The Impact of Hedging on Stock Return and Firm Value:

New Evidence from Canadian Oil and Gas Companies

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Abstract

This paper analyzes the impact of hedging activities of large Canadian oil and gas companies on their stock return and firm value. Differing from the existing literature this research pays attention to the nonlinear payoffs of hedging, which may not be fully revealed in the traditional linear framework. By using generalized additive models, which is semi-parametric in nature and can accommodate potential nonlinear relationships, this research finds that the impacts of hedging are indeed nonlinear. The large Canadian oil and gas firms are able to hedge against downside induced by unfavorable oil and gas price changes. But oil hedging appears to be more effective than gas hedging in protecting the stock return when downside risk presents. In addition, oil and gas reserves tend to have a positive (negative) impact on stock returns when the oil and gas prices are increasing (decreasing). Finally, hedging, in particular hedging on gas, together with profitability and leverage, has significant impacts 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 established are generally violated.

According to the theories of corporate risk management, maximizing shareholder value is one of the aims of the management. Generally, maximizing shareholder value means maintaining and increasing the flow of dividends and hence raising the value of owners' equity over time. In an efficient capital market, stock prices reflect the underlying business conditions and current and future earnings. Hedging can be an effective tool for managing uncertainty or unexpected events. Hedging activities usually include managing price risk, protecting mortgage portfolios from interest rate volatility, preventing erosion in the value of cash reserves, deriving better returns on short-term investments, locking in a future interest rate, enhancing the yield of an investment portfolio, designing an effective foreign currency swap program and so on. Theoretically, hedging may protect stock returns, increase firm value, and prevent shareholders from incurring unexpected losses.

But does hedging actually affect firm value? The literature has not reached a consensus and evidence is somewhat mixed. Some empirical studies support the hypothesis but some do not. The literature on the effectiveness of hedging has focused primarily on the hedging activities in the financial and commodity risk management. The former includes currency hedging and interest rate hedging. 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. Gagnon et al. (1998) employ constructed currency portfolios to show that dynamic hedging risk-minimizing strategies can indeed reduce risk. Allayannis and Weston (2001) use a linear model for the US firm data and find that hedging enhances firm value. Bartram et al. (2003) examine a large sample of multi-industry companies and find that interest rate hedging, not currency hedging, has a positive impact on firm value. Commodity hedging includes hedging activities on grain, jet fuel, oil and gas, and precious metal such as gold. Sephton (1993) shows that the commodity hedge ratio can be best estimated with the GARCH models. 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. Carter et al. (2003) 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. On the other hand, in the most recent study of the U.S. oil and gas companies Jin and Jorion (2005) find that hedging on oil and gas prices has little impact on firm value.

Although many empirical studies have evaluated the impact of various kinds of hedging activities on firm value, no study has ever examined the role of hedging in Canadian oil and gas companies.[2] Canada is recognized as the 3rd largest producer of natural gas and the 9th largest producer of crude oil in the world. Canada has significant, untapped natural gas reserves, with the largest growth areas expected in the North and on the East Coast.[3] Canada also has huge tar sand reserves, second to the petroleum reserves of Saudi Arabia. Because of Canada's geography, more than 80% of the oil and gas production is exported to the U.S.[4] For Canadian oil and gas producers, oil and gas prices, foreign exchange rates, and interest rates can generate financial and operational uncertainties. It is known that some large Canadian oil and gas companies have been using hedging to reduce the impact of oil and gas price volatility. But there is no systematic study and there is little empirical evidence as to what extent hedging activities have played any significant roles.

The purpose of this paper is to examine the impact of hedging activities on stock returns and firm value of large Canadian oil and gas companies and to add new evidence for the roles of hedging. As pointed out by Jin and Jorion (2005), 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

[2] Haushalter (2000) and Jin and Jorion (2005) have studied the impact of hedging activities in the U.S. oil and gas companies on firm value.

[3] The data is from Natural Resource Canada (NRC) 2003 annual reports.

[4] The data is 2003 annual reports of Canadian Association of Petroleum Producers (CAPP).

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 exert a more prominent influence to profitability and firm value.

This study uses a unique data set manually collected from large Canadian oil and gas companies during the period of 2000-2002. In this period, the oil and gas prices were volatile. The data collection procedure used here follows the method of Allayannis and Weston (2001), Carter et al. (2003) and Jin and Jorion (2005). It also considers the unique situations in Canada. In the existing study using the U.S. data, hedging value can be collected from Item 7A "Quantitative and Qualitative Disclosures about Market Risk" in the 10-K annual reports for the U.S. companies. However, the 10-K reports are not always available for most Canadian oil and gas companies. Only Imperial Oil and Nexen have filed the 10-K reports but there is no hedge information available in Item 7A for Imperial Oil and no Item 7A for Nexen at all. This research therefore collects the hedging data on futures, options, and swap contracts as well as fixed-price physical delivery contracts and volumetric production payments directly from the annual reports of these companies. This method is more precise than just employing notional amount of derivatives or hedging dummy variables. The accounting data, such as market value and dividend, are retrieved from the Datastream database.[5] After extensive search, only thirty-three companies are found to have hedging and reserves data during the period, resulting eighty-eight firm-years. Among them, twenty-eight companies and seventy-six firm-years are found to have the complete hedging, reserves and accounting data. To our knowledge, this is perhaps the most comprehensive data for large Canadian oil and gas companies at this time.

The preliminary statistical analysis of the data shows that relationships between hedging activities and payoffs (stock returns and firm value) are typically nonlinear whereas linear models are traditionally employed in the existing research literature. Therefore, this research proposes the

[5] Datasteam is a comprehensive database for global investment research, providing historical international data on broad economic and financial matters, including company accounts, economic indicators, equity, bonds, futures and options, commodities and interest rates, made by Thomson Financial.

use of flexible generalized additive models (GAM) [see Hestie (1990), Hestie and Tibshirani (1990), and Venables and Ripley (2002)], which is semi-parametric in nature and can accommodate potential nonlinear relationships. As shown later in the paper, GAMs are statistically superior to linear models in our study because GAMs can accommodate both linear and nonlinear relationships without being restricted to the former.

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

The remainder of the paper is organized as follows: Section 2 reviews the related literature. Section 3 explains the data collection and sample information. Section 4 reports the findings on the impact of hedging activities on the relationship between oil and gas prices and stock returns. Section 5 discusses the findings of the impact of hedging on firm value. Finally, Section 6 offers concluding remarks.

2. Hedging Literature

2.1 Roles of Hedging

When the financial market is imperfect, hedging activities of a firm can directly affect the cash flow of the firm. When oil/gas price falls, the oil/gas producer will lose revenue if it does not use fixed-price contracts or options to hedge against the risk of price volatility. When an income surges and hence tax liability increases the context of a convex tax schedule,[6] hedging can help the firm to smooth its cash flow and avoid the volatility of the cash flow exacerbated by the tax regime.

In the theoretical literature on hedging, three main motivations for hedging are discussed. First, hedging is used to reduce financial distress and avoid underinvestment. Second, it is used to

[6] This refers to the schedule where the effective tax rate is greater as the taxable income gets higher.

reduce expected tax costs. Third, hedging can alleviate the manager's personal risk exposure. These are reviewed as follows.

2.1.1 Financial Distress and Underinvestment

When high cash flow volatility is expected to cause a mismatch between the available liquidity and fixed payment obligations, managers need hedging. Smith and Stulz (1985) analyze the impact of hedging on expected bankruptcy costs and find that hedging can reduce the likelihood of financial distress of the firm, lower its expected bankruptcy costs and therefore increase its debt capacity and firm value. Mayer and Smith (1990) also find that the firm, by reducing cash flow volatility via hedging, can effectively reduce bankruptcy costs, minimize the loss of tax shields, and secure valuable growth options.

Stulz (1990) and Froot et al. (1993) note that hedging can help companies to maintain adequate internal funds available for good investment opportunities and thus avoid underinvestment. Without risk management, firms sometimes are forced to pursue suboptimal investment opportunities because low cash flow can prevent firms from pursuing optimal investment opportunities or obtaining low-cost financing. Therefore, everything else being equal, the more difficulties firms face in obtaining external financing, the less sufficient cash flow will be, and the higher the value of the hedge premium will be. By analyzing cash flow in a two-period investment/financing decision model, Froot et al. (1993) find that firms with costly external financed projects would be better off utilizing risk management to reduce the influence of external financing on these projects.

