The Impact of Hedging on Stock Returns and Firm Value: New Evidence from Canadian Oil and Gas Companies

Chang Dan, Hong Gu and Kuan Xu*

*Chang Dan, Financial Analyst, Chang Jiang Securities, Wuhan, China. Hong Gu, Associate Professor of Statistics, Department of Mathematics and Statistics, Dalhousie University, Halifax, Canada. Kuan Xu, Professor of Economics, Department of Economics, Dalhousie University, Halifax, Canada. Correspondence: Kuan Xu, Department of Economics, Dalhousie University, Halifax, Nova Scotia, Canada B3H 3J5. E-mail: kxu@is.dal.ca. We thank Shamsud Chowdhury, Iraj Fooladi, Greg Hebb, Yanbo Jin, Barry Lesser, Maria Pacurar, John Rumsey, Oumar Sy and participants of the School of Business and the Department of Economics Seminars at Dalhousie University for their helpful comments on the earlier draft of this paper. Remaining errors are, of course, the responsibility of authors.

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Abstract

In this paper we analyze (a) the impact of hedging activities on the relationships between oil and gas prices/reserves and stock returns and (b) the role of hedging on firm value among large Canadian oil and gas companies. Differing from the existing literature this research attempts to explore possible nonlinear impact of hedging activities, which may not be fully revealed in the traditional linear framework. By using generalized additive models, we find that factors that affect stock returns and firm value are indeed nonlinear. The large Canadian oil and gas firms are able to hedge against downside risk induced by unfavorable oil and gas price changes. But gas hedging appears to be more effective than oil hedging when downside risk presents. In addition, oil reserves tend to have a positive (negative) impact on stock returns when the oil prices are increasing (decreasing). Finally, hedging, in particular hedging for gas, together with profitability, leverage and reserves, has a significant impact on firm value.

Keywords: hedging, risk management, oil and gas, equity returns, Tobin's Q ratio, generalized additive model, semi-parametric model, nonlinearity

JEL classification: G100, C100

1 Introduction

According to the Modigliani-Miller theorem, in a perfect financial market, hedging would add no value to the firm when there is no asymmetric information, taxes, or transaction costs. However, in the real world, this conclusion may not hold because the assumptions on which the theorem is based are generally violated.

Maximizing shareholder value is one of the main aims of the corporate management. Maximizing shareholder value means maintaining and increasing the cash flow of the corporation over time. The literature on hedging notes that there are three main motivations for firms to hedge. First, hedging is used to reduce financial distress and avoid underinvestment [see, for example, Smith and Stulz (1985), Mayers and Smith (1990), Stulz (1990), Froot et al. (1993), Allayannis and Mozumdar (2000), and Adam (2002)]. Second, hedging is used to reduce expected tax costs [see, for example, Smith and Stulz (1985), Graham and Smith (1999), and Graham and Rogers (2002)]. Third, hedging can alleviate the manager's personal risk exposure [see, for example, Stulz (1984), Smith and Stulz (1985), DeMarzo and Duffie (1995), Tufano (1996), Whidbee and Wohar (1999), and Dionne and Triki (2005)].

The literature on the effectiveness of hedging has focused primarily on the hedging activities in the financial and commodity risk management. For financial risk management, Jorion (1990) illustrates that the foreign currency beta of the U.S. multinational companies is close to zero, meaning hedging on foreign currency does not influence firm value at all. Geczy et al. (1997) analyze foreign currency derivatives of Fortune 500 companies and find that hedging for foreign currency risk is more difficult to evaluate in multinational companies because the net impact of hedging can be distorted by many other factors such as foreign sales, foreign-denominated debts, foreign taxes, etc. On the other hand, Gagnon et al. (1998) employ constructed currency portfolios to show that dynamic hedging strategies can indeed reduce risk. Allayannis and Weston (2001) directly study the relationship between foreign currency hedging and firm value measured by Tobin's Q ratio of the U.S. non-financial firms and find that hedging is positively related to firm value. Bartram et al. (2006) examine a large sample of multi-industry companies and find that interest rate hedging, not currency hedging, has a positive impact on firm value.

For commodity hedging, Tufano (1996) studies the hedging activities of North American gold mining firms and finds little evidence to support risk management as a means of maximizing shareholder value. Rajgopal (1999) analyzes the informational role of the Securities and Exchange Commission (SEC)'s market risk disclosures of thirty-eight U.S. oil and gas companies and finds that oil and gas reserves, not hedging, have a positive impact on the relationship between stock returns and oil and gas prices. Jin and Jorion (2006) extend the work of Rajgopal (1999) and find that hedging can weaken the relationship between stock returns and oil and gas prices while oil and gas reserves can strengthen the relationship. On the other hand, Carter et al. (2006) investigate hedging for jet fuel by firms in the U.S. airline industry and find that jet fuel hedging increases firm value of the airline industry.

This paper therefore draw lessons from Rajgopal (1999), Allayannis and Weston (2001), and Jin and Jorion (2006) to examine, for large Canadian oil and gas companies, (a) the impact of hedging activities on the relationships between oil and gas prices/reserves and stock returns and (b) the role of hedging on firm value.[1] These companies are known for using hedging to reduce the impact of oil and gas price volatility. But there is no systematic study, neither is there any empirical evidence, on the role that hedging activities have played in the Canadian oil and gas industries. This study

[1]As pointed out by Jin and Jorion (2006), studying oil and gas industries for hedging has a number of advantages. First, the volatility of oil and gas prices can influence the cash flow of oil and gas companies directly and immediately. Second, the homogeneity of the oil and gas industries renders the study of hedging effects on Tobin's Q ratio based on the oil and gas industries more appropriate than those multi-industry studies where other significant factors may come into play. Third, because oil and gas reserves are main parts of the value of oil and gas companies, hedging may potentially influence profitability and firm value.

uses a unique data set manually collected from large Canadian oil and gas companies during the period of 2000-2002.

For the purpose of this study, we note that the linear models traditionally employed in the existing research literature may be too restricted for identifying heterogenous impact. Therefore, this research adopts the flexible generalized additive models (GAM) [see Hastie (1990), Hastie and Tibshirani (1990), Wood (2000), Venables and Ripley (2002), and Wood (2004)], which is semi-parametric in nature. As shown later in the paper, GAM is statistically superior to the linear model because GAM can accommodate both linear and nonlinear relationships without being restricted to the former.

By using a more general methodology and the unique Canadian data, this research presents new empirical evidence on the role of hedging and oil and gas reserves in the Canadian oil and gas sector. This research finds that the large Canadian oil and gas firms are able to use hedging to protect downside risk against unfavorable oil and gas price changes. But gas hedging appears to be more effective than oil hedging when downside risk presents. In addition, oil reserves tend to have a positive (negative) impact on stock returns when the oil prices are increasing (decreasing). Finally, hedging, in particular gas hedging, together with profitability, leverage and reserves, has a significant impact on firm value.

The remainder of the paper is organized as follows. Section 2 explains the data collection and sample information. Section 3 reports the findings about the impact of hedging activities on the relationships between oil and gas prices/reserves and stock returns. Section 4 discusses the findings of the impact of hedging on firm value. Finally, Section 5 offers concluding remarks.

2 Data and Sample Description

There are several issues that one must face in the data selection from the universe of the Canadian oil/gas exploration and production companies. First, the Canadian economy has a strong resources and mining sector with many oil and gas exploration and production firms. Many of them, however, are small exploration firms and generally not involved in hedging activities.[2] Hence we need to select relatively large and mature oil and gas exploration and production firms which are involved in hedging activities. Second, some of the large oil and gas companies with hedging activities are integrated oil and gas companies. That is, they are not only involved in the oil and gas exploration but also engaging in refinery and marketing. In order to evaluate the role of hedging activities, it is essential to include these companies. Ignoring them would cause the loss of valuable information and lead to a rather small sample. Third, some substantial oil and gas players in Canada are partly owned by international corporations and partly owned by investors in Canada (for example, Imperial Oil is partly owned by ExxonMobil in the US, Husky Energy is partly owned by Hutchison Whampoa in Hong Kong, China, and Shell Canada is partly owned by the Royal Dutch Shell in Holland[3]). These oil and gas firms also constitute a large share of the Canadian oil and gas sector and should be duly included. Fourth, Canadian economy is about one-tenth of the size of the US economy. Compared with the similar studies on the US oil and gas sector, the Canadian sample size would be considerably smaller although the oil and gas sector is a significantly large sector in Canadian economy.

In order to find a largest relevant sample of oil and gas companies in Canada, we have selected oil and gas companies with market value more than Cdn$500 million in 2004.[4] Thirty-eight oil/gas exploration and production companies (for example, EnCana, Cana-

[2] Haushalter (2000) also notes that in the U.S. large oil and gas firms are more likely to hedge.

[3] After the sample period, Shell Canada had been taken over by its parent.

