Vertical Integration and Value Relevance: Empirical Evidence from Oil and Gas Producers

by

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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 fair value estimates for oil and gas reserves mitigate the potential problem associated with the presence of intangible assets experienced in other industries.

Keywords: Company Valuation, Value-relevance, Oil and Gas Industry, Vertical Integration

JEL codes: M21, M40, G12, Q49.

I. INTRODUCTION

An important function of financial statement information, and in particular earnings, is the usefulness for predicting future cash flows (see e.g. Lev, 1989), something which is crucial for valuation of projects and enterprises. Nonetheless, there are several issues that can affect the relationship between accounting figures and market valuation of companies. One such factor is vertical integration. The objective of this paper is to better understand 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 case study, the paper examines how to determine the breaking points in the market value – accounting information relationship.

There have been relatively few studies examining the impact of industry affiliation on value relevance. Nevertheless, the literature suggests that key accounting subjects such as value relevance and earnings quality should be affected by industry specific features. For instance, Dechow (1994) finds that factors such as volatility, working capital requirements, investment and financing activities, length of performance interval and 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, Graham, Harvey & Rajgopal, 2013).

Degree of earnings volatility has been identified as having an adverse influence on earnings quality. Survey studies suggest that it is widely believed among managers that earnings volatility negatively affects earnings quality (Graham, Harvey & Rajgopal, 2005). Moreover, according to Dichev & Tang (2009), earnings volatility arises from two factors: volatility due to economic shocks and volatility due to problems in the accounting determination of income. Both of 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. Sadorsky, 2001; Boyer & Filion, 2007), the formers' earnings should be more volatile. 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).

Other studies suggest the role of intangible assets as a factor that might cloud the earnings-valuation relationship. A recent study by Srivastava (2014) suggests that the perceived reduction in earnings quality over time can be explained by a higher intangible intensity. According to Srivastava (2014) a high intangible intensity can result can reduce earnings quality for several reasons. The first is that an intangible-intensive firm exhibits a high revenue and cash flow volatility due to higher uncertainty around future benefits from intangible assets than tangible assets

(Kothari, Laguerre & Leone, 2002). Secondly, the intangible-intensive firms are more likely to have growth options, whose values are typically not fully recognized in the balance sheets and income statements (Smith & Watts, 1992; Watts, 2003; Roychowdhury & Watts, 2007; Skinner 2008). An analogy can be found in the oil and gas sector. Petroleum reserves show similar traits to 'intangible' assets in many ways. First, reserves are not found in the balance sheets neither as fair values nor market values. Only historical costs related to exploration activities are capitalized. However, oil and gas companies have to separately disclose their proved reserves amounts plus the net present value of such reserves. Also, there are uncertainties in the estimation of reserves amounts. Hence, there is uncertainty related to the future cash flows arising from the reserves. Secondly, the value realised is a function of uncertain amounts and cash flows (e.g. high tax rates which is also complex due to contractual agreements, volatility oil and gas revenues, etc.). Third, there are substantial growth options related to oil and gas exploration activities. 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, whose activities are focussed mainly on upstream oil and gas exploration (*E&Ps*), may have similarities with intangible-intensive companies that Srivastava (2014) refers to. In contrast, the other main type of oil and gas companies, the Integrateds, are invested in downstream assets such processing, chemicals, petroleum products in addition to their upstream assets. Downstream assets can be characterised as tangible assets. Furthermore, revenues for integrated companies are less likely to suffer from the negative impact of earnings volatility due to higher diversification of assets. In effect, the implication is that integrated companies should have a higher earnings quality due to both 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.

Which exact criteria that should be used to separate between E&Ps and integrated oil and gas companies? It is plausible that 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.

To test the research question we use the following empirical approach. First, we develop an empirical model for the relationship between accounting figures based on the Ohlson (1995) returns model combined with control variables. These additional variables include changes in net present values of reserves and changes in gas and oil prices. Furthermore, we include the Fama-French-Carhart (Fama & French, 1993, 1996; Carhart, 1997) risk factors to make the returns model consistent with finance theory. Finally, we use a fixed-firm effects model to control for unobserved fixed effects and therefore mitigate omitted variables bias.

To find the break-points we go through the following steps. First we define a measure of the extent of vertical integration as the ratio of book value of oil and gas assets divided by total assets. Pure E&Ps will have a ratio close to one, while integrated companies will have a lower ratio. By applying Chow tests (Chow, 1960; Gujarati, 1970a; 1970b) iteratively for different values for the vertical integration ratio, we will be able to identify the exact break points.

