

Misund, Bård

**Article**

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## FINANCIAL ECONOMICS | RESEARCH ARTICLE

# Vertical integration and value-relevance: Empirical evidence from oil and gas producers

Bård Misund<sup>1\*</sup>

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\*Corresponding author: Bård Misund,  
University of Stavanger Business School,  
N-4036 Stavanger, Norway  
E-mail: [bard.misund@uis.no](mailto:bard.misund@uis.no)

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**Abstract:** Oil and gas exploration companies (E&Ps) exhibit large variations in earnings due to volatile oil and gas prices. Furthermore, their primary asset, oil and gas reserves, is accumulated through highly risky exploration activities. In contrast, integrated oil and gas companies display lower variability in their earnings due a more diversified asset base. The literature suggests that companies with higher earnings volatility and higher levels of intangibles among their assets should have lower value relevance of accounting information than companies with higher levels of tangible assets on their balance sheets. For that reason, E&P companies should have lower value relevance than integrated companies. Contrary to expectations, we do not find lower value relevance for E&Ps earnings than integrated oil and gas companies. In fact, the results suggest that the presence of supplementary estimates for oil and gas reserves values mitigate the potential problem associated with the presence of intangible assets experienced in other industries.

**Subjects:** Corporate Finance; Banking; Financial Accounting; Financial Statement Analysis; Gas Industries

**Keywords:** company valuation; value-relevance; oil and gas industry; vertical integration; valuation; oil majors; oil integrateds; exploration & production; E&P

**JEL codes:** M21; M40; G12; Q49



Bård Misund

### ABOUT THE AUTHOR

Bård Misund is associate professor of Accounting and Finance at the University of Stavanger Business School. He has 10 years of industry experience from commodities companies. Before starting as a professor at the University of Stavanger, he worked as an economic analyst, and later as an advisor to the Norwegian oil and gas company Statoil ASA. His research covers several fields including accounting, finance and economics, mostly covering topics related to commodity markets. Research questions include commodity price behaviour, the spot-forward relationship in futures markets, determinants of commodity firm stock returns, financial statement analysis and valuation of oil and gas firms.

### PUBLIC INTEREST STATEMENT

The oil and gas sector is a large and important industry. The sector comprises a wide variety of companies, from companies specialized in upstream oil and gas exploration and production activities (E&Ps), to companies that are engaged in both upstream and downstream (processing, transportation and marketing) activities, to firms providing a wide range of services (oil service companies). This study examines the importance to investors of financial statement information supplied by oil and gas companies. We specifically address the topic if the relevance for investors of accounting information is affected by degree of vertical integration. Certain characteristics such as volatile earnings, choice of accounting method, type of assets inaccurate accounting methods vary between E&Ps and Integrateds. We ask if these traits lead to structural changes in the importance to investors of earnings information. Consistent with our expectations, we find that the relevance of earnings vary with changing vertical integration.

## 1. Introduction

The objective of this paper is to investigate how degree of vertical integration can lead to structural changes in the relationship between accounting figures and market valuation. Using the oil and gas industry as a case study, the current paper examines how to determine the breaking points in the market value—accounting information relationship, as a function of extent of vertical integration.

The literature suggests that industry specific features can affect the information content of firms' reported earnings (Dechow, 1994; Dichev, Graham, Harvey, & Rajgopal, 2013). Oil and gas exploration companies (E&Ps) exhibit large variations in earnings (i.e. "earnings volatility") due to volatile oil and gas prices. Their primary assets, oil and gas reserves, are accumulated through highly risky exploration activities. By contrast, integrated oil and gas companies display lower variability in their earnings due to a more diversified asset base. A recent study highlights the adverse effects of earnings volatility on "earnings quality" (Dichev et al., 2013). Earnings quality is a term describing the usefulness of reported earnings for investors and other users of accounting information. In addition to earnings volatility, certain characteristics of the oil industry can also result in variations in earnings quality across firms in the sector. For instance, current financial reporting regulation allows oil and gas companies to choose between two competing methods for capitalizing and expensing exploration costs. This choice will affect both income statement and balance sheet figures, potentially undermining their usefulness. Several studies find that the existence of two competing accounting methods affects the value-relevance of oil companies' earnings (Bryant, 2003; Misund, Asche, & Osmundsen, 2008; Misund, Osmundsen, & Sikveland, 2015).

Furthermore, the composition of assets on the balance sheet can also influence earnings quality. Srivastava (2014) argues that assets associated with a large degree of uncertainty, such as intangible assets, can lead to higher earnings volatility, due to either unrecognized growth options, or variations in earnings and cash flows stemming from uncertainty in the assets' future benefits. Examples of assets fitting this description can be found in the oil sector. Despite their obvious importance, petroleum reserves are associated with substantial uncertainty, prohibiting the assets from being included on the balance sheet (Wright & Gallun, 2007). Since the integrated oil and gas companies own more tangible assets than do E&Ps, increased vertical integration should mitigate the adverse effects on earnings quality of asset benefit uncertainty.

The current study empirically examines the impact on earnings quality of vertical integration across the oil&gas industry. We use the Ohlson (1995) value-relevance framework to investigate how earnings quality influences the association between accounting information and market valuation. In particular, we search for specific break points in the earnings-market value relationship as a function of extent of vertical integration. The existence of break points will suggest that the earnings-valuation relation has significantly changed.