[4] The hedging activities and records of these oil and gas firms are more likely to be available and documented systematically. SEDAR is developed in Canada for the Canadian Securities Administrators (CSA). The annual reports from SEDAR are available in www.sedar.com.

dian Natural Resources, Talisman Energy, and Nexen) and eight oil integrated companies (for example, Suncor Energy, Petro-Canada, Imperial Oil, and Husky Energy) meet the criterion. Thirty-three oil and gas companies of the above list have filed reports with the System for Electronic Document Analysis and Retrieval (SEDAR) during the period of 2000-2002. Thus, we have eighty-eight firm-year data, of which seventy-one firm-year data (about 80.7%) are for oil and gas exploration and production companies and seventeen firm-year data (about 19.3%) are for integrated oil companies. The largest five companies in the sample are Encana,[5] Imperial Oil, Shell Canada, Suncor Energy, and Petro-Canada, whose average market value is Cdn$23.8 billion in 2004. The smallest five firms are Gastar Exploration, Crescent Point Energy, Nuvista Energy, Ketch Resource, and Pan-Ocean Energy, whose average market value is about Cdn$522 million in 2004. Because we are interested in the hedging information of the selected firms, we use the financial market and accounting data of these firms for the period of 2000-2002.

When we analyze the impact of hedging on the relationship between oil and gas prices and stock returns, we use the monthly oil and gas prices from the New York Mercantile Exchange (NYMEX) and monthly stock returns of these oil and gas firms from Datastream. The monthly data are then combined with the annual accounting and hedging data, which are detailed in the following part of this paper.

All the hedging information of the sample is from the annual reports of selected companies filed at SEDAR or posted at the companies' websites. The existing research collect the hedging information primarily from the 10-K annual reports.[6] In 1997, the U.S. Securities and Exchange Commission (SEC) declared Financial Reporting Release No.48 (FRR 48), which requires disclosure for market risk for all firms for the fiscal year ending after June 15th, 1998.[7] However, there is no such regulation for Canadian com-

[5]Encana was established from merging Alberta Energy Company Ltd. and PanCanadian Energy Corporation in 2001.

[6]See, for example, Allayannis and Weston (2001) and Jin and Jorion (2006).

[7]Under this regulation, U.S. firms are required to report in their annual reports quantitative information on exposures of contract amounts and weighted average spot prices for forwards and futures;

panies at the time of the data collection. Hedging information may be found directly in two parts of an annual report: (a) Risk Management of Management's Discussion and Analysis and (b) Financial Instruments in Notes of Consolidated Financial Statement (see Appendix 1 for an example). In general, the information in Management's Discussion and Analysis highlights the hedging activities in the fiscal year. The information in Financial Instruments in Notes of Consolidated Financial Statement details hedging contracts such as outstanding hedging contract at the end of the fiscal year. The main hedging instruments used by Canadian oil and gas companies are fixed-price contracts, forwards, received-fixed swaps and options (including collars and three-way options) (see Appendix 2 for details).

We calculate individual contract deltas and sum them up for each firm for each fiscal year. This sum is a measure for the degree of hedging in each firm for that year. This method of calculating each delta is detailed in Table 1. The total delta value of crude oil and natural gas hedging for each firm-year is the sum of the products of deltas and their corresponding notional dollar values of all hedging contracts [The notional output measure of crude oil is expressed in barrel (bbl) and that of natural gas contracts is presented in million of British thermal unit (mmbtu)].

The value of delta computed as such is a non-positive number. We must multiply negative one to the value of delta to reflect the positive role of the adjusted total deltas in the stock return and firm value. The total delta value is then scaled by the annual production or the commodity reserves, named adjusted delta, such as the adjusted delta of oil production and that of oil reserves. We use gas production and gas reserves as an example to show how the adjusted deltas are defined:

$$Adjusted\ delta\ of\ gas\ production\ (Dgp) = -\left(\frac{Total\ delta\ value\ of\ gas\ hedging}{Value\ of\ next\ year\ gas\ production}\right)$$

weighted average pay and receive rates and/or prices for swaps; contract amounts and weighted average strike prices for options.

Table 1: Delta and Hedging Instruments

Delta	Hedging Instrument
-1	short *linear* contracts, including short futures and forwards, fixed-priced contracts, fixed-received swaps and volumetric production arrangements
value from Black-Scholes option models	*non-linear* contracts, including options, collars and three-way options

Note: The value of each contract is mark to the market.

$$Adjusted\ delta\ of\ gas\ reserves\ (Dgr) = -\left(\frac{Total\ delta\ value\ of\ gas\ hedging}{Value\ of\ same\ year\ gas\ reserve}\right)$$

That is, the adjusted delta of production, *Dgp*, represents the percentage of next year production that is effectively hedged, while the adjusted delta of reserves, *Dgr*, gives the proportion of current reserves that is effectively hedged. We use *Dop* and *Dor* to denote the adjusted deltas of oil production and oil reserves, respectively.

Table 2 shows the hedging and non-hedging information of the firm-years in the sample. There are 25 non-hedging (in both oil and gas) firm-years (about 28.4% of the sample), 56 firm-years hedging oil prices exposure (about 63.7% of the sample), 50 firm-years hedging gas prices exposure (56.8% of the sample), and 43 firm-year hedging both oil and gas prices exposure (about 48.9% of the sample).

Table 3 illustrates the basic statistics of the adjusted deltas. In terms of the number of the firms that hedge, Canadian oil and gas companies hedge less relative to the oil and gas reserves than the U.S. oil and gas companies do. The average *Dop*, *Dgp*, *Dor* and *Dgr* of the U.S. oil and gas companies are 33%, 41%, 4% and 5% respectively,

Table 2: Description of Firm-years: Hedging and Non-hedging

	Gas: Hedging Firm-year Count (%)	Gas: Non-Hedging Firm-year Count (%)	Total Firm-year Count (%)
Oil: Hedging Firm-year Count(%)	43 (48.9)	13 (14.8)	56 (63.7)
Oil: Non-Hedging Firm-year Count(%)	7 (8.0)	25 (28.4)	32 (36.3)
Total Firm-year Count(%)	50 (56.8)	38 (43.2)	88 (100)

Table 3: Basic Statistics of Adjusted Deltas

Adjust Delta	Mean	Standard Deviation	No. of Firm-years
Oil Production (*Dop*)	14.6%	20.4%	88
Gas Production (*Dgp*)	8.1%	14.8%	88
Oil Reserves (*Dor*)	1.8%	2.6%	88
Gas Reserves (*Dgr*)	1.3%	2.9%	88
Production Average	11.4%		
Reserves Average	1.6%		

while those of Canadian oil and gas companies in this study are 14.6%, 8.1%, 1.8% and 1.3%, respectively.[8] These numbers show that the U.S. companies are more likely to employ risk management than their Canadian counterparts are. However, the standard deviations of *Dop* and *Dgp* for the U.S. data are 33% and 40% respectively, higher than those of the Canadian sample — 20.4% and 14.8%. This suggests that the large Canadian oil and gas companies are more homogeneous in hedging than their U.S. counterparts.

[8]See Jin and Jorion (2006) for the U.S. numbers.

In this paper, we use the following equation for the Q ratio:[9]

$$Q = \frac{Book\ value\ of\ liabilities + Market\ value\ of common\ equity}{Book\ value\ of\ total\ assets}.$$

The market value of common equity can be found in the Datastream database. The book value of liabilities and total assets are from the annual reports.[10]

Panel A in Table 4 shows the summary statistics of total assets (in millions of Canadian dollars), market value of equity (in millions of Canadian dollars), and the corresponding Q ratios. The average Q ratio is 1.56, which is similar to that of the U.S. The standard deviations of the Canadian oil and gas companies' total assets and market value of common equity are huge. Panels B and C of Table 4 illustrate the basic statistics of the firms with hedging activities for oil and gas prices, respectively. On average, these firms hedge about 23.0% of their next year oil production, which amounts to about 3.0% of their oil reserves, and about 18.0% of their next year gas production, which represents about 2.0% of their gas reserves. All the ratios are less than those of the U.S. oil and gas companies. The Canadian oil and gas companies do not hedge as much as their U.S. competitors do. The average Q ratio for oil hedging firms is 1.35, while that of gas hedging firms is 1.31. Panel D of Table 4 shows the basic statistics of the firms without any hedging activities. The large standard deviations of total assets and market value of equity in non-hedging companies show that non-hedging occurs at both large and small firms and it is not dependent on the firm size. The average Q ratio for non-hedging firms is 2.00.

[9] Tobin suggested that the combined market value of all the companies on the stock market should be equal to their replacement costs [Tobin (1969) and Hayashi (1982)]. The Q ratio is theoretically defined as the market value of a firm's assets divided by the replacement value of the firm's assets. When the assets are priced properly in the capital market, the Q ratio should be equal to one. The change of the Q ratio is an direct measure of the change of the firm value in the capital market.