Our sample consists of accounting data oil and gas companies over the time period 1992-2013, in total more than 3000 firm-years. The dataset, collected from the IHS Herold database[1] includes both E&Ps and integrateds, both from North American and from the rest of the world.

We find a targeted industry study appropriate for several reasons. First of all, it provides a more homogenous sample of companies than a cross-industry sample. Secondly, the measurement of the extent of vertical integration can be less difficult with an industry study compared to a cross-industry study. An intra-industry study allows us to use industry-specific information. In fact, we use a rather simple measure for extent of vertical integration for oil and gas companies, related to their main asset – oil and gas reserves. Thirdly, U.S. listed oil and gas companies are

[1] www.ihs.com/herold

required to disclose additional information about oil and gas activities in their annual financial statement Securities and Exchange Commission (SEC) filings. This enables researchers to find industry specific variables that are value relevant, and improves the econometric inference. Furthermore, since any given industry has specialized accounting methods, regulations, and taxation it is difficult to generalize the results (Shevlin, 1996). Finally, industry specific analysis allows consideration of the economic context of reported accounting information (Bernard & Stober, 1989; Lev & Thiagarajan, 1993).

We identify two structural breaks in the relationship between accounting information and total shareholder returns. The first is when the ratio of oil and gas assets to total assets is around 20 percent and the latter is for ratios around 65 percent. This implies that the sample of oil and gas companies can be regarded as three distinct entities, integrateds (ratio less than 20 percent), semi-integrated (ratio between 20 and 60 percent) and concentrated E&Ps (ratio more or equal to 65 percent).

Our contribution to the literature is threefold. First, we develop an empirical methodology that can identify groups of companies based on similar market value-accounting data relations. This approach can be used to identify structural breaks in value relevance studies (or other research topics). Second, we show that the value relevance of accounting figures varies within an industry, and that this result is associated with degree of vertical integration. The vertical integration effect we uncover could be related to differences in operations (as suggested by Dechow (1994)) or related to differences in earnings quality related to differences in assets composition (tangible vs 'intangible') (as suggested by Srivastava, 2014), or an effect of differential exposure to macroeconomic factors, such as oil and gas price volatility. Third, we improve on earlier studies on the value relevance of accounting information by including both industry specific control variables, such as oil and gas reserve net present values and oil and gas prices and exposure to common financial market risk factors. We find that both oil and gas reserve net present values and commodity prices are significant factors. Also, in addition to the market risk premium, we find that the Fama-French small-minus-big (SMB) variable is also a significant risk factor, implying that this variable controls for size since pure E&Ps tend to be smaller than fully integrated oil and gas companies.

The remainder of the paper is organized as follows. The next section provides an overview of the literature. In Section III we describe the research design, econometric specification and hypothesis development. Section IV describes the data and Section V presents and discusses the result. In the last section we conclude our findings.

III. RESEARCH DESIGN

The value-relevance of accounting information

Ball & 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. Ohlson, 1995, 1999; Feltham & Ohlson, 1995, 1996). The Ohlson model provided a solid theoretical foundation linking market values to accounting information, stimulating a considerable amount of capital markets research (see e.g. Kothari, 2001 for a review).

Based on the dividend discount model, Ohlson (1995)[2] develops a model that describes how market value is related to abnormal earnings, book value, and other information:

$$MVE_t = BVE_t + \alpha_1 E_t^a + \alpha_2 v_t \tag{1}$$

where *MVE* is the market value of equity, *BVE* is the book value of equity, E^a is abnormal earnings and v is a vector of other value relevant information. According to Ohlson (1995), *other information* represents 'value-relevant events that have yet to have an impact on the financial statements.' Eq. (1) is the basis for numerous studies on value relevance of accounting information. However, concerns have been raised about empirical specifications based on Eq. (1) commonly applied in the literature on, especially for levels regressions (Holthausen & Watts, 2001; Barth, Beaver & Landsman, 2001, Kothari, 2001). Key issues are scale (see e.g.

[2] Ohlson (1995) contribution is his application of the residual income valuation model. Specifically, Ohlson (1995) models the information dynamics.

