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Exploration vs. acquisition of oil and gas reserves: Effect on stock returns

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Abstract: This paper examines how oil and gas companies' reserves growth affects their share price returns. In particular we examine three issues affecting the relation between reserves changes and oil and gas firm returns. First, we examine if investors value reserves replacement as a result of exploration activities differently to reserves growth through acquisitions. In the second analysis, we test if reserves replacement of oil reserves impacts stock returns differently than changes in gas reserves do. Third, we examine the impact of the Shale gas revolution and the subsequent oil and gas price divergence on the association between returns and replacement of oil versus gas reserves. The results suggest that investors seem to be indifferent to reserves replacement strategy (exploration or acquisition). However, we find that changes in oil reserves impact oil and gas company returns differently than changes in gas reserves does. Moreover, we find that there has been a structural shift in the relation between returns and changes in gas reserves (but not changes in oil reserves) after 2008, coinciding with the Shale gas revolution and the break in the oil-gas price link. This latter result can be relevant for understanding the impact of the recent fall in oil prices on investor valuation of oil and gas reserves.

Subjects: Industrial Economics; Investment & Securities; Financial Accounting; Financial Statement Analysis; Gas Industries; Petroleum & Oil Industries

Keywords: oil and gas reserves; reserves replacement; stock returns; acquisition; oil company; oil and gas company; exploration

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His research covers several fields including accounting, finance, and economics, mostly covering topics related to commodity markets. Misund's research interests include commodity price behavior, volatility transmission, the relationship between spot and futures prices, price formation in spot and futures markets, determinants of commodity firm stock returns, financial statement analysis, and valuation of oil and gas firms. He has published more than 25 papers in international peer-reviewed journals in economics, finance, and accounting.

PUBLIC INTEREST STATEMENT

Oil and gas reserves are the most important assets that oil and gas companies have, and represent their main source of revenues. The main objective of holding petroleum reserves is to generate future cash flows when they are extracted from oil and gas reservoirs and subsequently monetized. Replacing reserves as they are produced is crucial for the sustainability of their business model, and therefore an aspect of the industry that is followed closely by financial markets. Oil companies can pursue two main strategies for reserves replacement. They can either engage in risky exploration activities or purchase reserves from other agents. An interesting research question is how additions from organic growth through discoveries compare to reserve replacement through acquisition activities in terms of effects on security returns. On a risk-adjusted basis, an investor should be indifferent between organic growth and acquisitions. In this study, we address this issue and empirically examine if this is the case.

1. Introduction

Oil and gas reserves are clearly the most important assets that oil and gas companies have. The main objective of holding petroleum reserves is to generate future cash flows when they are extracted from oil and gas reservoirs and subsequently monetized. Replacing reserves as they are produced is crucial for the sustainability of their business model, and therefore an aspect of the industry that is followed closely by financial markets. Oil companies can pursue two main strategies for reserves replacement. They can either engage in risky exploration activities or purchase reserves from other agents. An interesting research question is how additions from organic growth through discoveries compare to reserve replacement through acquisition activities in terms of effects on security returns. On a risk-adjusted basis, an investor should be indifferent between organic growth and acquisitions. In this study, we address this issue and empirically examine if this is the case.

While the literature suggest that there is an empirical relationship between changes in petroleum reserves and security returns (see e.g. Berry, Hasan, & O'Bryan, 1998; Boyer & Filion, 2007; Clinch & Magliolo, 1992; Misund & Osmundsen, 2017; Spear, 1994), few studies have addressed the relative importance of the different types of reserves additions and deductions (see e.g. Spear, 1994).

An interesting research topic is whether the stock markets put equal value on proved reserves from organic resource growth and from acquisitions. Are the markets indifferent to oil and gas companies' opposing strategies for reserves growth? Furthermore, we wish to examine if there are differences between returns and discoveries of oil or gas reserves, or between returns and acquisitions of oil or gas reserves.

We estimate four empirical models for the relationship between returns and changes in returns. In the first model, we only examine the association between returns and the changes in total oil and gas reserves. The next model decomposes total reserves into gas and oil reserves. The third model examines the impact of the subcomponents of changes in total oil and gas reserves (including both purchases and organic growth of reserves), while the fourth model expands with a further decomposition into oil and gas reserves. We find a stepwise approach relevant for two reasons. Firstly, stability in the parameters offers insight into the robustness of the modeling procedure. Secondly, this approach also indicates if disaggregating total reserves into its subcomponents is meaningful.

Our sample consists of 4,218 firm-years for North American and international oil and gas companies. The results show that stock returns are associated with changes in oil and gas reserves. In line with expectations, the results suggest that investors do not seem to differentiate between changes in total oil and gas reserves from acquisitions or from purchases. However, this result does not hold when the changes in reserves are split into changes in oil reserves and changes in gas reserves. While the coefficients on oil reserve discoveries are higher than oil reserve purchases, the situation is opposite for changes in gas reserves. A possible explanation can be related to the increase in tight gas (shale gas) discovery and production since the late 2000s and the consequent fall in natural gas prices in the US. At the same time, oil prices have diverged from natural gas prices. Hence, the difference between the relation between security returns and discoveries or acquisitions oil vs. gas reserves can be linked to specific developments associated with the Shale gas revolution since 2009. Furthermore, returns are positively associated with increased oil production, but are not significantly affected by increases in natural gas production.

The main contribution of our study is to demonstrate that investors value acquisitions and organic growth of reserves when there is a structural change in the industry, such as the Shale gas revolution. Arguably, since the reserve additions and reductions are all measured as proved reserves, financial markets should not distinguish between the changes in reserves from acquisition or organic activities. If the markets price reserves growth from acquisitions differently from organic growth, this could potentially represent an arbitrage opportunity for investors, and the results from the empirical models can provide some insight into this topic.

The remainder of the paper is as follows. The next section presents the prior literature and provides a description of oil and gas reserves relevant for this study. Section 3 describes the empirical framework. Section 4 describes the data, followed by Section 5 which presents and discusses the results. Section 6 concludes.

2. Background and literature

2.1. What explains oil and gas stock returns?

Empirical investigations into the returns of oil companies has been the topic of numerous academic studies (see e.g. Ahmadi, Manera, & Sadeghzadeh, 2016; Chang & Yu, 2013; Cunado & Perez de Gracia 2014; Mollick & Assefa 2013; Shaeri, Adaoglu, & Katircioglu, 2016, for recent examples). One strand of the literature examines the relationship between oil prices and aggregate stock returns (Apergis & Miller, 2009; Ciner, 2001; Cunado & Perez de Gracia, 2014; Driesprong, Jacobsen, & Maat, 2008; Elyasiani, Mansur, & Odusami, 2011; Güntner, 2014; Huang, Masulis, & Stoll, 1996; Jones & Kaul, 1996; Kilian & Park, 2009; Kisswani & Elian, 2017; Lee, Yang, & Huang, 2012; Nandha & Faff, 2008; Narayan & Sharma, 2011; Park & Ratti, 2008; Sadorsky, 1999; Scholtens & Yurtsever, 2012). Another strand examines the effect of oil prices on industry sectors, including the oil and gas sector (Elyasiani et al., 2011; Faff & Brailsford, 1999; Gogineni, 2010; Hammoudeh, Dibooglu, & Aleisa, 2004; Kilian & Park, 2009; Lee et al., 2012; McSweeney & Worthington, 2008; Ramos, Tamouti, Veiga, & Wang, 2017; Ramos & Veiga, 2011; Scholtens & Yurtsever, 2012). And another focuses on the effect of oil prices on individual oil and gas stocks (see e.g. Aleisa, Dibooglu, & Hammoudeh, 2003; Al-Mudhaf & Goodwin, 1993; Hammoudeh & Li, 2005; Hilliard & Danielsen, 1984; Lanza, Manera, Grasso, & Giovannini, 2005; Nandha & Hammoudeh, 2007; Sadorsky, 2001, 2008; Scholtens & Wang, 2008; Talbot, Artiach, & Faff, 2013). The general impression from this strand of the literature is that commodity prices, such as oil and gas prices, influence the stock markets and in particular the returns on oil and gas companies.

Despite the substantial amount of research on the effect of commodity prices on aggregate, energy industry-specific and individual oil and gas stock returns, few studies assess the impact of fundamental information such as the impact of changes in production and oil and gas reserves on stock returns.

Using quarterly returns for Canadian firms set in a multifactor framework, Boyer and Filion (2007) find that the return on oil and gas stocks is positively associated with the Canadian stock market return, with increases in oil and natural gas prices, growth in internal cash flows and proven reserves. Surprisingly, the authors find a negative relationship between oil stock returns and changes in production of oil and gas.