[10] However, several companies do not have necessary market information such as market value and stock prices during the period of 2000-2002 in the Datastream database due to mergers and corporation reconstruction. Only twenty-eight companies and seventy-six firm-years are therefore used.

Figure 1: Book Value of Total Asset with or without Hedging

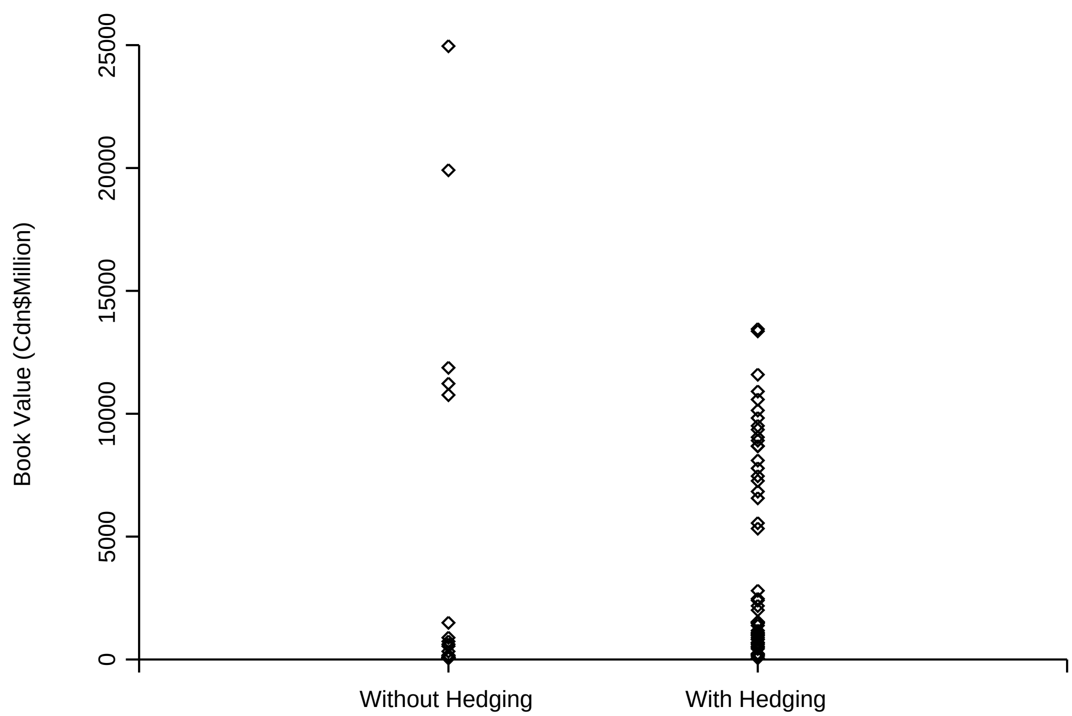


Figure 1 plots the book values of total assets of the oil and gas firms with or without hedging. It shows that non-hedging companies vary substantially in size (both very small and very large) while the hedging companies are concentrated in a particular range in terms of the values of total assets. This may reflect the fact that very large firms tend to be integrated oil companies which can diversify their operations in both up- and down-streams of the exploration, production, and distribution processes.

Table 4: Basic Statistics of Adjusted Deltas

Panel A: All Firm-years				
	No. of Obs.	Mean	Std. Dev.	Median
Total Assets (Cnd$M)	76	4019.22	5195.44	1135.98
MVE (Cnd$M)	76	3574.25	4857.15	838.46
Q ratio	76	1.56	0.93	1.34
Panel B: Firm-years with Hedging Activities for Oil				
	No. of Obs.	Mean	Std. Dev.	Median
Total Assets (Cnd$M)	46	4356.03	4302.58	1857.33
MVE (Cnd$M)	46	3740.24	4083.39	1406.85
Dop	46	0.23	0.22	0.18
Dor	46	0.03	0.03	0.02
Q ratio	46	1.35	0.49	1.26
Panel C: Firm-years with Hedging Activities for Gas				
	No. of Obs.	Mean	Std. Dev.	Median
Total Assets (Cnd$M)	41	4318.25	4323.21	2001.12
MVE (Cnd$M)	41	3180.61	3350.00	1263.33
Dgp	41	0.18	0.21	0.06
Dgr	41	0.02	0.03	0.01
Q ratio	41	1.31	0.40	1.24
Panel D: Firm-years without Hedging Activities				
	No. of Obs.	Mean	Std. Dev.	Median
Total Assets (Cnd$M)	23	3670.47	7059.76	167.30
MVE (Cnd$M)	23	3663.59	6628.01	260.50
Q ratio	23	2.00	1.47	1.81

Note: Total Assets represent the book value of assets. MVE represents the market value of equity. Total assets and MVE are in million Canadian dollars (Cdn$M). *Dop* and *Dor* denote the adjusted deltas of oil production and reserves, respectively. *Dgp* and *Dgr* denote the adjusted deltas of gas production and reserves, respectively. Panel A shows the statistics for the all firm-years. The statistics for subsamples of firm-years with hedging activities for oil and gas are reported, respectively, in Panels B and C. Panel D illustrates the statistics of firm-years without any hedging activities.

3 Impact of Hedging on the Relationship between Oil and Gas Prices/Reserves and Stock Returns

In this section, we first study the relationship between oil and gas prices and stock returns directly based on the monthly data. Then we extend the previous model in a more general setting to examine whether or not oil and gas hedging can moderate the impact of oil and gas price changes on stock returns.

As shown in Figure 2, monthly stock returns of hedging firms appear to have slightly lower volatility than those of non-hedging firms during the period of 2001-2002. But it is still unclear as what roles that hedging may play. Therefore, we need to study this in depth using the multi-factor models.

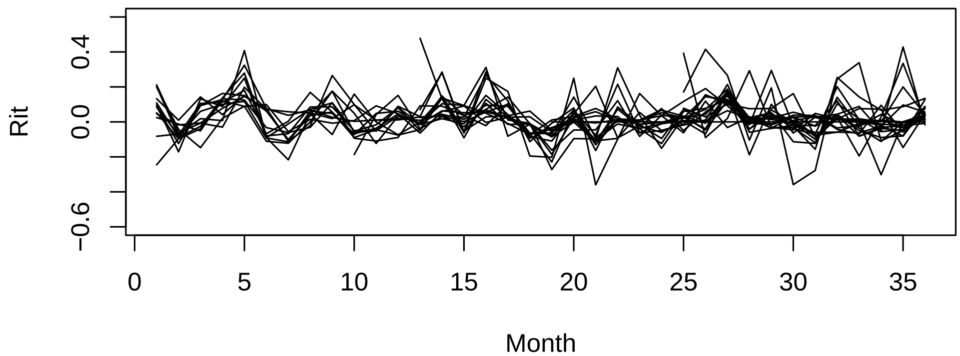
To examine the relationship between oil and gas price changes and stock returns, we first adopt the following model:

$$R_{it} = \alpha + \beta_m R_{mt} + \beta_o R_{ot} + \beta_g R_{gt} + \varepsilon_{it} \tag{1}$$

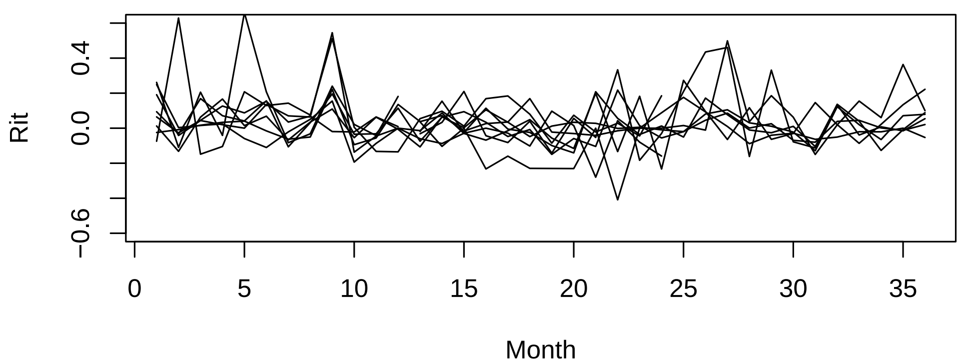
where R_{it} is the stock return for firm i at time t; R_{mt} denotes the market-index return or the S&P/TSX 60 index return at time t;[11] R_{ot} is the percentage change in the price of NYMEX near futures contracts for oil ("oil price change" hereafter) at time t; R_{gt} is the percentage change in the price of NYMEX near futures contracts for natural gas ("gas price change" hereafter) at time t; and ε_{it} is the error term for firm i at time t in this model. The advantage of this model is that betas associated with oil and gas price changes may illustrate the role of hedging indirectly. If these betas are close to zero, this indicates that stock returns are not sensitive to these price changes.

