month *t* (Panel B). *R_MKT* is the monthly rate of return in the S&P500 index. *R_OIL* is the monthly rate of change of the NYMEX near-month futures contract for oil. *R_GAS* is the monthly rate of change of the NYMEX near-month futures contract for natural gas. *SIG_MKT* is the annualized standard deviation of the market index daily returns during the month *t*. *SIG_OIL* and *SIG_GAS* are the annualized standard deviations of the oil (gas) daily returns during the month *t* (e.g., *R_OIL* and *R_GAS*). *HEDG_PORT_MAT* is the remaining maturity of the hedging portfolio observed at the end of the previous month *T-1*. *SWAP_MAT*, *PUT_MAT*, *COLLAR_MAT* are the remaining maturities observed at the end of the previous month *t-1*. *RES_MVE* stands for the lagged value of the ratio of discounted dollar value of oil (gas) developed reserves divided by the market value of equity *MKT_VALUE* measured by the logarithm of the market value of common shares outstanding (e.g., closing price at the end of the month multiplied by the number of common shares outstanding). *LEV* for the leverage ratio measured by the book value of long-term debt in current liabilities plus one-half long-term debt scaled by the book value of total assets; *Q_RATIO* for the quick ratio measured by the book value of cash and equivalent of cash scaled by the book value of current liabilities; *DTD* for distance-to-default; *IMR* is the Inverse Mills Ratio for oil hedgers and gas hedgers respectively coming from the Heckman first-step (Appendix A). Standard errors, corrected for heteroskedasticity and clustering using Huber-White-Sandwich estimator, are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

	Panel A Return Sensitivity				**Panel B Volatility Sensitivity**			
Variables	**(1) Gas Hedgers**	**(2) Oil Hedgers**	**(3) Gas Hedgers**	**(4) Oil Hedgers**	**(5) Gas Hedgers**	**(6) Oil Hedgers**	**(7) Gas Hedgers**	**(8) Oil Hedgers**
(R/SIG)_MKT	1.0155***	1.0723***	1.0143***	1.0700***	1.2699***	1.3036***	1.2679***	1.3037***
	(0.046)	(0.049)	(0.046)	(0.049)	(0.052)	(0.059)	(0.053)	(0.058)
(R/SIG)_OIL	0.2730***	0.3190***	0.2743***	0.2806***	0.2081***	0.1944***	0.2082***	0.2215***
	(0.023)	(0.056)	(0.023)	(0.045)	(0.035)	(0.052)	(0.035)	(0.049)
(R/SIG)_GAS	0.2418***	0.1916***	0.2152***	0.1920***	0.0250	0.0459***	0.0408**	0.0458***
	(0.042)	(0.016)	(0.033)	(0.016)	(0.020)	(0.012)	(0.017)	(0.012)
HEDG_PORT_MAT x	-0.0791***	-0.0562			0.0170	0.0182		
(R/SIG)_(OIL/GAS)	(0.023)	(0.037)			(0.015)	(0.029)		
SWAP_MAT x			-0.0410***	-0.0258			0.0092	0.0125
(R/SIG)_(OIL/GAS)			(0.016)	(0.028)			(0.012)	(0.030)
PUT_MAT x			-0.0273	0.0474			-0.0301	0.0036
(R/SIG)_(OIL/GAS)			(0.027)	(0.061)			(0.022)	(0.045)
COLLAR_MAT x			-0.0401**	-0.0262			0.0015	-0.0230
(R/SIG)_(OIL/GAS)			(0.019)	(0.027)			(0.013)	(0.023)
RES_MVE (OIL/GAS) x	0.0623***	0.0433**	0.0621***	0.0433**				
R_(OIL/GAS)	(0.020)	(0.020)	(0.021)	(0.020)				
MKT_VALUE					0.0000***	0.0000***	0.0000***	0.0000***
					(0.000)	(0.000)	(0.000)	(0.000)
LEV					0.5839***	0.5250***	0.5829***	0.5169***
					(0.084)	(0.106)	(0.084)	(0.105)
DTD					-0.0797***	-0.0823***	-0.0801***	-0.0827***
					(0.009)	(0.009)	(0.009)	(0.009)
Q_RATIO					-0.0213***	-0.0212**	-0.0206***	-0.0207**
					(0.007)	(0.009)	(0.007)	(0.009)
IMR	0.0080	-0.0014	0.0077	-0.0011	0.1145***	0.0895**	0.1112***	0.0826*
	(0.011)	(0.010)	(0.011)	(0.010)	(0.036)	(0.045)	(0.036)	(0.046)
CONSTANT	0.0059	0.0133**	0.0060	0.0131**	0.1920***	0.1976***	0.1952***	0.2030***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.046)	(0.050)	(0.046)	(0.049)
Obs (firm-month)	8,581	7,145	8,581	7,145	8,582	7,150	8,582	7,150
R-squared (within)	0.1840	0.1883	0.1838	0.1884	0.4718	0.4992	0.4720	0.4995
Number of clusters	106	99	106	99	106	99	106	99
F statistic	164.2872	131.2653	125.1299	100.1854	116.2512	114.0222	100.3655	95.3091
Rho	0.0381	0.0325	0.0383	0.0326	0.2148	0.2099	0.2157	0.2103
Sigma_U	0.0300	0.0275	0.0300	0.0275	0.1266	0.1221	0.1269	0.1222
Sigma_E	0.1505	0.1498	0.1506	0.1498	0.2421	0.2369	0.2420	0.2369