Using a sample of accounting data for oil and gas companies from 1992 to 2013, we identify two structural breaks in the relationship between accounting information and total shareholder returns. The first occurs when our measure of extent of vertical integration is around 20%, and the latter break point is found for vertical integration ratios at approximately 65%. This implies that the sample of oil and gas companies can be regarded as three distinct company groups, the integrateds (a ratio of less than 20%), the semi-integrated (a ratio between 20 and 60%) and the concentrated E&Ps (a ratio of around 65%).

The current study contributes to the literature in several ways. First, we demonstrate that the value relevance of accounting figures varies within an industry, influenced by the degree of vertical integration. Second, we develop an empirical methodology that can identify groups of companies based on similar market value-accounting data relations. Third, the current study improves on earlier studies investigating the value relevance of accounting information by including additional non-accounting variables, such as oil and gas reserve net present values and oil and gas prices, and

Fama-French-Carhart risk factors. Of these added variables, we find significant association between returns and both oil and gas reserve net present values and commodity prices.

The remainder of the paper is organized as follows. Section 2 provides an overview of the literature, followed by descriptions of the research design, econometric specification and hypothesis development in Section 3. Section 4 present the data sources and descriptive statistics, before presenting and discussing the results in Section 5. Section 6 concludes the findings.

## 2. Background and literature review

The term “Earnings quality” describes the ability of accounting earnings to reflect the underlying financial performance of a company (Dechow & Schrand, 2004). The concept of earnings quality stems from a key principle in accounting theory stating that earnings should be useful for predicting future cash flows (Lev, 1989). Consequently, one should expect a close relationship between accounting information and market valuation. The objective of empirical value-relevance studies is to investigate the nature of the market value-accounting information relationship. Several factors influence the latter relation, including industry belonging, earnings volatility, accounting method choice and asset benefit uncertainty.

The literature suggests that industry specific features can affect earnings quality. For instance, Dechow (1994) finds that factors such as volatility, working capital requirements, investment and financing activities, length of the performance interval, and the length of the company’s operating cycle, can affect earnings quality. These traits are common across many firms in the same industry. Furthermore, a recent survey finds that 50% of earnings quality is driven by non-discretionary factors such as industry and macroeconomic conditions (Dichev et al., 2013).

Moreover, high earnings volatility can adversely influence earnings quality. Survey studies suggest that it is widely believed among managers that earnings volatility negatively affects earnings quality (Graham, Harvey, & Rajgopal, 2005). According to Dichev and Tang (2009), earnings volatility arises from two factors: volatility due to economic shocks, and volatility originating from the inaccurate determination of accounting income. Both these factors are relevant for the oil and gas sector. First, as a natural consequence of highly fluctuating commodity prices, oil companies’ earnings are very volatile. Since pure exploration and development companies are more exposed to fluctuating oil and gas prices than integrated companies (see e.g. Boyer & Filion, 2007; Sadorsky, 2001), the formers’ earnings should be more volatile than the Integrated’s profits. Secondly, oil and gas companies are allowed to choose between two different approaches for accounting for exploration activities, the full cost and the successful efforts methods. These two methods result in different earnings and book values of equity (see e.g. Bryant, 2003), making it challenging to unveil the firms’ financial performance for analysts and investors. In conclusion, we expect the value relevance of accounting figures to be lower for E&P companies than for integrated companies.

A recent study discusses the role of intangible assets as a factor that might cloud the earnings-valuation relationship. According to Srivastava (2014), a high intangible intensity can reduce earnings quality for several reasons. First, an intangible-intensive firm exhibits high revenue and cash flow volatilities due to higher uncertainty around future benefits from intangible assets than do tangible assets (Kothari, Laguerre, & Leone, 2002). Secondly, the intangible-intensive firms are more likely to have growth options. Typically, balance sheets and income statements do not fully recognize these option values (Roychowdhury & Watts, 2007; Skinner, 2008; Smith & Watts, 1992; Watts, 2003). A parallel can be found in the oil and gas sector. Arguably, petroleum reserves show similar traits to “intangible” assets in many ways. Balance sheets do not include oil and gas reserves, as neither fair values, nor market values. Reserves values on the firms’ balance sheets are recorded only as capitalized expenses from exploration activities, and not necessarily related to the future cash flows they will generate. Oil and gas companies only disclose their proved reserves amounts and the net present value of reserves in a separate supplementary disclosure. In addition, reliable estimation of reserves quantities is very difficult. Consequently, there is substantial uncertainty

related to the future cash flows arising from the reserves. Secondly, the future cash flows that the reserves generate are also dependent on future oil and gas prices, which are highly uncertain. Moreover, the oil firm's are subject to fiscal terms that might change as a function of changing commodity prices (Kretzschmar, Misund, & Hatherly, 2007). Third, there are substantial growth options related to oil and gas exploration activities (Guedes & Santos, 2016; Sabet & Heaney, 2016). For instance, the successful exploration of one well in a specific acreage will tend to increase the likelihood of finding additional reserves in nearby areas.