[11] The S&P/TSX 60 index consists of 60 largest (measured by market capitalization) and most liquid (heavily traded) stocks listed on the Toronto Stock Exchange (TSX). They are usually domestic or multinational industry leaders in Canada.

Figure 2: Monthly Stock Returns with or without Hedging



Stock Returns vs. Time with Hedging



Stock Returns vs. Time without hedging

The time dummy and firm dummies are also tested in the model but they are not statistically significant. Hence, we pool the cross-sectional and time series data to estimate this model. Furthermore, because of their resulting extreme Cook's distance in the stock return estimates, some data points (Gastar Exploration in February 2002 and Peyto Exploration and Development in October 2001) are excluded from the sample.[12]

Table 5 shows the estimation results for the pooled monthly data during the period of 2000-2002. Panel A of Table 5 reports the linear relationships that stock returns have with oil and gas price changes. These relationships are mostly positive and statistically significant. On average, a 1% change in oil price leads to a 0.26% change in stock returns. This Canadian result is similar to that found by Rajgopal (1999) and Jin and Jorion (2006). But a 1% change in gas price only leads to a 0.10% change in stock returns, which is much lower than that of Rajgopal (1999) (0.41%) or Jin and Jorion (2006) (0.29%). The stock returns of these Canadian companies do not respond to gas price changes as much as they do to oil price changes. However, we note that the value of the beta associated with the market-index return is small and statistically insignificant. At this point, we do not know if stock returns and the market-index return could relate to each other nonlinearly.

To explore possible nonlinear relationships, we extend our analysis by using the generalized additive model (GAM),[13] which can be viewed as an extension of the generalized linear model (GLM).[14] The advantage of GAM over GLM is that GAM is a more flexible model for identifying nonlinear effects (Please see Appendix 3 for details).

Figure 3 and Panel B of Table 5 show that the nonlinear effects of changes in oil and gas prices on stock returns are very significant. In GAM, the χ^2 test is performed to

[12] Cook's distance is a metric for measuring the influential data points. A large Cook's distance for a data point indicates that the data point is influential in the linear regression [see Chambers and Hastie (1992), p. 230].

[13] See Hastie (1990), Hastie and Tibshirani (1990), Wood (2000), Venables and Ripley (2002), and Wood (2004).

[14] See McCullagh and Nelder (1989).

test the nonlinearity of each s function. It turns out that stock returns have nonlinear relationships with all of the three explanatory variables. The more flexible GAM fits the data better than the linear model and its R^2-adj reaches 0.194, a substantial increase from that of the linear model.

Figure 3 shows the estimated nonlinear effects of the explanatory variables on stock returns. These nonlinear effects take the form of $s(x, d)$, where $s(\cdot)$ represents the marginal impact of an explanatory variable x with d degrees of smoothness (see Appendix 3 for details). For simplicity, we suppress d in $s(x, d)$ so that we write $s(x)$ as the marginal impact of x on s. First, we note that $s(R_{mt})$ is quite flat when $R_{mt} > 0$. But $s(R_{mt})$ becomes negative at $R_{mt} = -0.10$ and becomes positive at $R_{mt} = -0.05$. In other words, stock returns of oil and gas companies do not have a linear sensitivity to the market-index return. Clearly, this nonlinear relationship could not be identified in the linear model. Second, we find that $s(R_{ot})$ has a slightly positive slope. $s(R_{ot})$ becomes negative when $R_{ot} = -0.05$ and becomes positive when $R_{ot} > 0.10$. If the oil price falls more than 5%, stock returns go down but do not fall as fast as the oil price does. If the oil price rises more than 10%, stock returns rise but do not rise as fast as the oil price does. This could result from some form of hedging. Third, we note that $s(R_{gt})$ has a slight negative slope. $s(R_{gt})$ become sensitive to R_{gt} when $R_{gt} < -0.20$ or > 0.20. It implies that stock returns rise when the gas price falls by 20%. However, stock returns fall when the gas price rises more than 20%. This is an indirect evidence of some form of hedging of gas prices.

Now we extend the previous model to examine explicitly whether or not oil and gas hedging can moderate the impact of oil and gas price changes on stock returns:

$$R_{it} = \alpha + \beta_m R_{mt} + [\gamma_1 + \gamma_2 Dop_{it} + \gamma_3 (OR_{it}/MVE_{it})] R_{ot} \qquad (2)$$

$$+[\gamma_4 + \gamma_5 Dgp_{it} + \gamma_6 (GR_{it}/MVE_{it})] R_{gt} + \epsilon_{it}$$

Table 5: Statistical Analysis of Stock Price Exposure

Panel A: Linear Three-factor Model for Stock Returns (R_{it})				
Explanatory Variables	Coefficient	Std. dev.	t-ratio	p-value
Intercept	0.020	0.004	5.044	0.000
R_{mt}	0.017	0.061	0.284	0.777
R_{ot}	0.263	0.050	5.318	0.000
R_{gt}	0.095	0.025	3.810	0.000
No. of obs.	881			
R^2-adj	0.055			

Panel B: Nonlinear Three-factor Model for Stock Returns (R_{it})				
Terms in GAM	Coefficient	Std. dev.	t-ratio χ^2 test for nonlinearity	p-value
Intercept	0.024	0.003	6.967	0.000
$s(R_{mt}, 8.51)$	—	—	62.862	0.000
$s(R_{ot}, 6.19)$	—	—	95.146	0.000
$s(R_{gt}, 4.71)$	—	—	20.009	0.019
No. of obs.	881			
R^2-adj	0.194			

Note: This table illustrates the estimation results of the linear coefficients and nonlinear functions in three-factor model. Panel A represents the estimation results of the linear model:

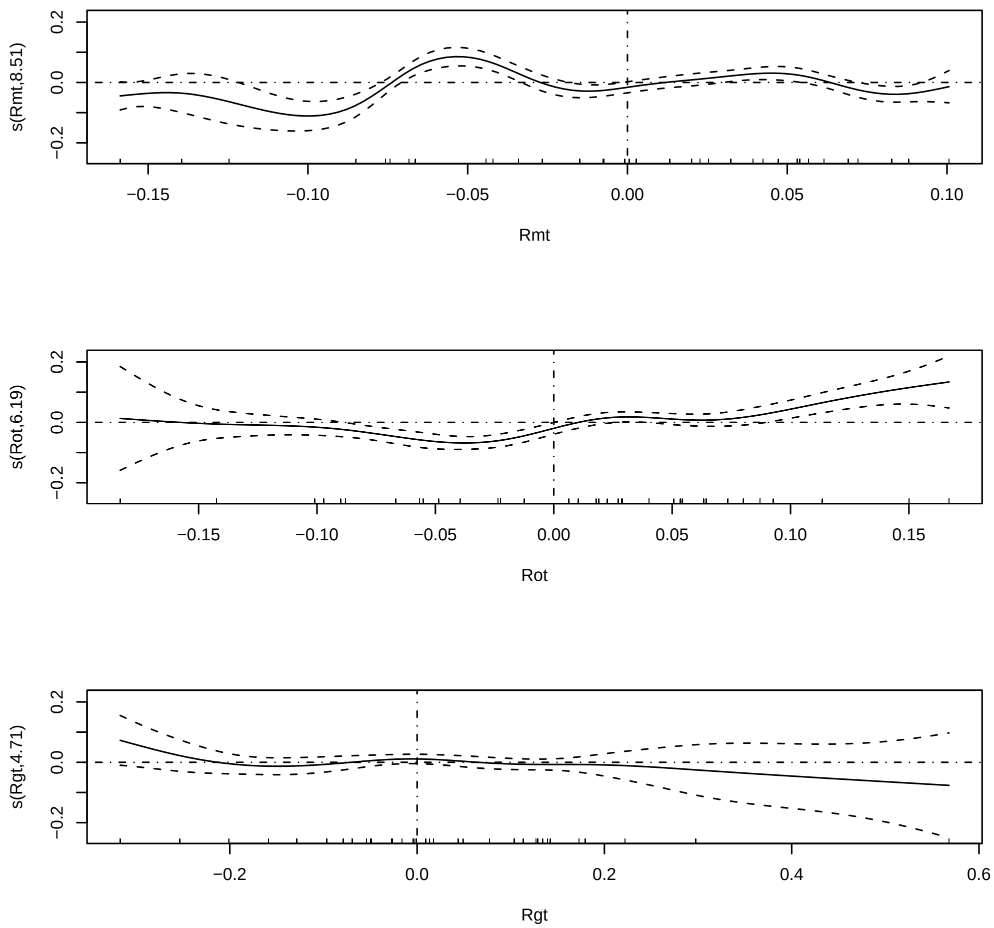
$$R_{it} = \alpha + \beta_m R_{mt} + \beta_o R_{ot} + \beta_g R_{gt} + \varepsilon_{it}.$$

Panel B shows the estimation of the generalized additive model.

$$R_{it} = \alpha + s(R_{mt}) + s(R_{ot}) + s(R_{gt}) + \varepsilon_{it}.$$

Here R_{it}, R_{mt}, R_{ot}, and R_{gt} denote the stock return of firm i at time t , the market-index return at time t, the percentage change in the NYMEX crude oil futures price at time t , and the percentage change in the NYMEX gas future price at time t, respectively. ε_{it} is the error term. The sample includes the pooled monthly data during the period of 2000-2002. $s(x, d)$ denotes the estimated nonlinear function of variable x with d degrees of smoothness.

