OIL AND GAS RISK FACTOR SENSITIVITIES FOR U.S. ENERGY COMPANIES

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The purpose of this study is to identify and assess the risk factors that drive U.S. oil and gas company stock returns. We examine whether the same risk factors hold in four sub-sectors: exploration and production, integrated oil and gas, oil equipment and services, and pipelines. We also include royalty trusts[1] in our

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sample. Moreover, we divide the full time period into three sub-periods with the objective to uncover variations in the sensitivities due to different pricing environments. To determine which risk factors affect U.S. oil and gas stock returns, we apply the multifactor models used by P. Jorion, R. Faff and H. Chan, R. Faff and T. Brailsford, and P. Sadorsky, as well as empirical evidence in this area.[2]

For a long time there has been general agreement among academics and practitioners that the market factor is a relevant driver for stock returns, but that there are other important elements too. There is less agreement over which these other factors are, but numerous proposals exist (see, e.g., P. Osmundsen et al.).[3] The lack of consensus on which other factors are relevant results in empirical diversity. More recent studies show a growing interest toward inclusion and assessment of several types of explanatory variables. Additional factors suggested are macroeconomic and financial variables as well as variables of financial ratios and accounting statements. The factors that are relevant to include becomes more complex with the unveiling of industrial and company-specific differences. Some studies identify new risk factors that drive the stock return, while others focus on entire countries and/or industries. This study examines the return for U.S. oil and gas stocks on the individual and sub-sectorial level.

Investors in the oil and gas sector follow oil price fluctuations because corporate managers and investors care about the exposure firms have to interest rates, exchange rates, and commodity prices.[4] A variety of empirical studies provide evidence indicating that both oil price and exchange rates have significant impacts on oil and gas industry returns. Companies exposed to these factors that do not engage in hedging activities to a full extent would experience significant price volatility that, in turn, would affect their cash flows.[5] Lower (higher) commodity prices would have a negative (positive) impact on the profit margin and, in return, affect stock prices. As such, commodity prices are risk factors relevant to this study.

Research focusing on the U.S. oil and gas industry exists but is scarce with regard to the inclusion of natural gas price factors, sub-sector analysis, inclusion of royalty trusts in the data sample, and renewed datasets. Prior valuation studies do not fully capture the effect of the shale gas revolution and the recent fall in the oil price (2014–2016), which is important for managers and investors interested in hedging against price shocks.[6] Inclusion of royalty trusts also is critical in understanding their non-operating exposure compared to their physically operating counterparts. Our paper contributes to the literature by showing that the average beta across the operating firms is 0.90, 0.27, and 0.13 toward market, oil price, and gas price fluctuations, respectively, and, furthermore, that royalty trusts maintain the overall exposure level.

The study is organized as follows: we begin with a review of the literature followed by a description of the methodology and common determinants; a presentation of the data; an overview of the theoretical background; a reporting of the empirical results; and, last, we offer the conclusions of our research.

Literature Review

The determinants of stock market returns are a salient issue in financial economics. Literature focused on explaining what factors drive oil and gas company stock returns have been the subject of great interest over the years. Most studies report significant macro factors (i.e., commodity prices, stock market returns, interest rates, and exchange rates) and significant fundamental factors at both the company (i.e., size, value, and momentum) and industry level (i.e., industrial production).

Early studies provide evidence that stock prices are positively associated with changes in oil prices in both the United States (R. Huang et al. and P. Sardosky)[7] and Australia (R. Faff and T. Brailsford).[8] In subsequent research, P. Sadorsky used a multifactor market model to estimate the expected returns to Canadian oil and gas industry stock prices.[9] Results demonstrated that the stock market index and crude oil prices have large and positive effects on stock price returns in the Canadian oil and gas industry. Exchange and interest rates were shown to have a significant negative effect. I. El-Sharif et al. implemented a multifactor model in their analysis of the U.K. oil and gas industry, at the time being Europe's largest oil and gas industry.[10] Their findings demonstrate that oil and gas stock returns are impacted by several risk factors such as changes in crude oil prices, the stock market as a whole, and (to a lesser extent) the exchange rate. M. Boyer and D. Filion find a positive relationship between stock returns of 105 Canadian oil and gas companies and appreciation in oil and gas prices.[11] They further revealed the Canadian energy stock returns to be positively correlated with the stock market, crude oil prices, natural gas prices, growth in internal cash flows, and proven reserves, while being negatively correlated with interest rates.

Using a global view, M. Nandha and R. Faff analyzed 35 Datastream global industry indices for the period April 1983 to September 2005 using monthly frequency.[12] Their findings indicate that oil price increases have a negative impact on all sectors except for mining and the oil and gas industries. The research of J. Park and R. Ratti also shows that increases in oil prices have a positive impact on equity returns of oil and gas industries of 13 European countries.[13] U. Oberndorfer found that oil price hikes lead to an appreciation in gas stocks in European countries.[14] S. Ramos and H. Veiga's analysis of investment in the oil and gas industry in 34 countries found evidence to support oil as a globally priced factor for the oil industry.[15] They reported that the oil industry returns react asymmetrically to oil price changes; that is, oil price hikes have a greater impact than oil price drops. Moreover, they observed that the asymmetric effects are stronger for industries in developed countries than for emerging countries.

Finally, S. Mohanty and M. Nandha used a firm-level approach when measuring the oil price risk sensitivities of U.S. oil and gas firms.[16] By augmenting Fama-French-Carhart's four-factor asset pricing model with both oil price and

interest rate factors, their results demonstrated that the market, book-to-market, size, and momentum characteristics of stocks as well as changes in oil prices are significant determinants of returns for the sector. By sorting the companies into sub-sectors and dataset in sub-periods; they found that the sub-sectors show various and distinct exposures dependent on the pricing environments. S. Mohanty and M. Nandha's paper has been used extensively to compare and discuss our results throughout the study.[17]

We were not able to find literature that included royalty trusts. As such, academics and practitioners have little evidence on the risk factor sensitivities of royalty trusts. The recent drop in oil price and the shale gas boom, justify why an update of the sample period is important for managers and investors interested in hedging and/or diversification possibilities. Last, few studies include natural gas as a risk factor in their models. Many companies are involved in both gas and oil production and as such the natural gas element is an important risk factor for company stock price returns.

Methodology and Common Determinants

Methodology: The methodology used in this study is based on the multifactor models used by P. Jorion, R. Faff and H. Chan, R. Faff and T. Brailsford, and P. Sadorsky.[18] The assumption is that variation of U.S. oil and gas company stock returns are mainly associated with common determinants. Our model builds on the well-established one-factor market model augmented with oil price, natural gas price, and interest rates. By using the generalized least squares (GLS) time-series linear model,[19] we control for serial correlation present in the data. All variables are monthly observations and transformed using the logarithmic function. The model can be written as follows:

$$R_{it} - R_{ft} = \alpha_{i_0} + \beta_{i,m}\left(R_{mt} - R_{ft}\right) + \beta_{i,\mathrm{OIL}}R_{\mathrm{OIL},t} + \beta_{i,\mathrm{GAS}}R_{\mathrm{GAS},t} + \beta_{i,INT}R_{INT,t} + \varepsilon_{it}$$

where $R_{it} - R_{ft}$ is the monthly excess return of stock i at t over the 1-month U.S. Treasury bill; $R_{\mathrm{m}t} - R_{ft}$ is the monthly excess return of the New York Stock Exchange (NYSE) on day t; and $R_{OIL,t}$ represents the geometric return in crude oil price. The oil price used throughout this study is the West Texas Intermediate (WTI) price in dollars-per-barrel terms and $R_{\mathrm{GAS},t}$ is the monthly return on natural gas prices. For the natural gas price, we use the New York Mercantile Exchange (NYMEX) natural gas futures in million British thermal units (MMBtu). $R_{INT,t}$ is the monthly change in the interest rate factor (term premium), calculated as the monthly logged change in the 10-year U.S. Treasury bond yield (a proxy for the interest rate). Finally, α is the constant and ε_t represents the residuals.

Common Determinants: Based on the theories by W. Sharpe and R. Merton, which were found to be a statistically significant factor across industries, the U.S. stock market is included in the model as a potential risk factor.[20] The market return acts as a proxy of changes in aggregate economic wealth that affect risk premia and expected return.[21] By including the market factor in our model, we are able to assess whether the U.S. oil and gas industry is more or less risky than the overall market—opening for discussion around the sector as part of a hedging strategy. Furthermore, we will be able to determine if the industry moves pro-cyclical or counter-cyclical.[22] We use the New York Stock Exchange composite index as our market factor.

The oil and gas production industry is well known for its capital-intensive operations, with U.S. oil and gas companies being no exception. The scale of investments necessary to operate in both onshore and offshore exploration ventures to find reserves with the goal to meet their growth and cash flow objectives is large as well. This capital intensity has ever-present consequences for the firm's financial structure in the sense that external financing is necessary. Thus, the use of debt is widely spread so interest rate variations represent an important risk factor.[23]

Concerning the commodity factors (crude oil and natural gas), we use the monthly returns on the West Texas Intermediate (WTI) Cushing and NYMEX natural gas price for two reasons. First, WTI and NYMEX are the most commonly used indices in North America.[24] Second, for firms that use futures, forwards, and other over-the-counter derivatives as part of their hedging strategies, the vast majority are based on the WTI and NYMEX natural gas prices.[25]

Data

Our data sample consists of 50 U.S. oil and gas companies and six royalty trusts. The companies are divided into four sub-sectors categorized as follows: 30 are exploration and production companies, seven are integrated oil and gas enterprises, nine are oil equipment and services firms, and four are pipeline companies. All companies operate in the United States and are traded on NYSE. The appendix 1 table lists all the companies included in this study. Data used are monthly observations (end of month), obtained from Datastream, denominated in U.S. dollars. Because of the sub-sectorial analysis, the number of included companies is limited due to maintaining the best possible balance between the subsectors. However, we only found four pipeline companies that met our criteria. This is taken into consideration when concluding sectorial differences. Table 1 presents a summary of how the independent variables were calculated.

A priori, we expect to see the market, as well as oil and gas price factors, to have a positive impact on the returns of oil and gas stocks, while the interest rate

Table 1
MEASURE OF INDEPENDENT VARIABLES[a]

Variable	Source	Measure (in percent)
Excess return market	Datastream	$r_M = ln$ ((NYSE monthly return – 1 month U.S. Treasury bill)$_t$ / (NYSE monthly return – 1 month U.S. Treasury bill) $_{t-1}$)
Return oil price	Datastream	$r_{OIL} = ln$ ((price of WTI barrel in U.S. dollars)$_t$ / (price of WTI barrel in U.S. dollars) $_{t-1}$)
Return natural gas price	Datastream	$r_{GAS} = ln$ ((price of NYMEX gas in U.S. dollars)$_t$ / (price of NYMEX gas in U.S. dollars) $_{t-1}$)
Change in interest rate	Datastream	$r_{INT} = ln$ ((10-year U.S. Treasury bill rate)$_t$ / (10-year U.S. Treasury bill rate) $_{t-1}$)

[a] All measures are monthly observations, logarithmic transformed.

has a negative impact. If oil and gas stocks are useful for hedging inflation, then the market beta should be negative.[26] Furthermore, we expect to see firms directly involved in production to show higher sensitivity toward oil and gas prices than service companies, pipeline companies, and royalty trusts. Finally, we expect to find different exposures dependent on the pricing environment.