Allayannis and Mozumdar (2000) study the S&P 500 non-financial firms and find that firms significantly exposed to the foreign exchange rate risk can use foreign currency derivatives to reduce their dependence on external cash flow for investment. Adam (2002) examines the roles of hedging in 111 North American gold mining companies and finds a positive relationship between the minimum revenue guaranteed by hedging and investment expenditures. The empirical evidence suggests that hedging can increase the likelihood of internal financing for investment and reduce its dependence on external financing.

2.1.2 Expected Tax Costs

Smith and Stulz (1985) discuss the tax-induced explanation for risk management. In the presence of a convex tax schedule, firms can employ risk management to reduce the volatility of taxable income that would otherwise be exacerbated by the expected tax liabilities. Firms would prefer hedging when they have high leverage, shorter debt maturity, lower interest coverage, less liquidity, and high dividend yields because they prefer stable cash flow. Therefore reducing the volatility of taxable income generates greater firm value if the firm faces a convex tax function. Graham and Smith (1999) analyze more than 80,000 COMPUSTAT firm-year cases and three measures for effective tax functions.[7] They find that, in approximately 50% of the cases, convex tax schedules lead to tax-based incentives to hedge. Graham and Rogers (2002) use the data of 3,232 U.S. companies and an explicit measure for the convex tax schedule and find that hedging does not reduce tax liability when facing a convex tax schedule. However, they suggest that these firms may smooth incomes by other means.

2.1.3 Managerial Risk

According to Stulz (1984) and Smith and Stulz (1985), risk averse managers tend to use hedging to reduce the variability of earnings but they usually cannot diversify firm-specific risk. This is particularly true if managers have wealth and human capital in their business and if it is costly to hedge on their own accounts. Smith and Stulz (1985) show that managers with greater stock ownership would prefer more risk management than those holding more options do. This is because stocks provide linear payoffs whereas options provide convex payoffs. The convexity of option payoffs may provide an incentive for managers to bear more risk. In addition, DeMarzo and Duffie (1995) point out that hedging may serve as a signal of managerial ability to external investors. Among a few empirical studies, Tufano (1996) examines the hedging activities of forty-eight North American gold mining companies and finds that firms whose managers hold more options use less risk management and firms whose managers holding more stocks use more risk management. This finding is consistent with the prediction of Smith and Stulz (1985). Whidbee

[7] The three variables are tax loss carry forwards, investment tax credit, and a binary variable that indicates whether the variation in the firm's historical pretax income makes it likely that the income of firm would be in the convex region of the tax code.

and Wohar (1999) analyze the information of 175 publicly traded bank holding companies and find that the managerial incentives and external monitoring affect the decision to use derivatives. Dionne and Triki (2005) find that independence and financial knowledge of the directors of the board would affect hedging decisions based on the data of the thirty-six North American gold mining firms.

2.2 Impact of Hedging on Firm Value

In the existing literature, Rajgopal (1999) examines the informational role of the Securities and Exchange Commission (SEC)'s market risk disclosures for thirty-eight U.S. oil and gas companies and finds that oil and gas reserves have a positive impact on the relationship between stock returns and oil and gas prices. Jin and Jorion (2005) extend the work of Rajgopal (1999) by adding hedging and find that hedging can weaken the relationship between stock returns and oil and gas prices and reserves can strengthen the relationship.

Allayannis and Weston (2001) directly examine the relationship between foreign currency hedging and firm value as measured by Tobin's Q ratio, based on a sample of 720 American non-financial firms with total asset more than USD$500 million. By adding some control variables such as profitability and leverage into the regression model, they find that hedging is positively related to firm value and firms with hedging have on average 4.87% higher firm value than those without. However, Geczy et al. (1997) analyze foreign currency derivatives of Fortune 500 companies and find that foreign currency risk is not possible to be hedged in multinational companies because the sources of the risk are complicated by many factors such as foreign sales, foreign-denominated debts, foreign taxes, etc. Based on the framework of Allayannis and Weston (2001), using a sample of twenty-seven American airline companies, Carter et al. (2003) examine commodity hedging on jet fuel and firm value and show that jet fuel hedging is positively related to airline firm value. The coefficients on the hedging variables in their regression suggest that the hedging premium contributes approximately a 12-16 percent increase in firm value. Jin and Jorion (2005) examine the hedging activities of 119 American oil and gas companies to evaluate their effect on firm value and find no evidence to support the view that hedging affects firm value.

However, the existing literature primarily focuses on linear models of hedging and firm value using the American data. This paper attempts to contribute to the literature by studying hedging and firm value for Canadian oil and gas companies based on more flexible semi-parametric nonlinear models.

3. Data and Sample Description

3.1 Sample Description

This study selects the data for Canadian oil and gas companies from 2000 to 2002 from the list of Canadian oil/gas exploration and production companies. There are several issues that one must face in the data selection. First, the Canadian economy has a strong resource 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.[8] 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 which is unlikely to give us an accurate picture. 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). These oil and gas firms also constitute a large share of the Canadian oil and gas industries and should be duly included. Fourth, Canadian economy is about one-tenth of the size of the US economy. Compare to the similar studies for the US oil and gas industries, the Canadian sample size would be considerably smaller. Therefore, we should use as much as the relevant information as we can while bearing in mind the limited scope of the Canadian oil and gas industries.

[8] The detailed analysis is given below.

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.[9] In the list, thirty-eight oil/gas exploration and production companies (for example, EnCana, Canadian 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. Only the thirty-three of these (eighty-eight firm-years) have filed reports with the System for Electronic Document Analysis and Retrieval (SEDAR)[10] during the period of 2000-2002**.** The largest five companies in the sample are Encana[11], 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. Table 1 shows the summary of market value in the sample firms.

[9] The hedging activities and records of these oil and gas firms are more likely to be available and documented systematically.

10 SEDAR is developed in Canada for the Canadian Securities Administrators (CSA).The annual reports from SEDAR are available in www.SEDAR.com.

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

Table 1 Firm-years Description

Companies	No. of Obs	% of the Sample	Book Value of Total Asset	
			Average (Cdn $ million)	Standard Deviation
Oil/Gas Exploration and Production	71	80.7	1720. 451	1874. 376
Oil Integrated	17	19.3	11104. 68	3044. 014

3.2 Hedging Information

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 such as Allayannis and Weston (2001) and Jin and Jorion (2005) collect the hedging information primarily from the 10-K annual reports. In 1997, the U.S. Securities and Exchange Commission ("SEC") declared Financial Reporting Release No.48 ("FRR 48"), which require disclosure for market risk for all firms for the fiscal year ending after June 15th, 1998.[12] However, there is no such regulation for Canadian companies at the time of this research. 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.

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

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

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.

Following the method proposed by Jin and Jorion (2005), we calculate individual 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 the Table 2.

The total delta value of crude oil and natural gas for each firm-year is the sum of the products of deltas and their corresponding notional dollar values of all 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 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. In this study the value of delta is zero or negative and we multiply negative one to the value to reflect the positive role of the adjusted total deltas in the stock return and firm value.

Table 2 Delta and Hedging Instruments

Delta	Hedging Instruments
-1	Short position *linear* relationship, including short futures and forwards, fixed-priced contracts, fixed-received swaps and volumetric production arrangements
From the Black-Scholes options model	*Non-linear* contracts, including options, collars and three-way options

We use gas production and gas reserves as an example to show how the adjusted deltas are defined:

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

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

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 3 shows the hedging and non-hedging information of the sample. There are 25 non-hedging (in both oil and gas) firm-years (about 28.41% of the sample), 56 firm-years hedge on oil prices exposure (about 63.64% of the sample), 50 firm-years hedge on gas prices exposure

(56.82% of the sample), and 43 firm-year hedge on both oil and gas prices exposure (about 48.9% of the sample). Table 4 illustrates the basic statistics of the adjusted deltas. Compared with the basic statistics in Jin and Jorion (2005), Canadian oil and gas companies have less oil and gas hedging 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, but those of Canadian oil and gas companies in this study are 14.6%, 8.1%, 1.8% and 1.3%, respectively. This shows 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* in Jin and Jorion (2005) 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 the U.S. oil and gas companies studied in Jin and Jorion (2005).