Figure 3: Nonlinear Variables in the Three-factor Model



Note: This figure shows the estimated nonlinear curves of the variables. R_{mt}, R_{ot}, and R_{gt} denote the market-index return, the oil price change and the gas price change, respectively. $s(x, d)$ denotes the nonlinear function of the variable x with d degrees of smoothness. Solid lines represent estimated nonlinear relationships. Broken lines show 95% confidence interval of nonlinear variables. Dotted lines are reference lines, which have angles of 0 and 90 respectively. The "rug" on the horizontal axis indicates the data density.

where Dop_{it} (Dgp_{it}) is the adjusted delta of oil (gas) production for firm i at time t; OR_{it} (GR_{it}) is the oil (gas) reserves of firm i at time t; and MVE_{it} is the market value of equity for firm i at time t. γ's are parameters and ε_{it} is the error term for firm i at time t. This extended model maintains the key explanatory variables and adds the variables for oil/gas hedging and oil/gas reserves.

The above model is used in the finance literature for the following hypotheses. The first hypothesis is that hedging by a firm can reduce the impact of oil and gas prices on its stock return; or γ_2 and γ_5 are expected to be negative. The second hypothesis is that a firm owning more oil and/or gas reserves has greater risk exposure to changes in oil and gas prices; or γ_3 and γ_6 should be positive. However, as noted that these linear relationships can be quite restricted if the partial responses to some explanatory variables are nonlinear.

Hence we fit both linear and nonlinear models surrounding the specification of equation (3). After an intensive model search, we identify the linear model shown in Panel A of Table 6. In this linear model, the significant explanatory variables are the oil price change, the gas price change, the interaction term between the oil price change and oil reserves, and the interaction term between the market-index return and the gas price change. The estimation results for the Canadian oil and gas companies are similar to those in Rajgopal (1999) and Jin and Jorion (2006) in the sense that they are consistent with the hypotheses for negative γ_2 and γ_5 and positive γ_3 and γ_6. But these parameter estimates are not all statistically significant.[15] Only the parameter estimate associated with the oil reserves is statistically significant but quantitatively small.

To further explore the relationship, we once again implement the more flexible GAM approach. Panel B of Table 6 shows that in addition to the significant explanatory variables in the linear model the market-index return becomes a statistically significant factor in the nonlinear model. In order to evaluate if the nonlinear model is indeed

[15]The presented model excludes the insignificant explanatory variables except R_{mt}.

superior to its linear counterpart, the null hypothesis under which the linear model is true is tested by the F-test based on the difference in deviances between the linear and nonlinear models with the dispersion parameter adjustment. The resultant p-value is close to zero. Hence the nonlinear model provides a better fit for this data. Other model selection criteria, such as the information criterion (AIC) and the goodness of fit (R^2-adj) also confirm this choice. The chosen model has the estimated residuals close to white noise.

In order to evaluate the nonlinear relationships implied by the two previously discussed hypotheses, we use the graphical approach for the nonlinear functions from the semi-parametric model. Panel B of Table 6 and Figure 4 show not only what explanatory variables are statistically significant but also how these variables affect stock returns in nonlinear ways. The first important finding is that the hedging activities on oil and gas in the Canadian companies appear to play little role as both $Dop_{it}R_{ot}$ and $Dgp_{it}R_{gt}$ fail to be statistically significant and hence are excluded from the chosen model.

Figure 4 shows the estimated curves and their 95% confidence intervals for statistically significant nonlinear functions between the statistically significant explanatory variables and stock returns. Specifically, Figure 4 demonstrates that the market-index return R_{mt} has a nonlinear relationship with stock returns $s(R_{mt})$. This nonlinear relationship corresponds to the conventional beta for the market-index return in the linear model. When the market-index return moves up and down by about 5%, stock returns rise. However, when the market-index return moves, up or down, beyond the 5 % stock returns fall.

Figure 4 shows that when the oil price R_{ot} falls by 0-5%, stock returns $s(R_{ot})$ fall. When the oil price R_{ot} rises by more than 10%, stock returns $s(R_{ot})$ rise. There is a positive relationship between the two but the slope of the curve is not as steep. On the other hand, the relationship between the gas price R_{gt} and stock returns $s(R_{gt})$ is fairly flat with the 95% confidence intervals covering zero although the slope of the curve is slightly positive (negative) when $R_{gt} < 0$ ($R_{gt} > 0$). Both nonlinear relationships show some non-responsiveness of stock returns to oil/gas price movements, in particular on the downside. This is consistent with the observation obtained from the previous model that there is an indirect evidence that some form of hedging is taking place.

Corresponding to the hypothesis that oil and gas reserves should be positively related to stock returns in the linear model, Figure 4 shows that the relationship between oil reserves $(OR_{it}/MVE_{it})R_{ot}$ and stock returns $s((OR_{it}/MVE_{it})R_{ot})$ is not linear. Further, the impact of oil reserves on stock returns is much greater in comparison with that of other factors. Stock returns rise when oil reserves marked to the market are higher. But when oil reserves marketed to the market are lower, stock returns fall. That is, oil and gas reserves are more likely to have a positive (negative) impact on stock returns when the oil and gas prices are increasing (decreasing).

Another important finding from Figure 4 is that the interaction term, $R_{mt}R_{gt}$, and its impact on stock returns, $s(R_{mt}.R_{gt})$, have a convex relationship with the positive part being statistically significant. That is, when the stock market and gas price rise or fall at the same time, stock returns increase. In other words, stock returns can benefit from the stock market rise and gas price hike. When the stock market and gas price fall simultaneously, stock returns can still increase if other factors such as hedging, cost cutting, and discovery and/or acquisition of new reserves play a significant role.

4 Hedging and Firm Value

Whether firms that hedge have a higher firm value or a higher Q ratio than those that do not is also an important question in evaluating the role of hedging. Therefore, we compare the values of hedging firms with those of non-hedging firms. Table 7 reports the univariate analysis of the differences in Q ratios, book values of total asset, and market values of equity between oil/gas hedging and non-hedging firms. Panel A and

Table 6: Effect of Hedging and Oil and Gas Prices on Stock Returns

Panel A: Linear Oil and Gas Beta Model (R_{it})				
Explanatory Variables	Coefficient	Std. dev.	t-ratio	p-value
Intercept	0.016	0.004	3.957	0.000
R_{mt}	0.001	0.061	0.013	0.990
R_{ot}	0.175	0.056	3.126	0.002
R_{gt}	0.134	0.028	4.669	0.000
$(OR_{it}/MVE_{it})R_{ot}$	0.008	0.004	2.320	0.021
$R_{mt} * R_{gt}$	0.949	0.357	2.660	0.008
No. of obs.	881			
R^2-adj	0.066			

Panel B: Nonlinear Oil and Gas Beta Model (R_{it})				
Explanatory Variables	Coefficient	Std. dev.	t-ratio χ^2 test for nonlinearity	p-value
Intercept	0.024	0.003	7.090	0.000
$s(R_{mt}, 8.08)$	—	—	68.330	0.000
$s(R_{ot}, 6.59)$	—	—	63.474	0.000
$s(R_{gt}, 2.18)$	—	—	19.593	0.022
$s(OR_{it}/MVE_{it})R_{ot}, 7.79)$	—	—	37.026	0.000
$s(R_{mt} * R_{gt}, 2.54)$	—	—	26.153	0.002
No. of obs.	881			
R^2-adj	0.222			