Theoretical Background

This section builds on S. Mohanty and M. Nandha's[27] interpretation of R. Huang et al.'s article,[28] illustrating a theoretical linkage between oil price and stock returns. Seeing that future oil prices can have a significant impact on the company stock return, R. Huang et al. define a general and intuitive approach describing the economic relationship. Seeing that stock prices are discounted values of expected future cash flows, when company i generates a constant expected cash flow, the stock price of that company, p, is simply the present value of expected future cash flows, $E(c)$, discounted by the discount rate, r, for an eternal cash flow,

$$p = \frac{E(c)}{E(r)} \tag{1}$$

where $E(\cdot)$ is the expectation operator. Realized stock returns, R, can be expressed approximately as:

$$R = \frac{d(E(c))}{E(c)} - \frac{d(E(r))}{E(r)} \tag{2}$$

where $d(\cdot)$ is the differentiation operator. As such, stock returns are affected by both systematic movements in expected cash flows and expected discount rates. Depending on the company being a net consumer or net producer, the future oil price can affect the stock price either positively or negatively. Oil and gas producers would intuitively have oil as an (major) output factor, indicating higher expected cash flows from oil price increases. On the other hand, companies that use oil as a major input factor (i.e., transportation sector – consumer of resources) would experience higher costs of purchase, resulting in lower expected cash flows and lower stock prices.[29]

Oil price fluctuations also can affect stock returns via the discount rate. The expected discount rate consists of both the expected inflation rate and expected real interest rate, both of which may, in turn, depend on the expected oil price.[30] An increase in the expected discount rate can lead to an increase in the minimum rate of return (hurdle rate) required by a manager or investor and a higher minimum rate of return then leads to a negative impact on a firm's stock price. As such, the real linkage between changes in oil price and company stock returns rests on the net effects due to a change in expected cash flow and expected discount rates.[31]

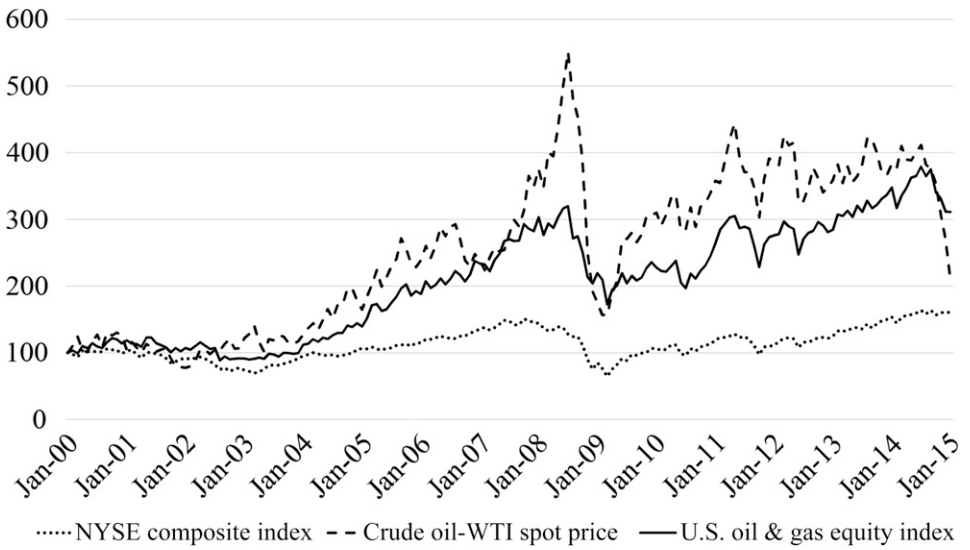
Empirical Results

Figure 1 presents the relative growth of WTI oil prices, NYSE composite price index, and the U.S. oil and gas industry equity index over the period January 2000 to January 2015. In this period, the oil price fluctuates from $17 per barrel to $145 per barrel. Concerning the first period (January 2000 to June 2007), we see the oil price as low as $17 and as high as $77. In the second period (July 2007 to January 2015) the oil price fluctuates between $31 to $146. Finally, for the special subperiod from May 2003 to July 2008, the oil price shows a high acceleration from its low at $27 to over $145 in July of 2008.

The graph also reveals different events taking place within the period. We notice how hurricane Katrina resulted in an oil price spike in 2005. The 2008 financial crisis and the following global recession are clearly recognizable—an event that affected the entire stock market along with the oil and gas industry. The oil price, already volatile in the aftermath of the global financial crisis, became even more unstable with the onset of the "Arab Spring" in 2011 as fears of potential oil supply disruptions from Middle East producers resulted in price spikes. From 2014 onwards, the figure displays the drop in oil prices and how it affects the entire U.S. oil and gas equity index.

Inspecting both the New York Stock Exchange and U.S. oil and gas equity index, we notice how they follow the oil price or rather how the 2003–2008

Figure 1
U.S. OIL AND GAS INDUSTRY EQUITY INDEX, NEW YORK STOCK EXCHANGE (NYSE) COMPOSITE PRICE INDEX, AND WEST TEXAS INTERMEDIATE (WTI) CRUDE OIL SPOT PRICE, JANUARY 2000–JANUARY 2015
(Base: January 2000 = 100)



economic boom caused the oil price to follow the economy.[32] We also observe how the U.S. oil and gas index rises throughout the special sub-period. For this reason, this period is included in our analysis to examine the effects of rapid increases in oil price on U.S. oil and gas stocks.[33]

Table 2 reports summary statistics for the monthly logged return data used in this study. Most companies have positive returns during the period. Still, 11 out of 56 companies have a negative mean return, which is interesting when compared to other studies (i.e., S. Mohanty and M. Nandha) that report positive mean returns for all companies.[34] A possible reason for this result could be explained by the 2008 financial crisis that affected all industries; however, the shale gas boom and more recent drop in oil price have made impacts on the oil and gas company stock prices. Royalty trusts show the lowest average mean return of the companies included in our sample.

Prior to running the multivariate regression model, a correlation analysis is conducted on the four risk factors (market, oil price, gas price, and interest rate) for the full sample period (January 2000 to January 2015) and for the three sub-periods (January 2000 to July 2007, August 2007 to January 2015, and May 2003 to December 2008). Table 3 presents the correlation matrix for the different factors.

Table 2
DESCRIPTIVE STATISTICS: MONTHLY RETURNS DATA,
JANUARY 2000 – JANUARY 2015[a]

Company	Ticker Symbol	Mean	Maximum	Minimum	Standard Deviation
EXPLORATION AND PRODUCTION COMPANIES					
ANADARKO PETROLEUM	APC	0.008922	0.318887	–0.371554	0.098579
APACHE CORP.	APA	0.007646	0.309699	–0.250386	0.096563
BP PLC	BP	–0.001806	0.286729	–0.396887	0.074484
CABOT OIL & GAS	COG	0.017061	0.450722	–0.431187	0.114076
CALLON PETROLEUM	CPE	–0.004385	0.593775	–1.437996	0.212988
CANADIAN NATURAL RESOURCES	CNQ	0.012167	0.259307	–0.303880	0.102240
CHESAPEAKE ENERGY	CHK	0.011320	0.554911	–0.489945	0.130587
CHINA PETROLEUM & CHEMICAL (SINOPEC)	SNP	0.009638	0.362731	–0.319867	0.096710
CIMAREX ENERGY	XEC	0.012086	0.380863	–0.354981	0.110868
CLAYTON WILLIAMS EN.	CWEI	0.009159	0.566853	–0.462594	0.175873
COMSTOCK RESOURCES	CRK	0.001209	0.536578	–0.522147	0.153827
DENBURY RESOURCES	DNR	0.010561	0.434426	–0.406272	0.127000
DEVON ENERGY	DVN	0.006850	0.265189	–0.344001	0.094622
ENCANA	ECA	–0.000777	0.192366	–0.508910	0.095697
ENI SPA	E	0.003239	0.225589	–0.205808	0.066027
EOG RESOURCES	EOG	0.017280	0.328724	–0.303297	0.103359
GOODRICH PETROLEUM	GDP	–0.003144	0.666022	–0.592501	0.182331
HESS	HES	0.007427	0.347960	–0.309856	0.097387
MARATHON OIL CORP.	MRO	0.004045	0.231734	–0.531217	0.095537
NEWFIELD EXPLORATION	NFX	0.004293	0.317412	–0.348177	0.113011
NOBLE ENERGY	NBL	0.012517	0.377279	–0.308448	0.092006
OCCIDENTAL PETROLEUM	OXY	0.011587	0.262257	–0.237800	0.077978
PANHANDLE OIL & GAS	PHX	0.017212	0.427382	–0.372837	0.117418
PENN VIRGINIA	PVA	0.000607	0.323920	–0.513162	0.147770
PETROCHINA CO. LTD.	PTR	0.011136	0.430850	–0.320232	0.103207
PETROQUEST ENERGY	PQ	0.002667	0.610054	–0.669727	0.181537
PIONEER NATURAL RES.	PXD	0.015926	0.370503	–0.630499	0.122265
RANGE RESOURCES	RRC	0.018062	0.671516	–0.391449	0.122667
SM ENERGY	SM	0.009891	0.370423	–0.417919	0.122378
STATOIL ASA	STO	0.005055	0.191375	–0.252294	0.081246
EXPLORATION AND PRODUCTION COMPANY AVERAGE		**0.006926**	**0.389185**	**–0.436620**	**0.118174**
INTEGRATED OIL AND GAS COMPANIES					
CHEVRON	CVX	0.004761	0.213219	–0.165514	0.059489
CONOCOPHILLIPS	COP	0.005447	0.197000	–0.342442	0.078336
EXXON MOBIL	XOM	0.004281	0.204522	–0.123821	0.050003
STONE ENERGY CORP.	SGY	–0.005405	0.673229	–0.773190	0.164539

(continued)

Table 2 (continued)

DESCRIPTIVE STATISTICS: MONTHLY RETURNS DATA, JANUARY 2000 – JANUARY 2015[a]

Company	Ticker Symbol	Mean	Maximum	Minimum	Standard Deviation
SUNCOR ENERGY INC.	SU	0.009485	0.333821	–0.566282	0.102504
SWIFT ENERGY CO.	SFY	–0.009153	0.417713	–0.756468	0.167077
ULTRA PETROLEUM CORP.	UPL	0.012317	0.344165	–0.411022	0.127243
INTEGRATED OIL AND GAS COMPANY AVERAGE		**0.003105**	**0.340521**	**–0.448390**	**0.107027**
OIL EQUIPMENT AND SERVICE COMPANIES					
BAKER HUGHES	BHI	0.005595	0.242243	–0.549389	0.106570
ENSCO INTL.	ESV	0.001125	0.337201	–0.416194	0.110681
HALLIBURTON	HAL	0.003794	0.278212	–0.492673	0.121059
HELMERICH PAYNE	HP	0.009395	0.386456	–0.339634	0.111527
NABORS INDUSTRIES LTD.	NBR	–0.001633	0.420369	–0.550528	0.132257
NOBLE	NE	–0.000053	0.410543	–0.366394	0.108611
SCHLUMBERGER	SLB	0.005950	0.271468	–0.413372	0.096053
TIDEWATER	TDW	–0.001145	0.273068	–0.264943	0.099039
WEATHERFORD	WFT	0.000188	0.406970	–0.428274	0.128191
OIL EQUIPMENT AND SERVICE COMPANY AVERAGE		**0.002580**	**0.336281**	**–0.424600**	**0.112665**
PIPELINE COMPANIES					
ENBRIDGE ENERGY PTNS. LP.	EEP	0.004508	0.217638	–0.315263	0.062198
OGE ENERGY	OGE	0.007233	0.189319	–0.167000	0.055136
PLAINS ALL AMER. PIPELINE LP.	PAA	0.011226	0.152634	–0.184549	0.052942
WILLIAMS CO.	WMB	0.001996	0.421941	–0.863151	0.145578
PIPELINE COMPANY AVERAGE		**0.006241**	**0.245383**	**–0.382490**	**0.078964**
ROYALTY TRUSTS					
CROSS TIMBERS ROYALTY TRUST	CRT	0.002436	0.270883	–0.589053	0.102763
DOMINION RES. BLACK WARRIOR TRUST	DOM	–0.003428	0.444251	–0.356840	0.102113
HUGOTON ROYALTY TRUST	HGT	–0.000754	0.269595	–0.670775	0.109175
PERMIAN BASIN ROYALTY TRUST	PBT	0.003434	0.258311	–0.315529	0.079991
SABINE ROYALTY TRUST	SBR	0.005692	0.217830	–0.309732	0.086483
SAN JUAN BASIN ROYALTY TRUST	SJT	0.001849	0.192126	–0.436287	0.093632
ROYALTY TRUSTS AVERAGE		**0.001538**	**0.275499**	**–0.446370**	**0.095693**

[a] The descriptive statistics for the sample is calculated over January 2000 to January 2015 using monthly data observations. The sample includes 50 oil and gas operational companies and six royalty trusts involved in oil and gas production. The companies are further divided into four sub-sectors: exploration and production (30), integrated oil and gas (7), oil equipment and services (9), and pipelines (4). All data are obtained from the Datastream database.