Scholtens and Wagenaar (2011) examine how revisions of petroleum reserves impact oil and gas company returns. Analyzing a total of 100 revisions in several countries between 2000 and 2010, the authors find that revisions significantly impact shareholder values. In fact, they uncover an asymmetric response whereby downward revisions had a much larger impact on returns than upward revisions did.

In summary, previous studies have shown that changes in reserves affect shareholder returns of oil and gas companies. However, there are some gaps in the literature on the shareholder returns–reserves relationship. First, changes in reserves can be decomposed into subcomponents, such as reserves additions by acquisition and through exploration activities. Second, total reserves can be split into oil and gas reserves. Investors might place different values on gas vs. oil reserves. Petroleum reservoirs contain a wide variety of hydrocarbons. Typically, the oil reserves are produced first, with gas production following. Hence, investors might value oil reserves higher than the energy-equivalent amount of gas reserves simply because the latters' cash flows will come further out in time. How investors value gas vs. oil reserves is not well known.

Third, the reserves–returns relationship may vary over time. In fact, studies suggest that in certain time periods exploration efforts may have adverse effects on market valuation (Jensen, 1986, 1988; McConnell & Muscarella, 1985; Picchi, 1985). In recent years, an industry event that may have influenced the reserves–returns relationship, and particular for gas reserves, is the so-called Shale gas revolution of the late 2000s. Improved technology led to several large discoveries, rapid development and production of natural gas from tight gas formations in the US. As a consequence, natural gas prices dropped, and are currently still at historical lows. This break in the oil–gas link may have had a substantial impact on the relative association between security returns and reserve amount changes for natural gas compared to oil since 2008.

2.2. Oil and gas reserves

One of the distinguishing factors for the oil and gas sector compared to other industries is the concept of reserves. Adelman and Watkins (2008) describe reserves as a “depletable” resource stock, limited by nature and doomed to decline. Oil and gas reserves are by far the most important assets that oil and gas companies own. Financial analysts and investors pay great attention to information related to reserve changes released from these companies. As a consequence, successful exploration will often result in substantial stock price appreciation. When the Swedish oil company Lundin on 30 September 2011 announced a significant discovery of oil and gas in Johan Sverdrup field on the Norwegian continental shelf, their share price appreciated more than 30% in one day. Conversely, decreases in reserves, due to downward revisions, can also have a huge impact on share prices. In January 2004, when Shell announced a 28% downward revision of their proved oil and gas reserves,[1] their share price fell 12% over the 3–4 weeks following the announcement. Moreover, Scholtens and Wagenaar (2011), analyzing 100 reserves revisions globally, found a significant impact on share prices.

Most academic studies have applied proved reserves when examining the relationship between reserves changes and returns. According to Osmundsen (2010), the information value of booked reserves (proved reserved) suffers from a number of weaknesses. First, reserves are recognized as profitable using average commodity prices over the previous fiscal year. Second, ownership and entitlement to the reserve and production are governed by contractual issues such as production sharing agreements vs. concessions (see Bindemann, 1999; Kretzschmar, Misund, & Hatherly, 2007 for a discussion on this topic). Finally, the estimation of reserves is not straightforward proved reserves is only one of the several reserves classifications. The Society of Petroleum Engineers (Society of Petroleum Engineers, 2011) characterizes petroleum reserves according to maturity and probability of recoverability (see Figure 1). Commercial reserves are classified as proved, probable, or possible reserves.

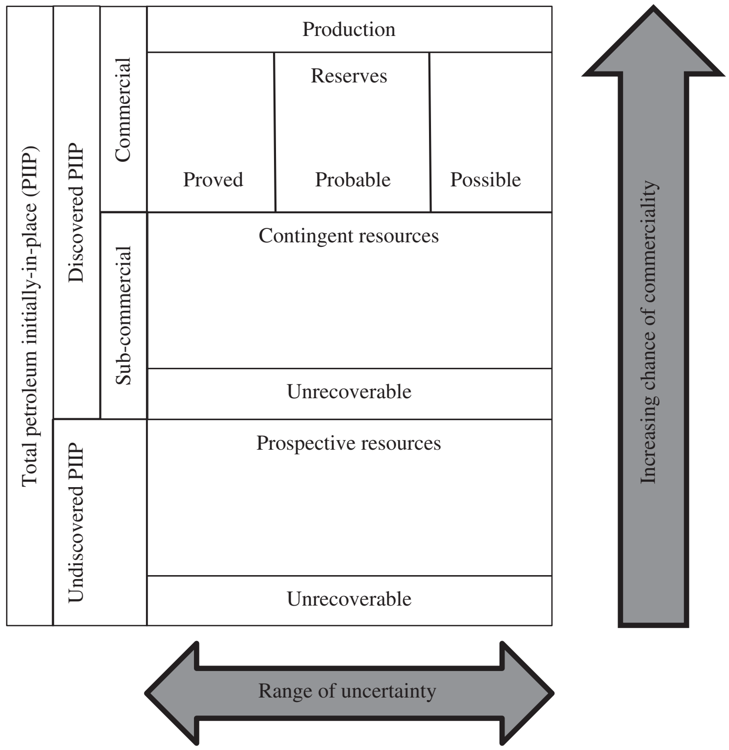
A recent study, however, finds that investors only to a limited degree rely upon less mature reserves (Misund & Osmundsen, 2017). We therefore find it appropriate to use proved reserves in our empirical study.

Since the early 1980s, both the US Securities and Exchange Commission (SEC) regulation and Financial Accounting Standards Board (FASB) accounting standards require oil and gas companies to disclose a substantial amount of supplementary information in addition to the standard financial reporting requirements such as income statement, balance sheet, cash flows, and notes (Financial Accounting Standards Board, 1977, 1982, 2009, 2010; Securities & Exchange Commission, 2008). The supplementary information relating to oil and gas exploration and production activities include a plethora of information. For instance, the oil major Exxon Mobil, in their 2013 10-K report, disclosed information on

- Results of operations related to oil and gas activities, according to geographical location.
- Oil and gas exploration and production costs (net capitalized costs, costs incurred in property acquisitions, exploration and development activities), according to geographical location.

Figure 1. Society of petroleum engineers' oil and gas reserves classification framework.

Source: Society of Petroleum Engineers (2011).



- Proved reserves for crude oil, natural gas, and unconventional petroleum, and across geographical location, both total and disaggregated.
- The standardized measure of discounted future cash flows, according to geographical location.
- Change in standardized measure of discounted future net cash flows relating to proved oil and gas reserves.

The changes in reserves amounts are split across geography, type of product (oil, gas, or unconventional) and are also disaggregated into sources and uses. The latter is a decomposition of the year-to-year change in booked reserves into the following elements

(1) Revisions and improved recovery
(2) Extensions and discoveries
(3) Purchases of reserves-in-place
(4) Sales of reserves-in-place
(5) Production

Positive reserves growth can thus be attributed to (1) organic growth through exploration and development, (2) growth through technology improvements and upward revisions, and (3) reserves additions through acquisitions. Conversely, a negative reserves growth can be realized through (4) downward revisions, (5) sales of reserves, and (6) production.

In our study, we will compare organic growth through extensions and discoveries with growth by way of acquisitions, by examining their association with returns. Moreover, we will examine if there are differences for oil vs. gas, and if the reserves changes–returns relationship changes as an effect of an event such as the shale gas revolution.

3. Methodology

Following Jorion (1990) and Sadorsky (2001), Boyer and Filion (2007), we apply a multifactor framework, regressing excess return of oil and gas stocks on a set of common risk factors and fundamental variables.[2] The common risk factors are the market risk premium, exchange rates, interest rates, and oil and gas prices. The fundamental variables are changes in reserves, production as well as financial leverage and cash flows. We improve on the approach applied by Boyer and Filion (2007) in five ways. First, the inclusion of both changes in reserves and production as explanatory variables can potentially be problematic since changes in reserves also includes changes in production and can therefore be correlated. Furthermore, since changes in reserves can be decomposed to several components, leaving out several of these may lead to the omitted variables bias. Our approach is therefore to include all the subcomponents of reserves in the empirical model. Secondly, we incorporate the common risk factors and a measure for profitability, namely cash flow from operations, in the Ohlson (1995) model. Thirdly, we expand the set of common risk factors to include the Fama–French–Carhart risk factors. We have not found studies explicitly including the Fama–French–Carhart risk factors for explaining the variation in oil and gas company returns.[3] Fourth, we explicitly examine the impact of oil vs. gas reserves changes on oil firm returns. Lastly, we use panel date techniques to control for unobservable effects.