Figure 1

Non-monotonic relationship between hedging maturity and leverage for gas hedgers

This figure illustrates the relation between hedging maturity and leverage ratio by: $Maturity = \alpha \times LEV + \beta \times LEV^2$ with α and β coming from the estimation of our base model SYS-GMM in table 6. The coefficients α and β equal 1.45 and -1.13 for swap contracts, 3.24 and -5.44 for put options, and 1.05 and -0.63 for costless collars (see Table 6 Columns 4, 8 and 12). For Fehle and Tsyplakov (2005), α and β equal 0.70 and -0.69 (see Table 15, pp.40 from Fehle and Tsyplakov (2005)).

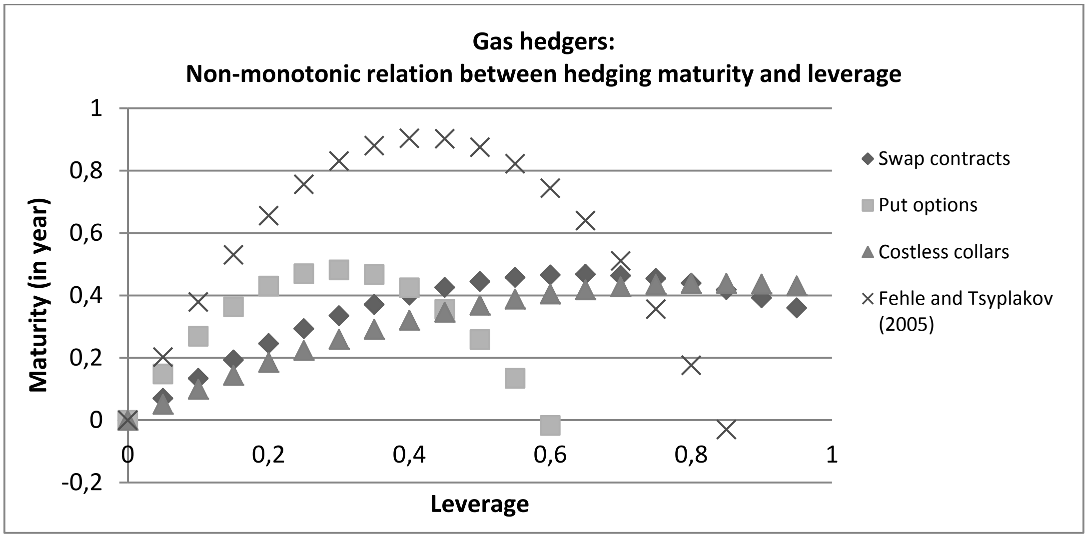

Figure 2

Non-monotonic relationship between hedging maturity and leverage for oil hedgers

This figure illustrates the relation between hedging maturity and leverage ratio by: $Maturity = \alpha \times LEV + \beta \times LEV^2$ with α and β coming from the estimation of our base model SYS-GMM in Table 7. The coefficients α and β equal 0.86 and -0.70 for swap contracts, 1.63 and -1.35 for put options, and 0.82 and -1.00 for costless collars (see Table 7 Columns 4, 8 and 12). For Fehle and Tsyplakov (2005), α and β equal 0.70 and -0.69 (see Table 15, pp.40 from Fehle and Tsyplakov (2005)).