From table 3 we see that crude oil and natural gas price returns are positively correlated in both the full period and the three sub-periods. We also find the oil price return to be positively correlated with the U.S. stock market return (NYSE), with the exception of the second sample period. Finally, interest rates seem to be fairly stable against the market factor throughout the full sample period and sub-periods.

Oil and Gas Price Sensitivities of U.S. Oil and Gas Companies: The appendix 2 table presents the result of the multivariate time-series regression of oil and gas companies' excess returns on the market, oil price, natural gas price, and the interest rate factor. For the entire time period (January 2000 – January 2015), the results are consistent with the market model; all stock market coefficients are statistically significant and scattered around unity. Concerning pipelines and royalty trusts, they generally have lower market coefficients compared to exploration and production companies, integrated companies, and oil equipment and service companies. Permian Basin Royalty Trust has the lowest beta at 0.39 and

Table 3
CORRELATION BETWEEN RISK FACTORS[a]

	Market $R_{mt} - R_{ft}$	**Oil Price** $R_{OIL,t}$	**Gas Price** $R_{GAS,t}$	**Interest Rate** $\Delta B_{YIELD,t}$
January 2000 – January 2015				
Market	1.0000			
Oil price	0.3410	1.0000		
Natural gas price	0.1166	0.2846	1.0000	
Interest rate	0.2974	0.2439	–0.0466	1.0000
January 2000 – July 2007				
Market	1.0000			
Oil price	–0.0882	1.0000		
Natural gas price	0.1121	0.2522	1.0000	
Interest rate	0.3151	–0.0513	–0.1421	1.0000
August 2007 – January 2015				
Market	1.0000			
Oil price	0.6051	1.0000		
Natural gas price	0.1363	0.3388	1.0000	
Interest rate	0.2895	0.4066	0.0217	1.0000
May 2003 – July 2008				
Market	1.0000			
Oil price	0.1029	1.0000		
Natural gas price	0.1085	0.3654	1.0000	
Interest rate	0.2351	0.0823	–0.0168	1.0000

[a] $R_{mt} - R_{ft}$ stands for the logarithmic return on the NYSE market index less risk-free rate; $R_{OIL,t}$ is the logarithmic return on WTI oil price; $R_{GAS,t}$ is the logarithmic return on the NYMEX natural gas price; and $\Delta B_{YIELD,t}$ stands for the logarithmic change in the10-year U.S. Treasury bond.

Callon Petroleum Company has a beta value of 1.64, making it the most volatile stock in our sample. Averaging the market betas for all 56 companies (including royalty trusts), we get a market beta of 0.90, indicating that the sampled companies have been slightly less risky than the market in the period. Furthermore, seeing that the market beta is positive, this indicates that the sampled companies were not a good hedging tool over the period.[35]

Inspecting the risk exposure sensitivities of oil price returns, OGE Energy Corporation demonstrates the lowest impact on stock returns with an oil beta equal to 0.03. Goodrich Petroleum has the highest impact with an oil price beta value of 0.60. The results also show that out of the 56 companies included in our study, 51 display statistically significant risk exposure against the oil price return, with a relatively high impact on stock price. The result provides evidence to support the conjecture that oil price movements impact oil and gas stock price and, furthermore, that oil exposure (oil betas) do vary across firms. The findings reflect earlier studies, such as R. Faff and T. Brailsford, P. Sadorsky, I. El-Sharif et al., M. Boyer and D. Filion, and S. Mohanty and M. Nandha, and are not surprising seeing that oil is a major output (indirectly for oil royalty trusts) for the sample companies.[36]

In regards to natural gas price, 42 companies show statistically significant coefficients. Interestingly, exposure to natural gas price fluctuations demonstrates a reduced impact on the sample stock price for most companies. M. Boyer and D. Filion offer two possible explanations: first, since the production of oil is, on average, greater than the production of natural gas, a change in crude oil prices should result in a more crucial impact on revenues and profits of U.S. oil and gas company stock price returns than natural gas prices.[37] Second, relating to G. Haushalter, among the companies that are hedging those focusing on gas production tend to hedge more extensively than their oil-production-based counterparts.[38] We also offer an alternative explanation—the effect of the shale gas revolution. (See the discussion on "decoupling" in the subsequent section on "Oil and Gas Price Sensitivities of U.S. Oil and Gas Companies: Sub-Period Analysis.")

Overall, the interest rate factor is seldom found to be a significant risk factor to oil and gas stock price returns in both the full period analysis and the sub-periods. Eleven companies display significant exposure.

The multifactor model has an average adjusted R^2 of 0.44 for oil and gas companies, which indicates that 44 percent of the variation in oil and gas share price returns can be explained by the excess market return, crude oil price return, natural gas price return, and change in interest rate. The explanatory power of the model when looking at royalty trusts averages 0.29. Appendix table 2 presents the full sample regression results, while appendix table 3 provides the sub-period analysis.

Oil and Gas Price Sensitivities of U.S. Oil and Gas Companies: Sub-Period Analysis: The results for the sub-period analysis presented in appendix table 3 show that the significance and impact of oil price exposure varies in the three

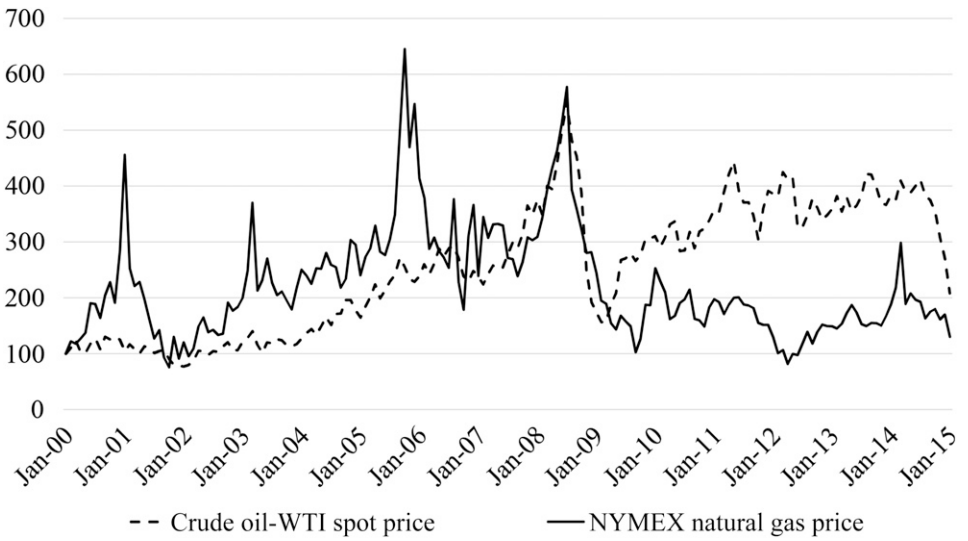
sub-periods. In the first half of the sample period (January 2000 to June 2007), 43 out of 56 firms have significant exposure toward oil price fluctuations. We also notice that the average impact on stock price returns has been reduced to 0.26 compared to 0.27 in the full sample period. Concerning natural gas exposure, 37 companies display significant exposure toward natural gas price fluctuations, with an average impact on stock price return of 0.13. This is around the same exposure level as the full sample period. As with the full period analysis, changes in the interest rate factor are rarely found to have significant impacts on stock price in our results. Opposite to the full sample period, total average interest rate coefficients are negative, indicating that higher interest rates negatively influence the oil and gas stock return in the period.

In the second sub-period (July 2007 to January 2015), the oil price exposure reduces to 39 significant coefficients. Total average impact on stock price returns have increased substantially to 0.32 when compared to the first and full sample period. On the other hand, natural gas price exposure decreases to 16 significant coefficients. In regard to the impact of natural gas fluctuations on stock price return, the results show the same reduction with a total average exposure of 0.09. The findings display that oil price fluctuations have a higher impact on stock price return in the second period compared to the first and the reverse occurs in the case of natural gas exposure, which is higher in the first period and lower in the second.

Numerous studies report oil and gas prices to be cointegrated (S. Brown and M. K. Yücel, P. Hartley et al., and J. Villar and F. Joutz) and, as such, it is interesting that our results report a reversed level of impact on stock price returns in the first and second period.[39] There are studies that report "decoupling" between oil and gas prices in the past, meaning that the relationship in some periods can be non-existent.[40] This could explain why we find the companies to be more exposed to fluctuations in oil price returns and less to natural gas prices in the second period. In fact we did see this non-existing relation shortly after the 2008 financial crisis. Starting in December 2008, the price of crude oil started to recover from its low of $31.41 per barrel (/bbl). By February 2009, it had already risen to $44.76/bbl. During the same time, the price of natural gas continued to fall from its already low level of $5.37/MMBtu, dropping to $4.03/MMBtu in February. For most of 2009, the prices continued to diverge; in October crude oil reached about $70/bbl while natural gas fell below $3/MMBtu. Natural gas then briefly spiked, but as of May 2010 crude oil was $86.19/bbl and natural gas was trading between $5.37/MMBtu to $3.86/MMBtu. Figure 2 provides an overview of oil and natural gas prices from 2000 to 2015 where the reader can clearly see the periods of decoupling between the two commodities.

The shale gas revolution is an example of how oil and gas prices can deviate in periods. By combining hydraulic fracking with horizontal drilling, the cost of shale gas recovery was significantly reduced, which led to an influx of so-called unconventional gas entering the domestic market. With a lack of sufficient export

Figure 2
WEST TEXAS INTERMEDIATE (WTI) CRUDE OIL SPOT PRICE AND NYMEX NATURAL GAS PRICE, JANUARY 2000–JANUARY 2015
(Base: January 2000 = 100)



capacity, this additional supply depressed U.S. natural gas prices substantially relative to pre-shale gas levels and oil price.[41] Consequently, U.S. natural gas was no longer integrated with U.S. oil prices.[42] Prior to the shale gas boom, U.S. oil and natural gas where integrated,[43] even though the relationship was weak and a significant share of natural gas prices was unaccounted for by oil prices.[44] Additionally, there have been earlier observations of decoupling between crude oil and natural gas prices as during the late 1990s and early 2000s when prices were not cointegrated. If oil and gas prices are unrelated (not cointegrated) after 2008, it is also less likely that both gas and oil prices will enter a stable relationship between oil stock prices and energy prices.

