Risk and return in oilfield asset holdings☆

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Abstract

Convention suggests that emerging market investment should provide commensurately lower risk or higher returns than comparable assets in developed countries. This study demonstrates that emerging markets contain regulatory specificities that challenge asset valuation model convergence and potentially invert risk return convention. 292 oilfield assets are used to provide evidence that, under upward oil prices, emerging markets are characterized by progressive state participation in oilfield cash flows. Specifically, this work advances the low oil price paradigm of prior oil and gas asset valuation studies and provides evidence that emerging market state participation terms limit the corporate value of globalization for the sector.

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1. Introduction

Convention suggests that emerging market investments should provide commensurately lower risk or higher returns than assets in developed countries. An analysis of state participation in oilfield asset revenue is used to provide evidence that, under rising oil prices, globally divergent forms of state oilfield participation terms have the potential to invert this convention. The expectation of an emerging market premium has been expanded by many studies that have begun to grapple with the distinction between emerging and developed equity market characteristics. Conover et al. (2002) provide ex ante tests for difference in equity risk premia, comparing developed and emerging market monetary cyclicalities. Bekaert and Harvey (2002) encapsulate the multidisciplinary and multifaceted problems facing comparative asset valuation in emerging markets, summarizing the global asset valuation challenge as one that needs to link

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international economics, asset characteristics, development economics and law with political science and country specific fiscal terms.

In this study, we use the variable ‘state participation’ to encompass all forms of taxation and royalties, as well as revenue and production sharing claims against oilfields in favor of the local government. State participation recognizes the contractual nature of state claims against oilfield assets, with corporate producers sharing the value of residual cash flows. A distinction is made between concession oilfield taxation terms and production sharing contracts; allowing the isolation of state participation across an extensive global sample of oilfield assets. This allows research insights into the effects of state participation on asset values (Bruner et al., 2002).

Concern about valuation model convergence has recently attracted increasing interest at colloquia with Bruner et al. (2002) and Bekaaert and Harvey (2002) identifying the need for further empirical study in this area. Bruner et al. (2002) advance reasons for the importance of emerging market valuation review, noting that investment flows into emerging markets continue to be material. Nowhere is this trend more evident than in the oil and gas sector where there is a strong economic and geopolitical relationship between state and corporate agents. Oilfield assets are therefore uniquely positioned to provide comparative insights into global real asset valuation and emerging market specificities. The oil and gas (O&G) sector has been extensively used in studies that attempt to isolate asset valuation and risk attributes, Haushalter et al. (2002) emphasize the cost of extraction on firm equity value while Jin and Jorion (2006) note that global commodity oil markets are homogeneous, well traded and have comparable oilfield assets subject to equivalent global oil price volatility.

A representative and comparative spread of oilfield assets between OECD (Organisation for Economic Co-operation and Development) and Non-OECD countries, enables us to demonstrate that, despite commodity homogeneity, corporate oilfield entitlement terms are heterogenous. Non-OECD market O&G countries tend to production sharing contracts (PSC), while OECD areas tend toward concession contracts. PSC agreements typically provide oilfield operators with guarantees to cover a return on their capital costs and, in exchange, impose a reserve entitlement structure that contractually escalates oilfield participation sharing by the local government based on the price of oil (Angola) and in some cases the volume of oil pumped (Indonesia). The explicit PSC link between operator asset entitlement and commodity prices (generally) differentiates Non-OECD country O&G sectors from OECD sectors, discussed in detail by Bindemann (1999). Legal and regulatory complexities are demonstrated to have the potential to cause asset valuation risk return inversion. The term ‘risk’ is, in this paper, measured in a relative sense — higher country risk in PSC regions is associated with oilfield assets that also have lower payoff from upward shifts in oil prices. It is important, however, to note that the corporate payoff function is dependent on taxation participation terms that relate to the field, rather than the location of concession fields. Specifically, evidence is provided that PSC oilfields in our sample have an initial operational cost advantage, however, as result of different state participation terms, for each shift upward in oil price — payoff is higher for operators of concession fields — who are not subject to progressive production sharing.

Findings demonstrate that state participation causes asset risk and return performance to differ significantly across global markets. The second contribution of this study is that it updates studies by Haushalter et al. (2002) and Jin and Jorion (2006), which relate to a period when oil prices range between US$18/bbl and US$35/bbl.

2. Research approach

Detailed oil and gas sector data are used to analyze expected cash flows to oilfield operators in the sector. Standard measures of operating and fiscal efficiency are defined and used to compare state participation effects on O&G asset values.

This analysis considers three simplifying assumptions. First, natural resource assets deplete, and as a result state agents find it optimal to extract value out of existing assets. Where applicable, natural gas is converted to barrel of oil equivalent in the analysis. Second, state agents do not have the skills or expertise to deliver technical O&G development projects. Finally, the rate of state taxation participation is deterministic, and is based on terms and rates in existence at January 2006. In line with Stulz (2005) this assumption is a necessary simplification since ad-hoc changes in either the deterministic tax regime or in political agents in countries are possibilities. The variables of oil price expectations, geographic holdings,
replacement reserve origin, and total cost ratio are used as independent determinants of the intensity of state intervention as between countries.

2.1. Data and sample selection

Detailed global information pertaining to oilfield asset risk and return exposures allows us to compare the effects of state participation on asset values. We use the O&G industry for which equivalent oil price exposure exists across both developed (concession regimes) and emerging markets (PSC regimes). Detailed data for oilfield reserve, production, extraction, cost and taxation are used to overcome measurement limitations by facilitating a global comparison of risk and return at the asset level. Through aggregation, a comparison of sector risk and cash flow participation is undertaken at the country level.