Ota, 2003; Easton & Sommers, 2003; Lo, 2004; Akbar & Stark, 2003; Barth & Clinch, 2009) heteroskedasticity, serial correlation and omitted variables bias. An imminent problem with estimation of a model which includes variables in levels form as in Eq. (2), is the problem of scale. Econometric issues related with scale can come in many forms and may cause the error term, ε, to violate assumptions underlying the estimation of Eq. (2) leading to inference problems (Barth & Clinch, 2009). A solution has been to deflate the variables using measures of scales such as book value of equity, previous year's market value of equity, the number of shares outstanding, the number of employees, total assets etc. However, using a deflator might introduce a new type of scale. Due to the numerous problematic econometric issues associated with the levels type of models, a returns specification is often preferred. Ohlson (1995) also derives a returns version of Eq. (1) where total shareholder returns[3] are modelled as a function of shocks to earnings and to 'other information'

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

where $r_t$is the total shareholder return, i.e. the sum of stock price return and dividend yield. The variables $\vartheta_t$and η_t are mean zero disturbance terms and represent shocks to earnings and other information, respectively. The discount rate is denoted by k, and $0 \leq \omega$ and $\gamma < 1$ are constants and $\alpha_1 = \omega/(k - \omega)$ and $\alpha_2 = k/(k-\omega)(k-\gamma)$.

[3] A total shareholder return is the sum of capital gains and dividend yield.

The next step is to develop an empirical model based on Eq. (2) 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 the two variables earnings per share, E and change in earnings per share ΔE, divided by the beginning of period price per share.

Ohlson's (1995) model also includes v which represents 'other information'. This is a variable that captures future profitability. Unfortunately, this variable is often omitted.[4] As omitting key explanatory variables in econometric models can potentially lead to the omitted variables bias we include an additional variable, the fair value of oil and gas reserves, as a proxy for v. Furthermore, we use a fixed firm and year model to control for unobservable omitted variables.

In previous value-relevance studies literature control variables are often included, but with varying significance. A possible explanation is that the control variables proxy for some yet unidentified effects. Consequently, a fixed effects model might be an appropriate methodology that can capture the impact of some of these unknown variables on market values. However, some variables that make economic sense can be included as proxies for v. The benefit of using a sample from a particular industry is that we can include industry-specific variables. We follow Bryant (2003) and include the discounted cash flow measure of oil and gas reserves

[4] See e.g. Ohlson (2001), Liu & Ohlson (1999) and Hand (2001) for a discussion on this topic.

as our proxy. We would like to include both the level, DCF, and change in the discounted cash flow measure, ΔDCF, in the same manner as for the earnings variables. Unfortunately, very high correlations (>0.70) prohibits us from doing so[5] and we therefore only include the one of the two discounted cash flows variables. We chose the change variable since this is arguably a better measure of shocks than the levels variable in the Ohlson returns model.

Next we turn to the cost of capital variable in Eq. (2). This is a variable that is often omitted in the empirical literature. For instance, Boone & Raman (2007) risk adjust the security returns in their oil and gas company value relevance by applying the market model. Other value relevance studies, such as Bryant (2003), do not risk-adjust returns. Omitting risk adjustment of the returns, or in other ways include risk variables in the empirical representation of Eq. (2) such as Boyer & Filion (2007), can potentially lead to the omitted variables bias with inconsistent and biased regression estimators.

The literature suggests two approaches to including cost of capital in the empirical specification. 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. Jorion, 1990; Sadorsky,

[5] High correlation between explanatory variables can lead to multicollinearity. Typically, a rule-of-thumb of 60% correlation is used in the empirical literature.

2001; Boyer & Filion, 2007). The benefit of this approach is that it provides additional information for the reader. For instance, the magnitude of the loadings on the risk variables can provide insight into the exposure to various types of risk. Moreover, the parameter on the market risk premium measures the average exposure to general financial market variation. 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 is that the risk-adjustment is not firm-specific, but rather represent common risk factors.

We apply two sets of risk variables. The first are the Fama-French-Carhart factors (Fama & French, 1993; Carhart, 1997). 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 as these are known to explain the variation in oil and gas company security returns (see e.g. Sadorsky, 2001; Boyer & Filion, 2007). While several earlier oil company value-relevance studies have included oil prices or oil price changes (see Osmundsen, Asche, Misund & Mohn, 2006; Osmundsen, Mohn, Misund & Asche, 2007; Misund, Asche & Osmundsen, 2008), gas prices changes are most often omitted. However, some studies, notably Boone (2002) and Boone & Raman (2007), apply time-fixed effects model with dummies for each year. This latter approach implicitly captures the effects of yearly oil and gas price changes. The benefit of our approach is that we explicitly extract the effects from oil and gas price changes, and other time varying effects from the common Fama-French-Carhart risk factors.