3.1. The Ohlson (1995) framework

Based on the hypothesis that asset prices represent the present value of all future dividends, Ohlson (1995) models the returns on stock prices to profitability and the discount rate

$$p_t = b_t + \alpha_1 x_t^a + \alpha_2 v_t, \text{ where } \alpha_1 = \omega/(k-\omega) \text{ and } \alpha_2 = k/(k-\omega)(k-\gamma), \quad (1)$$

where p_t is the stock price at time t, b_t is the book value of equity at time t, x_t^a is the profitability at time t measured as earnings less the expected return on equity, and v_t is value relevant information not yet captured by current measures of profitability ("other information"). The discount rate is denoted by k, and $0 \leq \omega$ and $\gamma < 1$ are constants. In addition to Equation (1), Ohlson (1995) also develops a model for stock price returns as a function of shocks to earnings and other information

$$r_t = k + (1+\alpha_1)\vartheta_t/p_{t-1} + \alpha_2\eta_t/p_{t-1}, \quad (2)$$

where r_t is the total shareholder return, i.e. the sum of stock price return and dividend yield, and ϑ_t and η_t are mean zero disturbance terms (shocks) for earnings and other information, respectively. The theoretical model in Equation (2) can be estimated using the following empirical model

$$r_{it} - \text{RF}_t = \theta_0 + \alpha_1 E_{it}/p_{it-1} + \alpha_2 \Delta E_{it}/p_{it-1} + \lambda R_t + \delta \text{ogr}_{it} + \varepsilon_{it}, \quad (3)$$

where r_{it} is the total shareholder return for company i at time t, E_{it} is the earnings for company i for the period from $t-1$ to t, and ΔE_{it} is the change in earnings from the previous time period. RF_t is the risk free rate at time t. The vector R_t in Equation (2), denotes a set of common risk factors including the Fama–French–Carhart (MRP_t is the market risk premium, SMB_t and HML_t are the returns on the Fama and French (1993, 1996) Small-minus-big and high-minus-low factor, respectively. MOM_t is the Carhart (1997) momentum factor,[4]) and commodity price risk factors (ΔOP and ΔGP for the changes in oil and gas price, respectively). The last element in Equation (3), ε_{it} is the error term. Earnings and changes in earnings are included to capture the shocks in earnings, while the Fama–French–Carhart factors are included as a proxy for the discount rate. In addition, we include changes in oil and gas prices since they are known to influence stock price returns (Boyer & Filion, 2007; Sadorsky, 2001). Moreover, oil and gas companies are allowed to choose between two competing methods for accounting for pre-discovery costs. Under the successful efforts method, only costs related to successful discoveries are allowed to be capitalized, and costs associated with dry holes are directly expensed. Whereas, under the competing method, the full cost method, all costs from exploration activities are booked on the balance sheets. The two methods can result in substantial differences in net income for the same firm if it was to change accounting method (Cortese, Irvine, & Kaidonis, 2009). Consequently, the literature suggests that cash flow from operations can be more appropriate profitability measures in the oil and gas sector than earnings (see e.g. Cormier & Magnan, 2002; Dechow, 1994; DeFond & Hung, 2003; Misund, Asche, & Osmundsen, 2008; Misund & Osmundsen, 2015; Misund, Osmundsen, & Sikveland, 2015). We therefore use cash flow from operations and changes in cash flow from operations as proxies for earnings and changes in earnings, respectively, in Equation (3).

The last variable, ogr, denotes a vector of oil and gas reserves variables (on changes form), and is decomposed in four ways in our study. In the first empirical model (Model 1), ogr represents the changes in total oil and gas reserves, while Model 2 uses both the changes in oil and gas reserves as separate explanatory variables. The third model (Model 3) splits ogr into the following components.

$$\mathrm{ogr}_t = \frac{(\mathrm{BOE}_t - \mathrm{BOE}_{t-1})}{\mathrm{BOE}_{t-1}} = \mathrm{rev}_t + \mathrm{ext}_t + \mathrm{imp}_t + \mathrm{pur}_t + \mathrm{sal}_t + \mathrm{oth}_t + \mathrm{pro}_t \tag{4}$$

where the BOE_{t-1} and BOE_t are total reserves amounts (in barrels of oil equivalent) at the beginning and end of the fiscal year, respectively. The changes in total oil and gas reserves can further be attributed to revisions (rev_t), extensions and discoveries (ext_t), improved recovery (imp_t), purchases of reserves (pur_t), sales of reserves (sal_t), other reasons (oth_t), and production (pro_t). All amounts of reserves are denoted in barrels of oil equivalent. Natural gas reserves are normally measured in billions of cubic feet, which are converted to oil equivalents by dividing by a factor of six. All changes in reserves components use the beginning of year barrels of oil equivalents in the denominator. In the final model (Model 4), the subcomponents in Model 3 are split further by commodity type, oil or gas. The four empirical models are as follows:

$$\text{Model 1} \quad R_{it} = \alpha_0^1 + \alpha_1^1 \mathrm{CF}_{it}/p_{it-1} + \alpha_2^1 \Delta\mathrm{CF}_{it}/p_{it-1} + \sum_{j=1}^{6} \lambda_j^1 R_t^j + \delta^{\mathrm{total}} \mathrm{ogr}_{it} + \varepsilon_{it}^1 \tag{5}$$

$$\text{Model 2} \quad R_{it} = \alpha_0^2 + \alpha_1^2 \mathrm{CF}_{it}/p_{it-1} + \alpha_2^2 \Delta\mathrm{CF}_{it}/p_{it-1} + \sum_{j=1}^{6} \lambda_j^2 R_t^j + \delta^{\mathrm{gas}} \mathrm{ogr}_{it} + \delta^{\mathrm{oil}} \mathrm{ogr}_{it} + \varepsilon_{it}^2 \tag{6}$$

$$\text{Model 3} \quad R_{it} = \alpha_0^3 + \alpha_1^3 \mathrm{CF}_{it}/p_{it-1} + \alpha_2^3 \Delta\mathrm{CF}_{it}/p_{it-1} + \sum_{j=1}^{6} \lambda_j^3 R_t^j + \sum_{l=1}^{7} \delta_l^{\mathrm{total}} \mathrm{ogr}_{it}^{l,\mathrm{total}} + \varepsilon_{it}^3 \tag{7}$$

$$\text{Model 4} \quad R_{it} = \alpha_0^4 + \alpha_1^4 \mathrm{CF}_{it}/p_{it-1} + \alpha_2^4 \Delta\mathrm{CF}_{it}/p_{it-1} + \sum_{j=1}^{6} \lambda_j^4 R_t^j + \sum_{l=1}^{7} \delta_l^{\mathrm{oil}} \mathrm{ogr}_{it}^{l,\mathrm{oil}} + \sum_{l=1}^{7} \delta_l^{\mathrm{gas}} \mathrm{ogr}_{it}^{l,\mathrm{gas}} + \varepsilon_{it}^4 \tag{8}$$

where the dependent variable R_{it}, are total shareholder returns for oil and gas companies in excess of the one-month T-Bill rate, R_t^j are the Fama–French–Carhart factors, where j represents the four factors ($j = 1$: Market risk premium, MRP; $j = 2$: Small-minus-big, SMB; $j = 3$: High-minus-low book-to-market, HML; *j* = 4: is momentum factor, MOM; *j* = 5: is the change in oil price, ΔOP and; *j* = 6: is the change in gas price, ΔGP). α_0 and ε_{it} are the intercept and residuals, respectively. Moreover, $\text{ogr}_{it}^{l,\text{total}}$ represents the changes in total oil and gas reserves, decomposed in seven subcomponents, and where *l* represents the different subcomponents (*l* = 1: rev; *l* = 2: ext; *l* = 3: imp; *l* = 4: pur; *l* = 5: sal; *l* = 6: oth; *l* = 7: pro). Finally, The vectors $\text{ogr}_{it}^{l,\text{oil}}$ and $\text{ogr}_{it}^{l,\text{gas}}$ denote each of the seven *l* subcomponents for both oil and gas reserves changes.

In a similar study, Boyer and Filion (2007) include several variables such as cash flow, reserves changes, and production. We improve on Boyer and Filion in two ways. First, we apply an empirical specification that is based on a theoretical model which includes profitability, cost of capital, and variables that capture future profitability, proxied by oil and gas reserves. Furthermore, we avoid using overlapping variables, since changes in reserves include changes in production and changes in the other reserves components. Our approach decomposes changes in total reserves into all the subcomponents as reported in the companies' supplements to their annual financial statements.