Concerning the special sub-period from May 2003 to July 2008, the results demonstrate that oil price return coefficients are positive and highly significant. Some 52 companies display significant exposure toward oil price fluctuations with an average impact on stock price return of 0.46. Remembering the characteristics of the period—a thriving global economy and soaring oil prices—energy companies seem to favor oil price increases that may be attributed to global demand shocks.[45] The results indicate that earnings in the U.S. oil and gas sector may have followed the global business cycle (moving pro-cyclically) and that global economic booms result in increased profit margins for the sector.[46] With respect to natural gas, the significance and level of impact remains the same as the second sub-period.

The reported results from both the full-sample period analysis along with the three sub-periods as shown in appendix 2 and appendix 3, respectively, provide evidence that most firms in the oil and gas sector have significant exposure to oil and gas price fluctuations and, moreover, that the level of exposure varies among the firms within the sector. Additionally, the results display altered exposure depending on the pricing environment. Most notably, we identify highly significant coefficients in the special sub-period from May 2003 to July 2008 and oil beta sensitivities have increased substantially from the first period to the second, but the gas beta has decreased. With a low gas price with little variation and high and volatile oil prices, it is natural that oil and gas stocks are more sensitive to oil prices than gas prices. It suggests that oil revenue is both more significant and more volatile, but this also depends on the relative size of oil and gas volumes of the companies.

Oil and Gas Price Risk Exposure of Oil and Gas Companies: Sub-Sector Analysis: To further examine differences between the sub-sectors, we run a time-series regression on firm *i* excess return as the dependent variable. We use the same model, augmenting the one-factor market model with oil and natural gas price return and change in interest rate. A Wald test is introduced to either confirm or reject equal coefficients among the sub-sectors and royalty trusts. Table 4 presents the sub-sector analysis.

Results from the sub-sector analysis indicate variation in impact on stock price returns among the five groups. First, exploration and production companies show high oil and gas price exposure, with oil betas ranging from 0.29 in the first period (2000 to 2007) to 0.53 in the special sub-period (2003 to 2008). Natural gas betas range from 0.16 in the first period to 0.11 in the second period. The coefficients are statistically significant throughout the four sample periods. Since exploration and production companies have oil and gas as a direct and major output factor, the coefficients are expected to be high for this sub-sector.

Integrated companies (e.g., Chevron), defined as taking part in both upstream[47] and downstream[48] operations, experience a lower impact on stock returns from oil and gas price fluctuations compared to exploration and production companies. The crude oil betas range from 0.25 in the first period to 0.46 in the special sub-period. Natural gas exposure ranges from 0.106 to 0.124 in the special and first period, respectively. Coefficients are statistically significant in all periods. Lower price effects are due to the fact that downstream operations use oil and gas as inputs, thus having a reverse price effect. This represents a natural hedge that reduces the overall price exposure of integrated oil companies.

Oil exposure of the oil equipment and service firms varies from 0.22 in the first period to 0.48 in the special sub-period. The exposure level is next to highest, after exploration and production companies, reflecting the cyclical demand in this sector, closely linked to current oil and gas prices. Coefficients are statistically significant in all sub-periods except for natural gas in the special sub-period.

Table 4
OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB-SECTOR ANALYSIS[a]

Feb. 2000 – Feb. 2015		Feb. 2000 – June 2007		July 2007 – Feb. 2015		May 2003 – July 2008	
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**
Exploration and production companies							
0.2928***	0.1532***	0.2922***	0.1559***	0.3058***	0.1149***	0.5263***	0.1301***
(17.63)	(15.71)	(10.47)	(10.53)	(7.93)	(5.62)	(20.93)	(7.89)
Integrated oil and gas companies							
0.2666***	0.1241***	0.2502***	0.1196***	0.2655***	0.1075***	0.4646***	0.1058***
(8.35)	(6.64)	(5.51)	(5.30)	(2.94)	(2.78)	(9.85)	(3.94)
Oil equipment and services companies							
0.2767***	0.1134***	0.2230***	0.1147***	0.3922***	0.0578**	0.4845***	0.0389
(10.90)	(7.61)	(4.82)	(4.57)	(8.23)	(2.02)	(11.29)	(1.54)
Pipelines							
0.0827**	0.0327	0.0856*	0.0225	0.1228**	0.0249	0.1349***	0.0109
(2.34)	(1.58)	(1.69)	(0.88)	(2.41)	(0.79)	(3.03)	(0.44)
Royalty trusts							
0.2503***	0.1556***	0.2446***	0.1461***	0.2579***	0.1589***	0.3318***	0.1794***
(8.19)	(8.67)	(7.02)	(7.85)	(3.42)	(3.73)	(7.41)	(7.43)
Wald test (H_0: All β_{OIL}/β_{GAS} are equal)							
$\chi 2$ – Statistics							
21.18	31.64	14.18	23.92	15.45	10.67	67.95	44.39
p-value							
0.0003	0.0000	0.0068	0.0001	0.0038	0.0305	0.0000	0.0000

[a] *** = significance at the 1-percent level; ** = significance at the 5-percent level; and * = significance at the 10-percent level. $R_{OIL,t}$ and $R_{GAS,t}$ stand for logarithmic return on West Texas Intermediate (WTI) oil price and NYMEX natural gas price, respectively. $B_{i,OIL}$ and $B_{i,GAS}$ provide measures of oil and gas price sensitivity, respectively, for firm i. ε_{it} is the idiosyncratic error term. Regression: $R_{it} - R_{ft} = \alpha_{io} + B_{i,M}\ (R_{Mt} - R_{ft}) + B_{i,OIL}R_{OIL,t} + B_{i,GAS}R_{GAS,t} + B_{i,INT}R_{INT,t} + \varepsilon_{it}$.

Interestingly, we find that the pipeline sub-sector displays fewer significant coefficients with relatively low t-values. Oil price is significant throughout the sample periods. The coefficients are also lower than for all other sectors (including royalty trusts). This result reflects the earlier findings (i.e., S. Mohanty and M. Nandha) and may indicate that pipeline firms have the ability to pass on higher costs and that, to a larger extent, they have long-term contracts not contingent on current oil and gas prices or they are subject to cost-based tariff regulation.[49]

With respect to royalty trusts, the coefficients are on the same level as the other sub-sectors, excluding the pipeline sector. The results show that royalty trusts, even though not directly involved in physical operations, still hold the average exposure level of their operating counterparts. This could be attributable to the specifics in the royalty contracts of which the royalty may be governed on the licensee selling price.

Finally, Wald's test rejects the null hypothesis that all oil coefficients ($\beta_{i,OIL}$) are equal among the sub-sectors and royalty trusts in both the full period (2000 to 2015) and the three sub-periods (2000 to 2007, 2007 to 2015, and 2003 to 2008). Appendix 4 summarizes the beta equality tests. The results reveal that the pipeline sub-sector has significantly different exposure throughout the sub-periods. Furthermore, the special sub-period (2003 to 2008) displays a larger number of statistically significant inequalities among oil and gas betas than for the other sample periods. This may be attributable to the characteristics of the pricing environment, differences in operating characteristics, their ability to pass on costs to customers, and the degree of financial hedging across oil and gas sub-sectors.[50]

Conclusion

There has been extensive research over the years directed toward the understanding of oil price movements and its impact on oil and gas stock returns in both the United States and other countries. This study contributes to the literature by studying the sensitivities of U.S. oil and gas stock returns to the stock market, oil price, natural gas price, and interest rate in an updated time span, including the more recent drop in oil prices. We further include royalty trusts in our sample, which, to our knowledge, is the first empirical study to do so. The empirical findings are that oil price fluctuations have positive and statistically significant impact on oil and gas company stock returns across countries. Natural gas prices, researched to a lesser extent, also are shown to have significant exposure for the companies. Last, interest rates often are not found to be significant, though there are exceptions (i.e., M. Boyer and D. Filion).[51]

This paper uses a multifactor model to investigate the relationship between various risk factors and U.S. oil and gas stock returns. We use monthly data (end of month) from January 2000 to January 2015 for companies listed on the New York Stock Exchange. By augmenting the one-factor market model with oil prices, gas

prices, and interest rates, we are able to raise the explanatory power of the model. The results demonstrate that U.S. oil and gas companies and royalty trusts have statistically significant exposure to the market, oil price, and natural gas price factors. Specifically, an increase in the market, oil price, and gas price factors raises the stock returns of U.S. oil and gas companies. From the sub-period analysis we find evidence that different pricing environments affect the companies' exposures. Most notably, the special sub-period of May 2003 to July 2008 displays higher numbers of significant coefficients with a larger impact on company stock price returns. The results indicate that the U.S. oil and gas sector favors oil price increases that may be attributed to global demand shocks and that the sector may have been driven by the global business cycle. Furthermore, the sub-period analysis reveals a reversed exposure level in the first and second sub-period concerning oil and natural gas price exposure. This could be attributable to a "decoupling" between oil and gas price in the second period following the financial crisis, additionally affected by the shale gas revolution.

In assessing potential differences between the sub-sectors due to distinctive operational characteristics, we ran a time-series regression with excess market return, oil price return, gas price return, and change in the interest rate as explanatory variables. The results display different commodity price impacts on company stock returns. We find the exploration and production company sub-sector to have the highest exposure and, interestingly, pipeline firms seem to have lower exposure to both oil and gas price fluctuations. Possible explanations may be their ability to pass on higher fuel costs to their customers and that, to a larger extent, they have long-term contracts not contingent on current oil and gas prices or they are subject to cost-based tariff regulation. Results also show that integrated firms are "naturally" hedged against oil and gas price fluctuations as they take part in both upstream (output) and downstream (input) operations. With respect to royalty trusts, they maintain the exposure level of their operating counterparts. Finally, by conducting Wald's test we provide evidence to show that the oil and gas price coefficients are not equal among the sub-sectors and royalty trusts. Most notably, the special sub-period exhibit more inequality then the other sub-periods and the pipeline sub-sector has statistically different oil and gas price exposure compared to the other sub-sectors and royalty trusts.

NOTES

[1]Royalty trusts are a type of special-purpose financing created to hold investments or their cash flows in operating companies. These trusts are neither stocks nor bonds but investments trusts (a legal entity). Royalty trusts buy the right to royalties on the production and sale of a natural resource company and pass on the profits to trust unit holders.

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[5]P. C. Fusaro, *Energy Risk Management: Hedging Strategies and Instruments for the International Energy Markets* (New York: McGraw Hill, 1998), and P. Sadorsky, "Risk Factors in Stock Returns of Canadian Oil and Gas Companies."

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[9]P. Sadorsky, "Risk Factors in Stock Returns of Canadian Oil and Gas Companies."

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[14]U. Oberndorfer, "Energy Prices, Volatility, and the Stock Market: Evidence from the Eurozone," *Energy Policy*, vol. 37, no. 12 (2009), pp. 5787–795.

[15]S. Ramos and H. Veiga, op. cit.

[16]S. K. Mohanty and M. Nandha, op. cit.

[17]Ibid.

[18]P. Jorion, op. cit.; R. Faff and H. Chan, op. cit.; R. Faff and T. Brailsford, op. cit.; and P. Sadorsky, "Risk Factors in Stock Returns of Canadian Oil and Gas Companies."

[19]A potential problem with time-series regression is the presence of serial-correlation in the observations. Serial-correlations are found to be present in our data, shown by the Durbin-Watson statistics. By using Cochrane-Orcutt estimations we adjust the linear model for serial-correlation in the error term.

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[23]Ibid.

[24]Ibid, and S. K. Mohanty and M. Nandha, op. cit.

[25]S. K. Mohanty and M. Nandha, op. cit.

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[27]S. K. Mohanty and M. Nandha, op. cit.