Oilfield data are industry standard whole life field data compiled by leading energy research house Wood Mackenzie. All data are derived from publicly available information and operator interviews by Wood Mackenzie oil and gas research teams. Specialist teams compile highly-detailed, full life field models, covering technical field development, production and extraction patterns for each commercial oil and gas field. These data contain industry standard oil field production, oil price, detailed tax terms and field cost data as estimated for the remaining life of the asset. The industry standard data are typically subscribed to by all major banks and oil companies and are commercially available in Wood Mackenzie’s Global Economic Model (GEM). This bottom-up data creates a robust foundation for evaluating O&G fields and enables a comparative global analysis.

Computational intensity, the application of state participation terms and the cost of oilfield data make it optimal to select a representative stratified sample of 292 oilfields from the countries of Gulf of Mexico (GoM), the UK Continental Shelf (UKCS) and the Norwegian Continental Shelf (NCS), and three PSC regimes, Angola (ANG), Egypt (EGY) and Indonesia (IDO). Selecting oilfield assets on an aggregated country and regime level within the oil and gas sector limits endogeneity, identified by Jin and Jorion (2006) in their oil field and gas sector study. Descriptive measures of the sample selection are presented in Table 1.

In the study, oilfields are modeled at the “tax ring fence” level, an important factor that allows us to isolate post-tax cash flows. Fields within a “ring fence” are all subject to the same tax terms, a legal specificity of the O&G sector.

Table 1
Data and sample summary

<table>
<thead>
<tr>
<th>Regulatory regime</th>
<th>Population</th>
<th>Number of sample fields</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Producing</td>
</tr>
<tr>
<td>Concession regimes</td>
<td>615</td>
<td>154 (167)</td>
</tr>
<tr>
<td>Gulf of Mexico</td>
<td>130</td>
<td>41 (50)</td>
</tr>
<tr>
<td>Norwegian Cont. Shelf</td>
<td>105</td>
<td>45 (50)</td>
</tr>
<tr>
<td>UK Cont. Shelf</td>
<td>380</td>
<td>68 (67)</td>
</tr>
<tr>
<td>PSC Regimes</td>
<td>172</td>
<td>128 (125)</td>
</tr>
<tr>
<td>Angola</td>
<td>48</td>
<td>28 (28)</td>
</tr>
<tr>
<td>Egypt</td>
<td>53</td>
<td>40 (42)</td>
</tr>
<tr>
<td>Indonesia</td>
<td>71</td>
<td>60 (55)</td>
</tr>
<tr>
<td>Total sample size</td>
<td>787</td>
<td>282 (292)</td>
</tr>
</tbody>
</table>

Table includes the number of fields analyzed per country and regime and the percentage of the total population. It also reports the division between small (<100 mmboe) and large (>100 mmboe) fields. All field data are provided by Wood Mackenzie GEM, containing remaining reserve estimates in a full life field model. Values in parentheses show the actual number of fields in the selected sample. For the following regression analysis 16 fields are excluded from the initial sample selection due to idiosyncratic behavior attributable to large gas reserves (gas reserves are not exposed to comparable market risk). To compensate for these adjustments, six additional fields are selected randomly.

1 GoM, UKCS and NCS represent regions within the territorial waters of the USA, UK and Norway. For improved readability and comparability to countries with PSC regimes, these concession regime regions are also referred to by their country names throughout this paper.
2.2. Field value and response measures

We model corporate and state agent participation in cash flow and risk and compare assets between concession and PSC regimes. Our asset approach builds on models by Kretzschmar and Kirchner (2007) who identify that asset values in response to price changes in PSC regimes differ from concession regimes. As opposed to concession regimes, PSC fields are subject to progressive production sharing contract terms. Whole field life annual estimates of oil and gas production, oil price, operating costs, capital expenditure and fiscal terms are extracted at the individual field level as at January 2006. Calculations are based on proven and probable (2P) reserves. The asset model values O&G fields based on conventional industry standard discounted cash flows and incorporates present value calculation of operational and market risks. We extend the whole field life model of Kretzschmar and Kirchner (2007) to incorporate the present value \((PV_{l,b,h})\) of time variant revenues and costs for three different price decks. Risk is modeled by the probability of loss calculated on stochastic field present values, defined later in this section. Oilfield reserve, production, extraction, cost and taxation data are used to determine present values \((PV)\) for all fields, enabling a comparative analysis of countries’ risk at the oilfield level.

All 292 fields are valued at three oil price decks of US$33.75/bbl \((l)\), US$45/bbl and US$90/bbl \((h)\) with movements in value used as a measure of return, quantified by corporate cash flow participation measured against the base deck valuation, natural gas is dealt with on a barrel of oil equivalent basis \((b)\).

\[
\begin{align*}
  l \text{ (LowDeck)} &= \text{US$33.75/bbl} \\
  b \text{ (BaseDeck)} &= \text{US$45.00/bbl} \\
  h \text{ (HighDeck)} &= \text{US$90.00/bbl}
\end{align*}
\]

(1)

For PV calculations the SEC prescribed discount rate of 10% is assumed as a constant throughout this paper resulting in a discount factor vector defined by:

\[
DF = \left( \frac{1}{(1+r)^n} \right) \quad \text{with} \quad r = \text{const.} \, 10\% \quad \text{and} \quad n = \text{FieldLife}.
\]

(2)

The extended vector model is used to meet the first research objective and provides insights on field cost structures. All cost variables are defined as time vectors. Present values \((PV_{l,b,h})\) of cost components are derived by multiplication of the transposed cost vectors with DF as shown in Eq. (3)

\[
\begin{align*}
  PV_{\text{opex}} &= (\text{opex})' \times DF \\
  PV_{\text{capex}} &= (\text{capex})' \times DF \\
  PV_{\text{opcap}} &= (\text{opcap})' \times DF \\
  PV_{\text{fiscal}} &= (\text{fiscal})' \times DF \\
  PV_{\text{totcost}} &= (\text{totcost})' \times DF
\end{align*}
\]

(3)

where

- \text{opex} \quad \text{All operational and transport costs for the production and extraction of oil and gas}
- \text{capex} \quad \text{All capital costs related to investments for future benefits and abandonment costs}
- \text{opcap} \quad \text{opex + capex}
- \text{fiscal} \quad \text{All Government claims that reflects state participation in income content of fiscal charges against field cash flows}
- \text{totcost} \quad \text{opcap + fiscal}.