Furthermore, we also apply firm-fixed effects[6] to model the impact of unobserved variables that are fixed over time for individual oil and gas companies. In this way we attempt to mitigate the omitted variables issue, and assume that the fixed effects partly proxy for risk associated with the market values, and in part for other non-accounting information that are important for the valuation of oil and gas firms, but have yet to be identified.

The empirical specification of the theoretical model in Eq. (2) then becomes

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

where ret_{it} are annual contemporaneous returns calculated as the sum of capital gains and the dividend yield less the risk free rate, and ε_{it}^3 is the error term. The firm fixed effects and time fixed effects are denoted by the vectors $\boldsymbol{FE_i}$ and $\boldsymbol{FE_t}$,

[6] Before choosing a fixed-firm effects model 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 (see the next section).

respectively. We find it appropriate to 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 & Raman (2007) use the latter approach. The rationale for using the latter approach is that the release of the annual financial statements (including the supplementary oil and gas disclosures) is up to three months after year-end. The returns are therefore calculated starting after the release of the financial statement. However, it can be argued that 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. Moreover, a significant proportion of information relating to the change in the net present value of reserves is also available. 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. The standardized measure is calculated using prices which are also known to investors at year-end. Hence, it can be argued that 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.

Other econometric modelling issues

Even though we attempt to control for the omitted variables bias, there might other econometric issues. We test for both heteroskedasticity and serial correlation in the error terms. If the tests confirm the presence of heteroskedasticity and serial correlation we apply the Arellano (1987) method for calculating consistent standard errors (HACSE) for fixed effects models.

To test whether a fixed-firm effects model is better than a pooled ordinary least squares 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).

Testing for structural breaks

Our data sample consists of both integrated companies and pure upstream oil and gas producers (the independent exploration and production companies, the E&Ps). While the integrated companies span a large part of the value chain, from upstream (exploration and crude oil production) to downstream (refinery and chemicals), the pure E&Ps are concentrated upstream. To examine how vertical integration impacts 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 lies between 0 and 1. This measure is used to separate between integrated and upstream companies. 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, b), we use the dummy variable approach to test for structural breaks. This approach allows us to run a single regression model, instead of two, which would be the case for the Chow test (Chow, 1960). According to Gujarati, the dummy variable method is preferable for several reasons, including a) substantially abridging the analyses, b) a single regression model makes it easier to test a variety of hypotheses, c) the Chow test does not explicitly indicate which coefficient, intercept or slope is different, and d) pooling increases the degrees of freedom and may improve the relative precision of the estimated parameters. Since we would examine both the impact of vertical integration on the value relevance of accounting numbers as an entire system and for individual variables, the dummy variable approach seems the most appropriate for our study.

To capture the difference between upstream and integrated companies, we include a dummy variable *INT*, in our model. The dummy variable *INT* is 1 for integrated companies and 0 for upstream companies. *INT* is included as both separately and as interaction terms multiplied with the other explanatory variables. We set *INT* 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. $V =$

$\{0.05, 0.10, \ldots, 0.90, 0.95\}$. By comparing the χ^2 test statistics compared to significance levels we are able to find the break points in the value-relevance of accounting figures in the oil and gas industry as a function of the extent of vertical integration. The regression model including the *INT* dummies is:

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

where β_j is the set of reference parameters for the full sample, both E&P and integrated companies, and $\beta_j^* = \beta_j$ x *INT* ($\forall_j = 0, \ldots, 3$) 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 χ^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.

Research hypotheses

The research hypothesis is that there is at least one break-point in the value-relevance between accounting information and security returns, separating integrated from companies concentrated in on exploration and production activities:

H₁: There is at least on structural break in the value relevance of all the explanatory variables collectively. χ^2 test statistics and significance provides evidence of this.

IV. DATA

Sample selection

The sample consists of accounting data from oil and gas companies for the years 1992-2013. Accounting data and the amounts of proven oil and gas reserves were collected from the IHS Herold database.[7] The IHS Herold database 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 as 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. Our data set includes a total of 3268 firm-years.