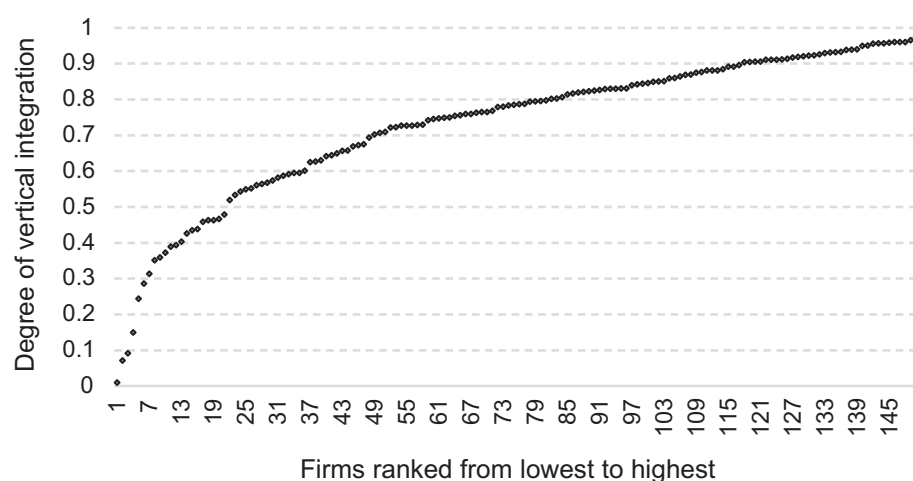
In summary, it seems that oil companies, especially those with activities concentrated to upstream oil and gas exploration, may have similarities with intangible-intensive companies that Srivastava (2014) refers to. In contrast, the other main type of oil and gas companies, the Integrated, are invested in downstream assets such processing, chemicals, petroleum products in addition to their upstream assets. Downstream assets will contain a higher proportion of tangible assets, and the revenues for integrated companies are less likely to suffer from the negative impact of earnings volatility. In effect, the implication is that integrated companies' earnings should be of a better quality since the latter companies should exhibit lower earnings volatility and lower "intangible-asset" effect. The expectation is therefore that the value relevance of accounting information should change as a function of the extent of vertical integration.

Recent studies suggest that vertical integration does influence the value relevance of oil&gas firm accounting figures. Misund and Osmundsen (2015) find that the value relevance of financial metrics differs between E&P and integrated oil and gas companies. Misund et al. (2015) who find that vertical integration affects the value relevance of accounting earnings, also corroborates this result.

A limitation of the study by Misund et al. (2015), is that the latter study uses a dichotomous variable to separate between integrated and E&P companies. As demonstrated by Figure 1, the distribution of degree of vertical integration in the oil&gas industry is much more diverse than a dichotomous variable would imply. Hence, using a single dummy variable might not fully capture the impact of degree of vertical integration on the value relevance of accounting figures in the oil&gas industry. We propose a more dynamic measure of vertical integration in the current study, the ratio of upstream assets to total assets. As Figure 1 shows, there is no clear cut divide, but rather a gliding scale of degree of vertical integration. An interesting research question, therefore, is how to determine the exact breaking points. The approach used in our paper is to examine structural changes in the relationship between earnings and market valuation as a way to separate between companies of different degrees of vertical integration. We postulate that similar types of companies should have similar earnings-valuation relationships. Structural breaks should be observed when there are fundamental changes in the value-earnings relation arising from varying extent of vertical integration. The methodology we apply to determine the structural break points is described in more detail in the next section.

**Figure 1. Degree of vertical integration across oil and gas firms.**

Notes: The degree of vertical integration is measured by calculating the ratio of oil and gas assets to total assets during the fiscal year of 2013. This metric ranges from 0 (no oil & gas assets) to 1 (all assets are classified as oil & gas assets). The firms are ranked from lowest to highest degree of vertical integration.



### 3. Research design

#### 3.1. The value-relevance of accounting information

Ball and Brown's (1968) and Beaver's (1968) seminal works on the relationship between accounting figures and valuation has prompted numerous studies. Nonetheless, until Feltham and Ohlson's revitalization of the Residual Income Valuation model the research framework lacked a formal theoretical model linking accounting figures to valuation (see e.g. Feltham & Ohlson, 1995, 1996; Ohlson, 1995, 1999). The Ohlson model provides a solid theoretical foundation, stimulating a considerable amount of capital markets research (see e.g. Kothari, 2001; Beisland, 2009 for literature reviews).

Based on the dividend discount model, Ohlson (1995) develops a model describing how market value relates to financial statement information, such as earnings. Ohlson (1995) models total shareholder returns as a function of shocks to earnings and to "other information:"

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

where  $r_t$  is the total shareholder return, i.e. the sum of stock price return and dividend yield, and  $p_{t-1}$  is the stock price at time  $t-1$ . The variables  $\vartheta_t$  and  $\eta_t$  are mean zero disturbance terms and represent shocks to earnings and other information, respectively. The discount rate is denoted by  $k$ , and  $\alpha_1$  and  $\alpha_2$  are constants.

The next step is to develop an empirical model based on Equation (1) and it is apparent that three elements are necessary; cost of capital, shocks to earnings and shocks to "other information". To model shocks in earnings, we follow typical representations in the accounting literature and include earnings per share,  $E$  and change in earnings per share  $\Delta E$ , divided by the beginning of period price per share. According to Ohlson (1995), "other information" represents value-relevant events that have yet to have an impact on the financial statements. We follow Bryant (2003) and include changes in the standardized measure for net present value of discounted cash flow measure of oil and gas reserves ( $\Delta DCF$ ) as our proxy of "other information".