\text{2} \quad \text{Price deck is defined as a series of future oil prices at, above or below current estimated oil prices.}

\text{3} \quad \text{It is noteworthy that any discount premium for emerging market oilfields would significantly improve the strength of the arguments for risk and return inversion in this paper. For example, discounting PSC fields at higher rates would further reduce their net present value relative to concession fields.}
The present value of field revenue $PV_{\text{revenue}}$ is defined accordingly by

$$PV_{\text{revenue}} = (\text{price} \times \text{production})' \times DF$$  \hspace{1cm} (4)$$

where the time variant vectors price and production are multiplied using the point-product (Hadamard Product). We define price as a series (price deck) of forward oil prices. The vector of production is defined according to Eq. (5).

$$\text{production} = \begin{cases} \text{totalproduction} & \text{for Concession regimes} \\ \text{entitledproduction} & \text{for PSC regimes} \end{cases}$$  \hspace{1cm} (5)$$

For concession regimes totalproduction refers to the variable annual production concessions use of the total of oilfield remaining reserves. In PSC regimes, participation terms (entitledproduction) vary with a contractual limit either on the entitlement to an internal rate of return (IRR) or annual variable production. As a consequence operators in PSC areas are only entitled to a portion of total remaining oilfield reserves, detailed insights are provided by Bindemann (2000). These insights are combined in field valuation models with deterministic field value pre-tax ($PV_{\text{pretax}}$) and post-tax ($PV_{\text{posttax}}$) at the US$45/bbl price deck defined by

$$PV_{\text{pretax}}^b = PV_{\text{revenue}}^b - PV_{\text{opcap}}^b$$  \hspace{1cm} (6)$$

$$PV_{\text{posttax}}^b = PV_{\text{revenue}}^b - PV_{\text{opcap}}^b - PV_{\text{fiscal}}^b = PV_{\text{revenue}}^b - PV_{\text{totcost}}^b$$  \hspace{1cm} (7)$$

Kretzschmar and Kirchner (in press) demonstrated risk measurement to be asset specific and to vary heterogeneously in response to the combined effects of state participation and market factors. To accommodate market risk in valuation models, we introduce oil price uncertainty. Mean reversion is set to co-exist with spot price volatility in a refinement of Bessembinder et al. (1995).

Stochastic simulations (292 fields pre- and post-tax) are used to measure the O&G field response to exogenous price volatility and stochastic field risk. This analysis is conducted using Monte Carlo simulations at the field level for the base price-deck $b$ of US$45/bbl. For the purpose of this study, a mean reverting oil price with $\sigma=30\%$ price volatility is assumed. The probability distribution function of stochastic pre- and post-tax field value ($PV_{\text{pretax}}^x$, $PV_{\text{posttax}}^x$) is estimated within the field model.

Each years spot price with exogenous price volatility is defined as a random variable $x$ following a truncated log-normal distribution.

$$f(x; \mu, \sigma) = \frac{1}{x' \sigma \sqrt{2\pi}} e^{-\frac{(\ln x - \mu)^2}{2 \sigma^2}} \begin{cases} 1 & \text{if } \ln x \geq \ln \mu + \sigma \sqrt{2 \ln 2} \\ 0 & \text{else} \end{cases}$$ \hspace{1cm} (8)$$

with $\mu = \text{US$45/bbl}$, $\sigma = 30\%$.

The probability distribution function of stochastic pre- and post-tax field value ($PV_{\text{pretax}}^x$, $PV_{\text{posttax}}^x$) is estimated by simulation within the field model.

Loss occurs when the estimated field value is below a predefined break-even point. In this study, break-even is defined by the deterministic present value for $PV_{\text{posttax}}^d$ at US$45/bbl$. The benchmark of $PV_{\text{posttax}}^d$ is applied to both pre- and post-tax stochastic present value distributions. Probabilities of loss ($\Lambda$) for stochastic $PV_{\text{pretax}}^x$ and $PV_{\text{posttax}}^x$ are calculated as the risk measure where $\text{PDF}[PV^x]$ represents the “best-fit”

---

4 The field valuation price deck at US$45/bbl starts at US$45/bbl in 2006, 'mean reverts' to US$36.70/bbl in 2009 before increasing by inflation set at 2.5 percent p.a. for the remainder of the field life. The same process is followed for each price deck.

5 'Stochastic' is used for oil fields whose behavior is non-deterministic in that the next state of field value is partially but not fully determined by the previous state of valuation inputs, in this study, the prior oil price. Annual changes in oil prices vary the state of the environment.