[28]R. Huang et al., op. cit.

[29]S. K. Mohanty and M. Nandha, op. cit.

[30]Ibid.

[31]Ibid.

[32]The boom was largely due to rising demand from emerging economies such as the BRIC countries (Brazil, Russia, India, and China) and the former Yugoslavia, as well as the result of concerns over long-term supply availability. The drivers of the price increases were various and included reports from the U.S. Department of Energy that expressed supply concerns, worries over peak oil, Middle East tensions, and oil price speculation.

[33]We also include this special period for comparison reasons with the article by S. K. Mohanty and M. Nandha, op. cit.

[34]S. K. Mohanty and M. Nandha, op. cit.

[35]P. Sadorsky, "Risk Factors in Stock Returns of Canadian Oil and Gas Companies."

[36]R. Faff and T. Brailsford, op. cit.; P. Sadorsky, "Risk Factors in Stock Returns of Canadian Oil and Gas Companies;" I. El-Sharif et al., op. cit.; M. Boyer and D. Filion, op. cit.; and S. K. Mohanty and M. Nandha, op. cit.

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[44]D. J. Ramberg and J. E. Parsons, op. cit.

[45]S. K. Mohanty and M. Nandha, op. cit.

[46]Ibid.

[47]Upstream operations include all exploration and production endeavors.

[48]Downstream operations are confined to refining and marketing activities.

[49]S. K. Mohanty and M. Nandha, op. cit.

[50]Ibid.

[51]M. Boyer and D. Filion, op. cit.

Appendix 1

U.S. OIL AND GAS COMPANIES

Company Name	Ticker	Sub–Sector
ANADARKO PETROLEUM	APC	Exploration and Production
APACHE CORP.	APA	Exploration and Production
BP PLC	BP	Exploration and Production
CABOT OIL & GAS 'A'	COG	Exploration and Production
CALLON PETROLEUM	CPE	Exploration and Production
CANADIAN NATURAL RESOURCES	CNQ	Exploration and Production
CHESAPEAKE ENERGY	CHK	Exploration and Production
CHINA PETROl. & CHEM. (SINOPEC)	SNP	Exploration and Production
CIMAREX ENENERGY	XEC	Exploration and Production
CLAYTON WILLIAMS ENERGY	CWEI	Exploration and Production
COMSTOCK RESOURCES	CRK	Exploration and Production
DENBURY RESESOURCES	DNR	Exploration and Production
DEVON ENERGY	DVN	Exploration and Production
ENCANA	ECA	Exploration and Production
ENI	E	Exploration and Production
EOG RESOURCES	EOG	Exploration and Production
GOODRICH PETROLEUM	GDP	Exploration and Production
HESS CORP.	HES	Exploration and Production
MARATHON OIL CORP.	MRO	Exploration and Production
NEWFIELD EXPLORATION	NFX	Exploration and Production
NOBLE ENERGY	NBL	Exploration and Production
OCCIDENTAL PETROLEUM	OXY	Exploration and Production
PANHANDLE OIL & GAS	PHX	Exploration and Production
PENN VIRGINIA	PVA	Exploration and Production
PETROCHINA CO. LTD.	PTR	Exploration and Production
PETROQUEST ENERGY	PQ	Exploration and Production
PIONEER NATURAL RESOURCES	PXD	Exploration and Production
RANGE RESOURCES	RRC	Exploration and Production
SM ENERGY	SM	Exploration and Production
STATOIL	STL	Exploration and Production
CHEVRON	CVX	Integrated Oil and Gas
CONOCOPHILLIPS	COP	Integrated Oil and Gas
EXXON MOBIL	XOM	Integrated Oil and Gas
STONE ENERGY	SGY	Integrated Oil and Gas
SUNCOR ENERGY	SU	Integrated Oil and Gas
SWIFT ENERGY CO.	SFY	Integrated Oil and Gas
ULTRA PETROLEUM CORP.	UPL	Integrated Oil and Gas
BAKER HUGHES	BHI	Oil Equipment and Services
ENSCO CLASS A	ESV	Oil Equipment and Services
HALLIBURTON	HAL	Oil Equipment and Services
HELMERICH & PAYNE	HP	Oil Equipment and Services

(continued)

Appendix 1 (continued)

U.S. OIL AND GAS COMPANIES

Company Name	Ticker	Sub–Sector
NABORS INDUSTRIES LTD.	NBR	Oil Equipment and Services
NOBLE	NE	Oil Equipment and Services
SCHLUMBERGER	SLB	Oil Equipment and Services
TIDEWATER	TDW	Oil Equipment and Services
WEATHERFORD INTL.	WFT	Oil Equipment and Services
ENBRIDGE ENERGY PRTS.	EEP	Pipelines
OGE ENERGY	OGE	Pipelines
PLAINS ALL AMER. PIPELINE LP.	PAA	Pipelines
WILLIAMS CO.	WMB	Pipelines
CROSS TIMBERS ROYALTY TRUST	CRT	Royalty Trust (Exploration & Production)
DOMINION RES. BLACK WARRIOR	DOM	Royalty Trust (Exploration & Production)
HUGOTON ROYALTY TRUST	HGT	Royalty Trust (Exploration & Production)
PERMIAN BASIN ROYALTY TRUST	PBT	Royalty Trust (Exploration & Production)
SABINE ROYALTY TRUST	SBR	Royalty Trust (Exploration & Production)
SAN JUAN BASIN ROYALTY TRUST	SJT	Royalty Trust (Exploration & Production)

Appendix 2

OIL AND GAS PRICE RISK EXPOSURE OF U.S. OIL AND GAS COMPANIES, 2000–2015[a]

Intercept (α_{i0})	Market ($B_{i,M}$)	Oil Price ($B_{i,OIL}$)	Gas Price ($B_{i,GAS}$)	Interest Rate ($B_{i,INT}$)	Adjusted R^2	DW
			EXPLORATION AND PRODUCTION COMPANIES			
ANADARKO PETROLEUM						
0.0052	0.9749***	0.1911***	0.1254***	–0.0382	0.4508	1.9790
(0.87)	(9.11)	(2.91)	(3.24)	(–0.54)		
APACHE CORP.						
0.0015	0.8091***	0.2573***	0.1698***	0.0327	0.5164	1.9599
(0.28)	(8.47)	(4.35)	(4.86)	(0.51)		
BP PLC.						
–0.0067	0.8119***	0.1660***	0.0087	0.0669	0.5123	1.9798
(–1.55)	(10.51)	(3.50)	(0.31)	(1.32)		
CABOT OIL & GAS						
0.0121*	0.8453***	0.0962	0.3276***	0.0940	0.4686	2.0113
(1.77)	(7.16)	(1.32)	(7.57)	(1.18)		
CALLON PETROLEUM						
0.0023	1.6417***	0.4548***	0.1979**	0.3729**	0.3603	1.9806
(0.17)	(6.42)	(2.93)	(2.17)	(2.27)		
CANADIAN NATURAL RESOURCES						
0.0064	0.9431***	0.5219***	0.0340	–0.0508	0.6270	2.0110
(1.23)	(10.14)	(9.15)	(1.01)	(–0.83)		
CHESAPEAKE ENERGY						
0.0060	0.9465***	0.2991***	0.3392***	0.0154	0.4598	2.0101
(0.78)	(6.57)	(3.43)	(6.62)	(0.17)		
CHINA PETROLEUM & CHEMICAL CORP. (SINOPEC)						
0.0057	1.0290***	0.1856***	–0.0865**	–0.0766	0.3853	1.9903
(0.91)	(9.07)	(2.67)	(–2.11)	(–1.03)		
CIMAREX ENERGY CO.						
0.0058	0.9169***	0.3135***	0.0547	0.0917	0.4379	2.0158
(0.91)	(7.85)	(4.41)	(1.31)	(1.21)		
CLAYTON WILLIAMS ENERGY						
0.0114	1.4771***	0.1541	0.2451***	0.0769	0.2897	1.9989
(0.98)	(6.59)	(1.15)	(3.13)	(0.55)		
COMSTOCK RESOURCES INC.						
–0.0029	0.9159***	0.1849*	0.3912***	0.2294**	0.3668	1.9458
(–0.30)	(5.11)	(1.69)	(6.08)	(1.97)		
DENBURY RESOURCES INC.						
0.0044	0.7940***	0.5536***	0.0985**	0.0899	0.4396	2.0332
(0.57)	(5.66)	(6.48)	(1.96)	(0.99)		
DEVON ENERGY CORP.						
0.0018	0.8776***	0.1476**	0.2120***	0.0478	0.5016	2.0055
(0.34)	(8.89)	(2.45)	(5.96)	(0.74)		

(continued)

Appendix 2 (continued)

OIL AND GAS PRICE RISK EXPOSURE OF U.S. OIL AND GAS COMPANIES, 2000–2015[a]

Intercept (α_{i0})	Market ($B_{i,M}$)	Oil Price ($B_{i,OIL}$)	Gas Price ($B_{i,GAS}$)	Interest Rate ($B_{i,INT}$)	Adjusted R^2	DW
ENCANA CORP.						
–0.0101*	0.6764***	0.3584***	0.0926**	–0.1365**	0.4064	1.9930
(–1.79)	(6.45)	(5.64)	(2.48)	(–2.03)		
ENI SPA						
–0.0037	0.7561***	0.2103***	0.0420*	–0.0079	0.5581	2.0164
(–1.00)	(11.04)	(5.06)	(1.72)	(–0.18)		
EOG RESOURCES INC.						
0.0120*	0.8037***	0.1264*	0.2695***	0.0728	0.4590	1.9136
(1.92)	(7.32)	(1.87)	(6.74)	(1.00)		
GOODRICH PETROLEUM						
–0.0102	0.7664***	0.5954***	0.1747**	0.1593	0.2460	1.9601
(–0.82)	(3.24)	(4.18)	(2.09)	(1.06)		
HESS CORP.						
0.0034	0.8993***	0.3166***	0.0562	0.1122	0.4678	1.9443
(0.60)	(8.20)	(4.81)	(1.45)	(1.63)		
MARATHON OIL CORP.						
0.0006	0.9130***	0.2955***	0.0189	0.0757	0.4838	1.9532
(0.11)	(8.95)	(4.75)	(0.52)	(1.14)		
NEWFIELD EXPLORATION						
–0.0004	0.9651***	0.2696***	0.1457***	0.0153	0.4011	2.0090
(–0.06)	(7.42)	(3.40)	(3.11)	(0.18)		
NOBLE ENERGY						
0.0057	0.8194***	0.2055***	0.1584***	–0.0267	0.4392	1.9816
(1.03)	(7.99)	(3.30)	(4.33)	(–0.40)		
OCCIDENTAL PETROLEUM						
0.0067	0.8364***	0.2252***	0.0548**	–0.0228	0.5470	1.8969
(1.59)	(10.84)	(4.78)	(1.98)	(–0.45)		
PANHANDLE OIL & GAS						
0.0084	0.6298***	0.2903***	0.1157**	–0.0146	0.2272	2.0753
(1.00)	(4.25)	(3.18)	(2.15)	(–0.15)		
PENN VIRGINIA						
–0.0030	0.8384***	0.2536**	0.2390***	0.2601**	0.2868	1.9908
(–0.31)	(4.54)	(2.29)	(3.68)	(2.24)		
PETROCHINA CO. LTD.						
0.0059	0.9828***	0.3648***	–0.0586	–0.1373*	0.4275	2.0054
(0.94)	(8.53)	(5.18)	(–1.41)	(–1.83)		
PETROQUEST ENERGY						
0.0011	1.1534***	0.5027***	0.1946**	0.1290	0.3048	1.9904
(0.09)	(5.11)	(3.70)	(2.44)	(0.90)		