The literature suggests two approaches to including cost of capital in value-relevance studies. The first is to risk adjust the returns (see e.g. Boone & Raman, 2007). The benefit of this approach is that the security returns are individually risk-adjusted, taking into account security-specific risk exposure. The second approach is to include risk variables as explanatory variables (see e.g. Boyer & Filion, 2007; Jorion, 1990; Sadorsky, 2001). The benefit of the latter approach is that it provides additional information for the reader. For instance, the magnitude of the loadings on the risk factors can provide insight oil firms' exposures to various sources of systematic risk. Moreover, the parameter on the market risk premium measures the average exposure to market excess returns. The coefficients on oil price changes will likewise provide insight into the average exposure to oil price changes. As we include six different risk variables in our empirical model, we find it appropriate to include them as separate explanatory variables. The downside of this approach is that it does not allow for estimating the individual firms' costs of capital. Rather, our approach leads to an average industry cost of capital.

We apply two sets of risk factors. The first are the Fama-French-Carhart factors (Carhart, 1997; Fama & French, 1996). We include risk factors calculated from the returns on hedge portfolios consisting of small minus big companies (SMB), companies with high book-to-market ratios minus the returns on companies with low book-to-market ratios (HML) and the returns on companies with positive momentum less negative momentum (MOM). The second set of risk variables are changes in both oil and gas prices since previous studies have demonstrated that the commodity prices are associated with oil and gas company returns and valuation (Boyer & Filion, 2007; Misund et al., 2008; Osmundsen, Asche, Misund, & Mohn, 2006; Osmundsen, Mohn, Misund, & Asche, 2007; Sadorsky, 2001).

Although we include accounting figures, “other information” and risk factors affecting returns, we need to also consider the relevance of other unobserved variables. We follow Boone (2002) and Misund and Osmundsen (2015) and apply panel data models. Panel data models can be applied as fixed effects, random effects, or as pooled sample OLS. We run a series of tests to ascertain if a fixed-effects model is better than the alternatives of pooled ordinary least squares or random effects. To test whether a fixed-firm effects model is better than a pooled OLS, we apply *F*-tests. Likewise, we test whether random effects model is better than a pooled ordinary least squares model using the Breusch-Pagan Lagrange multiplier test (Breusch & Pagan, 1979). Finally, we compare a random effects to a fixed effects model using the Hausman test (Hausman, 1978).

The empirical specification of the theoretical model in Equation (1) then becomes

$$ret_{it} = \beta_0 + \beta_1 \frac{E_{it}}{MVE_{it-1}} + \beta_2 \frac{\Delta E_{it}}{MVE_{it-1}} + \beta_3 \frac{\Delta DCF_{it}}{MVE_{it-1}} + \beta_4 MRP_t + \beta_5 SMB_t + \beta_6 HML_t + \beta_7 MOM_t + \beta_8 \Delta OP_t + \beta_9 \Delta GP_t + \gamma FE_i + \theta FE_t + \varepsilon_{it}^3 \quad (2)$$

where  $ret_{it}$  are annual contemporaneous returns calculated as the sum of capital gains and the dividend yield less the risk free rate, and  $\varepsilon_{it}^3$  is the error term. The firm fixed effects and time fixed effects are denoted by the vectors  $FE_i$  and  $FE_t$ , respectively. We use contemporaneous returns, i.e. calculated as the total shareholder return less the risk free rate from the beginning of the year to the year-end. The alternative is to calculate the annual returns for a period starting three to six months after the start of the year. Both approaches are used in the literature. For instance, Bryant (2003) uses contemporaneous returns, while Boone and Raman (2007) uses lagged returns. The rationale for using the latter approach is that the annual financial statements (including the supplementary oil and gas disclosures) are released up to three months after year-end. However, a substantial amount of the information has already been released prior to year-end. For instance, the companies in our sample release quarterly information on earnings. A significant proportion of information relating to the change in the net present value of reserves is also available before the annual financial reporting date. For instance, production, which is an important component in the change in oil and gas reserves amounts, are typically released on a quarterly basis. Furthermore, significant discoveries, downgrades, purchases and sales of reserves are typically disclosed to the financial market in a timely manner, prompting immediate stock market responses. Hence, a substantial amount of relevant information about reserves changes is available to the investor community in advance of formal disclosures in financial reports. We therefore use contemporaneous returns in our study.

### 3.2. Testing for structural breaks

To examine how vertical integration affects the relationship between accounting information and valuation, we use a measure of vertical integration, *V*. This measure is calculated as the ratio of capitalized costs from exploration, development and acquisition costs related to upstream activities divided by total assets. By design, this ratio must lie between 0 and 1. We want to find the value of the ratio that is able to separate between the two types of companies. In order to do this, we apply a structural break methodology. Following Gujarati (1970a, 1970b) and Misund et al. (2008), we use the dummy variable approach to test for structural breaks.