Table 3 Description of Sample by Distribution of Exposure and Hedging

No. of Firm-year	Gas Exposure Hedging (%)	Non Gas Exposure Hedging (%)	Total (%)
Oil Exposure Hedging	43 (48.9)	13 (14.8)	56 (63.7)
Non Oil Exposure Hedging	7 (8.0)	25 (28.4)	32 (36.3)
Total	50 (56.8)	38 (43.2)	88 (100)

Table 4 Basic Statistics of Adjusted Deltas

Adjusted Deltas	Mean	Standard Deviation	No. of Firm-year
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%		

3.3 Tobin's Q Ratio

Tobin hypothesized that the combined market value of all the companies on the stock market should be about 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. Then, when the assets are priced properly in the capital market, the Q ratio should be equal to one.

In this paper, we use the following equation for the theoretical Q ratio

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

The market value of common equity can be found in the Datastream database. The book value of liability and total assets are from the annual reports. However, several companies do not have necessary market information during the period of 2000-2002 in the Datastream database due to mergers and corporation reconstruction, such as market value and stock prices. Only 28 companies and 76 firm-years are used. Panel A in Table 5 shows the summary statistics of total asset (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 in Jin and Jorion (2005). The standard deviations of the Canadian oil and gas companies' total asset and market value of equity are huge because about one third of the sample (22 firm-years) has historical book values less than Cdn$500 million. Panels B and C of Table 5 illustrate the basic statistics of the firms with hedging activities on 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 14.0% 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 in Jin and Jorion (2005). The Canadian oil and gas companies do not hedge as much as their U.S. competitors do. Panel D of Table 5 shows the basic statistics of the firms without any hedging activities. The large standard deviations of total asset 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. This result is in contrast to the findings of Jin and Jorion (2005) that small companies prefer hedging because they are more sensitive with financial distress and more dependable on hedging. Figure 1 plots the book values of total asset of the oil and gas firms with or without hedging. According to Figure 1, 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 asset. This may reflect the fact that very large firms may use operational hedging to replace the need for financial hedging.

Figure 1 Book Value of Total Asset with or without Hedging

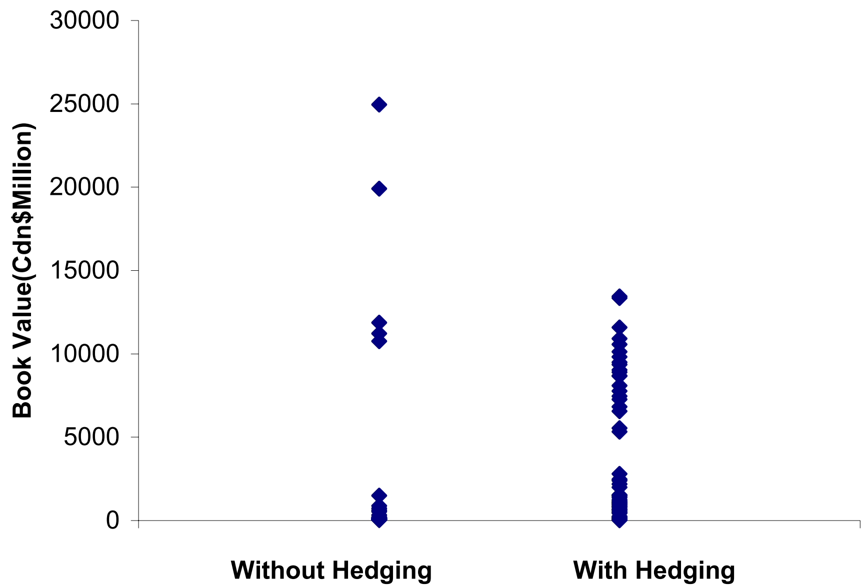


Table 5 Summary Statistics of Firm Characteristics

Paned A shows the sample of twenty-eight Canadian oil and gas companies from 2000 to 2002, with the total of seventy-six firm-years observations. The sub-samples of firm-years with hedging activities oil and gas are reported in Panels B and C respectively. Panel D illustrates the firm-years without any hedging activities. Total Asset represents the book value of asset. "MVE" means the market value of equity. Total asset and MVE are in million Canadian dollars (Cdn$M). "*Dop*" and "*Dor*" denote the adjusted deltas of oil production and reserves. "*Dgp*" and "*Dgr*" denote the adjusted deltas of gas production and reserves.

Panel A: All Firm-years

	No. of Obs.	Mean	Std.dev	Median
Total Asset (Cdn$M)	76	4019.22	5195.436	1135.98
MVE (Cdn$M)	76	3574.25	4857.15	838.455
Q ratio	76	1.56	0.93	1.34

Panel B: Firm-years with Hedging Activities on Oil

	No. of Obs.	Mean	Std.dev	Median
Total Asset (Cdn$M)	46	4356.03	4302.58	1857.33
MVE(Cdn$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	0.02

Panel C: Firm-years with Hedging Activities on Gas

	No. of Obs.	Mean	Std.dev	Median
Total Asset (Cdn$M)	41	4318.25	4323.21	2001.12
MVE (Cdn$M)	41	3180.61	3350	1263.33
Dgp	41	0.14	0.18	0.06
Dgr	41	0.02	0.04	0.01
Q ratio	41	1.31	0.4	1.24

Panel D: Firm-years without Hedging Activities

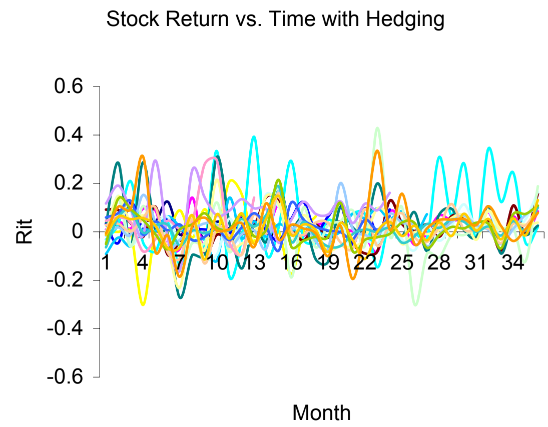
	No. of Obs.	Mean	Std.dev	Median
Total Asset(Cdn$M)	23	3670.47	7059.76	167.3
MVE(Cdn$M)	23	3663.59	6628.01	260.5
Q ratio	23	2.00	1.47	1.81

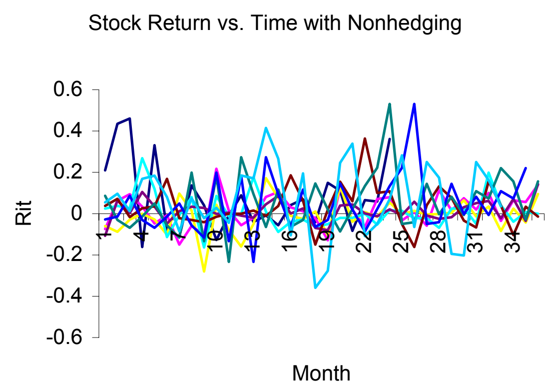
4. Impact of Hedging on the Relationship between Oil/Gas Prices and Stock Returns

In this section, by employing both linear and nonlinear models, we examine the impact of hedging on the relationship between stock returns and oil and gas prices. Section 4.1 studies the relationship between stock returns and oil and gas prices. Section 4.2 augments the models in Section 4.1 to further evaluate the roles of hedging and reserves on stock returns.

Because of high volatilities of oil and gas prices during the period of 2000-2002, the crude oil and natural gas future prices also demonstrated high volatilities in the New York Mercantile Exchange (NYMEX). In this environment, the firms that hedged against volatile changes in oil and gas prices could lower their revenue volatilities. 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. This appears to be consistent with the observation for the U.S. oil and gas companies noted by Jin and Jorion (2005).

Figure 2 Monthly Stock Returns: Hedging vs. Non-hedging





Note: "R_{it}" denotes the monthly stock return of the Canadian oil and/or gas company i at time t.

"Month" denotes t th month in the period of 2000-2002.

4.1 Relationship between Oil and Gas Prices and Stock Returns

To examine the relationship between stock returns and oil and gas price changes, the following model is adopted by Jin and Jorion (2005):

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

where R_{it} is the stock return for Canadian oil and/or gas company i at time t; R_{mt} denotes the market-index return or the S&P/TSX 60 index return at time t;[13] 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 company 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 the stock return is not sensitive to these price changes due to, possibly, some forms of hedging.