6 We use Latin-Hypercube discipline in simulations, testing equal sides of the price distribution for 2500 trials and 999 bins.
probability distribution function of stochastic field value using Anderson–Darling goodness of fit tests for the simulated \(PV_{\text{pretax}}^x\) and \(PV_{\text{posttax}}^x\) frequency distributions.

\[
A_{\text{pretax}} = \int_{PV_{\text{posttax}}^b}^{PV_{\text{pretax}}^b} \text{PDF}[PV_{\text{pretax}}^b] \, dx
\]
\[
A_{\text{posttax}} = \int_{PV_{\text{posttax}}^b}^{PV_{\text{posttax}}^h} \text{PDF}[PV_{\text{posttax}}^b] \, dx
\]

2.3. Isolating state effects on return and risk measures

To evaluate country O&G sector performance, we subject fields to price changes and calculate cash flows (upside) and losses (downside) in Eq. (10) in order to compare regime sensitivity and price variability.

\[
\text{upside} = \frac{PV_{\text{posttax}}^b}{PV_{\text{revenue}}^b} - \frac{PV_{\text{posttax}}^b}{PV_{\text{totcost}}^b}
\]
\[
\text{downside} = \frac{PV_{\text{posttax}}^l}{PV_{\text{revenue}}^b} - \frac{PV_{\text{posttax}}^l}{PV_{\text{totcost}}^b}
\]

Each field has technical, geological and taxation idiosyncracies that influence field valuation results and their interpretation. State tax terms are attached at the field level and also linked to the oilfield’s stage of development. The regression analysis in this study uses dummy variables to encapsulate size and state effects.

Analyses of field cost structures relative to revenue are performed. Regression models isolate the oil price conditions under which sector risk and return conventions hold. The expression of operating and fiscal costs as a percentage of expected revenue provides a useful basis for analyzing the characteristics of the oil and gas fields. Relative cost structures for the three price decks \((l, b, h)\) are defined by \(PV_{\text{totcost}}^{b,l,h}\) as a percentage of \(PV_{\text{revenue}}^{b,l,h}\). We determine the drivers of cash flow upside for the US$45/bbl price deck through linear Eq. (12) regression, using relative \(PV_{\text{totcost}}^b\) as the independent variable. The regression model is used to provide insights into oilfield valuation for oil prices in the range US$45/bbl to US$90/bbl. Linear regressions on a country basis test for regime specific trends in cash flow upside.

\[
\text{upside} = \alpha + \beta_1 X_1 \quad \text{with} \quad X_1 = \frac{PV_{\text{revenue}}^b}{PV_{\text{totcost}}^b}
\]

Dummy variables for PSC regimes \((D_{\text{psc}})\) and field size below 100 mmboe remaining reserves \((D_{\text{size}})\) enable differentiation between country effects in concession and PSC markets, and large and small fields where large (small) fields are classified as retaining more (less) than 100 mmboe of remaining reserves.

\[
\text{upside} = \alpha + \beta_1 X_1 + \beta_2 D_{\text{psc}} + \beta_3 D_{\text{size}} \quad \text{with} \quad X_1 = \frac{PV_{\text{revenue}}^b}{PV_{\text{totcost}}^b}
\]

3. Empirical analysis

3.1. State participation effects on sector operational risk

Measures at US$45/bbl Field present value \((PV_{\text{revenue}}^{b,h,l})\) cost structures are analyzed as percentage of \(PV_{\text{revenue}}^{b,l,h}\) as between representative concession and PSC country oilfield holdings. Ratios are calculated for the three different price decks. This allows the isolation of the comparative pre-tax operational advantage between concession and PSC regimes at each price level. Findings demonstrate that when state participation is included, the comparative pre-tax operational advantage of PSC regimes is reversed. We use the US$45/bbl price deck as a benchmark to illustrate that a higher total cost structure for \(PV_{\text{totcost}}^b\) results in a greater probability of loss. The separation of pre- and post-tax cost structures isolates the state participation effects on asset values.

Average country sector asset values at US$45/bbl are described in Eq. (3). Contrary to findings by Haushalter et al. (2002), at US$45/bbl \(PV_{\text{opex}}\) and \(PV_{\text{capex}}\) only comprise 18% and 8% of concession \(PV_{\text{revenue}}^b\).
Costs and cost structures as percentage of PV revenue at $45/bbl

Absolute numbers are stated in US$M, cost structures relative to PV revenue at a 99% level is indicated by the probability of loss (\(\Lambda\)). This is opposite to the higher PV pretax for difference fields. Table 2 shows the country segmentation and field present value (PV\(^b\)) and cost structure components as percentages of PV\(^b\) revenue. All absolute numbers are stated in US$M, cost structures relative to PV\(^b\) revenue are presented in parentheses. The last two columns present the probability of loss (\(\Lambda\)) for PV posttax based on Eq. (9). The existence of significant differences between measure of relative cost structures for PV\(_{opcap}\), PV\(_{fiscal}\) and PV\(_{totcost}\) is verified through two-sided t-tests at the field level of the selected sample. Significance at a 99% level is indicated by ***. p-values are quoted in parentheses.

Table 2
Oilfield mean revenue and relative cost components for (PV) at US$45/bbl by country and regime