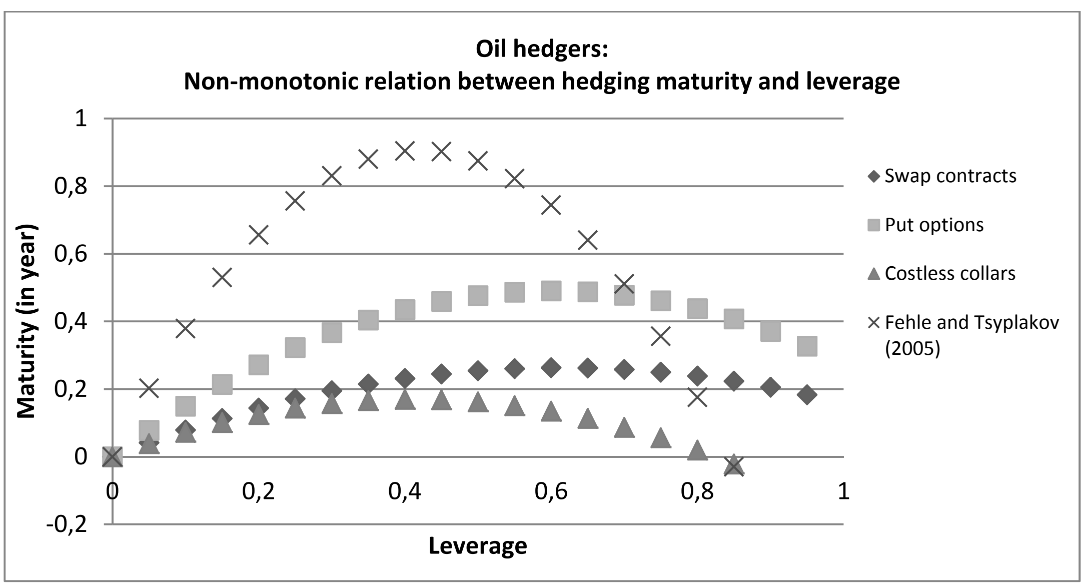

Figure 3

Non-monotonic relationship between hedging maturity and gas spot prices for gas hedgers

This figure illustrates the relation between hedging maturity and leverage ratio by: $Maturity = \alpha \times GAS\_SPOT + \beta \times GAS\_SPOT^{2}$ with α and β coming from the estimation of our base model SYS-GMM in Table 6. The coefficients α and β equal 0.131 and -0.008 for swap contracts, 0.146 and -0.007 for put options, and 0.100 and -0.005 for costless collars (see Table 6 Columns 2, 6 and 10).

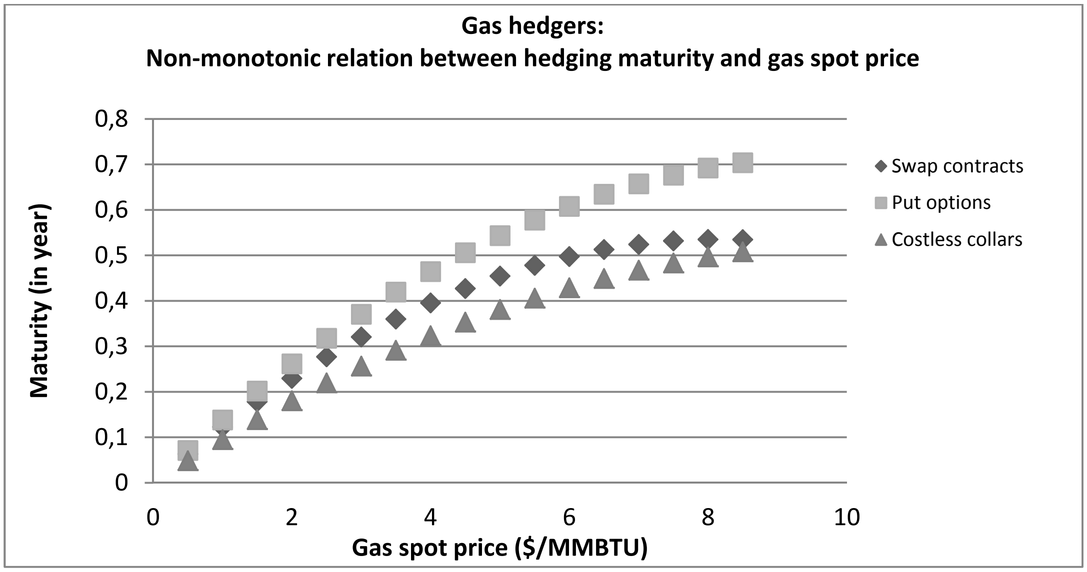

Figure 4

Non-monotonic relationship between hedging maturity and oil spot prices for oil hedgers

This figure illustrates the relation between hedging maturity and leverage ratio by: $Maturity = \alpha \times OIL\_SPOT + \beta \times OIL\_SPOT^{2}$ with α and β coming from the estimation of our base model SYS-GMM in Table 7. The coefficients α and β equal 0.015 and -0.0001 for swap contracts, 0.0043 and -0.00000185 for put options, and 0.008 and -0.00004 for costless collars (see Table 7 Columns 2, 6 and 10).