The pair-wise correlation between the market-index return and the gas/oil price change is relatively high ranging from 0.489 to 0.512. Therefore, an interaction term between the market-index return and the oil price change and that between the market-return and the gas price change are added into the above model [equation (1)]. But only the interaction term between the market-index return and the gas price change is statistically significant. The time dummy and firm dummies are also tested in the model but they are not statistically significant. 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.[14]

Table 6 shows the estimation results based on the monthly data during the period of 2000-2002 as the reported hedging contracts typically would mature in the next fiscal year. Panel A of Table 6 shows that the stock return has linear relationships to the risk exposures due to oil and gas

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[13] 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.

[14] Cook's distance is defined as standardized distance between the regression parameter estimates with or without a particular data point, it also equals to the Euclidean distance between the estimated response variable without this particular data point and the estimated response variable from using all the data. Thus Cook's distance measures the total difference it will make in the estimation by omitting one data point. Cook's distance is calculated for each point in the data, large Cook's distances indicate those influential data points.

price changes. These relationships are mostly positive and statistically significant. For the average oil and gas companies, a 1% change in oil price leads to a 0.23% change in the stock return. This Canadian result is similar to that found by Rajgopal (1999) and Jin and Jorion (2005). But a 1% change in gas price only leads to a 0.13% change in the stock return, which is much lower than that of Rajgopal (1999) (0.41%) or Jin and Jorion (2005) (0.29%). The stock returns of these Canadian companies do not respond to the gas price change as much as they do to oil price change.

As the linear model may be quite restrictive, we consider extending our analysis with the GAM, which takes the form of $y = \alpha + s_1(x_1) + s_2(x_2) + \cdots + s_k(x_k) + \varepsilon$. In the GAM, the explained variable y is a function of the sum of k nonlinear functions of explanatory variables $x_1, x_2, \cdots, x_k$. The nonlinear functions are estimated nonparametrically by natural splines of these explanatory variables with appropriate degrees of smoothness i [i.e., ($s(x,i)$)].[15] The degree of smoothness is selected by generalized cross-validation (GCV) [Please see Hastie and Tibshirani (1990) for more details].

To find the suitable degrees of smoothness for the functions of these explanatory variables simultaneously, we use AIC criterion to compare different GAMs. The model representing the underlying data generating process best is then selected and given in Figure 3. Panel B of Table 6 shows that the nonlinear effects of changes in oil and gas prices on the stock return are very significant. In GAM, the F-test is performed to test the nonlinearity based on the difference of the residual deviances[16] between the nonlinear and linear models, since the linear model is nested in the nonlinear model.

From the estimated nonlinear impact of the explanatory variables on the stock return shown in Figure 3, we can make following observations. First, these three nonlinear responses of the stock return are graphed in the similar scale and none of them dominates the others. Second, $s(R_{mt}, 5)$ is a bimodal curve with its two peaks at about -5% and

15 Earlier references are Whittaker (1923) and Wahba (1990).

16 Please see Appendix 2 for the definition of deviance.

+5%. Thus, when other factors are fixed, the stock return peaks when the market-index return is at about +/-5%. However when the market-index return is close to zero, the stock return does not change. But when the market-index return changes by more than +/- 5%, the stock return falls. Third, $s(R_{ot},3)$ has a quadratic curve with its trough at about -5%. That is, with everything else fixed, the stock return is the lowest when the oil price drops by 5%. If the oil price drops more than 5%, it appears that some hedging will start to work as the stock return will not go down with the oil price drop. If the oil price changes in the range greater than - 5%, the stock return rises. This could result from an optimal level of hedging. Fourth, $s(R_{gt},5)$ has a quadratic curve with its trough at about -15%. That implies the stock return is the lowest if the gas price drops by 15% when everything else is held constant. However, if the gas price drops beyond this level or increases, the stock return tends to move away from the negative territory or increase, in particular when the gas price drops sharply. This is a clear indication that some form of hedging is at work.

Table 6 Statistical Analysis of Stock Price Exposure

This table illustrates the statistical properties of the linear coefficients and nonlinear functions in three-factor model (interaction terms are not showed in the equations and tables). Panel A represents the estimation 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} are the stock return, the market-index return, the percentage change in the NYMEX crude oil futures price, and the percentage change in the NYMEX gas future price. The sample includes the monthly data for 28 companies and 76 firm-years during the period of 2000-2002. $s(x, i)$ denotes the estimated nonlinear function of variable x and i degrees of smoothness. Df denotes degree freedom.

Panel A: Linear Three-factor Model for Stock Returns (R_{it})

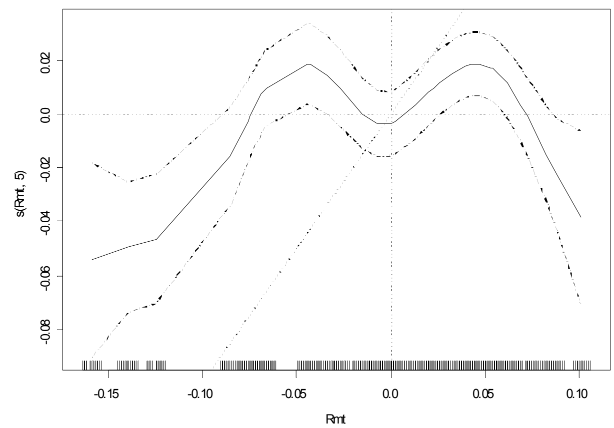
Explanatory Variables	R_{mt}	R_{ot}	R_{gt}
Coefficient	0.009	0.229	0.133
Standard deviation	0.061	0.051	0.028
p-value	0.000	0.000	0.000
Residual Deviance	10.805 on 876 Df		

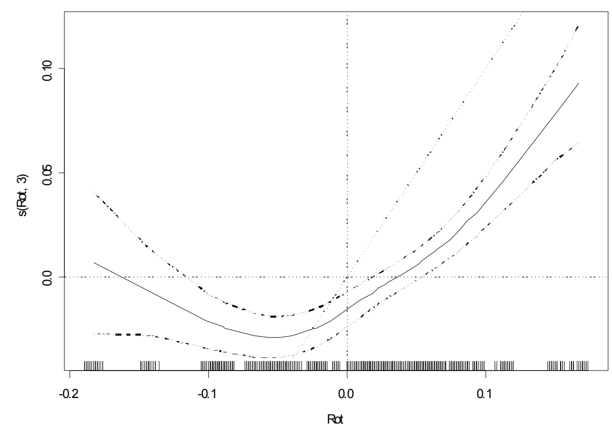
Panel B: Nonlinear Three-factor Model for Stock Returns (R_{it})

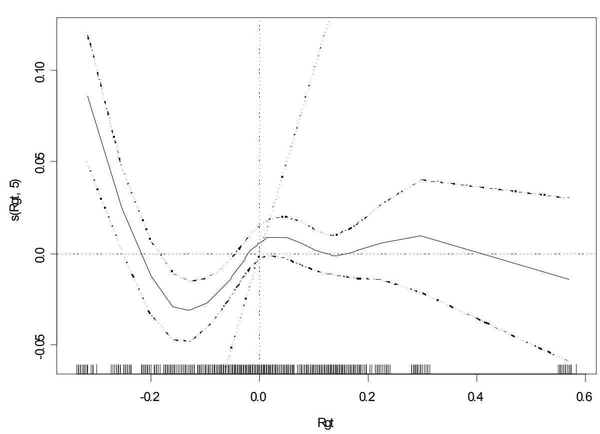
	$s(R_{mt},5)$	$s(R_{ot},3)$	$s(R_{gt},5)$
F test for nonlinearity:			
p-value	0.000	0.000	0.000
Residual Deviance	9.712 on 867 Df		

Figure 3: Nonlinear Variables in Three-factor Model

Figure 3 shows the estimated nonlinear curves of the variables. *Rmt* (for R_{mt}), *Rot* (for R_{ot}), and *Rgt* (for R_{gt}) denote the market-index return, the oil price change and the gas price change, respectively. $s(x, i)$ denotes the nonlinear function of the variable x with i 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^o and 90^o respectively. The "rug" on the horizontal axis indicates the data density.