3.2. Panel data models

As Fields, Lys, and Vincent (2001, p. 300) point out, accounting information, such as profitability, can often only explain a minor part of the variability share price returns. Therefore, if only accounting information, such as earnings and proved reserves, is included in the empirical model we run the risk of running into econometric issues such as the omitted variables bias. The problem with the omitted variables bias is that it can lead to biased estimators. Consequently, it is crucial to try to mitigate the omitted variables bias. One approach is to include control variables. However, it can be difficult to identify relevant control variables. Moreover, the significance and relevance of the control variables can vary over time, and from study to study, possibly because they proxy for some unidentified variable. Another approach is to apply panel data techniques such as fixed effects or random effects models. The benefit of a fixed effects model is that it can capture the effects of unobservable factors which are constant across time or constant across the firms in the sample. For instance, Boone (2002) finds an opposite result regarding the value relevance of the standardized measure compared to an earlier study by Harris and Ohlson (1987) by applying a fixed effects model. In order to mitigate the possible negative effects of omitted variables, we apply panel data techniques. To find the appropriate panel model, we carry out three diagnostics tests. First, we test if we should use a panel model (fixed effects or random effects) instead of pooled OLS. Next, we test between random effects and fixed effects using the Hausman test.

To mitigate the negative impact of heteroscedasticity, robust standard errors are calculated to correct for heteroscedasticity and serial correlation in the error terms (Arellano, 1987).

3.3. Hypotheses

We test three hypotheses relating to the association between reserves quantities and oil and gas company shareholder returns.

3.3.1. Hypothesis 1: Organic growth vs. acquisition

H_0: (total reserves): coefficients on changes in reserves extensions and discoveries (organic growth) are the same as coefficients on changes in purchased reserves (acquisitions). Formally, this is a *F*-test of coefficient equality, $\delta_{\text{ext}} - \delta_{\text{pur}} = 0$. If the null hypothesis is rejected, then the results provide evidence that investors value changes in reserves due to discoveries differently than changes in reserves due to acquisitions.

3.3.2. Hypothesis 2: Gas vs. oil

H_0: (oil and gas reserves): coefficients on changes in oil or gas reserves extensions and discoveries (organic growth) are the same as coefficients on changes in purchased oil or gas reserves (acquisitions)

3.3.3. Hypothesis 3: Structural shift: Impact of shale gas revolution

H_0: There has been a structural shift in the coefficients on the interaction variables between gas reserves changes and a dummy variable for onset of the Shale gas revolution (the dummy variable equals one for years after 2008, and zero before or in 2008).

4. Data-set and variables

Our sample consists of accounting data and returns for a selection of oil and gas companies for the time period 1992 to 2013, comprising more than 20 years of data. The accounting data, both cash flow from operations and supplementary data on reserves, are collected from the IHS Herold database (www.ihs.com/herold). This database contains data on both North American and International companies. We use contemporaneous returns in our analysis. However, studies vary with respect to the use of contemporaneous (end of year minus end of year previous year) vs. lagged returns (returns as of end of March vs. end of March previous year). The arguments for the latter approach are that the accounting information is released after the end of the year, typically within the first two months following the year end. Hence, the returns calculations should reflect this time discrepancy between year end and disclosure of accounting information. However, this view does not take into account that some of the information is publically available before year end and will be reflected in the share prices at year end. For instance, an oil and gas company will typically inform the market of any major oil and gas discoveries. Likewise, oil and gas companies will also inform the market of purchases or sales of assets. Finally, production amounts are released on a quarterly basis, meaning that the market has received information on production changes for the first three quarters of the year. For these reasons, we use contemporenous returns in this study. This approach differs from event studies such as applied by Spear (1994).

The changes in oil and natural gas prices are calculated as the annual return on the front month futures contracts, and are collected from the US Department of Energy (www.doe.gov/eia). Finally, the Fama–French–Carhart risk factors are extracted from Ken French' site. The descriptive statistics are presented in Table 1. The mean change in reserves was 14.7% from 1992 to 2003. This indicates that the companies in the sample experienced a substantial growth in reserves. Most of the growth came from extensions and discoveries at 15.3%, followed by purchases at 11.3% average change. Production of reserves dominated the downward change in reserves at 11.1% per annum. The 14.7% increase in total reserves can be attributed to changes in oil and gas reserves of 8.2 and 6.5%, respectively.

All variables we use in the empirical analysis are stationary (Table 2) and no first differencing is needed.

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Table 1. Descriptive statistics

Variable	Mean	St. dev.	25%	Median	75%	*N*
R	0.1648	0.5372	−0.1849	0.0942	0.4295	4,218
CF	0.2103	0.2849	0.1087	0.1761	0.2617	4,218
ΔCF	0.0268	0.2374	−0.0144	0.0215	0.0675	4,218
MRP	0.0821	0.1945	0.0083	0.1069	0.2021	23
SMB	0.0323	0.1192	−0.0373	0.0039	0.0747	23
HML	0.0232	0.1588	−0.0795	0.0371	0.1321	23
MOM	0.0587	0.2343	0.0324	0.0863	0.1775	23
ΔOP	0.1458	0.4018	−0.0709	0.0815	0.3361	23
ΔGP	0.1753	0.7483	−0.2094	0.0527	0.2623	23
ΔBOE	0.1472	0.5404	−0.0485	0.0424	0.1951	4,218
ΔBOE^{REV}	0.0108	0.2315	−0.0446	0.0045	0.0504	4,218
ΔBOE^{EXT}	0.1532	0.3013	0.0159	0.0765	0.183	4,218
ΔBOE^{IMP}	0.0069	0.0598	<0.0001	<0.0001	<0.0001	4,218
ΔBOE^{PUR}	0.1133	0.3830	<0.0001	0.0042	0.0787	4,218
ΔBOE^{SAL}	−0.0302	0.0937	−0.0168	−0.0004	<0.0001	4,218
ΔBOE^{OTH}	0.0039	0.1067	<0.0001	<0.0001	<0.0001	4,218
ΔBOE^{PRO}	−0.1111	0.0701	−0.1348	−0.0979	−0.0706	4,218
ΔOIL	0.0820	0.4140	−0.0187	0.0099	0.0782	4,218
ΔOIL^{REV}	0.0182	0.1724	−0.0100	0.0034	0.0283	4,218
ΔOIL^{EXT}	0.0618	0.2287	0.0008	0.0193	0.0534	4,218
ΔOIL^{IMP}	0.0051	0.0546	<0.0001	<0.0001	<0.0001	4,218
ΔOIL^{PUR}	0.0559	0.2831	<0.0001	0.0004	0.0214	4,218
ΔOIL^{SAL}	−0.0129	0.0521	−0.0048	<0.0001	<0.0001	4,218
ΔOIL^{OTH}	0.0027	0.0780	<0.0001	<0.0001	<0.0001	4,218
ΔOIL^{PRO}	−0.0489	0.0493	−0.0624	−0.0418	−0.0195	4,218
ΔGAS	0.0650	0.2597	−0.0257	0.0064	0.0984	4,218
ΔGAS^{REV}	−0.0072	0.1187	−0.0295	<0.0001	0.0157	4,218
ΔGAS^{EXT}	0.0916	0.1673	0.0021	0.0327	0.1141	4,218
ΔGAS^{IMP}	0.0018	0.0203	<0.0001	<0.0001	<0.0001	4,218
ΔGAS^{PUR}	0.0574	0.1794	<0.0001	0.0008	0.0307	4,218
ΔGAS^{SAL}	−0.0173	0.0651	−0.0071	<0.0001	<0.0001	4,218
ΔGAS^{OTH}	0.0012	0.0525	<0.0001	<0.0001	<0.0001	4,218
ΔGAS^{PRO}	−0.0624	0.0578	−0.0859	−0.0503	−0.0251	4,218

Notes: ΔBOE, ΔOIL, ΔGAS are changes in total oil and gas reserves, oil reserves and gas reserves, respectively. The superscript describes the type of disaggregated reserves; REV = revisions, EXT = extensions, IMP = improvements, PUR = purchases, SAL = sales, OTH = other, and PRO = production.