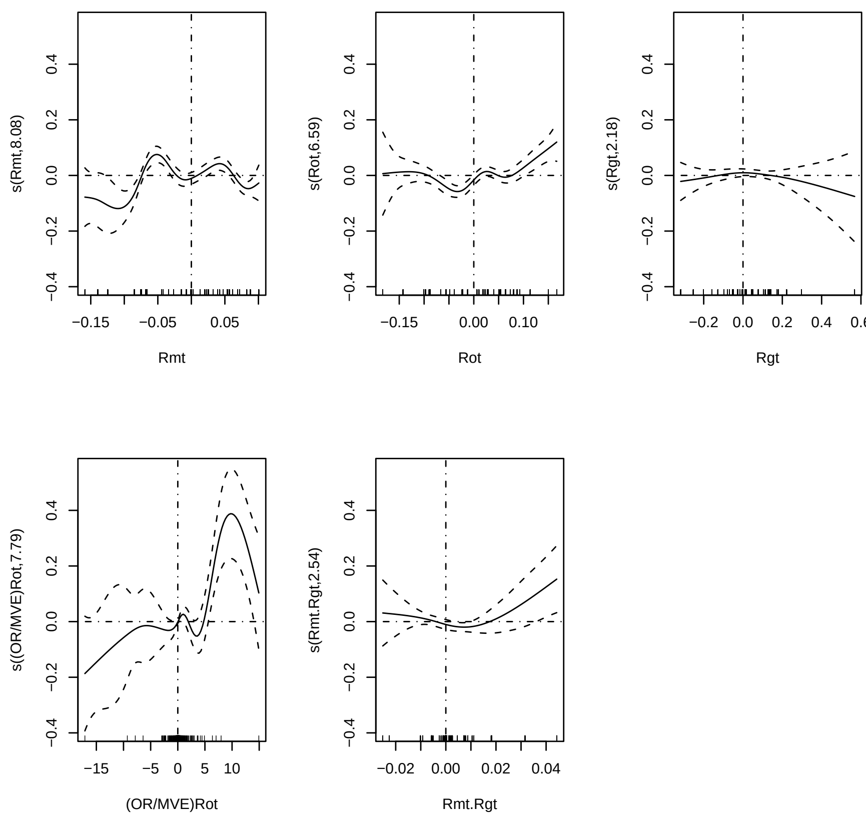
Note: The table shows the pooled cross-section time-series regressions of stock returns on the market and oil (gas) price changes, with coefficients adjusted for the effect of hedging and reserves, for the period of 2000-2002. In Panel A, the joint linear model is given by:

$$R_{it} = \alpha + \beta_m R_{mt} + [\gamma_1 + \gamma_2 Dop_{it} + \gamma_3(OR_{it}/MVE_{it})]R_{ot}$$

$$+[\gamma_4 + \gamma_5 Dgp_{it} + \gamma_6(GR_{it}/MVE_{it})]R_{gt} + \epsilon_{it}$$

R_{it}, R_{mt}, R_{ot}, and R_{gt} denote the stock return of firm i at time t , the market-index return at time t, the percentage change in the NYMEX crude oil futures price at time t , and the percentage change in the NYMEX gas future price at time t, respectively. Dop_{it} (Dgp_{it}) is the adjusted deltas of oil (gas) production of firm i at time t. OR_{it} (GR_{it}) is the value of oil (gas) reserves of firm i at time t. MVE_{it} is the market value of equity of firm i at time t. ε_{it} is the error term. Panel B shows GAM results. $s(x, d)$ denotes the nonlinear function of the variable x with d degrees of smoothness. The sample includes the pooled monthly data during the period of 2000-2002.

Figure 4: Nonlinear Effect of Hedging and Oil and Gas Prices on Stock Returns



Note: This figure shows curves of the significant nonlinear relationships. Rmt (for R_{mt}), Rgt (for R_{gt}), and Rot (for R_{ot}) denote the market-index return, the gas price change and the oil price change, respectively. (OR/MVE)Rot (for $(OR_{it}/MVE_{it})R_{ot}$) denotes the sensitivities to oil reserves. Rmt.Rgt (for $R_{mt}R_{gt}$) is the interaction term between the market-index return and the gas price change. $s(x, d)$ denotes the nonlinear function of the variable x with d degree freedom. Solid lines represent the estimated nonlinear relationships. Broken lines give the 95% confidence intervals of the estimated nonlinear relationships. Dotted lines are reference lines, which have angles of 0 and 90 respectively. The "rug" on the horizontal axis indicates the data density.

B of Table 7 show the basic statistics for the oil hedging firms with respect to non-oil hedging and non-hedging firms, respectively. The similar analysis is reported for the gas hedging firms with respect to non-gas hedging and non-hedging firms, respectively in Panel C and D. Table 7 shows that the differences between hedging and non-hedging firms are primarily in the Q ratio and that the firms with oil and gas hedging tend to have lower Q ratios.

However, the Q ratio is likely to be determined by many different factors and hence we adopt the following more general framework:

$$\ln Q_{it} = \alpha + \beta_1 (Oil\ Heding\ Dummy)_{it} + \beta_2 (Gas\ Hedging\ dummy)_{it} \tag{3}$$

$$+\beta_3 Dop_{it} + \beta_4 Dor_{it} + \beta_5 Dgp_{it} + \beta_6 Dgr_{it} + \gamma (Control\ Variables)_{it} + \varepsilon_{it},$$

where subscript i is for firm i and subscript t is for time t.

As in Allayannias and Weston (2001) and Jin and Jorion (2006), the control variables are return on asset, investment growth, access to financial markets, leverage, and production cost. *Return on assets* (*Roa*) is measured by the ratio of net income to book value of total assets. It is expected to have a positive association with the Q ratio because highly profitable firms tend to have a high Q ratio. *Investment growth* is measured by the ratio of capital expenditure to book value of total assets. It is expected to have a positive coefficient because firm value depends more on future investment. *Access to financial market* is measured by a dividend dummy variable that equals 1 if the firm has paid a dividend in the current year, 0 otherwise. There are two different views on the information role of dividend payment. Some suggest that dividend-paying firms are less financially constrained and may invest in less optimal projects. Hence, they have lower Q ratios [see Allayannis and Weston (2001)]. Others argue that dividend-paying firms typically have good management and hence higher Q ratios [see Jin and Jorion (2006)]. *Leverage* is measured by the ratio of book value of long-term debt to market value of

Table 7: Comparison of Firm Values between Hedging and Non-hedging Firms

Panel A: Oil Hedging and Non-oil Hedging Firms					
Variables	Hedging (46 obs.)	Non-hedging (30 obs.)	Difference	t-test (mean) Z-test (median)	p-value
Q(mean)	1.35	1.87	-0.52	-2.09	0.04
Q(median)	1.27	1.55	-0.28	-2.27	0.02
BV(mean)	4356.03	3502.78	853.25	0.64	0.52
BV(median)	1857.33	433.20	1424.13	2.66	0.01
MVE(mean)	3740.24	3319.73	420.51	0.34	0.74
MVE(median)	1406.85	488.68	918.17	2.01	0.04
Panel B: Oil Hedging and Non-hedging Firms					
Variables	Hedging (46 obs.)	Non-hedging (23 obs.)	Difference	t-test (mean) Z-test (median)	p-value
Q(mean)	1.35	2.00	-0.65	-2.05	0.05
Q(median)	1.27	1.81	-0.55	-1.97	0.05
BV(mean)	4356.03	3670.47	685.56	0.43	0.67
BV(median)	1857.33	167.30	1690.03	2.83	0.00
MVE(mean)	3740.24	3663.59	76.65	0.05	0.96
MVE(median)	1406.85	260.50	1146.35	2.09	0.04
Panel C: Gas Hedging and Non-gas Hedging Firms					
Variables	Hedging (41 obs.)	Non-hedging (35 obs.)	Difference	t-test (mean) Z-test (median)	p-value
Q(mean)	1.31	1.85	-0.54	-2.47	0.02
Q(median)	1.24	1.75	-0.51	-2.63	0.01
BV(mean)	4318.25	3668.93	649.33	0.53	0.60
BV(median)	2001.12	540.60	1460.52	2.82	0.00
MVE(mean)	3180.61	4035.37	-854.76	-0.73	0.47
MVE(median)	1263.33	439.05	824.28	1.74	0.08
Panel D: Gas Hedging and Non-hedging Firms					
Variables	Hedging (41 obs.)	Non-hedging (23 obs.)	Difference	t-test (mean) Z-test (median)	p-value
Q(mean)	1.31	2.00	-0.69	-2.21	0.04
Q(median)	1.24	1.81	-0.57	-2.14	0.03
BV(mean)	4318.25	3670.47	647.79	0.40	0.69
BV(median)	2001.12	167.30	1833.82	3.04	0.00
MVE(mean)	3180.61	3663.59	-482.98	-0.33	0.75
MVE(median)	1263.33	260.50	1002.83	2.38	0.02

Note: This compares means and medians of Q ratios (Q), book values (BV) of total asset and market values of equity (MVE) between hedging and non-hedging companies. Panels A and B show the comparison between oil hedging companies and non-oil hedging and non-hedging companies respectively. Similarly, Panels C and D show the comparisons between gas hedging companies and non-gas hedging and non-hedging companies respectively. A t-test assuming unequal variances is used for comparing means. Wilcoxon ranksum Z-test is used for comparing medians. Two-side p-values are reported. Both BV and MVE are in million Canadian dollar (Cdn$M).

common equity. It is expected to be negatively related to the Q ratio. *Production cost* refers the cost of extracting oil and gas as reported in annual reports. This variable is expected to be negatively related with the Q ratio [see Jin and Jorion (2006)]. Although the book value of total asset can be a reasonable proxy for firm size, we do exclude this variable as a control variable in the model to avoid the endogenous problem because the Q ratio is also directly linked to the book value.