4.2 Hedging on Betas

In this section, we extend the previous model to a more general setting in order to examine explicitly whether oil and gas hedging can moderate the impact of oil and gas price changes on the stock return. We use the following extended model for this purpose:

$$R_{it} = \alpha + \beta_m R_{mt} + \left[\gamma_1 + \gamma_2 Dop_{it} + \gamma_3 \left(OR_{it} / MVE_{it}\right)\right] R_{ot} + \left[\gamma_4 + \gamma_5 Dgp_{it} + \gamma_6 \left(GR_{it} / MVE_{it}\right)\right] R_{gt} + \varepsilon_{it} \tag{2}$$

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; MVE_{it} is the market value of equity for firm i at time t.

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. As shown later we can extend the relationships captured by γ_2, γ_5, γ_3 and γ_6 to corresponding nonlinear relationships.

In the following analysis, we have adopted two modeling strategies: fitting both linear and nonlinear models. Surrounding the specification of equation (2), we have conducted an intensive model search. The resultant linear model from this intensive search is shown in Panel A of Table 7. In this linear model, the significant factors are the market-index return, 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. Although the estimation results for the Canadian oil and gas companies are similar to those in Rajgopal (1999) and Jin and Jorion (2005), which do not contradict the hypotheses for negative γ_2 and γ_5 and positive γ_3 and γ_6, most of these parameter estimates of the linear model are not statistically significant. Only oil reserves are statistically significant but with a small impact. Hence the evidence for the above hypotheses is weak at the best. This might be caused by the restrictive nature of the linear model.

The more flexible GAM approach is then implemented. After an intensive search among nonlinear models for all the explanatory variables included in the linear model given in equation (2), we find that the best nonlinear model, according to a set of model selection criteria (AIC, BIC, F-tests, the goodness of fit), is the one within which the previously chosen linear model is nested. The nonlinear model is given in Panel B of Table 7, which shows that in addition to the significant factors in the linear model the gas reserves become an important factor in the nonlinear model. In order to evaluate if the nonlinear model is indeed 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 (2.553513e-015). Hence we can conclude that the nonlinear model provides a better fit to this data. Further more, the model search according to other criteria, such as the information criterion (*AIC*) and the goodness of fit ($R^2 - adjusted$), also confirms this conclusion.

The two previously discussed hypotheses, which boil down to two sets of linear restriction hypotheses in the linear model, can no longer be tested directly any more in the nonlinear setting. Instead, the graphical presentation for the discovered nonlinear functions from the nonlinear model is useful to infer the relationships of our interest. The combination of Panel B of Table 7 and Figure 4 shows not only what factors are statistically significant but also how these factors affect the stock return nonlinearly. This is the difference between this research and the previous work. The first important finding from the Canadian oil and gas companies is that the hedging activities on oil and gas appear to play little role. That is, the statement that γ_2 and γ_5 are positive in the linear model cannot be supported by the Canadian data. The delta and delta-related variables (Dop_{it} , Dgp_{it} , $Dop_{it} * R_{ot}$, and $Dgp_{it} * R_{gt}$) are statistically insignificant when included in any of our searched nonlinear models.

Figure 4 shows the estimated curves and their 95% confidence intervals for statistically significant nonlinear functions between the stock return and the market-index return, the oil price change, the gas price change, the oil reserves, the gas reserves, and the interaction term between the market-index return and the gas price change, respectively. Let us examine these nonlinear relationships one by one. Figure 4 demonstrates that the market-index return *Rmt* (for R_{mt}) has a nonlinear relationship with the stock return *s*(*Rmt, 5*) [for $s(R_{mt}, 5)$]. This nonlinear relationship corresponds to the conventional beta if the linear structure is imposed as in equation (2). When the market-index return moves up and down by about 7.5%, the stock return remains positively related to the market-index return. However, when the market-index return moves, up or down, beyond the 7.5 percentage point, the stock return drops sharply.

The case of oil price change is also interesting [see *Rot* (for R_{ot}) and *s*(*Rot, 5*) (for $s(R_{ot}, 5)$) in Figure 4]. When the oil price change moves, up or down, by less than 7.5%, the stock return is negative. However, if the oil price change moves, up or down, by more than 7.5%, the stock return will be in the positive territory. Although the oil hedging variables are not statistically significant and hence are excluded from the nonlinear model, it appears that some business financial and real hedging activities in oil are at work. The role of gas price change is positive but small on the downside [see *Rgt* (for R_{gt}) and *s*(*Rgt,5*) (for $s(R_{gt}, 5)$) in Figure 4]. It is interesting to note that the stock return can be negative when the gas price increases. This can happen if the hedging on gas price provides some protection on the down side but forgoes the profitability on the upside.

Corresponding to the hypothesis relating to positive γ_3 and γ_6, oil and gas reserves should be positively related to the stock returns in the linear model. As shown in Figure 4, the relationships between *OR.Rot.MVE* (for $R_{ot} * OR_{it} / MVE_{it}$) and s(*OR.Rot.MVE,2*) [for $s(R_{ot} * OR_{it} / MVE_{it}, 2)$] and between *GR.Rgt.MVE* (for $R_{gt} * GR_{it} / MVE_{it}$) and s(*GR.Rgt.MVE,2*) [for $s(R_{gt} * GR_{it} / MVE_{it}, 2)$] are not linear. Instead, the former is positive only when *OR.Rot.MVE* is positive. The latter can be positive only when *GR.Rgt.MVE* is positive in a small range. That is, oil and gas reserves are more likely to have a positive (negative) impact on the stock return when the oil and gas prices are increasing (decreasing).

Another important finding in Figure 4 is that the interacting term, *Rmt.Rgt* (for $R_{mt} * R_{gt}$), and their impact on the stock return, s(*Rmt.Rgt,4*) [for $s(R_{mt} * R_{gt}, 4)$], have a convex relationship. When this interaction term is in the range of 0.00%-0.02%, the stock return is negative. However, beyond this range the stock return will be positive but this phenomenon only corresponds to a few observations (see the observation marks, also called the "rug", on the horizontal axis). This reflects the fact that when the gas price change and the market-index return move in the opposite direction, which leads to the negativity of the interaction term, the stock return will still benefit either from the rise of the whole market even if the gas price drops or from the gas price hike even if the whole market is down.

To further justify the nonlinear model, Figure 5 compares the model residuals and fitted values of the dependent variable (stock returns) in the linear model with those in the nonlinear model. It appears that nonlinear model has a better fit for the data than the linear model does. There is an obvious gap between the fitted values of the linear model, and the residuals of the linear model are slightly larger.

Table 7 Effect of Hedging on Oil and Gas prices to Stock Returns

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:

$$R_{it} = \alpha + \beta_m R_{mt} + \left[\gamma_1 + \gamma_2 Dop_{it} + \gamma_3 \left(OR_{it} / MVE_{it}\right)\right] R_{ot} + \left[\gamma_4 + \gamma_5 Dgp_{it} + \gamma_6 \left(GR_{it} / MVE_{it}\right)\right] R_{gt} + \varepsilon_{it}$$

Panel B shows GAM results. *s*(*x*,*i*) denotes the nonlinear function of the variable *x* with *i* degrees of smoothness. R_{mt}, R_{ot} and R_{gt} denote the market-index return, the percentage oil-price change, and the percentage gas-price change, respectively. Dop_{it} (Dgp_{it}) are adjusted deltas of oil (gas) production. OR_{it} (GR_{it}) is the value of oil (gas) reserves. MVE_{it} is the market value of equity. *Df* denotes degrees of freedom. * denotes the significance at the 5% level.

Panel A: Joint Linear Oil and Gas Beta Model

Independent variables	*Coefficients*	*Std. Dev.*	*t-ratio*
Intercept	0.016	004	3.957
R_{mt}	0.001	0.061	0.013
R_{ot}	0.175	0.056	3.126
R_{gt}	0.134	0.028	4.700
$R_{ot} * OR_{it} / MVE_{it}$	0.008	0.004	2.320
$R_{mt} * R_{gt}$	0.949	0.357	2.660
Residual Deviance	10.7392 on 875 Df	R-sq = 0.076	AIC=10.887
No. of Firm-year	76	Adj-R-sq=0.071	
No. of Obs.	881		

Panel B: Joint Nonlinear Oil and Gas Beta Model

Independent variables	*Df*	*Nonparametric Df*	*Nonparametric F-test for nonlinearity*	` *p-value*
s(R_{mt} ,5)	1	4.0	18.595	0.000*
s(R_{ot} ,5)	1	4.0	12.029	0.000*
s(R_{gt} ,5)	1	4.0	6.978	0.000*
s($R_{ot} * OR_{it} / MVE_{it}$,2)	1	6.3	4.834	0.000*
s($R_{gt} * GR_{it} / MVE_{it}$,2)	1	10.3	2.143	0.018*
s($R_{mt} * R_{gt}$,4)	1	3.0	17.923	0.000*
Residual Deviance	8.904892 on 842.4037 Df	R-sq=0.230 Adj R-sq=0.196		AIC=9.721
No. of Firm-year	76			
No. of Obs.	881			

Figure 4: Nonlinear Variables in Joint Model

Figure 4 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.Rot.MVE* (for $R_{ot} * OR_{it} / MEV_{it}$) and *GR.Rgt.MVE* (for $R_{gt} * GR_{it} / MVE_{it}$) denotes the sensitivities to oil and gas reserves, respectively. *Rmt.Rgt* (for $R_{mt} * R_{gt}$) is the interaction term between the market-index return and the gas price change. $s(x)$ denotes the nonlinear function of the variable x with degree freedom 4. 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^o and 90^o respectively. The "rug" on the horizontal axis indicates the data density.