Table 2. Test for unit root using the Augmented Dickey–Fuller test (ADF)

Variable	BOE		OIL		GAS	
	ADF-value	*p*-value	ADF-value	*p*-value	ADF-value	*p*-value
R	−37.483	<0.001				
CF	−37.483	<0.001				
ΔCF	−31.190	<0.001				
MRP	−39.818	<0.001				
SMB	−40.948	<0.001				
HML	−42.172	<0.001				
MOM	−34.591	<0.001				
ΔOP	−51.559	<0.001				
ΔGP	−37.820	<0.001				
TOT	−34.130	<0.001	−35.541	<0.001	−31.424	<0.001
REV	−33.704	<0.001	−36.612	<0.001	−31.006	<0.001
EXT	−31.070	<0.001	−32.707	<0.001	−26.360	<0.001
IMP	−31.749	<0.001	−33.583	<0.001	−29.035	<0.001
PUR	−33.052	<0.001	−35.160	<0.001	−30.901	<0.001
SAL	−35.786	<0.001	−35.674	<0.001	−36.129	<0.001
OTH	−38.005	<0.001	−37.151	<0.001	−38.730	<0.001
PRO	−22.144	<0.001	−21.238	<0.001	−20.668	<0.001

Notes: For simplicity the ADF results are split into three, for changes in total reserves (columns 2 and 3), changes in oil reserves (columns 4 and 5), and changes in gas reserves (columns 6 and 7). The variable for changes in total, oil and gas reserves attributed to purchases is denoted by *PUR* in this table (across three columns), but ΔBOE^{PUR}, ΔOIL^{PUR}, and ΔGAS^{PUR}, respectively in Table 1. TOT = total reserves, REV = revisions, EXT = extensions, IMP = improvements, PUR = purchases, SAL = sales, OTH = other, and PRO = production. Results with a statistical significance better than 5% is marked in bold.

5. Results and discussion

In this section, we present the results from the empirical analysis. We do this in several steps. First, we examine which type of panel models are appropriate using three tests. Two pooling test will indicate if we should use pooled OLS or fixed or random effects. Then, we apply a Hausman test to see if random effects are better than fixed effects. Secondly, we test the null hypotheses of no heteroskedasticity or serial correlation in the residuals. If we fail to reject the hypotheses, we need to correct the standard errors in the coefficients of the regressions before making inferences. Finally, we estimate four different empirical models.

The diagnostics tests indicate that we should use random effects for Model 1 and fixed effects for Models 2 to 4 (Table 3). Furthermore, the data show the presence of both heteroskedasticity and serial correlation and we therefore apply the Arellano (1987) approach for correcting the standard errors of the four empirical models.

Table 4 presents the results for the empirical estimation of the four models. In Model 1 (Table 4, column 2), both cash flow from operations and changes in cash flow are statistically significant. Moreover, three of the common risk factors, market risk premium, small-minus-big and high-minus-low, contribute to explaining the variation in oil and gas company returns. Furthermore, both oil and gas prices are positively associated with market valuations. In line with previous studies such as Boyer and Filion (2007), we find that changes in total oil and gas reserves impact security returns. However, our results contradict Osmundsen et al. (2006) who did not find a significant relationship between the reserves replacement ratio (RRR) and valuation of large international oil and gas companies. However, the latter study used valuation multiples instead of returns, which could explain

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Table 3. Panel data tests and tests for heteroskedasticity and serial correlation

	Model 1	Model 2	Model 3	Model 4
Pooled vs. fixed	1.370 (<0.001)	1.357 (<0.001)	1.370 (<0.001)	1.364 (<0.001)
Pooled vs. random	82,175.8 (<0.001)	81,491.9 (<0.001)	81,503.4 (<0.001)	80,123.9 (<0.001)
Random vs. fixed	6.900 (0.648)	18.879 (0.042)	96.521 (<0.001)	94.434 (<0.001)
Heteroskedasticity	999.646 (<0.001)	909.629 (<0.001)	1103.993 (<0.001)	973.135 (<0.001)
Serial correlation	<0.001 (0.982)	50.538 (<0.001)	47.283 (<0.001)	51.357 (<0.001)

Notes: Pooled vs. fixed has H_0: Pooled model is a better fit than a fixed effects model (*F*-test). Pooled vs. random has H_0: Pooled model is a better fit than a random effects model (Breusch–Pagan test: Breusch and Pagan (1979)). Random vs. fixed has H_0: Random effects model is a better fit than a fixed effects model (Hausman test: Hausman, 1978). Presence of heteroskedasticity is tested using a Breusch–Pagan test (Breusch & Pagan, 1979) with H_0: no heteroskedasticity present in the data, and presence of serial correlation is tested using a Breusch–Godfrey/Wooldridge test (Breusch, 1978; Godfrey, 1978; Wooldridge, 2002) with H_0: no serial correlation present in the data. Results with a statistical significance better than 5% is marked in bold.

the differences in results. The methodology in our study is more comparable to Boyer and Filion (2007).

In Model 2 (Table 4, column 3), we expand Model 1 by examining the differential effect of changes in oil vs. gas reserves. The results show that both oil and gas reserves impact returns, but the coefficient on gas (measured in barrels of oil equivalent) is more than three times higher than for the latter variable (gas: 0.274 and oil: 0.083). The *F*-test confirms that they are also statistically different from each other. This result suggests that changes in gas reserves have had a bigger impact on returns than oil reserves have.

In Model 3 (Table 4, column 4), we extend Model 1 by examining the impact of the subcomponents of the change in total oil and gas reserves on returns. The coefficient on reserves from organic growth (ΔBOE^{EXT}) is 0.165, while that from purchases (ΔBOE^{PUR}) is approximately the same at 0.167. Hence, investors seem to put the same price on changes in total reserves due to organic growth through extensions as growth through discoveries and acquisition of reserves. The results of the *F*-test also confirm this (Table 5, Hypothesis 2) with a *F*-statistic of 0.299, which is insignificant.

Model 4 (Table 4, column 5) examines the impact of disaggregate oil vs. gas reserves. Although the coefficients vary between 0.065 and 0.381 for changes in oil and gas reserves attributed to purchases and acquisitions, they are in general not statistically significant from each other. As indicated in Table 5, only the coefficients on gas purchases and oil purchases are statistically significantly different. This result suggests that investors are indifferent between increases in oil and gas reserves due to discoveries. However, they do separate between oil and gas reserve changes from acquisitions, placing a higher loading on acquisition of gas reserves.

Contrary to Boyer and Filion (2007), we do find that oil and gas company returns are positively associated with production. However, we only find evidence that this is valid for oil reserves, not gas reserves. Moreover, the coefficient is only statistically significant at the 10% level, so it is not a strong result. Hence, it seems that production is a measure with a weak (if any) influence on returns. A possible reason for this is that production is a contemporaneous measure, while returns are forward looking.

Table 4. Regression results

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Intercept	**−0.056 (0.003)**			
CF	0.177 (0.059)	**0.277 (0.015)**	**0.271 (0.016)**	**0.285 (0.014)**
ΔCF	**0.172 (0.017)**	0.081 (0.164)	0.102 (0.083)	0.085 (0.146)
MRP	**0.524 (<0.001)**	**0.587 (<0.001)**	**0.588 (<0.001)**	**0.584 (<0.001)**
SMB	**0.322 (<0.001)**	**0.289 (0.001)**	**0.273 (0.002)**	**0.292 (0.001)**
HML	**0.889 (<0.001)**	**0.886 (<0.001)**	**0.890 (<0.001)**	**0.889 (<0.001)**
MOM	0.071 (0.114)	**0.133 (0.003)**	**0.133 (0.004)**	**0.129 (0.005)**
ΔOP	**0.394 (<0.001)**	**0.381 (<0.001)**	**0.383 (<0.001)**	**0.383 (<0.001)**
ΔGP	**0.105 (<0.001)**	**0.106 (<0.001)**	**0.105 (<0.001)**	**0.105 (<0.001)**
ΔBOE	**0.161 (<0.001)**			
ΔBOE^{REV}			**0.114 (0.037)**	
ΔBOE^{EXT}			**0.165 (0.003)**	
ΔBOE^{IMP}			−0.113 (0.171)	
ΔBOE^{PUR}			**0.167 (<0.001)**	
ΔBOE^{SAL}			0.041 (0.688)	
ΔBOE^{OTH}			−0.012 (0.873)	
ΔBOE^{PRO}			0.217 (0.224)	
ΔOIL		**0.083 (0.002)**		
ΔOIL^{REV}				0.061 (0.320)
ΔOIL^{EXT}				0.127 (0.084)
ΔOIL^{IMP}				−0.107 (0.179)
ΔOIL^{PUR}				**0.065 (0.003)**
ΔOIL^{SAL}				0.144 (0.333)
ΔOIL^{OTH}				0.103 (0.372)
ΔOIL^{PRO}				0.691 (0.058)
ΔGAS		**0.274 (<0.001)**		
ΔGAS^{REV}				**0.244 (0.025)**
ΔGAS^{EXT}				**0.252 (0.001)**
ΔGAS^{IMP}				−0.205 (0.477)
ΔGAS^{PUR}				**0.381 (<0.001)**
ΔGAS^{SAL}				−0.001 (0.998)
ΔGAS^{OTH}				−0.150 (0.314)
ΔGAS^{PRO}				0.197 (0.292)
Adjusted R^2	0.272	0.252	0.250	0.256
F-statistic	**175.160 (<0.001)**	**149.223 (<0.001)**	**98.354 (<0.001)**	**69.206 (<0.001)**
RE/FE/pooled	RE	FE	FE	FE

Notes: RE is random effects and FE is fixed effects. ΔBOE, ΔOIL, ΔGAS are changes in total oil and gas reserves, oil reserves, and gas reserves, respectively. The superscript describes the type of disaggregated reserves; REV = revisions, EXT = extensions, IMP = improvements, PUR = purchases, SAL = sales, OTH = other, and PRO = production. Results with a statistical significance better than 5% is marked in bold.