To capture the difference between upstream and integrated companies, we include a dummy variable *INT*, in the model. *INT* is included separately, and as interaction terms multiplied with the other explanatory variables. *INT* is set to 1 if *V* is above a certain value, and 0 if otherwise. In order to find these break point values of *V*, representing a structural change in the value-relevance of the accounting figures, we carry out an iterative process. We run the regression over several possible values for *V*, from 0.05 to 0.95, in increments of 0.05, i.e.  $V = \{0.05, 0.10, \dots, 0.90, 0.95\}$ . The regression model including the *INT* dummies is:

$$\begin{aligned} \text{ret}_{it} = & (\beta_0 - \beta_0^*) + (\beta_1 - \beta_1^*) \frac{E_{it}}{MVE_{it-1}} + (\beta_2 - \beta_2^*) \frac{\Delta E_{it}}{MVE_{it-1}} + (\beta_3 - \beta_3^*) \frac{\Delta DCF_{it}}{MVE_{it-1}} + \beta_4 MRP_t \\ & + \beta_5 SMB_t + \beta_6 HML_t + \beta_7 MOM_t + \beta_8 \Delta OP_t + \beta_9 \Delta GP_t + \gamma FE_i + \theta FE_t + \varepsilon_{it}^4 \end{aligned} \quad (3)$$

where  $\beta_j$  is the set of reference parameters for the full sample, both E&P and integrated companies, and  $\beta_j^* = \beta_j \times INT$  ( $\forall j = 0, \dots, 3$ ) represents the shift parameters for the integrated companies. The testing of structural breaks in the model is achieved by testing for joint significance of the shift parameters using an  $\chi^2$ -test. If the null hypothesis is rejected, this result can be interpreted as evidence for a structural break in the econometric model of the relationship between accounting information and valuation. By examining the significance of each of the shift parameters we are able to make inferences about their impact on the valuation process.

#### 4. Sample selection and description of data

Accounting data and the amounts of proven oil and gas reserves were collected from the IHS Herold database for the years 1992–2013. The IHS Herold database ([www.ihs.com/herold](http://www.ihs.com/herold)) consists of financial and operating data from annual financial statements of publicly traded energy companies worldwide. As a measure of market value, we use market capitalization at year-end. Market value of equity, accounting figures and book equity are all scaled by the previous year's year-end market value of equity. As a measure of *other information*, we use the net present value of oil and gas reserves. The data-set includes a total of 3,268 firm-years.

Although the raw sample from IHS Herold includes a wide range of international companies, we only include firms that are listed on U.S. stock exchanges and disclose their financial statements under the Securities and Exchange Commission (SEC) regulation. All accounting data used in this study is therefore in accordance with U.S. Generally Accepted Accounting Practises (U.S. GAAP).

Oil and gas prices are collected from the U.S. Department of Energy. We collect the year end prices for the front month futures contracts, and calculate the  $\Delta OP$  and  $\Delta GP$  variables as annual returns on the futures contracts for oil and gas, respectively.

Since all the firms are listed on U.S. stock exchanges, we use the *SMB*, *HML* and *MOM* risk factors calculated from U.S. equities, and collected from Ken French' website.

The sample descriptive statistics for the variables in the models are reported in Table 1. The average annual shareholder return in excess of the risk free rate is 32.8%, with a substantial standard deviation of 92.6%. The percentiles indicate that there is a positive skewness in the returns. The three accounting variables are also characterized by large standard deviations. In order to mitigate non-linearity created by extreme ratios, we have capped the observations by excluding the highest and lowest  $\pm 0.5\%$  of the values.

In Table 2, we present the average values for the observations as a function of  $V$ , the ratio of oil and gas net accumulated costs to the total assets. The average return seems to increase as a function of  $V$ , indicating that the average return increases with upstream exposure. Conversely, the lowest average returns are observed for integrated companies. Interestingly, average earnings and changes in earnings decreases with  $V$ . A low earnings to market value of equity ratio is the same as a high price-to-earnings (P/E) multiple. Hence, the Integrations have lower P/E's than exploration companies. The ratio of changes in net present value of reserves to market value of equity seems to increase with  $V$ , although the association does not appear to be linear. However, companies with a vertical integration ratio higher than 80%, have substantially higher average changes in *DCF* than for companies with a lower ratio, indicating that the net present values of reserves for these companies are substantial.



**Table 1. Descriptive statistics**

	Average	SD	25% percentile	Median	75% percentile
Returns	0.328	0.926	-0.144	0.128	0.521
<i>E/MVE</i>	0.017	0.298	-0.003	0.054	0.098
$\Delta E/MVE$	0.009	1.229	-0.036	0.008	0.050
$\Delta DCF/MVE$	0.534	28.920	-0.122	0.070	0.330
<i>MRP</i>	0.084	0.191	0.008	0.107	0.202
<i>SMB</i>	0.030	0.116	-0.037	0.002	0.048
<i>HML</i>	0.025	0.156	-0.080	0.037	0.132
<i>MOM</i>	0.054	0.239	0.0324	0.086	0.178
$\Delta OP$	0.153	0.395	-0.071	0.082	0.353
$\Delta GP$	0.191	0.766	-0.209	0.053	0.262

Notes: Returns are annual total shareholder returns, including both capital gains and dividend yields ( $N = 3,268$ ). *E* and  $\Delta E$  are earnings and change in earnings, respectively ( $N = 3,268$ ).  $\Delta DCF$  is change in the net present value of proved oil and gas reserves as disclosed by the oil and gas firms ( $N = 3,268$ ). *MVE* is the market value of equity at year-end ( $N = 3,268$ ). *MRP*, *SMB*, *HML*, *MOM* are the Fama-French-Carhart risk factors for U.S. equities ( $N = 21$ ).  $\Delta OP$  and  $\Delta GP$  are annual changes in the front month futures contract prices for U.S. crude oil and natural gas, respectively ( $N = 21$ ).