Table 8 illustrates the regression results for both linear and nonlinear models after an intensive model search. The resulting linear model is nested in the selected nonlinear model. Based on the AIC, R^2 and R^2-adj, the nonlinear model has a better fit for the data. The tests based on the difference in deviance and the F-tests also support the conclusion that the nonlinear model, which is the mixture of linear and nonlinear relationships, is superior to the linear model.

Table 8 shows that both selected linear and nonlinear models do not include the following explanatory variables: *investment growth*, *assess to financial market*, *production cost*, *delta values relative to oil production and reserves*, and *oil and gas hedging dummy variables*. These variables, if included in the model, are not statistically significant. Table 8 shows that in both selected linear and nonlinear models only *return on assets*, *leverage*, *adjusted delta of gas production*, and *adjusted delta of gas reserves* are statistically significant. R^2-adj of the nonlinear model is 0.359, higher than that of the linear model (0.242). The nonlinear model contains both linear and nonlinear relationships. Firm value has a positive linear relationship with return on asset and adjusted delta of gas reserves, a negative linear relationship with adjusted delta of gas production, and a nonlinear relationship with leverage.

Because our chosen GAM is fitted on the logarithm of the Q ratio, these partial effects of these explanatory variables may be interpreted as multiplicative explanatory variables for the Q ratio itself. Each penal in Figure 6 shows the partial effect of the explanatory variable on $\ln Q$ while holding other explanatory variables fixed. When *Roa* is set to 1%, the Q-ratio is $e^{(2.372)(0.01)} = 1.024$. In other words, 1% increase in *Roa* leads to an increase of 0.024 in the Q ratio. Clearly the higher the return on assets, the higher the Q ratio. When *Dgp* is set to 1%, the Q-ratio is $e^{(-1.731)(0.01)} = 0.983$. That is, 1% increase in *Dgp* leads to a decrease of 0.017 the Q ratio. When *Dgr* is set to 1% the Q ratio is $e^{(10.063)(0.01)} = 1.106$. That is, 1% increase in *Dgr* leads to an increase of 0.106 in the Q ratio. These discovered relationships suggest that higher gas reserves relative to gas production for a given level of hedging activities lead to a higher Q ratio. Finally, *leverage* appears to have a nonlinear relationship with $\ln Q$. When *leverge* takes values between 0%–105%, the Q ratio is around 1. However, when *leverage* rises by more than 150%, the Q ratio falls below 1. This indicates that a moderate *leverage* enhances firm value but high *leverage* reduces firm value.

5 Concluding Remarks

In this research, we have examined the impact of hedging on stock returns and firm value among large Canadian oil and gas companies during the period of 2000-2002.

We have used nonlinear semi-parametric additive models to accommodate possible nonlinear impact of hedging activities because linear models may be too restrictive. Indeed, our data analysis indicates that nonlinear semi-parametric additive models are superior to their linear parametric counterparts.

By examining the impact of hedging on relationships between stock returns and oil/ gas price changes, we have found that stock returns indeed respond to these price changes in nonlinear ways and stock returns do not fall as oil and gas prices are falling. We have also found that gas hedging appears to be more effective than oil hedging is.

We have further incorporated into our model direct measures of oil and gas hedging and the direct measures of oil and gas reserves. Once again, the oil and gas hedging do

Table 8: Hedging and Firm Value

Linear Model				
Explanatory Variable	Coefficient	Std. dev.	t-ratio	p-value
Intercept	0.437	0.085	5.173	0.000
Dgp	-1.857	0.704	-2.640	0.001
Dgr	10.003	3.735	2.679	0.009
Roa	1.845	0.578	3.194	0.002
Leverage	-0.685	0.182	-3.763	0.000
No. of Obs.	76			
R^2-adj	0.242			
Nonlinear Model				
Explanatory Variable	Coefficient	Std. dev.	t-ratio χ^2 test for nonlinearity	p-value
Intercept	0.194	0.063	3.070	0.003
Dgp	-1.731	0.660	-2.623	0.011
Dgr	10.063	3.492	2.882	0.005
Roa	2.372	0.563	4.213	0.000
$s(Leverage, 6.363)$	—	—	37.671	0.000
No. of Obs.	76			
R^2-adj	0.359			

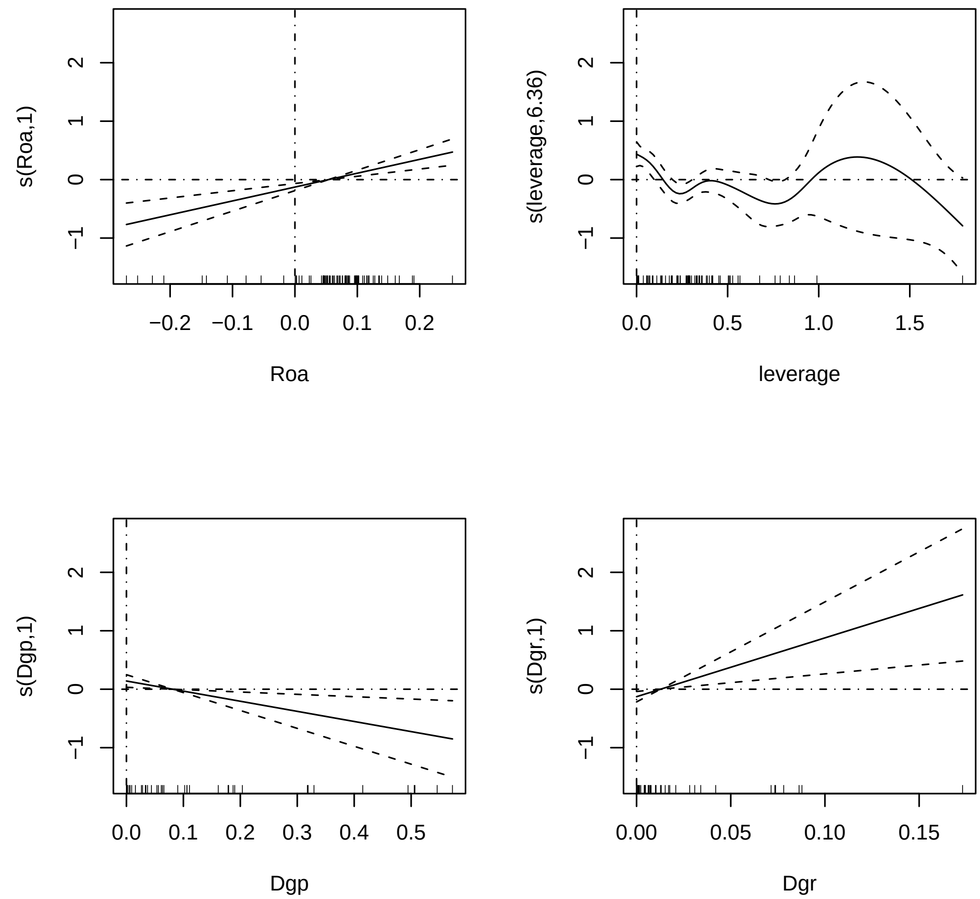
Note: This table shows the selected linear and nonlinear regression models for analyzing the impact of hedging on firm value. These models are variants of the following specification:

$$\ln Q_{it} = \alpha + \beta_1(Oil\ Heding\ Dummy)_{it} + \beta_2(Gas\ Hedging\ dummy)_{it}$$

$$+\beta_3 Dop_{it} + \beta_4 Dor_{it} + \beta_5 Dgp_{it} + \beta_6 Dgr_{it} + \gamma(Control\ Variables)_{it} + \varepsilon_{it},$$

This sample includes twenty-eight firms and seventy-six firm-years from 2000 to 2002. *Dgp* is the delta value relative to gas production. *Dgr* is the delta value relative to gas reserves. *Roa* is the ratio of net income over book value of total asset. *Leverage* is measured by the book value of long-term debt to market value of common equity. $s(Leverage, 6.363)$ denotes the nonlinear function of the variable leverage with 6.363 degrees of smoothness.

Figure 5: Linear and Nonlinear Relationships for Firm Value



Note: This figure shows the estimated linear and nonlinear relationships in solid lines for $\ln Q$. Roa is the ratio of net income to book value of total asset. The partial impact of Roa on lnQ $[s(Roa, 1)]$ is linear. $Leverage$ is measured by the ratio of book value of long-term debt to market value and has a nonlinear relationship with $\ln Q$ $[s(Leverage, 3.36)]$. The higher the leverage is, the lower the firm value is. Dgp denotes the delta value relative to gas production and it has a negative linear relationship with $\ln Q$ $[s(Dgp, 1)]$. Dgr denotes the delta value relative to gas reserves and it has a positive linear relationship with $\ln Q$ $[s(Dgr, 1)]$. Broken lines give the 95% confidence intervals of the estimated nonlinear relationships. Dotted lines are reference lines, which have angles of 0 and 90 respectively. The "rug" on the horizontal axis indicates the data density.

not have strong influence on stock returns as the oil and gas reserves do. The evidence shows that Canadian oil and gas firms are able to hedge against some down side risk such as unfavorable changes in oil and gas prices. In addition, oil reserves are more likely to have a positive (negative) impact on stock returns when oil prices are increasing (decreasing).