In the last part of the analysis, we examine if there has been a structural shift in the reserves–returns relationship before and after 2008/2009. We hypothesis that only the coefficients on gas reserves have been affected, and expect the coefficients on oil reserve changes remain unchanged. This hypothesis is tested using the Chow test. The results confirm our expectations (Table 6). Moreover, the Chow test for gas reserve interactions formally confirms this (χ^2 = 22.812,

Table 5. *F*-tests and Chow test

Hypotheses	*F*-statistic (*p*-value)	χ^2-statistic (*p*-value)
Hypothesis 1		
Model 2: H_0: $\delta^{oil}_{tot} - \delta^{gas}_{tot} = 0$	**10.804 (0.001)**	
Model 4: H_0: $\delta^{oil}_{ext} - \delta^{gas}_{ext} = 0$	1.250 (0.264)	
Model 4: H_0: $\delta^{oil}_{pur} - \delta^{gas}_{pur} = 0$	**16.097 (<0.001)**	
Hypothesis 2		
Model 3: H_0: $\delta^{boe}_{ext} - \delta^{boe}_{pur} = 0$	<0.001 (0.976)	
Model 4: H_0: $\delta^{oil}_{ext} - \delta^{oil}_{pur} = 0$	0.299 (0.587)	
Model 4: H_0: $\delta^{gas}_{ext} - \delta^{gas}_{pur} = 0$	1.774 (0.183)	
Hypothesis 3		
H_0: no structural shift on interaction terms on oil reserves changes		9.720 (0.205)
H_0: no structural shift on interaction terms on gas reserves changes		**22.812 (0.002)**

Note: Results with a statistical significance better than 5% is marked in bold.

Table 6. Shale gas

Variable	Pre-2008	Post-2008
Intercept		**−0.174 (<0.001)**
ΔOIL^{REV}	0.044 (0.421)	0.151 (0.190)
ΔOIL^{EXT}	0.101 (0.245)	0.104 (0.472)
ΔOIL^{IMP}	−0.502 (0.414)	0.445 (0.468)
ΔOIL^{PUR}	**0.081 (0.020)**	−0.044 (0.469)
ΔOIL^{SAL}	0.155 (0.424)	−0.022 (0.949)
ΔOIL^{OTH}	0.200 (0.100)	−0.621 (0.123)
ΔOIL^{PRO}	**0.849 (0.036)**	−0.566 (0.263)
ΔGAS^{REV}	0.065 (0.565)	**0.566 (0.002)**
ΔGAS^{EXT}	**0.268 (0.002)**	−0.167 (0.225)
ΔGAS^{IMP}	−0.289 (0.380)	**0.829 (0.043)**
ΔGAS^{PUR}	**0.336 (<0.001)**	0.412 (0.088)
ΔGAS^{SAL}	0.100 (0.605)	−0.542 (0.168)
ΔGAS^{OTH}	−0.110 (0.675)	0.131 (0.725)
ΔGAS^{PRO}	0.187 (0.348)	−0.024 (0.960)
Adjusted R^2	0.256	0.268
F-statistic	69.206 (<0.001)	44.047 (<0.001)

Notes: For simplicity, only the coefficients on the reserves variables are presented. ΔBOE, ΔOIL, ΔGAS are changes in total oil and gas reserves, oil reserves, and gas reserves, respectively. The superscript describes the type of disaggregated reserves; REV = revisions, EXT = extensions, IMP = improvements, PUR = purchases, SAL = sales, OTH = other, and PRO = production. Results with a statistical significance better than 5% is marked in bold.

p-value = 0.002). The Chow test for the interaction coefficients on the oil reserves is not significant.

Hence, the results provide evidence that there has been a structural shift in the gas reserves–return relationship that coincides in time with the Shale gas revolution and the break in the gas–oil link.

6. Conclusion

In this paper, we have examined the relation between changes in reserves and oil company stock returns, and specifically examined whether reserves changes attributed to exploration activities vs. acquisitions of reserves are priced differently by investors. The empirical methodology is based on the Ohlson (1995) framework which explains stock returns in terms of current and future profitability (earnings) and the discount rate. As a proxy for the discount rate, we incorporate the multifactor model approach adopted by Sadorsky (2001) and Boyer and Filion (2007). We augment the latter studies by also including the Fama–French–Carhart risk factors in addition to the market risk premium.

The results show that stock returns are associated with changes in oil and gas reserves. In line with expectations, the results suggest that investors do not seem to differentiate between changes in total oil and gas reserves from acquisitions or from purchases. However, this is not that case when the changes in reserves are split into changes in oil reserves and changes in gas reserves. While the coefficients on oil reserve discoveries are higher than oil reserve purchases, the situation is opposite for changes in gas reserves. A possible explanation can be related to the increase in tight gas (shale gas) discovery and production since the late 2000s and the consequent fall in natural gas prices in the US. At the same time, oil prices have diverged from natural gas prices. Hence, the difference between the relation between security returns and discoveries or acquisitions oil vs. gas reserves can be linked to specific developments associated with the Shale gas revolution since 2009. This latter result is of relevance for understanding the impact of the recent fall in oil prices. During late 2014 to early 2015, crude oil prices fell from above 100 USD/barrel to below 50 USD/barrel. Many commentators attributed the substantial fall in oil prices to increased US onshore shale oil production. Consequently, our results suggest that a similar structural break in the return-oil reserves might occur following the recent shale oil revolution.

An alternative explanation to the structural shift can be worldwide events taking place at the same time. In 2007–2009, world financial markets were adversely affected by the credit crisis originating in the banking sector. Both crude oil and natural gas prices plummeted. However, the crude oil prices soon rebounded, but natural gas prices did not. This suggests that the prolonged fall in natural gas prices were not necessarily caused by the "credit crunch," but rather have a more fundamental cause – the increased supply of natural gas originating from the shale gas revolution.

Finally, we find that several common risk factors are important variables for explaining the variation in oil and gas shareholder returns. Prior studies typically only include the market risk premium. We demonstrate that also other variables such as the small-minus-big, high book-equity ratio minus low book-equity ratio and momentum can help explain oil company stock returns. In this study, we have applied the risk factors as common factors but it is also possible to include them as individual factors, e.g. a Fama–MacBeth approach.

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Notes

1. Royal Dutch Shell plc announced that they downgraded their reserves from proved to probable.
2. There is also a strand of research in the literature that investigate the impact on oil company valuation multiples from fundamentals such as profitability and operational information on reserves and production (see e.g. Asche & Misund, 2016; Misund, 2016, 2017; Osmundsen, Asche, Misund, & Mohn, 2006; Osmundsen, Mohn, Misund, & Asche, 2007; Quirin, Berry, & O'Bryan, 2000).
3. It is worth noting that Kretzschmar and Kirchner (2009) and Misund, Mohn, and Sikveland (2017) examine additional risk factors such as geographical location of oil and gas reserves, as well as exploration risks.

4. The momentum effect was originally identified by Jegadeesh and Titman (1993).

References

Adelman, M. A., & Watkins, G. C. (2008). Reserve prices and mineral resource theory. *The Energy Journal, 29*, 1–16.

Ahmadi, M., Manera, M., & Sadeghzadeh, M. (2016). Global oil market and the U.S. stock returns. *Energy, 114*, 1277–1287. Retrieved from https://www.sciencedirect.com/science/article/pii/S036054421631191

Aleisa, E., Dibooglu, S., & Hammoudeh, D. (2003). Relationships among U.S. oil prices and oil industry equity indices. *International Review of Economics & Finance, 15*, 1–29.