(continued)

Appendix 2 (continued)

OIL AND GAS PRICE RISK EXPOSURE OF U.S. OIL AND GAS COMPANIES, 2000–2015[a]

Intercept (α_{i0})	Market ($B_{i,M}$)	Oil Price ($B_{i,OIL}$)	Gas Price ($B_{i,GAS}$)	Interest Rate ($B_{i,INT}$)	Adjusted R^2	DW
PIONEER NATURAL RESOURCES						
0.0145**	1.1159***	0.4271***	0.1717***	0.1205	0.5581	1.9781
(2.13)	(8.98)	(5.63)	(3.84)	(1.49)		
RANGE RESOURCES						
0.0087	0.4415***	0.2775***	0.2264***	0.0878	0.2859	2.0339
(1.09)	(3.21)	(3.26)	(4.50)	(0.95)		
SM ENERGY						
0.0066	1.0361***	0.2963***	0.2437***	0.0593	0.4811	2.0185
(0.91)	(7.87)	(3.68)	(5.13)	(0.69)		
STATOIL ASA						
–0.0022	0.7698***	0.3666***	0.0215	0.0378	0.6057	1.9993
(–0.52)	(10.08)	(7.84)	(0.78)	(0.76)		
EXPLORATION AND PRODUCTION COMPANY AVERAGE						
0.0032	**0.9129**	**0.2969**	**0.1428**	**0.0579**	**0.4334**	
INTEGRATED OIL AND GAS COMPANIES						
CHEVRON						
–0.0015	0.7180***	0.0965**	0.0408*	–0.0013	0.5300	1.8825
(–0.43)	(11.68)	(2.55)	(1.83)	(–0.03)		
CONOCOPHILLIPS						
0.0021	0.9036***	0.2286***	0.0289	0.0323	0.5808	1.9538
(0.49)	(11.72)	(4.85)	(1.04)	(0.64)		
EXXON MOBIL						
–0.0029	0.6546***	0.0208	0.0316	0.0322	0.4502	2.0175
(–0.86)	(10.66)	(0.56)	(1.44)	(0.81)		
STONE ENERGY						
–0.0024	1.4083***	0.4171***	0.2183***	0.2641**	0.4633	2.0054
(–0.25)	(7.77)	(3.85)	(3.44)	(2.33)		
SUNCOR ENERGY INC.						
0.0057	0.9766***	0.4482***	0.0526	–0.0081	0.5831	2.0270
(1.05)	(9.85)	(7.41)	(1.48)	(–0.13)		
SWIFT ENERGY CO.						
–0.0116	1.0054***	0.4482***	0.2273***	0.2589**	0.3547	1.9084
(–1.09)	(5.11)	(3.76)	(3.24)	(2.05)		
ULTRA PETROLEUM CORP.						
0.0038	0.6259***	0.2925***	0.2382***	0.1666*	0.3285	1.9896
(0.47)	(4.21)	(3.24)	(4.49)	(1.74)		
INTEGRATED OIL AND GAS COMPANY AVERAGE						

(continued)

Appendix 2 (continued)

OIL AND GAS PRICE RISK EXPOSURE OF U.S. OIL AND GAS COMPANIES, 2000–2015[a]

Intercept (α_{i0})	Market ($B_{i,M}$)	Oil Price ($B_{i,OIL}$)	Gas Price ($B_{i,GAS}$)	Interest Rate ($B_{i,INT}$)	Adjusted R^2	DW
–0.0010	**0.8989**	**0.2788**	**0.1197**	**0.1064**	**0.4701**	
		OIL EQUIPMENT AND SERVICE COMPANIES				
BAKER HUGHES						
0.0032	1.1569***	0.2133***	0.1108***	0.0043	0.5112	2.0294
(0.52)	(10.49)	(3.15)	(2.77)	(0.06)		
ENSCO						
–0.0016	1.1786***	0.3000***	0.1253***	–0.0022	0.5231	2.0572
(–0.25)	(10.11)	(4.25)	(3.02)	(–0.03)		
HALLIBURTON						
0.0044	1.2906***	0.3280***	0.0965**	0.0028	0.4920	2.0151
(0.62)	(9.73)	(4.08)	(2.04)	(0.03)		
HELMERICH & PAYNE						
0.0037	0.8788***	0.3017***	0.1702***	0.1153	0.4135	2.0032
(0.55)	(6.73)	(3.87)	(3.73)	(1.42)		
NABORS INDUSTRIES LTD.						
0.0007	1.4280***	0.2499***	0.2289***	0.1152	0.5407	1.9993
(0.10)	(10.33)	(2.99)	(4.66)	(1.31)		
NOBLE						
–0.0030	0.9984***	0.2404***	0.0945**	0.1453*	0.4373	2.0442
(–0.45)	(8.17)	(3.23)	(2.16)	(1.83)		
SCHLUMBERGER						
0.0038	1.1721***	0.2322***	0.0227	0.0278	0.6061	2.0984
(0.73)	(13.01)	(4.17)	(0.69)	(0.46)		
TIDEWATER						
–0.0029	1.0183***	0.2332***	0.0638	0.0211	0.4522	2.0024
(–0.50)	(9.22)	(3.49)	(1.63)	(0.30)		
WEATHERFORD						
0.0008	1.2856***	0.3200***	0.0924*	0.1368	0.4734	2.0316
(0.10)	(9.06)	(3.74)	(1.84)	(1.52)		
OIL EQUIPMENT AND SERVICE COMPANY AVERAGE						
0.0010	**1.1564**	**0.2687**	**0.1117**	**0.0629**	**0.4944**	
		PIPELINE COMPANIES				
ENBRIDGE ENERGY PRT. LP.						
–0.0051	0.5215***	0.1191**	–0.0164	0.0902	0.2830	2.0157
(–1.09)	(6.19)	(2.31)	(–0.54)	(1.64)		
OGE ENERGY						
0.0009	0.7870***	0.0332	0.0112	–0.1177***	0.4784	2.0254
(0.26)	(12.07)	(0.83)	(0.48)	(–2.76)		
PLAINS ALL AMER. PIPELINE LP.						

(continued)

Appendix 2 (continued)

OIL AND GAS PRICE RISK EXPOSURE OF U.S. OIL AND GAS COMPANIES, 2000–2015[a]

Intercept (α_{i0})	Market ($B_{i,M}$)	Oil Price ($B_{i,OIL}$)	Gas Price ($B_{i,GAS}$)	Interest Rate ($B_{i,INT}$)	Adjusted R^2	DW
0.0006	0.4820***	0.0791*	–0.0588**	0.0217	0.2981	2.0035
(0.15)	(7.18)	(1.92)	(–2.42)	(0.49)		
WILLIAMS CO.						
0.0011	1.2162***	0.0987	0.1858***	0.1651	0.2955	1.9916
(0.13)	(6.72)	(0.94)	(3.06)	(1.56)		
PIPELINE COMPANY AVERAGE						
–0.0006	**0.7517**	**0.0825**	**0.0305**	**0.0398**	**0.3388**	
			ROYALTY TRUSTS			
CROSS TIMBERS ROYALTY TRUST						
–0.0074	0.5120***	0.2360***	0.1888***	0.0395	0.2849	2.0550
(–1.05)	(4.07)	(3.06)	(4.15)	(0.48)		
DOMINION RESOURCES BLACK WARRIOR ROYALTY TRUST						
–0.0137*	0.5256***	0.1465*	0.0818*	–0.0164	0.1317	2.0054
(–1.82)	(3.77)	(1.73)	(1.65)	(–0.18)		
HUGOTON ROYALTY TRUST						
–0.0099	0.5659***	0.2565***	0.2501**	0.0431	0.3232	2.0037
(–1.37)	(4.16)	(3.13)	(5.20)	(0.50)		
PERMIAN BASIN ROYALTY TRUST						
–0.0086	0.3915***	0.3249***	0.0683*	–0.0223	0.2918	2.0050
(–1.57)	(3.83)	(5.27)	(1.89)	(–0.34)		
SABINE ROYALTY TRUST						
–0.0055	0.5464***	0.3244***	0.0833**	–0.1067*	0.3913	1.9471
(–0.97)	(5.87)	(5.57)	(2.41)	(–1.67)		
SAN JUAN BASIN ROYALTY TRUST						
–0.0082	0.5791***	0.1952***	0.2277***	–0.1118	0.3412	2.0027
(–1.36)	(5.00)	(2.83)	(5.63)	(–1.56)		
ROYALTY TRUSTS AVERAGE						
–0.0088	**0.5201**	**0.2473**	**0.1500**	**–0.0291**	**0.2940**	
TOTAL AVERAGE						
0.0008	**0.8967**	**0.2695**	**0.1277**	**0.0541**	**0.4261**	
TOTAL AVERAGE (EXCLUDING ROYALTY TRUSTS)						
0.0019	**0.9419**	**0.2722**	**0.1250**	**0.0641**	**0.4419**	

[a] *** = significance at the 1-percent level; ** = significance at the 5-percent level; * = significance at the 10-percent level; and DW = Durbin–Watson statistic. $R_{mt} - R_{ft}$ stands for the logarithmic return on NYSE stock index less risk-free rate. $R_{OIL,t}$, $R_{GAS,t}$, and $R_{INT,t}$ stand for the logarithmic returns on West Texas Intermediate (WTI) oil price, NYMEX natural gas price, and change in the 10-year U.S. Treasury bond, respectively. $B_{i,M}$, $B_{i,OIL}$, $B_{i,GAS}$, and $B_{i,INT}$, provide measures of market, oil price, gas price, and interest rate risk sensitivities, respectively, for firm i. ε_{it} is the idiosyncratic error term. Regression: $R_{it} - R_{ft} = \alpha_{io} + B_{i,M}\,(R_{Mt} - R_{ft}) + B_{i,OIL}R_{OIL,t} + B_{i,GAS}\,R_{GAS,t} + B_{i,INT}R_{INT,t} + \varepsilon_{it}$.