The sample descriptive statistics for the variables in our models are reported in Table 1. The average annual shareholder return in excess of the risk free rate is

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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, which are calculated as ratios of accounting information divided by the previous' years end-of-year market value of equity, are also characterised by large standard deviations. This is not unexpected as a low denominator will inflate ratios. In order to mitigate non-linearity created by extreme ratios we have capped the observations by excluding the highest and lowest +/- 0.5 percent of the values. Still, these variables are characterized by large standard deviations.

Table 1:

Descriptive statistics

	Average	St.Dev.	25% percentile	Median	75% percentile
returns	0.328	0.926	-0.144	0.128	0.521
E/MVE	0.017	0.298	-0.003	0.054	0.098
ΔE/MVE	0.009	1.229	-0.036	0.008	0.050
ΔDCF/MVE	0.534	28.920	-0.122	0.070	0.330
MRP	0.084	0.191	0.008	0.107	0.202
SMB	0.030	0.116	-0.037	0.002	0.048
HML	0.025	0.156	-0.080	0.037	0.132
MOM	0.054	0.239	0.0324	0.086	0.178
ΔOP	0.153	0.395	-0.071	0.082	0.353
ΔGP	0.191	0.766	-0.209	0.053	0.262

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 average returns are lowest for the 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 Integrateds 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 ratio of oil and gas net accumulated costs to the total assets 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 2

Descriptive statistics for different values for V

V	Returns	E/MVE	ΔE/MVE	ΔDCF/MVE	N
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

We carry out unit root tests on the data sample. Table 3 shows the results from the augmented Dickey-Fuller test (Said and Dickey, 1984). The results show that all variables reject the null hypothesis of a unit root, meaning that they are stationary and it is therefore not necessary to use first differences.

TABLE 3

Stationarity

Variable	**ADF test statistics**
returns	-33.496 ***
E/MVE	-29.258 ***
ΔE/MVE	-33.315 ***
ΔDCF/MVE	-33.013 ***
MRP	-35.910 ***
SMB	-35.100 ***
HML	-36.416 ***

MOM	-30.518 ***
ΔOP	-47.019 ***
ΔGP	-33.645 ***

Notes: The critical values for the ADF tests -2.58, -1.95, and -1.62 for significance levels of 1, 5 and 10% respectively. The significance of the ADF tests are denoted by asterisks: *p<0.10, **p<0.05 and ***p<0.01.

V. 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 Eq. (3), 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. Second, we test for the presence of heteroskedasticity and serial correlation in the residuals in order to determine if the standard errors should be made heteroskedasticity and autocorrelation consistent. Third, we iteratively run the empirical model in Eq. (4) using different values for *V* and in each run applying Chow 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. We also find the presence of both heteroskedasticity and serial correlation and we therefore apply the Arellano (1987) approach for HACSE in fixed effects models.

TABLE 4

Model diagnostics tests

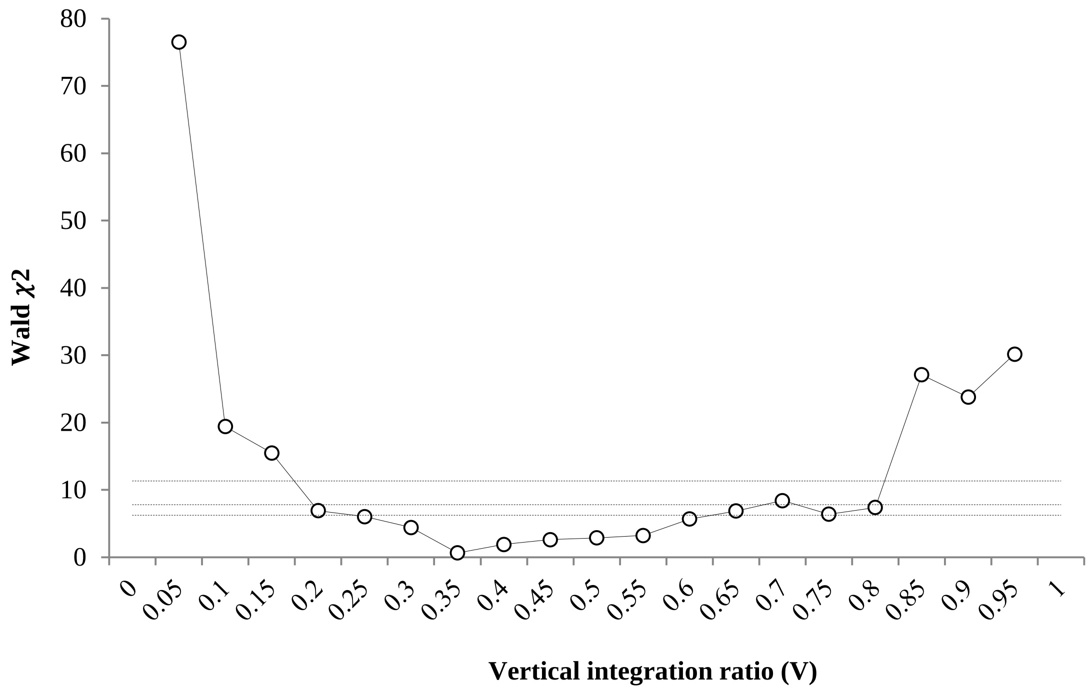
Heteroskedasticity	Serial correlation	Poolability fixed	Hausman
1136.444 (<0.001)	38.014 (<0.001)	1.498 (<0.001)	57.637 (<0.001)