<table>
<thead>
<tr>
<th>Average</th>
<th>PV(_{revenue})</th>
<th>PV(_{opex})</th>
<th>PV(_{capex})</th>
<th>PV(_{opcap})</th>
<th>PV(_{fiscal})</th>
<th>PV(_{totcost})</th>
<th>PV(_{pretax})</th>
<th>PV(_{posttax})</th>
<th>(\Lambda)_{pretax} (%)</th>
<th>(\Lambda)_{posttax} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concession</td>
<td>3930</td>
<td>695</td>
<td>328</td>
<td>1023</td>
<td>1841</td>
<td>2864</td>
<td>2908</td>
<td>1067</td>
<td>&lt;0.001</td>
<td>20.44</td>
</tr>
<tr>
<td>(100%)</td>
<td>(18%)</td>
<td>(8%)</td>
<td>(26%)</td>
<td>(47%)</td>
<td>(73%)</td>
<td>(74%)</td>
<td>(27%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GoM</td>
<td>3259</td>
<td>241</td>
<td>283</td>
<td>524</td>
<td>1175</td>
<td>1699</td>
<td>2735</td>
<td>1560</td>
<td>&lt;0.001</td>
<td>22.99</td>
</tr>
<tr>
<td>(100%)</td>
<td>(7%)</td>
<td>(9%)</td>
<td>(16%)</td>
<td>(36%)</td>
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<td>(84%)</td>
<td>(48%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UKCS</td>
<td>1804</td>
<td>339</td>
<td>131</td>
<td>470</td>
<td>752</td>
<td>1222</td>
<td>1314</td>
<td>582</td>
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<td>19.76</td>
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<tr>
<td>(100%)</td>
<td>(19%)</td>
<td>(7%)</td>
<td>(26%)</td>
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<td>(74%)</td>
<td>(32%)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>NCS</td>
<td>7755</td>
<td>1646</td>
<td>666</td>
<td>2312</td>
<td>4094</td>
<td>6406</td>
<td>5443</td>
<td>1349</td>
<td>&lt;0.001</td>
<td>20.65</td>
</tr>
<tr>
<td>(100%)</td>
<td>(21%)</td>
<td>(9%)</td>
<td>(30%)</td>
<td>(53%)</td>
<td>(83%)</td>
<td>(70%)</td>
<td>(17%)</td>
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<td>PSC</td>
<td>3173</td>
<td>360</td>
<td>310</td>
<td>670</td>
<td>1801</td>
<td>2471</td>
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<td>702</td>
<td>&lt;0.001</td>
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<tr>
<td>(100%)</td>
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<td>(10%)</td>
<td>(21%)</td>
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<td>(79%)</td>
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<td>4745</td>
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<td>1465</td>
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<td>(8%)</td>
<td>(12%)</td>
<td>(20%)</td>
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<td>(80%)</td>
<td>(24%)</td>
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<tr>
<td>Egypt</td>
<td>1895</td>
<td>112</td>
<td>68</td>
<td>180</td>
<td>1245</td>
<td>1425</td>
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<td>470</td>
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<tr>
<td>(100%)</td>
<td>(6%)</td>
<td>(4%)</td>
<td>(10%)</td>
<td>(65%)</td>
<td>(75%)</td>
<td>(91%)</td>
<td>(25%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>2609</td>
<td>463</td>
<td>264</td>
<td>728</td>
<td>1380</td>
<td>2108</td>
<td>1881</td>
<td>501</td>
<td>&lt;0.001</td>
<td>47.69</td>
</tr>
<tr>
<td>(100%)</td>
<td>(18%)</td>
<td>(10%)</td>
<td>(28%)</td>
<td>(53%)</td>
<td>(81%)</td>
<td>(72%)</td>
<td>(19%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Concession vs PSC t-test

for difference

- - (0.0001)**
- (0.0018)**
- (0.0001)**

Table shows the country segmentation and field present value (PV\(^b\)) and cost structure components as percentages of PV\(^b\) revenue. All absolute numbers are stated in US$M, cost structures relative to PV\(^b\) revenue are presented in parentheses. The last two columns present the probability of loss (\(\Lambda\)) for PV posttax based on Eq. (9). The existence of significant differences between measure of relative cost structures for PV\(_{opcap}\), PV\(_{fiscal}\) and PV\(_{totcost}\) is verified through two-sided t-tests at the field level of the selected sample. Significance at a 99% level is indicated by ***. p-values are quoted in parentheses.

respectively. Fiscal take by contrast comprises 47% of PV\(_{revenue}\). This trend is mirrored in PSC areas. Average field cost present values are calculated relative to PV\(_{b}\) revenue to derive the corresponding relative field cost structures for PV\(^b\). Cost structures provide insight into the operational risks. Table 2 shows that for US$45/bbl, the average concession field PV\(_{b}\)\(_{copcap}\) is 26%, significantly above PSC fields of 21% suggesting a comparative operating advantage for PSC regimes.

PV\(_{b}\)\(_{fiscal}\) in Table 2 highlights that in concession countries state participation is 47% of PV\(_{b}\)\(_{revenue}\) vs 57% in PSCs. This is opposite to the higher PV\(_{b}\)\(_{pretax}\) for PSC fields of 79% compared to 74% for concession fields. However, when taxation is added to operating and capital costs, the comparative advantage in PSC oilfields is reversed where the PSC market PV\(_{b}\)\(_{totcost}\) increases to 78% compared to the concession market average, comparatively lower at 73% (2). This state participation effect shows that any shift in comparative advantage pre- and post-tax between concession and PSC assets is directly caused by state participation. Two-sided t-tests indicate highly significant differences (99% level) in means between concession and PSC oilfield asset holdings for PV\(_{b}\)\(_{opcap}\), PV\(_{b}\)\(_{fiscal}\) and PV\(_{b}\)\(_{totcost}\). Cost findings suggest that both PV\(_{b}\)\(_{opcap}\) and PV\(_{b}\)\(_{fiscal}\) are likely to be important independent variables in natural resource valuation.

State participation directly increases the probability of loss (\(\Lambda\)\(_{posttax}\)) for PSC countries. The concession \(\Lambda\)\(_{posttax}\) is 20.44% vs 42.95% for PSCs (Table 2). This cost effect on the post-tax asset value at US$45/bbl is consistent throughout the sample. The loss effect is noteworthy in that fiscal costs comprise the greater proportion of total costs which, in turn, directly affect \(\Lambda\)\(_{posttax}\).