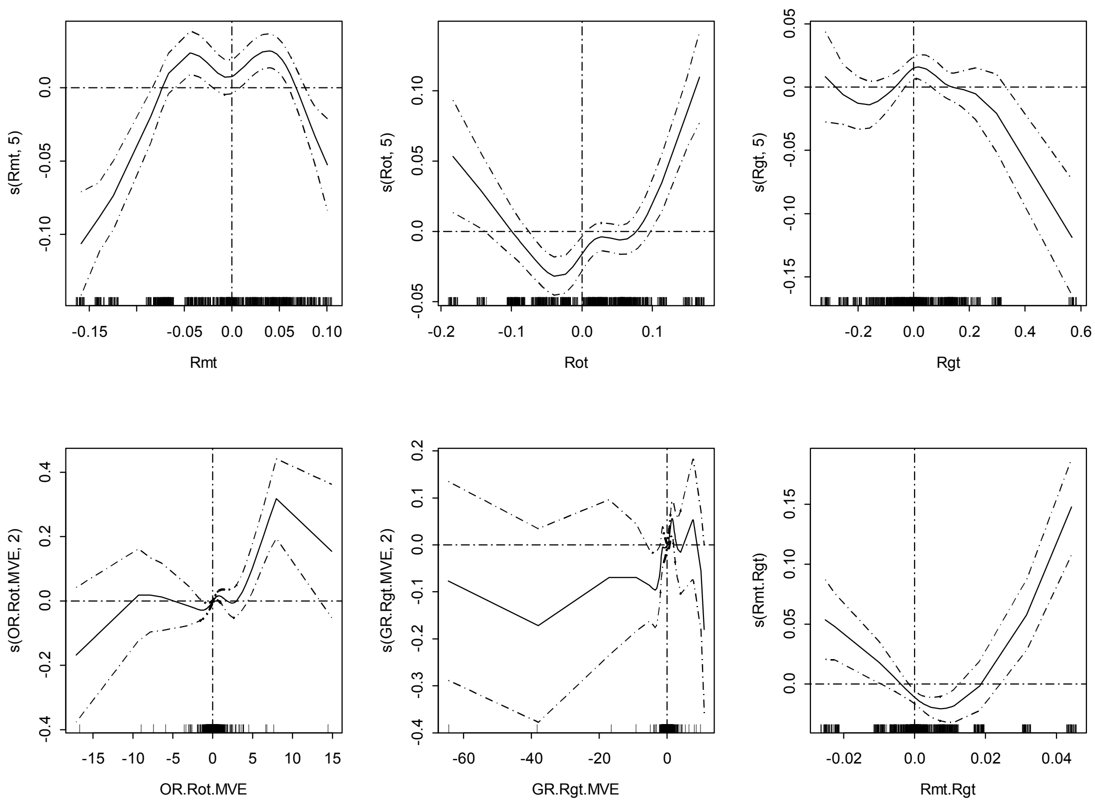
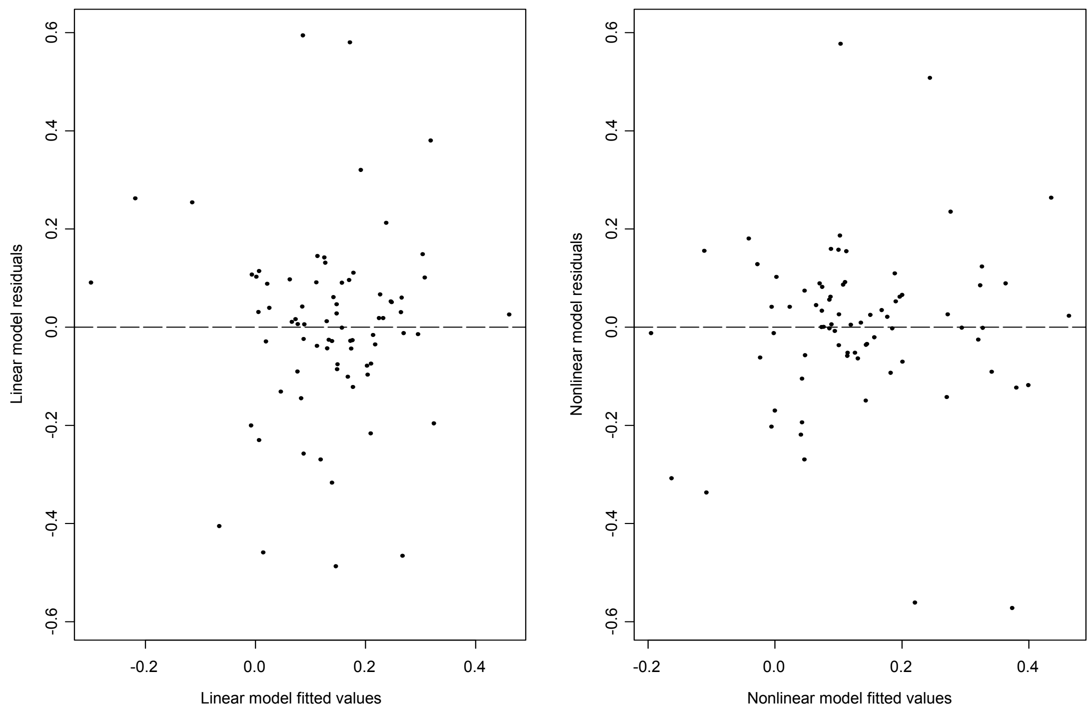


Figure 5: Nonlinearity vs. Linearity

Figure 5 shows the residuals versus the fitted values in both linear (the left part) and nonlinear (the right part) models. The evidence supports the better fit of the nonlinear model.



5. Firm Value and Hedging

5.1 Univariate Analysis

Whether firms with hedging have a higher firm value or a higher Q ratio than those without is also an important question in this literature. Therefore, this research compares the values of hedging firms with those of non-hedging firms. Table 8 reports the univariate analysis of differences in the Q ratios, book value of total asset, and market value of equity between oil/gas hedging and non-hedging firms. In Table 8, Panel A and B 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 of Table 8. Table 8 shows that the differences between hedging and non-hedging firms are primarily in Q ratios and that the firms with oil and gas hedging tend to have lower Q ratios.

Table 8 Comparison of Firm Values between Hedging and Non-hedging Firms

The table 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. Panel A and B show the comparison between oil hedging companies and non-oil hedging and non-hedging companies respectively. Similarly, Panel 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).