Finally, we have examined the impact of hedging on firm value measured by Tobin's Q ratio using both linear and nonlinear models. We have found that profitability (return on assets) has a positive impact on firm value and that excess leveraging has a negative impact on firm value. In addition, for a given level of gas hedging, higher gas reserves relative to gas production lead to a higher Q ratio.

There are several other issues left for future studies. First, the hedging information from annual reports may be incomplete as some companies may under-report their hedging activities in their annual reports. Second, most of Canadian oil and gas companies export oil and gas directly to the U.S. and many of them may rely on hedging on foreign-exchange-rate exposure rather than oil-and-gas-price exposure. These interesting issues are left for future research.

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Appendix 1 Hedging Information in 2002 Annual Report of Acclaim Energy Trust

A. Information in Management's Discussion & Analysis

COMMODITY MARKETING AND PRICE RISK MANAGEMENT

Upon closing the acquisition of Elk Point, Acclaim's natural gas weighting increased to 53 percent of production, while conventional oil and NGLs and heavy oil comprise 39 percent and 8 percent respectively.

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WTI averaged US$26.11 per bbl in 2002, a slight increase to the average of US$25.97 per bbl in 2001. Acclaim's price is also influenced by the Canadian$/US$ exchange rate as well as the degree of gravity of the oil and hedging activity. The majority of Acclaim's production is classified as light oil which trades at a premium relative to medium and heavy oil. Early in 2003, the benchmark WTI has been very strong averaging US$34.86 per bbl in the first quarter due primarily to uncertainties associated with the conflict in the Middle East.

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As of March 2003, Acclaim had hedging contracts in place originating from Acclaim, Ketch Energy, Elk Point and various predecessor companies. Since the combination of Acclaim with Ketch Energy, the Trust has layered on additional marketing contracts and will continue to do so on an ongoing basis, in order to maintain the stability of long-term cash distributions.

B. Information in Notes of Consolidated Financial Statement

15. HEDGING AND FINANCIAL INSTRUMENTS

The Trust's financial instruments recognized on the consolidated balance sheets include accounts receivable, accounts payable and accrued liabilities, bank debt and hedging and capital lease obligations. The fair values of financial instruments other than bank debt approximates their carrying amounts due to the short-term nature of these instruments. The carrying value of bank debt approximates its fair value due to floating interest terms; the fair value of the obligation under capital lease approximates carrying value due to current rates for comparable terms of the lease obligation. The fair value of the interest rate swaps associated with bank debt is disclosed in Note 6.

The Trust is exposed to the commodity price fluctuations of crude oil and natural gas and to fluctuations of the Canada - US dollar exchange rate. The Trust manages this risk by entering into various on and off balance sheet derivative financial instruments. A portion of the Trust's exposure to these fluctuations is hedged through the use of swaps and forward contracts. The Trust's exposure to interest rate fluctuations is disclosed in Note 6. The Trust is exposed to credit risk due to the potential non-performance of counter parties to the above financial instruments. The Trust mitigates this risk by dealing only with larger, well-established commodity marketing companies and with major national chartered banks. As a result of commodity hedging transactions, petroleum and natural gas sales for 2002 increased by $0.5 million (2001 - $5.5 million).

December 31, 2002 outstanding contracts (see the following table)

Crude Oil: Outstanding Contracts

Financial Instrument	Daily Volume (bbls)	Floor/Ceiling	Term
Three way collar	1,000	US$20.00–25.00–29.00	Jan.1, 2003–Jul.31, 2003
Three way collar	1,000	US$22.00–24.00–28.60	Jan.1, 2003–Dec.31, 2003
Collar	500	US$22.00–29.00	Jan.1, 2003–Dec.31, 2003
Collar	500	US$22.00–29.50	Jan.1, 2003–Dec.31, 2003
Collar	500	US$24.00–29.00	Jan.1, 2003–Jun.30, 2003
Collar	500	US$24.00–29.07	Jan.1, 2003–Jun.30, 2003

Appendix 2 Hedging Instruments

In hedging activities, fixed-price contracts, forwards, received-fixed swaps and options (including collars and three-way options) are the main instruments used by Canadian oil and gas companies.

A fixed-price contract obliges the supplier to deliver a defined commodity to a consumer at a predetermined price. Many such contracts include significant penalties for non-delivery. A fixed-price contract shifts most or all risks from the buyer to the supplier, and simultaneously shifts the management burden from the buyer to the supplier.

Forward or a forward contract is an over-the-counter contractual obligation to buy or sell a financial instrument/a commodity at an agreed price and to make a payment or a delivery at a pre-set future time between the two counterparties. Forward contracts generally are arranged to have zero mark-to-market value at inception, although they may be off-market. Examples include forward foreign exchange contracts in which one party is obligated to buy foreign exchange from another party at a fixed rate for delivery on a pre-set date. Off-market forward contracts are often used in structured combinations, with the value on a forward contract offsetting the value of another instrument or other instruments.

Received-fixed commodity swaps are the swaps in which exchanged flows are dependent on the prices of a commodity (or an underlying commodity index). The commodity producer who wishes to avoid the commodity price fluctuation can engage in this kind of swaps by paying a fee to a financial institution that is willing to pay the producer the fixed payments for the commodity and accept the commodity price fluctuation.

A collar, or a zero cost collar option, is a positive-carry collar that secures a return through the purchase of a floor and sale of a cap. An example of a zero cost option collar for selling commodity is the purchase of a put option and the sale of a call option with a higher strike price. The sale of the call will cap the return if the price of the underlying commodity rises, but the premium collected from the sale of the call will offset the cost of the purchased put.

The three-way options is an option strategy created by adding to a collar, another long put (call) option position whose strike price is lower (higher) than that of put (call) option in the collar to benefit from falling (rising) prices. In other words, the motive of those hedging activities for each oil and gas companies is to sell oil and gas with ideal prices.

Appendix 3 General Additive Models

Let the sample counterparts of random variables

$$Y, X_1, X_2, \ldots, X_p$$

be

$$y, x_1, x_2, \ldots, x_p.$$

The GAM takes the following functional form:

$$g[\mu(x_1, x_2, \ldots, x_p)] = \alpha + s_1(x_1) + \cdots + s_p(x_p), \tag{4}$$

where $\mu(x_1, x_2, \ldots, x_p) = E(Y|X_1, X_2, \ldots, X_p)$, g is the link function, α is a constant, and s is a continuous and twice differentiable function. When Y is a real valued variable and the error is assumed to be Gaussian, and the link function g is the identity function, the GAM is reduced to the additive model as follows

$$E(Y|X_1, \cdots, X_p) = \alpha + s_1(x_1) + \cdots + s_p(x_p). \tag{5}$$

The above structure regression can be deemed as the first order analysis of variance (ANOVA) decomposition of $E(Y|X_1, \cdots, X_p) = s(x_1, \ldots, x_p)$ in a p-dimensional real space R^p.

The nonlinear functions $s_j(x_j)(j = 1, \ldots, p)$ are estimated jointly by the backfitting algorithm. This algorithm minimizes a penalized residual sum of squares

$$PRSS(\alpha, s_{1,\cdots,}s_p) = \sum_{i=1}^{N} \left(y_i - \alpha - \sum_{j=1}^{p} s_j(x_j) \right)^2 + \sum_{j=1}^{p} \lambda_j \int s_j^{''}(t_j)^2 dt_j \tag{6}$$

by iteratively fitting nonlinear functions $s_j(x_j)(j = 1, \cdots, p)$ using a one dimensional natural spline with its smoothness controlled by the penalty term

$$\lambda_j \int s_j''(t_j)^2 dt_j.$$

The tuning parameter λ_j can be either pre-specified or automatically searched in each step by minimizing the generalized cross-validation (GCV) score. Sometimes we write $s_j(x_j)$ as $s(x_j, d_j)$ where d_j is the degree of smoothness. d_j may be non-integer. A more recent version of GAM fitting implemented in the `mgcv` package in R by Wood (2000, 2004) selects the multiple smoothing parameters more efficiently through minimization of the GCV score. This package employs a Bayesian approach to estimate the variance so that it makes the confidence interval calculation for $s(x_j, d_j)(j = 1, \ldots, p)$ easier.[16]

[16] See Wood (2000) for details.