3.2. State participation and price variability from US$45/bbl to US$33.75/bbl and US$45/bbl to US$90/bbl

Price response findings provide insights into the effect of oil price increase on cash flow participation in concession and PSC regimes. To provide insights into the role of state participation in field valuation, we calculate the field values at US$33.75/bbl, US$45/bbl and US$90/bbl. This enables insights into the effect on cost ratios and to isolate the effect of taxation regulation on asset return profiles between concession and PSC regions.

Table 5 in Appendix A illustrates a cross-sectional analysis of movements in revenue and total cost structures for oil prices at US$33.75/bbl and US$45/bbl. Concession costs reduce from 76 to 68% of total revenue over the price range in panels A and B, compared to an increase from 78 to 80% over comparable ranges for PSC fields.
Tests for difference in responses between concession and PSC assets are conducted based on individual field data underpinning Table 5 in Appendix A. Significant differences occur in the changes in cost structures relative to PV\textsubscript{revenue} for concession and PSC assets.

### 3.3. Country effects on cash flow and risk

The strength and consistency of tests for difference as between concessions and PSCs are supportive of early observations by Bekaert and Harvey (2002), that legal and fiscal environments in PSC markets are likely to mitigate against model convergence.

Fig. 1 shows the expanded effect of price variability on PV\textsubscript{pretax} and PV\textsubscript{posttax} for concession and PSC markets – country level breakdowns are also provided. Pre- and post-tax PV figures are based on oil prices at US$33.75/bbl, US$45/bbl and US$90/bbl respectively, found in Tables 2 and 5 in Appendix A. PV payoff profiles pre- and post-tax are shown. Comparing pre- and post-tax figures: notwithstanding the high levels of NCS taxation percentages, a progressive limitation on upside is not observable in NCS and the GoM.
Concession regimes show a uniform response relation between PV\textsubscript{pretax} and PV\textsubscript{posttax}. For a price increase from US$45/bbl to US$90/bbl there is a significant difference between PV\textsubscript{pretax} and PV\textsubscript{posttax} in PSC regimes. PSC countries do not reflect the same difference in PV movements pre- and post-tax. Significant differences exist between concession and PSC oilfield responses. Findings suggest that regulatory and fiscal differences challenge asset valuation convergence.

When the sample is revalued at US$33.75/bbl, Table 5 in Appendix A shows that PSC markets have an 8% PV\textsubscript{pretax} advantage (73% vs 65%). This changes to a PV\textsubscript{posttax} disadvantage of 2% (22% vs 24%) when state participation is included. This effect is directly caused by higher levels of PSC state participation of 51% as compared to 42% in concession countries.

Fig. 2 illustrates the component cost changes for oil price movement from US$45/bbl to US$33.75/bbl. Relative cost structures for PV\textsubscript{opex}, PV\textsubscript{capex}, PV\textsubscript{fiscal} and PV\textsubscript{totcost} for concession and PSC countries as a percentage of PV\textsubscript{revenue} on the y-axis in response to a price downshock from US$45/bbl (b) to US$33.75/bbl (i). The x-axis reflects cost structure movements for individual underlying countries and aggregates for concession and PSC asset holdings.

Concession regimes show a uniform response relation between PV\textsubscript{pretax} and PV\textsubscript{posttax}. For a price increase from US$45/bbl to US$90/bbl there is a significant difference between PV\textsubscript{pretax} and PV\textsubscript{posttax} in PSC regimes. PSC countries do not reflect the same difference in PV movements pre- and post-tax. Significant differences exist between concession and PSC oilfield responses. Findings suggest that regulatory and fiscal differences challenge asset valuation convergence.

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Fig. 2 illustrates the component cost changes for oil price movement from US$45/bbl to US$33.75/bbl. Relative cost structures for PV\textsubscript{opex} and PV\textsubscript{capex} increase relative to field revenue for concession countries in our sample. For PSC asset holdings, the decrease in oil price actually decreases the total cost percentage, a direct result of state participation terms that allow cost recovery by producers. The exception is Indonesia with mature production sharing contracts recognizing that producers have completed cost recovery and now entered flat state profit splits.

At US$90/bbl (Table 5 in Appendix A), the effect of progressive state participation is more noticeable. PSC markets experience a 2% PV\textsubscript{pretax} advantage (89% vs 87%). PV\textsubscript{posttax}, PSC markets experience a 12% adverse swing (20% vs 32%). Again, the reversal of the pre-tax operational advantage in PSC asset holdings is directly caused by state participation being higher (69%) in PSC countries, compared to 55% in concession countries. Findings suggest that during periods of increasing oil prices, the progressive nature of production sharing and their inclusion in the cost structure has a direct effect on total cost of PSC oilfields.

Insights are provided in Figs. 2 and 3 which deconstruct the component cost changes for oil price movement from US$45/bbl to US$33.75/bbl and US$45/bbl to US$90/bbl. The percentage of total cost for
concession asset holdings reduces for an increase in oil price. Exogenous increases in oil price are not usually accompanied in operating costs and concession fiscal costs are not progressive (the exception is when increases in oil prices make more expensive extraction processes economic). An increase in relative total cost in response to oil price increase can therefore only be driven by fiscal participation terms. This effect is observable for PSC asset holdings, the increase in oil price actually increases total cost, a direct result of progressive state participation.

3.4. Regression analysis of state effects on cash flow and risk

Regression analysis is used to lift out the extent of state and operational cost structure on the directionality of O&G sector return and risk measures. When interpreting results, it is noteworthy that no prior academic global asset study exists that compares concession and PSC asset performance to the level of detail in this study. The isolation of economic state variables also allows insights into the outstanding Fama and French (1995) question relating to the effect of underlying economic and state variables on asset values. The regressions analyze the effect of operational and capital expenditure on potential field return represented by the relative cost structure for $PV_{\text{totcost}}$ and upside respectively. Inputs are derived from the detailed field models that are used to underpin field value variations. Regression analyses demonstrate the progressive tax nature and limited upside for PSC fields, and the higher gain for concession markets.