Panel A: Oil Hedging and Non-oil Hedging Firm-year

Variable	Hedging (46 obs.)	Non-hedging (30 obs.)	Difference	T-stat(mean) Z-score(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	2.67	0.01
MVE(mean)	3740.24	3319.73	420.51	0.34	0.74
MVE(median)	1406.85	488.68	918.17	2.02	0.04

Panel B: Oil Hedging and Non-hedging Firm-years

Variable	Hedging (46 obs.)	Non-hedging (23 obs.)	Difference	T-stat(mean) Z-score(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	0.64	0.52
BV(median)	1857.33	167.3	1690.02	2.84	0.00
MVE(mean)	3740.24	3663.59	76.65	0.05	0.96
MVE(median)	1406.85	260.50	1146.35	2.10	0.04

Panel C: Gas Hedging and Non-gas Hedging Firm-years

Variable	Hedging (41 obs.)	Non-hedging (35 obs.)	Difference	T-stat(mean) Z-score(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	2.83	0.00
MVE(mean)	3180.61	4035.37	-854.76	-0.73	0.47
MVE(median)	1263.33	439.05	824.28	1.75	0.08

Panel D: Gas Hedging and Non-hedging Firm-Years

Variable	Hedging (41 obs.)	Non-hedging (23 obs.)	Difference	T-stat(mean) Z-score(median)	P-value
Q (mean)	1.31	2.00	-0.69	-2.21	0.04
Q(median)	1.24	1.81	-0.57	-2.15	0.03
BV(mean)	4318.25	3670.47	647.79	0.40	0.69
BV(median)	2001.12	167.3	1833.82	3.04	0.00
MVE(mean)	3180.61	3663.59	-482.98	-0.3268	0.75
MVE(median)	1263.33	260.5	1002.83	2.39	0.02

5.2 Multivariate Analysis

Because the Q ratio is likely to be determined by many different factors, Allayannis and Weston (2001) analyze the determination of the Q ratio by separating the hedging dummy variables from oil and gas price changes and adding oil and gas deltas and other control variables. In this research, a more general regression model is employed:

$$\ln Q_{it} = \alpha + \beta_1 \left(\text{Oil Hedging Dummy}_{\text{it}}\right) + \beta_2 \left(\text{Gas Hedging Dummy}_{\text{it}}\right)$$

$$+\beta_3 Dop_{it} + \beta_4 Dor_{it} + \beta_5 Dgp_{it} + \beta_6 Dgr_{it} + \gamma \left(\text{Control Variables}_{\text{it}}\right) + \varepsilon_{it} \qquad (3)$$

where the subscript i is for firm i and the subscript t is for time t. The year and firm-specific dummy variables are tested in equation (3) but they are not statistically significant and hence are removed. Because the correlations between Dor_{it} and Dop_{it} and between Dgr_{it} and Dgp_{it} are fairly high, we therefore add their interaction terms to equation (3).

Following Allayannias and Weston (2001) and Jin and Jorion (2005), we also tested additional control variables such as *return on asset, investment growth, access to financial markets, leverage, and production cost* in the model. *Return on asset* (*Roa*) is measured by net income over book value of total asset. 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 asset. 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 company has paid a dividend in the current year, 0 otherwise. The impact is ambiguous. It can have a negative coefficient because dividend-paying firms are less financially constrained and may invest in less optimal projects and hence have lower Q ratios. [see Allayannis and Weston (2001)]. On the other hand, this coefficient can be positive because dividend-paying firms typically have good management and hence higher Q ratios [see Jin and Jorion (2005)]. *Leverage* is measured by the ratio of book value of long-term debt to market value of 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.[17] The coefficient of this variable is expected to be negative [see Jin and Jorion (2005)]. Although the book value of total asset can be a reasonable proxy for firm size, we do not 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 9 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 $R^2 - adjusted$, the nonlinear model has a better fit for the data. The tests based on the difference in deviance and the F-tests also show that the nonlinear model is superior to the linear model.

Table 9 and Figure 6 show 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*. This is because these variables, if included into the model, are not statistically significant. In these models only *return on asset*, *leverage*, *adjusted delta of gas production*, and *adjusted delta of gas reserves* are statistically significant. The nonlinear model is preferred to the linear one according to a set of model selection criteria. The nonlinear model shows that 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. Note that the generalized additive model is fitted on the logarithm of the Q ratio, these partial effects of these additive 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 *lnQ* while holding other explanatory variables fixed. Under this condition, when *Dgp* increases by 1%, the Q-ratio will decrease by about exp(0.8)=2.23%. Under the same condition, when *Dgr* increases by 1% the Q ratio will increase

[17] Production cost is evaluated by barrel of oil equivalent (boe) in oil and gas companies. One barrel of oil equivalent is equal to one barrel of crude oil or six thousand of British thermal units (mbtu).

by about exp(4.5)= 90. 02%. The relationship between two gas hedging variables demonstrates the need for some delicate balance between gas hedging relative to production and gas hedging relative to reserves in order to obtain the highest Q-ratio. The discovered relationships imply that within a feasible choice set, a lower ratio of *Dgp* to *Dgr* leads to a higher Q ratio. This means that higher gas reserves relative to gas production for a given level of hedging activities will lead to a higher Q ratio. This also shows that the firm value is highly responsive to gas hedging, gas production, and gas reserves. When the gas production is too low (high) but the gas delta value is too high (low), the firm can decrease (increase) its value. When the gas reserves are too low (high) but the gas delta value is too high (low), the firm can increase (decrease) its value.

These Canadian results are similar to those in Jin and Jorion (2005) but not entirely identical. In particular, we have explored both linear and nonlinear relationships of our interest. Jin and Jorion (2005) find that hedging and hedging dummy are not statistically significantly related to Q ratios and that investment growth is statistically significant. But they find that leverage is not statistically significantly. Our results confirm their finding that hedging and hedging dummy are not statistically significant. But we do not find investment growth statistically significant. Instead, we find that leverage is statistically significant. Further, our nonlinear model shows that leverage has a prominent negative nonlinear relationship with firm value.

Figure 7 compares the model residuals and the fitted values of the dependent variable in the linear model with those in the nonlinear model. The comparison shows that the nonlinear model has a better fit for the data than the linear model does. Thus, there are some advantages for using the generalized additive model in this work.

Table 9 Hedging and Firm Value

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:

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

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

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*, *5*) denotes the nonlinear function of the variable *leverage* with *5* degrees of smoothness. Df denotes degrees of freedom.

Model / Variables	**Joint Linear Model**			**Joint Nonlinear Model**		
No. of Obs	76			76		
Residual Deviance	2.697 on 71 Df			2.225 on 66.998 Df		
	Coefficients	**Std. Dev.**	**t-ratio**	**Coefficients/Nonparametric Df**	**Std. Dev./Nonparametric F-test for nonlinearity**	**t-ratio/p-value**
Intercept	0.190	0.037	5.173	Coefficient 0.176	Std. Dev. 0.033	t-ratio 5.284
Dgp	-0.807	0.306	-2.640	Coefficient -0.766	Std. Dev. 0.278	t-ratio -2.759
Dgr	4.345	1.622	2.679	Coefficient 4.449	Std. Dev. 1.473	t-ratio 3.020
Roa	0.801	0.251	3.194	Coefficient 1.000	Std. Dev. 0.229	t-ratio 4.383
Leverage[s(leverage,5)]	-0.298	0.079	-3.763	Nopar. Df 4	Nonpar. F-test 3.550	p-value 0.011
	AIC=-26.051	R-sq = 0.283		AIC =-12.067	R-sq = 0.408	
		Adj R-sq = 0.242			Adj R-sq = 0.337	

Figure 6: Linear and Nonlinear Relationships for Firm Value (*LnQ*)

Figure 6 shows the estimated linear and nonlinear relationships in solid lines for *lnQ*. *Roa* is the ratio of net income over book value of total asset. The partial impact of *Roa* on *lnQ* is linear. *Leverage* is measured by the ratio of book value of long-term debt to market value and has a nonlinear relationship with *lnQ*. The higher the leverage is, the lower the firm value will be. *Dgp* denotes the delta value relative to gas production and it has a negative linear relationship with *lnQ*. *Dgr* denotes the delta value relative to gas reserves and it has a positive linear relationship with *lnQ*. Broken lines show the 95% confidence intervals of estimated relationships. Dotted lines are reference lines, which have angles of 0^o, and 90^o respectively. The "rug" on the horizontal axis indicates the data density.