Appendix 3

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i.\ INT}$)**
EXPLORATION AND PRODUCTION COMPANIES								
ANADARKO PETROLEUM								
0.1399*	0.1833***	–0.0890	0.2534**	–0.0096	–0.0308	0.4310***	0.1362***	0.0096
(1.75)	(4.53)	(–0.75)	(2.08)	(–0.12)	(–0.32)	(4.79)	(3.03)	(0.09)
APACHE CORP.								
0.2532***	0.1901***	–0.2849**	0.2645***	0.0793	0.1657**	0.5174***	0.1229***	–0.2077*
(3.16)	(4.73)	(–2.39)	(2.65)	(1.25)	(2.21)	(5.71)	(2.77)	(–1.92)
BP PLC.								
0.2797***	–0.0068	–0.0035	0.0139	0.0343	0.1288*	0.3823***	0.0393	0.0678
(5.88)	(–0.28)	(–0.05)	(0.15)	(0.56)	(1.72)	(7.00)	(1.48)	(1.06)
CABOT OIL & GAS								
0.0966	0.3090***	0.0970	0.1551	0.3577***	0.0877	0.4878***	0.2891***	0.1058
(1.02)	(6.46)	(0.69)	(1.16)	(4.11)	(0.82)	(3.44)	(4.16)	(0.63)
CALLON PETROLEUM								
0.1576	0.2999***	0.2547	0.7757**	–0.0550	0.2804	0.3898***	0.2783***	0.2353
(1.00)	(3.77)	(1.08)	(2.43)	(–0.27)	(1.19)	(2.93)	(4.13)	(1.42)
CANADIAN NATURAL RESOURCES								
0.5505***	0.0072	–0.3048**	0.4385***	0.0522	0.0422	0.8467***	0.0451	–0.2018
(6.69)	(0.17)	(–2.47)	(5.18)	(0.94)	(0.61)	(6.92)	(0.74)	(–1.36)
CHESAPEAKE ENERGY								
0.2142*	0.4117***	–0.2490	0.3923***	0.1361	0.0767	0.5263***	0.3087***	–0.0469

(continued)

Appendix 3 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**
(1.72)	(6.48)	(–1.33)	(2.83)	(1.55)	(0.74)	(4.57)	(5.41)	(–0.34)
CHINA PETROLEUM & CHEMICAL CORP. (SINOPEC)								
0.2861***	–0.0908*	0.0555	0.1673	–0.1104	–0.1263	0.3667**	–0.1450*	0.1762
(2.89)	(–1.81)	(0.37)	(1.50)	(–1.53)	(–1.44)	(2.36)	(–1.88)	(0.94)
CIMAREX ENERGY								
0.2770***	0.0313	–0.2338**	0.2676*	0.1067	0.2116*	0.5137***	0.1695***	–0.1968
(4.13)	(0.92)	(–2.33)	(1.84)	(1.15)	(1.91)	(4.59)	(3.06)	(–1.45)
CLAYTON WILLIAMS ENERGY								
0.2334	0.2801***	0.1113	0.2205	0.1380	0.0650	0.4076	0.1601	0.2259
(1.37)	(3.20)	(0.43)	(0.87)	(0.88)	(0.36)	(1.58)	(1.23)	(0.71)
COMSTOCK RESOURCES								
0.0806	0.3269***	–0.1447	0.4324**	0.4371***	0.2727*	0.5557***	0.2595***	0.2006
(0.63)	(5.10)	(–0.76)	(2.19)	(3.53)	(1.90)	(3.63)	(3.40)	(1.07)
DENBURY RESOURCES								
0.4041***	0.1741***	–0.0844	0.7792***	–0.1232	0.0924	0.7533***	0.0240	0.0343
(3.43)	(2.94)	(–0.48)	(5.71)	(–1.43)	(0.92)	(6.22)	(0.41)	(0.24)
DEVON ENERGY								
0.2182**	0.2218***	–0.1534	0.0911	0.1515***	0.1395*	0.3598***	0.2298***	–0.1299
(2.52)	(5.06)	(–1.19)	(0.92)	(2.39)	(1.85)	(4.14)	(5.43)	(–1.26)
ENCANA								
0.3571***	0.0581	–0.2488**	0.3296***	0.1488*	–0.1114	0.5827***	0.1910***	–0.2307*
(4.73)	(1.52)	(–2.2)	(2.68)	(1.91)	(–1.23)	(5.42)	(3.59)	(–1.77)

(continued)

Appendix 3 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i.\ INT}$)**
ENI SPA								
0.2382***	0.0190	–0.1825**	0.1265*	0.0700	0.0608	0.2738***	0.0267	–0.0710
(4.46)	(0.69)	(–2.27)	(1.71)	(1.48)	(1.08)	(4.82)	(0.94)	(–1.02)
EOG RESOURCES INC.								
0.1292	0.3215***	–0.0153	0.2209	0.1218	0.0900	0.4087***	0.2543***	–0.0751
(1.44)	(7.07)	(–0.11)	(0.12)	(0.08)	(0.09)	(3.12)	(3.92)	(–0.47)
GOODRICH PETROLEUM								
0.5720***	0.0764	–0.0068	0.6633**	0.3367*	0.1544	0.8808***	0.2152	0.3125
(4.09)	(1.07)	(–0.03)	(2.21)	(1.78)	(0.7)	(3.25)	(1.61)	(0.96)
HESS CORP.								
0.2851***	0.0344	–0.0809	0.4216***	0.0616	0.1540*	0.5813***	0.0541	0.0496
(3.03)	(0.71)	(–0.57)	(3.79)	(0.89)	(1.93)	(4.21)	(0.79)	(0.29)
MARATHON OIL CORP.								
0.3370***	0.0285	–0.0342	0.2154*	–0.0466	0.1198	0.4324***	0.0204	0.0447
(4.54)	(0.76)	(–0.31)	(1.81)	(–0.62)	(1.36)	(3.57)	(0.34)	(0.3)
NEWFIELD EXPLORATION								
0.1350	0.1843***	–0.0982	0.3847**	0.0490	0.0197	0.5720***	0.1509**	–0.0244
(1.38)	(3.75)	(–0.67)	(2.6)	(0.53)	(0.18)	(4.79)	(2.57)	(–0.17)
NOBLE ENERGY								
0.1710**	0.1813***	–0.2575**	0.3302***	0.0560	0.0244	0.5221***	0.1481***	–0.0892
(2.02)	(4.2)	(–2.03)	(3.16)	(0.84)	(0.31)	(5.35)	(3.08)	(–0.76)

(continued)

Appendix 3 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**
OCCIDENTAL PETROLEUM								
0.2127***	0.0492	–0.1078	0.2686***	0.0433	–0.0160	0.5130***	–0.0054	–0.1061
(3.16)	(1.44)	(–1.07)	(3.31)	(0.84)	(–0.27)	(6.51)	(–0.14)	(–1.13)
PANHANDLE OIL & GAS								
0.4322***	0.1202*	–0.5163***	0.1981	0.0359	0.1684	0.5544***	0.1338	–0.3194
(3.51)	(1.91)	(–2.8)	(1.33)	(0.37)	(1.42)	(3.15)	(1.54)	(–1.5)
PENN VIRGINIA								
0.2156**	0.1697***	0.1214	0.0535	0.3432**	0.3322*	0.4457***	0.1037*	0.2590**
(2.33)	(3.66)	(0.88)	(0.22)	(2.29)	(1.94)	(3.98)	(1.91)	(1.97)
PETROCHINA CO. LTD.								
0.4937***	–0.0996**	–0.0244	0.2374**	–0.0136	–0.1690*	0.6844***	–0.1080	–0.0250
(5.12)	(–2.05)	(–0.17)	(2.01)	(–0.18)	(–1.88)	(4.35)	(–1.39)	(–0.13)
PETROQUEST ENERGY								
0.5632***	0.1067	0.0708	0.4234*	0.3462**	0.1488	0.6537***	0.1583	0.0950
(2.89)	(1.07)	(0.24)	(1.86)	(2.41)	(0.89)	(3.2)	(1.59)	(0.4)
PIONEER NATURAL RESOURCES								
0.1531	0.2639***	–0.1025	0.7213***	–0.0455	0.1330	0.4551***	0.1942***	0.0501
(1.57)	(5.36)	(–0.7)	(5.95)	(–0.58)	(1.41)	(3.55)	(3.01)	(0.32)
RANGE RESOURCES								
0.3957***	0.2021***	0.0149	0.3813***	0.1936***	0.0907	0.3506**	0.1859**	–0.1479
(2.83)	(2.88)	(0.07)	(3.37)	(2.68)	(1.06)	(2.39)	(2.58)	(–0.84)

(continued)

Appendix 3 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i.\ INT}$)**
SM ENERGY								
0.1545*	0.2502***	–0.1557	0.3565**	0.2425**	0.1156	0.6457***	0.1505**	–0.0068
(1.66)	(5.38)	(–1.13)	(2.29)	(2.48)	(1.02)	(5.19)	(2.49)	(–0.05)
STATOIL ASA								
0.3678***	0.0029	–0.0408	0.4220***	0.0242	0.0686	0.5861***	0.0424	0.0843
(5.68)	(0.09)	(–0.42)	(5.23)	(0.48)	(1.16)	(6.95)	(1.04)	(0.85)
EXPLORATION AND PRODUCTION COMPANY AVERAGE								
0.2801	**0.1435**	**–0.0898**	**0.3335**	**0.1054**	**0.0930**	**0.5227**	**0.1278**	**0.0024**
INTEGRATED OIL AND GAS COMPANIES								
CHEVRON								
0.2017***	0.0340	–0.0265	0.0523	0.0361	0.0322	0.3281***	0.0586*	0.0288
(3.86)	(1.29)	(–0.34)	(0.85)	(0.91)	(0.66)	(4.89)	(1.77)	(0.36)
CONOCOPHILLIPS								
0.2693***	0.0490	0.1070	0.1979**	–0.0170	0.0163	0.4145***	0.0696*	0.0898
(4.16)	(1.49)	(1.1)	(2.43)	(–0.33)	(0.26)	(5.02)	(1.69)	(0.89)
EXXON MOBIL								
0.1524***	0.0223	0.0883	–0.0202	0.0252	0.0352	0.2230***	0.0459	–0.0333
(2.98)	(0.86)	(1.16)	(–0.34)	(0.67)	(0.79)	(3.22)	(1.34)	(–0.4)
STONE ENERGY								
0.2381**	0.2006***	–0.1153	0.4188*	0.1996	0.4114**	0.5708***	0.1304*	–0.0141
(2.54)	(4.25)	(–0.82)	(1.8)	(1.39)	(2.51)	(4.26)	(1.95)	(–0.09)

(continued)

Appendix 3 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i.\ INT}$)**
SUNCOR ENERGY								
0.3202***	0.0866**	–0.2407**	0.4493***	–0.0189	0.0472	0.6395***	–0.0132	–0.1520
(4.06)	(2.14)	(–2.03)	(4.51)	(–0.29)	(0.6)	(6.41)	(–0.27)	(–1.26)
SWIFT ENERGY CO.								
0.2972*	0.2371***	–0.2350	0.5027**	0.1209	0.3817**	0.4583***	0.1802**	–0.0419
(1.97)	(3.09)	(–1.04)	(2.31)	(0.88)	(2.35)	(3.01)	(2.41)	(–0.23)
ULTRA PETROLEUM CORP.								
0.3096***	0.1286*	0.0145	0.3320***	0.3887***	0.1678*	0.5103***	0.2608***	–0.0920
(2.34)	(1.91)	(0.07)	(2.6)	(4.71)	(1.68)	(3.35)	(3.5)	(–0.51)
INTEGRATED OIL AND GAS COMPANY AVERAGE								
0.2555	**0.1083**	**–0.0582**	**0.2761**	**0.1050**	**0.1560**	**0.4492**	**0.1046**	**–0.0307**
OIL EQUIPMENT AND SERVICE COMPANIES								
BAKER HUGHES								
0.1784**	0.0845*	–0.1235	0.1209	0.1838**	0.0538	0.5435***	–0.1001*	–0.0072
(2.01)	(1.87)	(–0.93)	(1)	(2.36)	(0.57)	(4.97)	(–1.82)	(–0.05)
ENSCO								
0.1554	0.1449**	–0.1914	0.6103***	0.0076	–0.0249	0.3798***	0.0884	0.0564
(1.42)	(2.57)	(–1.16)	(7.48)	(0.14)	(–0.38)	(3.1)	(1.45)	(0.38)
HALLIBURTON								
0.2631**	0.0995	–0.0628	0.4779***	0.0578	–0.0134	0.5737***	0.1052**	–0.1031
(2.02)	(1.49)	(–0.32)	(4.3)	(0.81)	(–0.16)	(5.34)	(2)	(–0.8)

(continued)