The regression model (11) analyzes the relation between static cost structures and field performance measured by cash flow upside.

The regime specific total cost effect on cash flow upside is used in the regression model as specified in Eq. (11). The country analysis provides evidence for an aggregate sample discussion. The regime effect loading in the regression quantifies directionality at the country level (Table 3) where the concession
from the upside. Table 4 isolates the effects of regime on cash flow upside from US$45/bbl to US$90/bbl. Table 4 reports a positive and significant negative loading on $D_{psc}$ illustrating PSC regimes are limited in the upside as they are subject to production sharing. We find a positive, although not significant, loading on $D_{size}$ suggesting a limited ability of small fields to generate higher returns on cash flow, consistent with Kreizschmar and Moles (2006). This result is best understood by considering a field that is previously at or close to break-even in terms of its relative total cost structure. Any increase in price, in the case from US$45/bbl to US$90/bbl, would shift the field in to a profitable position as the incremental revenues cover cost with cash flow benefitting directly from the upside. Table 4 isolates the effects of regime on cash flow upside.

### Table 4

Regression results for cash flow upside US$45/bbl–US$90/bbl

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Value</th>
<th>t-statistic</th>
<th>p-value</th>
<th>F-statistic</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>-0.3947</td>
<td>-1.4077</td>
<td>(0.1605)</td>
<td>95.2384</td>
<td>0.5445</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>2.5183</td>
<td>13.1514**</td>
<td>(0.0001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>-0.7665</td>
<td>-14.7374**</td>
<td>(0.0001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>0.0759</td>
<td>1.5763</td>
<td>(0.1163)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Regression results for cash flow upside directionality are based on Eq. (12). Fiscal cost structures are included in relative total cost structure represented by the independent variable $X_i$. We isolate effects of fiscal regulations by using dummy variables for PSC regimes ($D_{psc}$) and field size ($D_{size}$). Significance at a 99% level is indicated by **; p-values are quoted in parentheses.

$\text{Upside} = \alpha + \beta_1X_1 + \beta_2D_{psc} + \beta_3D_{size}$ with $X_1 = \frac{PV_{total cost}}{PV_{revenue}}$.

---

**Panel A: Concession field upside US$45/bbl–US$90/bbl**

Concession 131
- $\alpha = -0.2927$, $-2.0692^*$ ($0.0405$)
- $\beta_1 = 2.7380$, 13.2384** ($0.0001$)
- GoM 41
- $\alpha = -0.4910$, $-11.9187^*$ ($0.0001$)
- $\beta_1 = 3.2861$, 42.5585** ($0.0001$)
- NCS 42
- $\alpha = -9.8643$, $-11.90162^*$ ($0.0001$)
- $\beta_1 = 13.81165$, 14.24853** ($0.0001$)
- UKCS 48
- $\alpha = -0.8985$, $-8.3199^*$ ($0.0001$)
- $\beta_1 = 3.7653$, 21.8715** ($0.0001$)

**Panel B: PSC field upside US$45/bbl–US$90/bbl**

PSC 112
- $\alpha = -0.0745$, $-0.2178$ ($0.8280$)
- $\beta_1 = 1.4249$, 3.2639** ($0.0015$)
- Angola 19
- $\alpha = -0.8810$, $-1.9664^*$ ($0.0658$)
- $\beta_1 = 1.7745$, 3.1057** ($0.0064$)
- Egypt 38
- $\alpha = 0.8655$, 4.5942** ($0.0001$)
- $\beta_1 = 0.0748$, 0.3094 ($0.7588$)
- Indonesia 55
- $\alpha = -0.3906$, $-1.6621$ ($0.2504$)
- $\beta_1 = 2.1570$, 5.0534** ($0.0001$)

Regression results for cash flow upside directionality are based on Eq. (11). Fiscal cost structures are included in relative total cost structure represented by the independent variable $X_i$. The table presents the key regression statistics for cash flow upside (upside) on a country basis. Significance at a 99% level is indicated by *, at a 95% level by ** respectively; p-values are quoted in parentheses.

$\text{Upside} = \alpha + \beta_1X_1$ with $X_1 = \frac{PV_{total cost}}{PV_{revenue}}$.
3.5. Oil prices and oilfield cash flows

Visual inspection of the data distribution at the aggregate sample level indicates a different cash flow responses for concession and PSC countries (Fig. 4).

The most important factor to highlight is that concession assets (left column) experience an exponential increase in value as result of flat state participation. The top left graph in Fig. 4 shows distinct concession state agency effects. These effects are disaggregated by regime type. Columns in Fig. 4 distinguished between concession and PSC respectively. Concession asset holdings particularly display distinct characteristics suggesting that the upside in response to price movements (as measured by the y-axis) is directionally significant. Values increase as prices increase. This is consistent with findings at the aggregate sample level, except that country level de-construction leads to increased significance in the quality of directionality. The first column of Fig. 4 illustrates highly interesting trends. The GoM has the lowest spread of operational cost structures ranging from approximately 45% to 70%. This results in an average increase in cash flows between 75% and 150% as oil price increase occurs. A result reflected in the GoM regime regression by a R² of 98%, the highest for the sample. The R² for the NCS in Fig. 4, Graph E, lifts out two important principles: The first relates to the fact that concession cash flows are extremely responsive to high oil prices when the cost structure for the field is high. The second important principle is concession assets do not have progressive taxation and therefore corporate owners participate in asset value upsides in response to positive price shocks.