**Table 2. Descriptive statistics for different values for *V***

<i>V</i>	Returns	<i>E/MVE</i>	$\Delta E/MVE$	$\Delta DCF/MVE$	<i>N</i>
0.10	0.277	0.071	0.041	0.043	143
0.20	0.249	0.050	0.028	0.046	120
0.30	0.246	0.064	0.021	0.038	174
0.40	0.231	0.064	0.018	0.057	235
0.50	0.256	0.063	0.016	0.075	264
0.60	0.279	0.060	0.023	0.117	310
0.70	0.298	0.054	0.027	-0.022	324
0.80	0.312	0.039	0.036	0.061	541
0.90	0.335	0.027	0.017	0.648	813
1.00	0.328	0.017	0.009	0.535	344

Notes: *E* and  $\Delta E$  are earnings and change in earnings, respectively.  $\Delta DCF$  is change in the net present value of proved oil and gas reserves as disclosed by the oil and gas firms. *MVE* is the market value of equity at year-end. *V* is the ratio of oil and gas capitalized costs to total assets.

We carry out unit root tests on the data sample. Table 3 shows the results from the augmented Dickey-Fuller test (Said & Dickey, 1984). The results show that all variables reject the null hypothesis of a unit root. The variables are therefore stationary, and we can proceed without calculating first differences.

Heteroskedasticity and serial correlation is often found in financial data. Standard tests demonstrate that this is also the case for the data used in our study, and we therefore adjust the regression coefficient standard errors using the Arellano (1987) procedure for panel data models.

**Table 3. Stationarity**

Variable	ADF test statistics
Returns	-33.496***
<i>E/MVE</i>	-29.258***
$\Delta E/MVE$	-33.315***
$\Delta DCF/MVE$	-33.013***
<i>MRP</i>	-35.910***
<i>SMB</i>	-35.100***
<i>HML</i>	-36.416***
<i>MOM</i>	-30.518***
$\Delta OP$	-47.019***
$\Delta GP$	-33.645***

Notes: *E* and  $\Delta E$  are earnings and change in earnings, respectively.  $\Delta DCF$  is change in the net present value of proved oil and gas reserves as disclosed by the oil and gas firms. *MRP*, *SMB*, *HML*, *MOM* are the Fama-French-Carhart risk factors for U.S. equities.  $\Delta OP$  and  $\Delta GP$  are annual changes in the front month futures contract prices for U.S. crude oil and natural gas, respectively. *MVE* is the market value of equity at year-end.

\*\*\* $p < 0.01$ .

### 5. Results and discussion

In this section, we present the results. First, we examine which type of panel data model is appropriate for the empirical model in Equation (2), i.e. without a structural break. We test for the choice between pooled OLS and fixed effects and between a random effects and fixed effects model. Then, we iteratively run the empirical model in Equation (3) using different values for *V* and in each run applying statistical tests to determine the structural break in the model.

The model diagnostics tests in Table 4 suggest that a fixed effects model is preferable to a pooled OLS model, and also preferable to a random effects model. Hence, we proceed with a fixed-firm effects model.

Figure 1 plots Wald  $\chi^2$  test statistics as a function of the degree of vertical integration, *V*. We run the regressions over several levels of vertical integration, ranging from 0.05 to 0.95 in increments of 0.05. Wald  $\chi^2$  values are calculated for each regression and compared against the critical levels (dashed horizontal lines in Figure 2).

Figure 2 suggests that there are two distinct structural breaks in the association between accounting data and returns. The first break occurs for values of *V* equal to, or below, 0.20 (at the 10% significance level). Furthermore, we also identify a break point at a value of *V* of 0.65 and above (at the 10% significance level).

**Table 4. Model diagnostics tests**

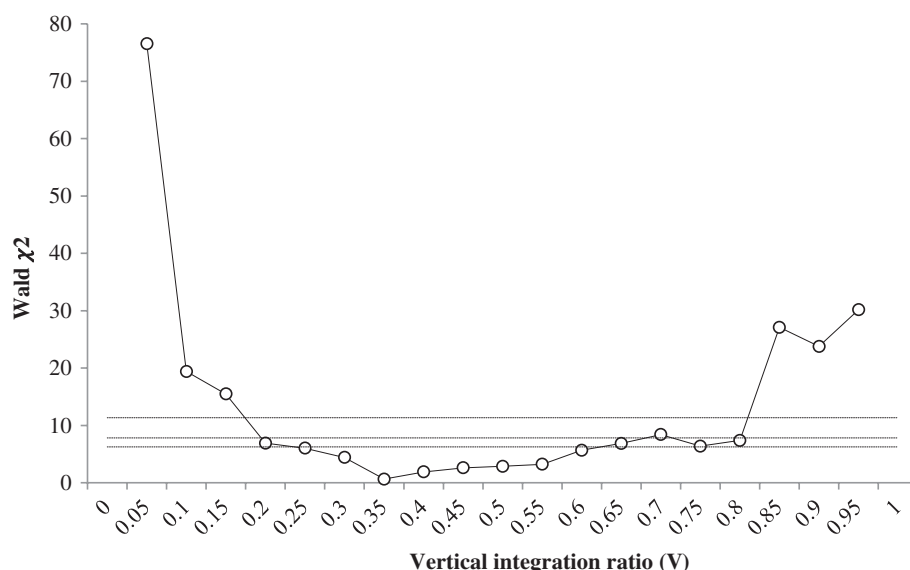
Heteroskedasticity	Serial correlation	Poolability fixed	Hausman
1136.444***	38.014***	1.498***	57.637***