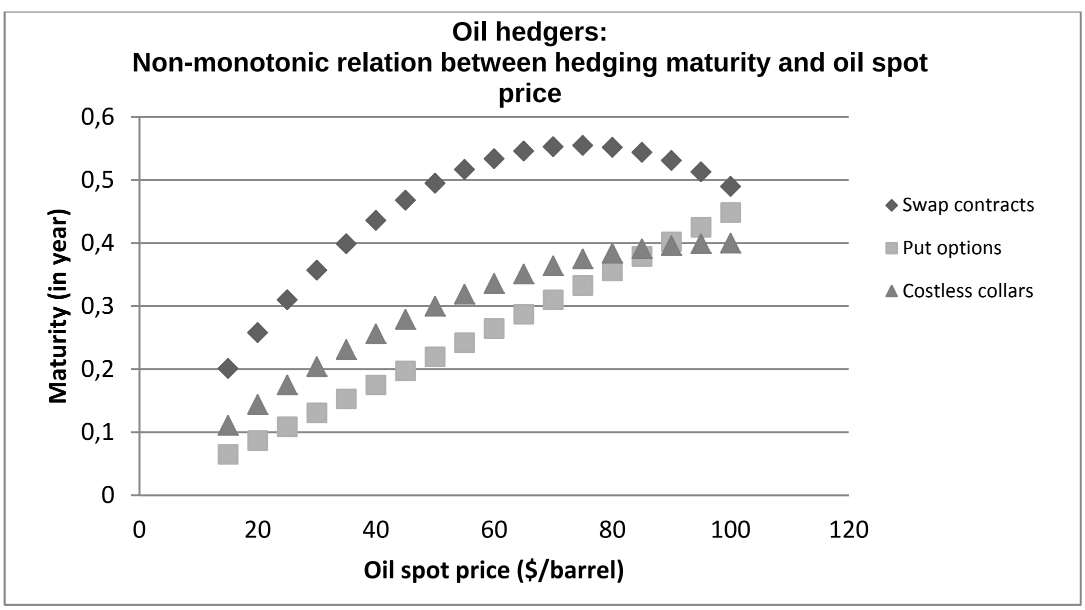

Table A.I: First Step of the Two-Step Heckman regressions with sample selection: Determinants of the oil or gas hedging decision

This table reports the coefficients estimates of the Probit model. The dependent variable is the hedging decision dummy variable that takes the value of 1 if the oil and gas producer have any oil and gas hedging position for the quarter and 0 otherwise. The independent variables are: *TAX_SAVE* for the expected percentage of tax saving; *LEVERAGE* for the leverage ratio measured by the book value of long-term debt scaled by the book value of total assets; *CASH_COST* is the production cost per Barrel of Oil Equivalent (BOE); *BVCD* for the book value of convertible debt scaled by the book value of total assets. *Q_RATIO* for the quick ratio measured by the book value of cash and equivalent of cash scaled by the book value of current liabilities; *RES_OIL* and *RES_GAS* are the quantities of proven reserves for oil (for oil hedgers) and gas (for gas hedgers); *MKT_VALUE* measured by the logarithm of the market value of common shares outstanding (i.e., closing price at the end of the quarter multiplied by the number of common shares outstanding); *SALES* measured by the logarithm of sales at the end of the quarter. Standard errors are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Variable	Oil hedge	Gas hedge
TAX_SAVE	0.9005**	0.1232
	(0.366)	(0.428)
LEVERAGE	1.5843***	1.9170***
	(0.091)	(0.096)
CASH_COST	0.0398***	0.0605***
	(0.003)	(0.005)
BVCD	-1.2947***	-1.2417***
	(0.246)	(0.214)
Q_RATIO	-0.1056***	-0.1288***
	(0.014)	(0.014)
RES_(OIL/GAS)	-0.0009***	-0.0001***
	(0.000)	(0.000)
MKT_VALUE	0.3924***	0.5700***
	(0.043)	(0.043)
SALES	0.1994***	0.0894***
	(0.019)	(0.017)
CONSTANT	-2.2678***	-2.1663***
	(0.088)	(0.089)
Observations	5,798	5,798
Pseudo-R squared	0.3025	0.3129
Chi-squared	2399.4838	2512.4946
Significance	0.0000	0.0000