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), χ^2-statistic (Breusch-Godfrey / Wooldridge and Hausman tests), and F-statistics (Poolability test). P-values denoted using asterisks, * = p<0.10, ** = p<0.05 and *** = p <0.01.

Figure 1 plots Wald χ^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 0.05 in increments of 0.05. Wald χ^2values are calculated for each regression and compared against the critical levels (dashed horizontal lines in Figure 1).

FIGURE 1

Structural shift in value relevance as a function of vertical integration (Wald χ^2 test statistic)



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

Figure 1 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 and below 0.20 (at the 10% significance level). This particular break point represents the division between the fully integrated oil and gas companies such as BP and Exxon, and the remainder of the sample. Furthermore, we also identify a break point at a value of *V* of 0.65 and above (at the 10% significance level). The implication of this is that there is a marked shift in the relationship between accounting figures for oil and gas companies with lower and higher than 65% of the ratio of oil and gas assets to total assets. This particular break separates the E&P pure plays from the rest of the sample.

In summary, we are able to identify two break points, thereby suggesting that there are three groups of oil and gas companies that have similar association between accounting numbers and market valuation. The first group are the large integrateds with 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 5 we present the regression results for the final models with *V*=0.20 and *V*=0.65.

TABLE 5

Regression results at the break-points

$$ret_{it} = (\beta_0 - \beta_0^*) + (\beta_1 - \beta_1^*)\frac{E_{it}}{MVE_{it-1}} + (\beta_2 - \beta_2^*)\frac{\Delta E_{it}}{MVE_{it-1}}$$

$$+ (\beta_3 - \beta_3^*)\frac{\Delta DCF_{it}}{MVE_{it-1}} + \beta_4 MRP_t + \beta_5 SMB_t + +\beta_6 HML_t$$

$$+ +\beta_7 MOM_t + \beta_8 \Delta OP_t + \beta_9 \Delta GP_t + \boldsymbol{\gamma FE_i} + \boldsymbol{\theta FE_t} + \varepsilon_{it}^4$$

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 x V	0.298 (0.553)	0.510 (0.471)
ΔE	0.225 (<0.001)	0.246 (0.046)
ΔE x V	1.106 (<0.001)	-0.043 (0.953)
ΔDCF	0.009 (<0.001)	0.010 (0.042)
ΔDCF x 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^2 (within)	0.150	0.171
F-value	45.423 (<0.001)	45.342 (<0.001)
Wald χ^2	6.909 (0.075)	14.304 (0.002)

Notes: Significance for the coefficients in the regression is represented by p-values in parentheses. The Wald χ^2 critical values are 11.34, 7.81, and 6.25 for significance levels of 1, 5 and 10%, respectively.

VI. CONCLUSION

In this study we examine if the degree of vertical integration in 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 to 2013, covering more than 20 years of data. Using the Ohlson model combined with Chow test, 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 large integrateds (often referred to as global oil and gas majors) from the rest of the sample. The second break, at a ratio of 65% separates the more upstream concentrated E&Ps from the rest of the sample. Our results suggest that this methodology can be used to identify structural breaks in the accounting-returns relation. However, further research is needed to identify which factors that contribute to creating the structural breaks.

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