Al-Mudhaf, A., & Goodwin, T. H. (1993). Oil shocks and oil stocks: Evidence from the 1970s. *Applied Economics, 25*, 181–190. https://doi.org/10.1080/00036849300000023

Apergis, N., & Miller, S. M. (2009). Do structural oil-market shocks affect stock prices? *Energy Economics, 31*(4), 569–575. https://doi.org/10.1016/j.eneco.2009.03.001

Arellano, M. (1987). Computing robust standard errors for within-groups estimators. *Oxford Bulletin of Economics and Statistics, 49*(4), 431–434.

Asche, F., & Misund, B. (2016). Who's a major? A novel approach to peer group selection: Empirical evidence from oil and gas companies. *Cogent Economics & Finance, 4*, 1264538. doi:10.1080/23322039.2016.1264538

Berry, K. T., Hasan, T., & O'Bryan, D. (1998). Relative information content of proven reserves: The BOEs-revenue versus BOEs-energy. *Journal of Energy Finance and Development, 3*(1), 1–11. https://doi.org/10.1016/S1085-7443(99)80064-7

Bindemann, K. (1999). *Production-sharing agreements: An economic analysis. WPM 25*. Oxford: Oxford Institute for Energy Studies.

Boone, J. (2002). Revisiting the reportedly weak value relevance of oil and gas asset present values: The roles of measurement error, model misspecification, and time-period idiosyncrasy. *The Accounting Review, 77*(1), 73–106. https://doi.org/10.2308/accr.2002.77.1.73

Boyer, M. M., & Filion, D. (2007). Common and fundamental factors in stock returns of Canadian oil and gas companies. *Energy Economics, 29*, 428–453. https://doi.org/10.1016/j.eneco.2005.12.003

Breusch, T. S. (1978). Testing for autocorrelation in dynamic linear models. *Australian Economic Papers, 17*, 334–355. https://doi.org/10.1111/j.1467-8454.1978.tb00635.x

Breusch, T. S., & Pagan, A. R. (1979). A simple test for heteroskedasticity and random coefficient variation. *Econometrica, 47*(5), 1287–1294. https://doi.org/10.2307/1911963

Carhart, M. M. (1997). On persistence in mutual fund performance. *The Journal of Finance, 52*(1), 57–82. https://doi.org/10.1111/j.1540-6261.1997.tb03808.x

Chang, K.-L., & Yu, S.-T. (2013). Does crude oil price play an important role in explaining stock return behavior? *Energy Economics, 39*, 159–168. https://doi.org/10.1016/j.eneco.2013.05.008

Ciner, C. (2001). Energy shocks and financial markets: Nonlinear linkages. *Studies in Nonlinear Dynamics and Econometrics, 5*, 203–212. https://doi.org/10.1162/10811820160080095

Clinch, G., & Magliolo, J. (1992). Market perceptions of reserve disclosures under SFAS No. 69. *The Accounting Review, 67*(4), 843–861.

Cormier, D., & Magnan, M. (2002). Performance reporting by oil and gas firms: Contractual and value implications. *Journal of International Accounting, Auditing and Taxation, 11*(2), 131–153. https://doi.org/10.1016/S1061-9518(02)00071-X

Cortese, C. L., Irvine, H. J., & Kaidonis, M. A. (2009). Extractive industries accounting and economic consequences: Past, present and future. *Accounting Forum, 33*, 27–37. https://doi.org/10.1016/j.accfor.2008.07.005

Cunado, J., & Perez de Gracia, F. P. (2014). Oil price shocks and stock market returns: Evidence for some European countries. *Energy Economics, 42*, 365–377. https://doi.org/10.1016/j.eneco.2013.10.017

Dechow, P. M. (1994). Accounting earnings and cash flows as measures of firm performance. *Journal of Accounting and Economics, 18*, 3–42. https://doi.org/10.1016/0165-4101(94)90016-7

DeFond, M. L., & Hung, M. (2003). An empirical analysis of analysts' cash flow forecasts. *Journal of Accounting and Economics, 35*, 73–100. https://doi.org/10.1016/S0165-4101(02)00098-8

Driesprong, G., Jacobsen, B., & Maat, B. (2008). Striking oil: Another puzzle? *Journal of Financial Economics, 89*(2), 307–327. https://doi.org/10.1016/j.jfineco.2007.07.008

Elyasiani, E., Mansur, I., & Odusami, B. (2011). Oil price shocks and industry stock returns. *Energy Economics, 33*(5), 966–974. https://doi.org/10.1016/j.eneco.2011.03.013

Faff, R. W., & Brailsford, T. J. (1999). Oil price risk and the Australian stock market. *Journal of Energy Finance and Development, 4*, 69–87. https://doi.org/10.1016/S1085-7443(99)00005-8

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics, 33*(1), 3–56. https://doi.org/10.1016/0304-405X(93)90023-5

Fama, E. F., & French, K. R. (1996). Multifactor explanations of asset pricing anomalies. *The Journal of Finance, 51*(1), 55–84. https://doi.org/10.1111/j.1540-6261.1996.tb05202.x

Fields, T. D., Lys, T. Z., & Vincent, L. (2001). Empirical research on accounting choice. *Journal of Accounting and Economics, 31*, 255–307. https://doi.org/10.1016/S0165-4101(01)00028-3

Financial Accounting Standards Board. (1977). *Statement of financial accounting standards No. 19: Financial accounting and reporting by oil and gas producing activities*. Stamford, CT: Author.

Financial Accounting Standards Board. (1982). *Statement of financial accounting standards No. 69: Disclosures about oil and gas producing activities*. Stamford, CT: Author.

Financial Accounting Standards Board. (2009). *Financial accounting codification topic 932: Extractive activities – oil and gas*. Stamford, CT: Author.

Financial Accounting Standards Board. (2010). *Financial accounting series. Accounting standards update. Extractive activities – oil and gas (Topic 932): Oil and gas reserves estimation and disclosures. An amendment of the FAB accounting standards codification*. Stamford, CT: Author.

Godfrey, L. G. (1978). Testing against general autoregressive and moving average error models when the regressors include lagged dependent variables. *Econometrica, 46*(6), 1293–1302. https://doi.org/10.2307/1913829

Gogineni, S. (2010). Oil and the stock market: An industry level analysis. *Financial Review, 45*(4), 995–1010. https://doi.org/10.1111/fire.2010.45.issue-4

Güntner, J. H. (2014). How do international markets respond to oil demand supply shocks? *Macroeconomic Dynamics, 18*(8), 1657–1682. https://doi.org/10.1017/S1365100513000084

Hammoudeh, S., Dibooglu, S., & Aleisa, E. (2004). Relationships among U.S. oil prices and oil industry equity indices. *International Review of Economics and Finance, 13*, 427–453. https://doi.org/10.1016/S1059-0560(03)00011-X

Hammoudeh, S., & Li, H. (2005). Oil sensitivity and systematic risk in oil-sensitive stock indices. *Journal of Economics and Business, 57*(1), 1–21. https://doi.org/10.1016/j.jeconbus.2004.08.002

Harris, T. S., & Ohlson, J. A. (1987). Accounting disclosures and the market's valuation of oil and gas properties. *The Accounting Review, 62*(4), 651–670.

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica, 46*(6), 1251–1271. https://doi.org/10.2307/1913827

Hilliard, J. E., & Danielsen, A. L. (1984). World oil prices and equity returns of major oil and auto companies. *Resources and Energy, 6*(3), 259–276. https://doi.org/10.1016/0165-0572(84)90009-4

Huang, R., Masulis, R., & Stoll, H. (1996). Energy shocks and financial markets. *Journal of Futures Markets, 16*, 1–27. https://doi.org/10.1002/(ISSN)1096-9934

Jegadeesh, N., & Titman, S. (1993). Returns to buying winners and selling losers: Implications for stock market efficiency. *The Journal of Finance, 48*, 65–91. https://doi.org/10.1111/j.1540-6261.1993.tb04702.x

Jensen, M. C. (1986). Agency costs of free cash flow, corporate finance and takeovers. *The American Economic Review, 76*(2), 323–329.

Jensen, M. C. (1988). The takeover controversy: Analysis and evidence. In J. Coffee, L. Lowenstein, & S. Rose-Ackerman (Eds.), *Knights, raiders and targets: The impact of the hostile takeover* (pp. 314–355). Oxford: Oxford University Press.