Notes: Heteroskedasticity tested using the Breusch-Pagan test (H0: homoskedasticity), Serial correlation tested using Breusch-Godfrey/Wooldridge (H0: no serial correlation), poolability using *F*-test (H0: pooled OLS better than fixed effects model), Hausman test (H0: random effects model better than fixed effects model). Values are BP-statistic (Breusch-Pagan),  $\chi^2$ -statistic (Breusch-Godfrey / Wooldridge and Hausman tests) and *F*-statistics (Poolability test).

\*\*\* $p < 0.01$ .

**Figure 2. Structural shift in value relevance as a function of vertical integration (Wald  $\chi^2$  test statistic).**

Notes:  $V$  is the ratio of oil and gas assets to total assets. The dashed horizontal lines are critical levels for  $\chi^2$  at 1% (top), 5% (middle) and 10% (lowest).



In order to aid in the interpretation of the specific break points, we include a table that contains information on the type of companies we would find for different levels of  $V$  (Table 5). Analysts covering the oil and gas sector typically divide oil and companies into group of companies, while the approach followed in the current study is to use an objective metric to measure the extent of vertical integration,  $V$ . Table 5 shows the selection of peer groups that the oil sector analytics company IHS Herold uses, combined with information on type of company, market capitalization, average earnings, size of oil and gas reserves, and both the range of highest and lowest  $V$ , and the average ratio.

The integrated companies are also the largest companies (Table 5). The group with the highest average market capitalization is the Global Integrated oil&gas companies, also referred to

**Table 5. Peer groups in the oil and gas sector**

IHS Herold group	Average market value (billion USD 2013)	Asset values (billion USD 2013)	Net income (billion USD 2013)	Reserves (mill barrels of oil equivalent, 2013)	Range of $V$ (min-max) in 2013	Average $V$ in 2013
Global integrated (e.g. Exxon, BP, Total)	234.4	300.4	21.1	15.8	0.44–0.56	0.49
European integrated (e.g. BG, ENI, Statoil)	49.6	83.0	3.1	2.7	0.09–0.59	0.35
Canadian integrated (e.g. Husky, Imperial, Suncor)	35.5	41.8	2.2	2.7	0.60–0.73	0.65
Rest of world integrated (e.g. Petrobras, Lukoil, Petrochina)	58.7	139.9	7.5	17.1	0.07–0.57	0.40
Large North American E&Ps (e.g. Anadarko, Apache, Marathon)	30.9	37.5	1.6	2.4	0.43–0.94	0.74
Mid-sized U.S. E&Ps (e.g. Berry, Cabot, Quicksilver)	75.8	7.4	0.3	0.6	0.55–0.92	0.79
Small U.S. E&Ps (e.g. Bill Barrett, Comstock, EXCO)	22.2	5.0	–0.003	0.1	0.01–0.96	0.83
Smallest U.S. E&Ps (e.g. Magnum Hunter, McMoRan, Panhandle)	0.8	0.6	–0.03	0.03	0.31–0.93	0.74

Note:  $V$  is the ratio of oil and gas capitalized costs to total assets.

as “the majors”. The ratio of oil&gas assets to total assets,  $V$ , ranges between 0.44 and 0.56, with an average just short of 0.5. Hence, approximately 50% of the assets of companies belonging to the Global Integrated group are related to exploration and production activities, and the other half from downstream activities. The Canadian Integrateds seem to be less integrated, with a higher  $V$ , than the oil majors. The rest of the world Integrateds and the European Integrateds, however, display a larger variation in  $V$ , ranging from 0.07 to 0.59 (average  $V$  of 0.35–0.40). The last four categories in Table 5 contains oil and gas companies belonging, from the group of the smallest E&P firms (average market capitalization of approx. 1 billion USD (2013)), to the largest E&P firms (average market capitalization of approx. 31 billion USD in 2013). The  $V$  varies substantially among these companies, from 0.01 to 0.96, with an average of around 0.74–0.83. These companies are clearly more tilted towards upstream E&P activities. In summary, Integrated companies have a lower average  $V$  compared to E&Ps. However, the vertical integration ratio varies substantially, suggesting that the traditional approach of dividing the oil and gas companies into groups of geographical location, integrated vs. E&P companies, and size, might be too crude. In the current paper, we collect the firms in groups according to their level of  $V$ .

Returning to the results in Table 4, a break point of 0.20 suggests a group of firms that would contain companies all across the range of traditional groups, not necessarily just confined to the integrated companies. The break point group would contain companies from the European Integrateds, the Rest of the world Integrateds, as well as companies defined as small U.S. E&Ps.