Appendix 3 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i.\ INT}$)**
HELMERICH & PAYNE								
0.2938***	0.1712***	–0.3088*	0.4298***	0.1042	0.2456***	0.4620***	0.0776	–0.1176
(2.76)	(3.1)	(–1.92)	(3.51)	(1.34)	(2.66)	(3.21)	(1.06)	(–0.65)
NABORS INDUSTRIES LTD.								
0.0823	0.2466***	–0.1604	0.4995***	0.1359	0.1324	0.3350***	0.2325***	–0.1027
(0.86)	(5.04)	(–1.12)	(3.2)	(1.36)	(1.1)	(2.65)	(3.67)	(–0.66)
NOBLE								
0.0965	0.1276**	–0.2219	0.4709***	–0.0412	0.1962**	0.5242***	–0.0129	–0.1052
(0.9)	(2.32)	(–1.37)	(4.47)	(–0.6)	(2.34)	(4.68)	(–0.23)	(–0.77)
SCHLUMBERGER								
0.1678**	0.0107	–0.1633	0.3087***	0.0225	0.0670	0.4614***	–0.1141**	–0.0868
(2.03)	(0.26)	(–1.32)	(3.68)	(0.41)	(0.98)	(3.98)	(–2.01)	(–0.63)
TIDEWATER								
0.3547***	0.0967**	–0.1584	0.1436	–0.0692	0.1114	0.4018***	0.0287	–0.0582
(3.76)	(2)	(–1.12)	(1.4)	(–1.05)	(1.42)	(3.06)	(0.43)	(–0.35)
WEATHERFORD								
0.1328	0.0981*	–0.4331***	0.5539***	0.0160	0.2467**	0.6092***	0.0259	–0.2358
(1.2)	(1.72)	(–2.6)	(3.98)	(0.18)	(2.32)	(5)	(0.42)	(–1.56)
OIL EQUIPMENT AND SERVICE COMPANY AVERAGE								
0.1916	**0.1200**	**–0.2026**	**0.4017**	**0.0464**	**0.1128**	**0.4767**	**0.0368**	**–0.0845**

(continued)

Appendix 3 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**
				PIPELINE COMPANIES				
ENBRIDGE ENERGY PRT. LP.								
0.1361**	–0.0260	–0.1597*	0.0727	–0.0086	0.1963***	0.1062	–0.0036	–0.1318
(2.2)	(–0.83)	(–1.73)	(0.78)	(–0.14)	(2.71)	(1.28)	(–0.09)	(–1.29)
OGE ENERGY								
–0.0027	0.0161	–0.2912***	0.1044*	–0.0128	–0.0836*	0.0639	–0.0407	–0.2168**
(–0.05)	(0.53)	(–3.29)	(1.83)	(–0.34)	(–1.82)	(0.82)	(–1.04)	(–2.26)
PLAINS ALL AMER. PIPELINE LP.								
0.1041*	–0.0556**	–0.1188	0.0421	–0.0806*	0.0876	0.0856	–0.0819**	–0.0508
(1.88)	(–1.99)	(–1.43)	(0.59)	(–1.77)	(1.62)	(1.08)	(–2.08)	(–0.53)
WILLIAMS CO.								
0.1595	0.1818**	0.1967	0.3140***	0.1478**	0.0874	0.2194	0.1743**	–0.0742
(0.94)	(2.03)	(0.76)	(3.29)	(2.41)	(1.18)	(1.56)	(2.52)	(–0.44)
PIPELINE COMPANY AVERAGE								
0.0993	**0.0291**	**–0.0933**	**0.1333**	**0.0114**	**0.0719**	**0.1188**	**0.0120**	**–0.1184**
				ROYALTY TRUSTS				
CROSS TIMBERS ROYALTY TRUST								
0.1993**	0.1992***	0.0481	0.4086***	0.1485*	0.0054	0.1066	0.2520***	0.0744
(2.28)	(4.41)	(0.36)	(2.86)	(1.59)	(0.05)	(0.94)	(4.41)	(0.53)
DOMINION RESOURCES BLACK WARRIOR ROYALTY TRUST								
0.1934**	0.0817*	–0.0145	0.0801	0.0661	–0.0140	0.3057**	0.1347**	0.0492
(2.28)	(1.89)	(–0.11)	(0.45)	(0.59)	(–0.11)	(2.58)	(2.27)	(0.34)

(continued)

Appendix 3 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: SUB–PERIOD ANALYSIS[a]

January 2000 – June 2007			July 2007 – January 2015			May 2003 – July 2008		
Oil price ($\beta_{i,\ OIL}$)	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i,\ INT}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Interest rate ($\beta_{i.\ INT}$)**
HUGOTON ROYALTY TRUST								
0.2812***	0.2245***	–0.2033	0.2537	0.2718**	0.1242	0.3749***	0.2110***	–0.1879
(3.18)	(4.98)	(–1.54)	(1.51)	(2.56)	(1)	(3.15)	(3.48)	(–1.26)
PERMIAN BASIN ROYALTY TRUST								
0.3253***	0.0589	–0.0871	0.4177***	0.0580	–0.0137	0.3002**	0.1481**	–0.0888
(4.36)	(1.53)	(–0.78)	(3.58)	(0.78)	(–0.16)	(2.5)	(2.45)	(–0.6)
SABINE ROYALTY TRUST								
0.3171***	0.0802*	–0.1901	0.4103***	0.0666	–0.0929	0.4343***	0.1032*	–0.2057
(3.69)	(1.87)	(–1.49)	(4.38)	(1.08)	(–1.21)	(3.77)	(1.84)	(–1.52)
SAN JUAN BASIN ROYALTY TRUST								
0.2573***	0.1942***	–0.2023*	0.1132	0.2983***	–0.0520	0.4302***	0.2079***	–0.2703**
(3.26)	(4.73)	(–1.69)	(0.85)	(3.54)	(–0.52)	(4.19)	(3.99)	(–2.11)
ROYALTY TRUSTS AVERAGE								
0.2623	**0.1398**	**–0.1082**	**0.2806**	**0.1516**	**–0.0072**	**0.3253**	**0.1762**	**–0.1048**
TOTAL AVERAGE								
0.2480	**0.1268**	**–0.1062**	**0.3173**	**0.0941**	**0.0918**	**0.4561**	**0.1072**	**–0.0358**

[a] *** = significance at the 1-percent level; ** = significance at the 5-percent level; and * = significance at the 10-percent level. $R_{mt} - R_{ft}$ stands for the logarithmic return on NYSE stock index less risk-free rate. $R_{OIL,t}$, $R_{GAS,t}$, and $R_{INT,t}$ stand for the logarithmic returns on West Texas Intermediate (WTI) oil price, NYMEX natural gas price, and change in the 10-year U.S. Treasury bond, respectively. $B_{i,M}$, $B_{i,OIL}$, $B_{i,GAS}$, and $B_{i,INT}$, provide measures of market, oil price, gas price, and interest rate risk sensitivities, respectively, for firm i. ε_{it} is the idiosyncratic error term. Regression: $R_{it} - R_{ft} = \alpha_{io} + B_{i,M}\,(R_{Mt} - R_{ft}) + B_{i,OIL}R_{OIL,t} + B_{i,GAS}R_{GAS,t} + B_{i,INT}R_{INT,t} + \varepsilon_{it}$.

Appendix 4

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: BETA EQUALITY WALD TEST[a]

	Feb. 2000 - Feb. 2015		Feb. 2000 - June 2007		July 2007 - Feb. 2015		May 2003 - July 2008	
Wald Test	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**	**Oil price ($\beta_{i,\ OIL}$)**	**Gas price ($\beta_{i,\ GAS}$)**
H_0 : All $\beta_{EXPLORATION} = \beta_{INTEGRATED}$								
χ^2 – Statistics	0.31	1.86	0.72	2.21	0.18	0.03	1.53	0.77
p-value	0.5749	0.1731	0.3954	0.1370	0.6728	0.8557	0.2162	0.3799
H_0 : All $\beta_{EXPLORATION} = \beta_{SERVICE}$								
χ^2 – Statistics	0.18	3.39	2.05	2.49	2.11	3.08	0.78	11.25
p-value	0.6733	0.0654	0.1517	0.1143	0.1461	0.0794	0.3783	0.0008
H_0 : All $\beta_{EXPLORATION} = \beta_{PIPELINE}$								
χ^2 – Statistics	20.13	28.38	13.75	22.45	8.43	6.14	62.84	18.53
p-value	0.0000	0.0000	0.0002	0.0000	0.0037	0.0132	0.0000	0.0000
H_0 : All $\beta_{EXPLORATION} = \beta_{ROYALTY}$								
χ^2 – Statistics	1.08	0.01	1.13	0.18	0.33	0.90	15.21	3.23
p-value	0.2996	0.9111	0.2871	0.6751	0.5641	0.3423	0.0001	0.0725
H_0 : All $\beta_{INTEGRATED} = \beta_{SERVICE}$								
χ^2 – Statistics	0.05	0.20	0.25	0.03	1.75	1.33	0.12	4.41
p-value	0.8317	0.6511	0.6155	0.8641	0.1858	0.2485	0.7281	0.0358
H_0 : All $\beta_{INTEGRATED} = \beta_{PIPELINE}$								
χ^2 – Statistics	11.14	12.95	6.58	9.76	2.62	3.57	28.8	8.95
p-value	0.0008	0.0003	0.0103	0.0018	0.1056	0.0589	0.0000	0.0028
H_0 : All $\beta_{INTEGRATED} = \beta_{ROYALTY}$								
χ^2 – Statistics	0.10	1.63	0.01	0.99	0.01	0.92	4.70	5.46
p-value	0.7572	0.2012	0.9218	0.3188	0.9410	0.3374	0.0302	0.0195

(continued)

Appendix 4 (continued)

OIL AND GAS PRICE SENSITIVITIES OF U.S. OIL AND GAS COMPANIES: BETA EQUALITY WALD TEST[a]

	Feb. 2000 - Feb. 2015		Feb. 2000 - June 2007		July 2007 - Feb. 2015		May 2003 - July 2008	
Wald Test	**Oil price ($\beta_{i,\,OIL}$)**	**Gas price ($\beta_{i,\,GAS}$)**	**Oil price ($\beta_{i,\,OIL}$)**	**Gas price ($\beta_{i,\,GAS}$)**	**Oil price ($\beta_{i,\,OIL}$)**	**Gas price ($\beta_{i,\,GAS}$)**	**Oil price ($\beta_{i,\,OIL}$)**	**Gas price ($\beta_{i,\,GAS}$)**
H_0 : All $\beta_{SERVICE} = \beta_{PIPELINE}$								
χ^2 – Statistics	13.14	8.91	4.54	7.38	14.16	0.70	31.56	0.64
p-value	0.0003	0.0028	0.0330	0.0066	0.0002	0.4030	0.0000	0.4220
H_0 : All $\beta_{SERVICE} = \beta_{ROYALTY}$								
χ^2 – Statistics	11.37	2.92	0.16	1.34	2.11	3.95	10.65	19.23
p-value	0.0007	0.0873	0.6904	0.2476	0.1461	0.0469	0.0011	0.0000
H_0 : All $\beta_{PIPELINE} = \beta_{ROYALTY}$								
χ^2 – Statistics	0.29	20.6	6.64	15.05	3.09	6.80	6.30	28.4
p-value	0.5884	0.0000	0.0100	0.0001	0.1461	0.0091	0.0121	0.0000

[a] $R_{OIL,t}$ and $R_{GAS,t}$ stand for logarithmic return on West Texas Intermediate (WTI) oil price and NYMEX natural gas price, respectively. $B_{i,OIL}$ and $B_{i,GAS}$ provide measures of oil and gas price sensitivities, respectively, for firm i. ε_{it} is the idiosyncratic error term. Regression: $R_{it} - R_{ft} = \alpha_{io} + B_{i,M}(R_{Mt} - R_{ft}) + B_{i,OIL}R_{OIL,t} + B_{i,GAS}R_{GAS,t} + B_{i,INT}R_{INT,t} + \varepsilon_{it}$.