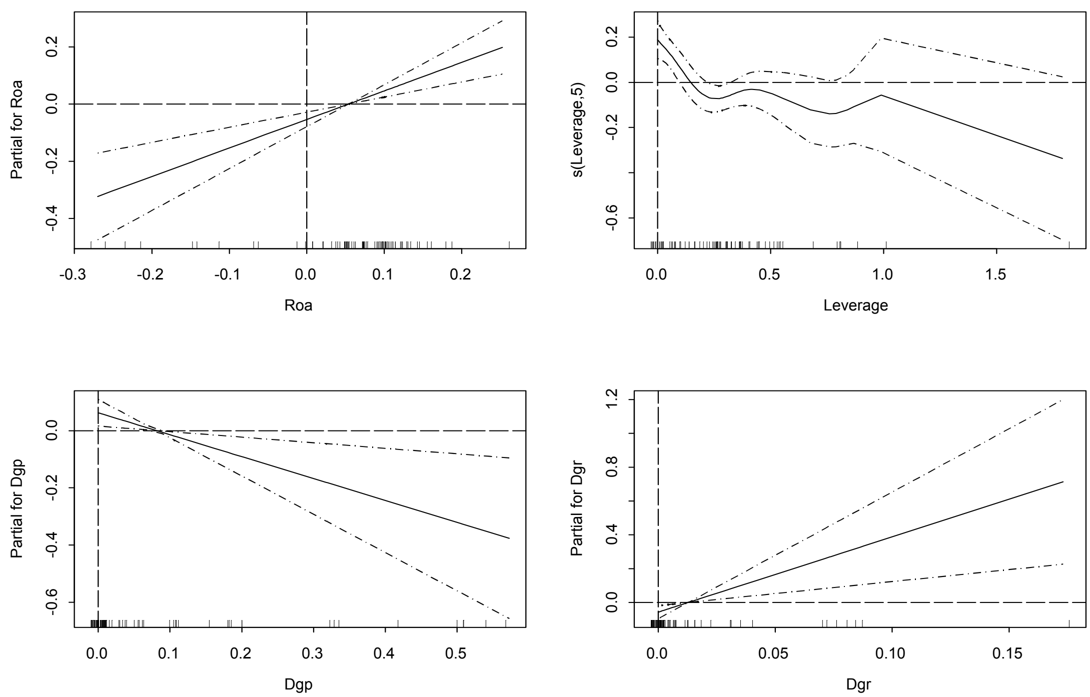
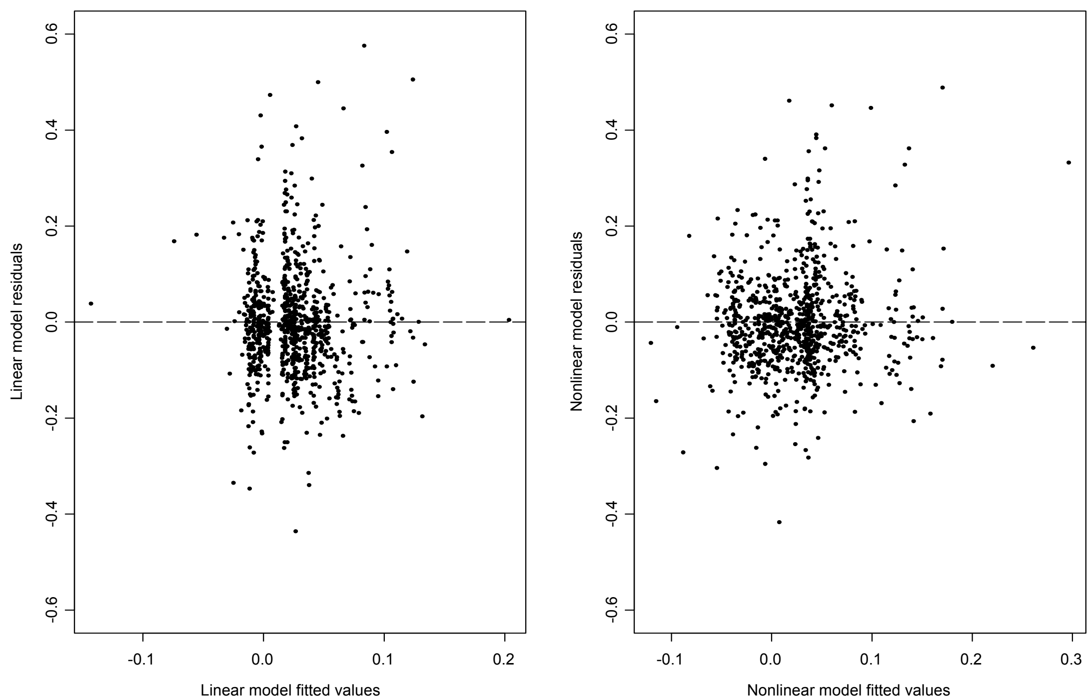


Figure 7 Nonlinearity vs. Linearity

Figure 7 shows the model residuals and fitted values of dependent variable-stock returns. The left-side graph is for the linear model. The right-side graph is for the nonlinear model. The horizontal (vertical) axis represents stock returns raw data (residuals).



6 Conclusions

This paper aims to uncover the relationships between hedging activities and firm value in large Canadian oil and gas companies by examining the impact of oil and gas hedging for the period of 2000-2002. This is perhaps the first systematic study of this kind with the Canadian oil and gas data.

This paper also extends the methodology in the existing studies from linear parametric models to nonlinear semi-parametric additive models to accommodate nonlinear payoffs of various hedging strategies. The nonlinear models have the potential for uncover nonlinear relationships between hedging and stock returns and between hedging and firm value. This approach permits an analysis of nonlinear roles of hedging that would otherwise not be possible within a linear framework. Indeed, the data analysis in this paper indicates that nonlinear semi-parametric additive models are superior to their linear parametric counterparts.

By examining the impact of hedging on relationships between the stock return and oil/gas price changes, this research shows that the stock return indeed responds to these price changes in nonlinear ways. While the nonlinear model can recover how the stock return reacts to oil/gas price changes, it is found that oil hedging appears to be more effective than gas hedging is. The downside protection of the stock return starts to work as the oil price falls more than five percentage points while it only starts to work as the gas price drops more than fifteen percentage points. These findings are not observable in the linear model.

Then we further incorporate into the model direct measures of oil and gas hedging and the direct measures of oil and gas reserves. Once again, the direct measures of oil and gas hedging are not as important as the oil and gas reserves are in influencing the stock return. The evidence shows that Canadian oil and gas firms are able to have some down side protection against unfavorable changes in the oil and gas prices. In addition, oil and gas reserves are more likely to have a positive (negative) impact on the stock return when the oil and gas prices are increasing (decreasing).

In order to analyze the role of hedging further, this research examines its impact on firm value. This research measures the value of a firm using Tobin's Q ratio and finds that the Q ratio can be better modeled by nonlinear models. But many hypothesized factors such as oil and gas hedging dummy variables, investment growth, assess to financial market, and so on cannot be supported by the Canadian data except for leverage. This research confirms the positive impact of profitability (return on asset) on firm value and the negative impact of borrowing on firm value. In addition, hedging activities relative to gas production and to gas reserves, respectively, have significant negative and positive impacts on firm value at the margin. This may indicate the need for some delicate balance between gas hedging relative to production and gas hedging relative to reserves in order to obtain the highest Q-ratio. The discovered relationships imply that within a feasible choice set, a lower ratio of *Dgp* to *Dgr* leads to a higher Q ratio. This means that higher gas reserves relative to gas production for a given level of gas hedging activities will 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. If Canada has a new regulation like FRR 48 in the U.S. more information will be available. 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 more 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).

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December 31, 2002 outstanding contracts

An Example:

Crude Oil

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: Deviance

To test the goodness of fit the likelihood ratio test can be used. The likelihood ratio approach leads to a statistic called deviance. The deviance of a model compares the log-likelihood of the fitted model of interest to the log-likelihood of a saturated model, that is, a model that has more parameters and that fits the sample data well.

Let the maximum likelihood estimates for the fitted model be $\hat{\beta}$. The value of the log-likelihood function for the fitted model $\ln L(\hat{\beta})$ can never exceed the value of the log-likelihood function for the saturated model ln*L*(saturated model), because the fitted model contains fewer parameters than the saturated model does. The deviance compares the log-likelihood of the saturated model with the log-likelihood of the fitted model. Specifically, deviance $D(\beta)$ is defined as

$$D(\beta) = 2\ln L(\text{saturated model}) - 2\ln L(\hat{\beta})$$

$$= 2[l(\text{saturated model}) - l(\hat{\beta})]$$

where l denotes the log of the likelihood function. If the sample is large, $D(\beta)$ has an approximate chi-square distribution. Large values of the deviance would indicate that the model is not sufficient while a small value of the model deviance indicates that the fitted model fits the data almost as well as the saturated model does. Residual deviance indicates how well the model fits the data, which is used in this paper to compare the goodness of fit in linear and nonlinear models. Furthermore, in the standard normal-error linear regression model, the deviance turns out to be the error or residual sum of squares divided by the error variance δ^2. For more detailed information, please see McCullagh and Nelder (1989).