The PSC column provides an insightful counterpoint to the concession state participation characteristics. Progressive state participation is apparent in that the price increase attracts progressive taxation against field values. The most notable effect is that for PSC countries the upside in the sample overview is limited, findings consistent with Kretzschmar and Moles (2006). Total field cost structures on average above 60%.

At high prices, the corporate cost of conducting business in PSC regimes is significantly above concession regimes, but more significantly taxation is progressive with the result that the corporate benefit of oil price increase is limited. Fig. 4 illustrates a distinguishing feature in PSC (in the case US$45/bbl to US$90/bbl) cash flow upside is limited by progressive state participation. Angola reflects the same trend with a 36% R². Egypt displays the least explanatory power in its total cost structures with a R² of 0.3% (Fig. 4, Graph F). We assess sample residuals in order to determine heteroscedasticity for regression results. Concession markets exhibit high variances between small and large fields. The analysis of the residuals confirm that concession assets have a non-linear response to oil price variability.

4. Concluding remarks

This paper examines the country effects on risk return characteristics between concession and PSC regimes in the oil and gas sector. In response to oil price increase, PSC assets have progressive taxes that increase their total cost structures. In comparison, assets in concession countries experience a reduction in total cost structure as oil prices increase. Our sector findings indicate that, despite an initial operational cost advantage in PSC countries, the progressive nature of state participation reverses the comparative advantage at higher oil prices. This result shows the limits to the benefits of emerging market investment, findings consistent with Stulz (2005). Regression results provide empirical evidence of state effects on field valuation in response to price changes. A significant negative effect of PSC regulations on field upside is observable. These divergent findings go some way to providing empirical support for the intuition of Bruner et al. (2002), that regulatory differences are likely to mitigate against global asset valuation model convergence.

We conclude by providing evidence of potential risk and return inversion as between concession and PSC oilfield assets. There is a need for future bottom-up studies of emerging market asset holdings and whether market idiosyncrasies are reflected in lower stock returns. In the oil and gas sector our ex ante expectation is that high oil prices will begin to increase value divergence between companies with asset holdings in emerging and emerging markets.
developed markets. Given the importance of the role of asset values in the book to market measure proposed by Fama and French (1992) the expectation is that as oil prices increase, corporates with high PSC asset holdings are likely to begin to experience share price under-performance relative to corporates with low PSC asset holdings.

Findings suggest that valuation model convergence will, to a large extent, be driven by empirical studies that provide both the insights into differences in underlying PSC assets and method for dealing with global idiosyncracies. Scope exists to extend these findings to other asset classes that are affected by state participation effects, and is likely to be a rich research area in future emerging market literature.

Appendix A

Table 5
Price variability effect on concession and PSC revenue and cost components at US$33.75/bbl–US$90/bbl

<table>
<thead>
<tr>
<th>Average</th>
<th>PV_revenue</th>
<th>PV_capex</th>
<th>PV_fiscal</th>
<th>PV_totcost</th>
<th>PV_pretax</th>
<th>PV_posttax</th>
<th>ΔPV_posttax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A: Costs and cost structures as percentage of PV_revenue at $33.75/bbl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concessions</td>
<td>2963</td>
<td>695</td>
<td>328</td>
<td>1233</td>
<td>2256</td>
<td>1941</td>
<td>707</td>
</tr>
<tr>
<td>GoM</td>
<td>2446</td>
<td>241</td>
<td>283</td>
<td>825</td>
<td>1349</td>
<td>1923</td>
<td>1097</td>
</tr>
<tr>
<td>UKCS</td>
<td>1372</td>
<td>339</td>
<td>131</td>
<td>514</td>
<td>984</td>
<td>902</td>
<td>389</td>
</tr>
<tr>
<td>NCS</td>
<td>5838</td>
<td>1646</td>
<td>666</td>
<td>2693</td>
<td>5005</td>
<td>3526</td>
<td>833</td>
</tr>
<tr>
<td>PSCs</td>
<td>2471</td>
<td>360</td>
<td>125</td>
<td>1582</td>
<td>1801</td>
<td>543</td>
<td>−159</td>
</tr>
<tr>
<td>Angola</td>
<td>5067</td>
<td>494</td>
<td>753</td>
<td>2558</td>
<td>3805</td>
<td>3820</td>
<td>1262</td>
</tr>
<tr>
<td>Egypt</td>
<td>1424</td>
<td>112</td>
<td>68</td>
<td>892</td>
<td>1072</td>
<td>1244</td>
<td>352</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1957</td>
<td>463</td>
<td>264</td>
<td>895</td>
<td>1623</td>
<td>1229</td>
<td>334</td>
</tr>
<tr>
<td>Panel B: Costs and cost structures as percentage of PV_revenue at $90/bbl</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Concessions</td>
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<td>4303</td>
<td>5326</td>
<td>6777</td>
<td>2474</td>
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<tr>
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<td>3411</td>
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<tr>
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<td>3062</td>
<td>1345</td>
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<tr>
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<td>12,097</td>
<td>13,112</td>
<td>3327</td>
</tr>
<tr>
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<td>310</td>
<td>4393</td>
<td>5063</td>
<td>5677</td>
<td>1284</td>
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<tr>
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<td>2867</td>
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<tr>
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<td>264</td>
<td>3341</td>
<td>4068</td>
<td>4490</td>
<td>1150</td>
</tr>
</tbody>
</table>

The table columns contain average country field revenues and costs calculated at US$33.75/bbl and US$90/bbl. Additionally, the last column shows the absolute (relative) change in PV_posttax for the two price changes. Panel A summarizes at US$33.75/bbl (l) and Panel B the US$90/bbl (h). All absolute numbers stated in US$M. Relative cost structures presented in parentheses.

References