Jones, C., & Kaul, G. (1996). Oil and gas stock markets. *The Journal of Finance, 51*, 463–491. https://doi.org/10.1111/j.1540-6261.1996.tb02691.x

Jorion, P. (1990). The exchange-rate exposure of U.S. multinationals. *The Journal of Business, 63*(3), 331–345. https://doi.org/10.1086/jb.1990.63.issue-3

Kilian, L., & Park, C. (2009). The impact of oil price shocks and the U.S. stock market. *International Economic Review, 50*(4), 1267–1287. https://doi.org/10.1111/iere.2009.50.issue-4

Kisswani, K. M., & Elian, M. I. (2017). Exploring the nexus between oil prices and sectoral stock prices: Nonlinear evidence from Kuwait stock exchange. *Cogent Economics & Finance*. Retrieved from https://www.cogentoa.com/article/10.1080/23322039.2017.1286061

Kretzschmar, G. L., & Kirchner, A. (2009). Oil price and reserve location – Effects on oil and gas sector returns. *Global Finance Journal, 20*, 260–272. https://doi.org/10.1016/j.gfj.2009.08.001

Kretzschmar, G. L., Misund, B., & Hatherly, D. (2007). Market risks and oilfield ownership – Refining oil and gas disclosures. *Energy Policy, 35*(11), 5909–5917. https://doi.org/10.1016/j.enpol.2007.06.007

Lanza, A., Manera, M., Grasso, M., & Giovannini, M. (2005). Long-run models of oil stock prices. *Environmental Modelling & Software, 20*, 1423–1430. https://doi.org/10.1016/j.envsoft.2004.09.022

Lee, B. J., Yang, C. H., & Huang, B. H. (2012). Oil price movements and stock markets revisited: A case of sector stock price indexes in the G-7 countries. *Energy Economics, 34*, 1284–1300. https://doi.org/10.1016/j.eneco.2012.06.004

McConnell, J., & Muscarella, C. (1985). Corporate capital expenditure decisions and the market value of the firm. *Journal of Financial Economics, 14*(3), 399–422. https://doi.org/10.1016/0304-405X(85)90006-6

McSweeney, E. J., & Worthington, A. C. (2008). A comparative analysis of oil as a risk factor in Australian industry stock returns, 1980–2006. *Studies in Economics and Finance, 25*, 131–145. https://doi.org/10.1108/10867370810879447

Misund, B. (2016). Vertical integration and value-relevance: Empirical evidence from oil and gas producers. *Cogent Economics and Finance, 4*, 1264107. doi:10.1080/23322039.2016.1264107

Misund, B. (2017). Accounting method choice and market valuation in the extractive industries. *Cogent Economics and Finance, 5*, 1408944. doi:10.1080/23322039.2017.1408944

Misund, B., Asche, F., & Osmundsen, P. (2008). Industry upheaval and valuation: Empirical evidence from the international oil and gas industry. *The International Journal of Accounting, 43*(4), 398–424. https://doi.org/10.1016/j.intacc.2008.09.007

Misund, B., Mohn, K., & Sikveland, M. (2017). Exploration risk in oil and gas shareholder returns. *Journal of Energy Markets, 10*(4), 1–22.

Misund, B., & Osmundsen, P. (2015). The value-relevance of accounting figures in the oil and gas industry: Cash flows or accruals. *Petroleum Accounting and Financial Management Journal, 34*(2), 90–110.

Misund, B., & Osmundsen, P. (2017). Probable oil and gas reserves and shareholder returns. The impact of shale gas. *Cogent Economics and Finance, 5*, 1385443. doi:10.1080/23322039.2017.1385443

Misund, B., Osmundsen, P., & Sikveland, M. (2015). International oil company valuation: The effect of accounting method and vertical integration. *Petroleum Accounting and Financial Management Journal, 34*(1), 1–20.

Mollick, A. V., & Assefa, T. A. (2013). U.S. stock returns and oil prices: The tale from daily data and the 2008-2009 financial crisis. *Energy Economics, 36*, 1–18. https://doi.org/10.1016/j.eneco.2012.11.021

Nandha, M., & Faff, R. (2008). Does oil move equity prices? A global view. *Energy Economics, 30*, 986–997. https://doi.org/10.1016/j.eneco.2007.09.003

Nandha, M., & Hammoudeh, S. (2007). Systematic risk, and oil price and exchange rate sensitivities in Asia-Pacific stock markets. *Research in International Business and Finance, 21*(2), 326–341. https://doi.org/10.1016/j.ribaf.2006.09.001

Narayan, P. K., & Sharma, S. S. (2011). New evidence on oil price and firm returns. *Journal of Banking & Finance, 35*(12), 3253–3262. https://doi.org/10.1016/j.jbankfin.2011.05.010

Ohlson, J. A. (1995). Earnings, book values, and dividends in equity valuation. *Contemporary Accounting Research, 11*(2), 661–687. https://doi.org/10.1111/care.1995.11.issue-2

Osmundsen, P. (2010). Chasing reserves: Incentives and ownership. In E. Bjørndal, M. Bjørndal, P. M. Pardalos, & M. Rönnqvist (Eds.), *Energy, natural resources and environmental economics* (pp. 19–38). Berlin Heidelberg: Springer-Verlag. https://doi.org/10.1007/978-3-642-12067-1

Osmundsen, P., Asche, F., Misund, B., & Mohn, K. (2006). Valuation of international oil companies. *The Energy Journal, 27*(3), 49–64.

Osmundsen, P., Mohn, K., Misund, B., & Asche, F. (2007). Is oil supply choked by financial market pressures? *Energy Policy, 35*(1), 467–474. https://doi.org/10.1016/j.enpol.2005.12.010

Park, J., & Ratti, R. A. (2008). Oil price shocks and stock markets in the U.S. and 13 European countries. *Energy Economics*, 2587–2608. https://doi.org/10.1016/j.eneco.2008.04.003

Picchi, B. (1985, July). *Structure of the U.S. oil industry: Past and future*. New York, NY: Salomon Brothers.

Quirin, J. J., Berry, K. T., & O'Bryan, D. (2000). A fundamental analysis approach to oil and gas firm valuation. *Journal of Business Finance & Accounting, 27*(7&8), 785–820. https://doi.org/10.1111/jbfa.2000.27.issue-7&8

Ramos, S. B., Tamouti, A., Veiga, H., & Wang, C.-W. (2017). Do investors price industry risk? Evidence from the cross-section of the oil industry. *Journal of Energy Markets, 10*(1), 79–108.

Ramos, S. B., & Veiga, H. (2011). Risk factors in oil and gas industry returns: International evidence. *Energy Economics, 33*(3), 525–542. https://doi.org/10.1016/j.eneco.2010.10.005
Sadorsky, P. (1999). Oil price shocks and stock market activity. *Energy Economics, 2*, 449–469. https://doi.org/10.1016/S0140-9883(99)00020-1
Sadorsky, P. (2001). Risk factors in stock returns of Canadian oil and gas companies. *Energy Economics, 23*, 17–28. https://doi.org/10.1016/S0140-9883(00)00072-4
Sadorsky, P. (2008). The oil price exposure of global oil companies. *Applied Financial Economics Letters, 4*, 93–96. https://doi.org/10.1080/17446540701537764
Scholtens, B., & Wagenaar, R. (2011). Revisions of international firms' energy reserves and the reaction of the stock market. *Energy, 36*(5), 3541–3546. https://doi.org/10.1016/j.energy.2011.03.060
Scholtens, B., & Wang, L. (2008). Oil risk in oil stocks. *The Energy Journal, 29*(1), 89–112.
Scholtens, B., & Yurtsever, C. (2012). Oil price shocks and European industries. *Energy Economics, 34*, 1187–1195. https://doi.org/10.1016/j.eneco.2011.10.012
Shaeri, K., Adaoglu, C., & Katircioglu, S. T. (2016). Oil price risk exposure: A comparison of financial and non-financial subsectors. *Energy, 105*, 712–723. Retrieved from https://www.sciencedirect.com/science/article/pii/S0360544216305801
Securities and Exchange Commission. (2008). *Modernization of oil and gas reporting requirements: The final rule*. Washington, DC: SEC.
Society of Petroleum Engineers. (2011, November). *Guidelines for application of the petroleum management system*. Richardson, TX: Author. Retrieved from http://www.spe.org/industry/docs/PRMS_Guidelines_Nov2011.pdf
Spear, N. A. (1994). The stock market reaction to the reserve quantity disclosures of U.S. oil and gas producers. *Contemporary Accounting Research, 11*(1), 381–404. https://doi.org/10.1111/care.1994.11.issue-1
Talbot, E., Artiach, T., & Faff, R. (2013). What drives the commodity price beta of oil industry stocks? *Energy Economics, 37*, 1–15. https://doi.org/10.1016/j.eneco.2013.01.004
Wooldridge, J. M. (2002). *Econometric analysis of cross-section and panel data*. MIT Press.