The next break point was observed for  $V$ 's around 0.65, representing companies with a proportion of upstream assets to total assets of more than 65%. This means that there is a marked shift in the relationship between market values and accounting figures for oil and gas companies with lower and higher than 65% of the ratio of oil and gas assets to total assets. From Table 5, we can deduce that this particular break point coincides with the average  $V$  for the Canadian Integrateds, the highest average  $V$  among the integrated oil and gas firms. This result suggests that the 0.65 break point represents the division between the integrated companies as a group, and the E&Ps as a whole.

In summary, we are able to identify two break points, providing evidence for the existence of three groups of oil and gas companies with similar associations between accounting numbers and market valuation. The first group are a mixed group of large integrateds and some of the small E&Ps. Oil and gas firms belonging to this group of companies has a ratio of oil and gas assets to total assets of below 20%. The second group are the pure E&P companies with more than 65% of their assets consisting of oil and gas assets. The last group are the remaining firms situated between the other two groups. In Table 6 we present the regression results for the final models with  $V = 0.20$  and  $V = 0.65$ . The coefficients for the two regressions are very similar, except for the coefficients on earnings, and the interaction term between  $V$  and earnings and changes in earnings. This result suggests that the value relevance of earnings is higher for E&P companies, as compared to the integrated companies. It seems that the investors have more confidence in the E&P companies' earnings than for the integrated oil and gas firms' earnings. Further research is necessary to understand the nature of this difference.

**Table 6. Regression results at the break-points**

$$ret_{it} = (\beta_0 - \beta_0^*) + (\beta_1 - \beta_1^*) \frac{E_{it}}{MVE_{it-1}} + (\beta_2 - \beta_2^*) \frac{\Delta E_{it}}{MVE_{it-1}} + (\beta_3 - \beta_3^*) \frac{\Delta DCF_{it}}{MVE_{it-1}} + \beta_4 MRP_t + \beta_5 SMB_t + \beta_6 HML_t + \beta_7 MOM_t + \beta_8 \Delta OP_t + \beta_9 \Delta GP_t + \gamma FE_t + \theta FE_t + \epsilon_{it}^4$$

Variable	Coefficients (V = 0.20)	Coefficients (V = 0.65)
V	0.046 (0.666)	0.194 (<0.001)
E	0.045 (0.530)	-0.043 (0.865)
E × V	0.298 (0.553)	0.510 (0.471)
ΔE	0.225 (<0.001)	0.246 (0.046)
ΔE × V	1.106 (<0.001)	-0.043 (0.953)
ΔDCF	0.009 (<0.001)	0.010 (0.042)
ΔDCF × V	-0.344 (0.008)	-0.042 (0.663)
MRP	0.618 (<0.001)	0.639 (<0.001)
SMB	0.466 (0.008)	0.437 (0.028)
HML	1.031 (<0.001)	1.077 (<0.001)
MOM	0.047 (0.645)	0.078 (0.460)
ΔOP	0.421 (<0.001)	0.437 (<0.001)
ΔGP	0.239 (<0.001)	0.227 (<0.001)
Adjusted R <sup>2</sup> (within)	0.150	0.171
F-value	45.423 (<0.001)	45.342 (<0.001)
Wald χ <sup>2</sup>	6.909 (0.075)	14.304 (0.002)

Notes: E and ΔE are earnings and change in earnings, respectively. ΔDCF is change in the net present value of proved oil and gas reserves as disclosed by the oil and gas firms. MRP, SMB, HML, MOM are the Fama-French-Carhart risk factors for U.S. equities. ΔOP and ΔGP are annual changes in the front month futures contract prices for U.S. crude oil and natural gas, respectively. MVE is the market value of equity at year-end. Significance for the coefficients in the regression are represented by p-values in parentheses. The Wald χ<sup>2</sup> critical values are 11.34, 7.81 and 6.25 for significance levels of 1, 5 and 10%, respectively.

## 6. Conclusions

In this study, we examine if the degree of vertical integration in the oil and gas industry causes structural breaks in the association between accounting figures and market returns. We use a sample of North American and international oil and gas companies, during 1992–2013, covering more than 20 years of data. Using the Ohlson model, we test for structural breaks in value relevance of oil and gas companies. We are able to identify two structural breaks. The first break, measured at a ratio 20% of oil and gas assets to total assets, separates the firms with the lowest proportion of upstream assets from the rest of the integrateds and E&Ps. The second break, at a ratio of 65% separates the upstream concentrated E&Ps from the integrateds. The results suggest that this methodology can be used to identify structural breaks in the accounting information-returns relation. In fact, we find that the sample of oil and gas companies can be categorized into three separate samples in terms of the relationship between accounting figures and market valuation. This contrasts the assumption in other empirical studies which often divide the population into only two samples.

However, there are some limitations to our study. Further research is needed to identify which factors that contribute to creating the structural breaks. In this study, we have used the ratio of oil and gas assets to total assets to measure degree of vertical integration. Other measures could have been used instead. A topic for further study is to try to analyse different measures for vertical integration to see if the results still hold. Furthermore, the relationship between accounting figures and market valuation might change over time, and there might be structural breaks in the time dimension as well.

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### Author details

Bård Misund<sup>1</sup>

E-mail: [bard.misund@uis.no](mailto:bard.misund@uis.no)

ORCID ID: <http://orcid.org/0000-0001-7069-5707>

<sup>1</sup> University of Stavanger Business School, N-4036 Stavanger, Norway.

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