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Moderating effect of vertical integration on the relationship between sustainability and performance: evidence from oil and gas energy sector

Muhammad Kashif Ali[1*], Muhammad Khurram Zahoor[1], Asif Saeed[2] and Safia Nosheen[3]

Abstract

This research study aims to examine the impact of sustainability on firm performance and analyze how vertical integration moderates the connection between performance and sustainability in the oil and gas sector. We analyzed a sample dataset of oil and gas companies from the top ten oil-producing countries spanned over ten years (2011–2020). The pool-fixed regression technique confirms that sustainability and its three components, i.e., social, environmental, and governance, are negatively related to performance. However, vertical integration moderated the connection between sustainability and performance in the case of the oil and gas sector. We have identified firm size, age, and return share price positively related to firm performance in the oil and gas industry. At the same time, the debt ratio negatively impacts the firm's performance. The findings are significant for the management of oil and gas firms and the policymakers and regulatory authorities of oil-producing and exporting countries.

Keywords Sustainability, Vertical integration, Firm performance, Oil and gas industry, Policymakers and regulatory authorities

Introduction

As momentum grows behind initiatives to promote renewable energy, sustainability, and the energy transition, environmental, social, and governance (ESG) investing is quickly emerging as one of the oil and gas industry's most prominent and long-lasting megatrends. The upstream sector of the oil and gas value chain is under the most attention for its effects on the environment, while the midstream is under investigation for its social impact and governance structure. According to the Daily Oil Bulletin's poll of executives and ESG professionals conducted late in 2020, oil and gas operators desire to engage with suppliers who share their corporate values and dedication to ESG principles.

The oil and gas industry has addressed some ESG components for a long time, but the need to address the complete ESG programmes is more recent. Environmental pressure has long been a factor for large oil firms, typically due to significant environmental catastrophes like the Exxon Valdez and the Deepwater Horizon. However, the response typically fell under crisis management rather than programmatic environmental measures.

The high volatile price and demand for hydrocarbon are the significant challenges faced by the petroleum sector today. Furthermore, hazardous exploration activities of conventional and unconventional resources,

*Correspondence:
Muhammad Kashif Ali
m.kashifali@uet.edu.pk
[1] Department of Petroleum and Gas Engineering, University of Engineering and Technology-Lahore, G T Road, Lahore 54890, Pakistan
[2] Business Administration Division, Mahidol University International College, 999 Phutthamonthon 4 Rd., Salaya, Phutthamonthon 73170, Nakhon Pathom, Thailand
[3] Hassan Murad School of Management, University of Management and Technology-Lahore, C-2 Johar Town, Lahore 54770, Pakistan

multinationalism of oil companies, and unpredictable hydrocarbon prices have made the petroleum sector investigate different integration techniques. The more diversified asset base of integrated oil and gas companies demonstrates minor variability in their earnings.

Vertical integration is a crucial technique to stay successful in the business, given the rising rivalry among companies in the petroleum sector. The differentiated character of the production stages in the petroleum industry makes it an exciting area to be studied by researchers and to look at the effects of vertical integration on a company's performance and cost reduction. To preserve or improve the company's competitive position and satisfy the company's proportion of the global energy demand, this strategy is used by operational and general managers with significant strategic decision-making responsibilities. Such strategies will help to uphold long-term value, improve safety and profitability, and boost hydrocarbon reserves and production.

Reported results on sustainability, performance, and vertical integration in the oil and gas sector, still need to be clarified. Uncertainty is infused into comprehending the issues by such unclear and contradictory findings, making it challenging for managers to decide how best to proceed with their commitments to sustainability initiatives and environmental investments. The oversimplified mathematical models for calculating efficiency and rates of return fail to account for a corporation's need to balance its financial gains with the social benefits of the society in which it works [47]. It is essential to recognize the value of research that develops ideas and frameworks to understand this conundrum.

The novelty of the research study is to investigate the impact of sustainability on performance and to explore whether the VI moderates the relationship between sustainability and the performance of the petroleum and gas sector. Up to the existing literature, no study that has looked at the moderating role of VI on the relationship between sustainability and performance, specifically in the petroleum sector. VI is an essential strategy that firms adopt to synergize their existing resources.

Oil and gas are the necessary energy sources; the future development of petroleum resources is crucially dependent on the sustainable petroleum sector. Despite the evolution of hydrocarbon potential, risks associated with sustainability, such as safety risks, climate change, and community differences, employ pressure on the financial viability of the oil and gas exploration projects. The practice of vertical integration (VI) significantly affects the profit margins of petroleum companies. As might be seen in the pandemic, COVID-19 badly affected crude oil prices worldwide, and for the very first time in history, the price of crude oil stooped to negative. From this perspective, the strongest argument is associated with the fluctuating nature of crude oil prices within the global commodity market [36].

Literature review and development of hypotheses

Sustainability is an area that investors and the general public are very interested in, and they now have the resources to follow these issues at specific companies closely. Sustainable development discovers the connection between economic development, social equity, and environmental quality. Investors in the recent era are now more concerned about the organization's overall development and performance on environmental effects, diversity and inclusion initiatives, or the organization's apparent commitment to good governance and transparency. Furthermore, they request access to sustainability and governance data in a situation where they believe transparency is lacking.

Sustainability and firm performance

It is vital to undertake a thorough research study that notices the influence of sustainability practices from many dimensions on firm performance, considering the growing need for sustainable growth in global enterprises. Investors' attention is currently focused more on sustainable business practices than operational and financial success. Investors respond negatively if companies overlook environmental, social, and governance concerns and do not apply ESG principles to their daily operations [62]. Sustainability reporting is a framework that combines social and environmental objectives with financial objectives and supports businesses' efforts for the welfare of a broader range of stakeholders. [29].

The firms with low sustainability performance show volatile behavior in the market due to their irresponsible nature. Due to organizations' increased capacity to concentrate on high-return strategies, sustainable business practices are helpful in asset management and investment returns [61]. Many businesses use the legitimacy device, typically the annual report, to share the corporation's opinions on numerous environmental and social concerns to create perceptions about the company's operations. As a result, this will enhance their reputation and make them more appealing to society. Such practices will result in an infusion of highly skilled workers, investors, and customers, improving business performance [67].

Research supports that management can lower capital expenditures and raise the firm's valuation by focusing on sustainability. That is because those businesses will access larger pools of capital as investors want to participate in businesses with more robust, sustainable performance. In addition, governments and worldwide regulators demand

disclosures relating to environmental, social and governance sustainability; companies can preserve their valuations by taking proactive measures and being transparent on environmental, social and governance issues [60].

A series of studies argued the positive relationship between sustainability and firm performance. According to Lee et al. [47] empirical findings, oil and gas firms have strong ties between sustainability and performance. Dong et al. [22] studied the impact of sustainability on investment efficiency and found a positive relationship.

However, several studies on the impact of sustainability on firm performance have yielded conflicting results; a negative relationship between ESG practices and firm performance is reported in studies [24, 27, 57, 64]. Mao et al. [50] indicated in their study that improvement in sustainability process improves ESG indicators but hinders firm's financial performance. According to the study conducted by Atan et al. [7], there is an inverse association between sustainability and financial performance. Harjoto and Jo [34] studied the influence of ESG components on the firm value and found a negative relationship. Alareeni and Hamdan [2] discussed the impact of ESG practices, a sustainability indicator, on the performance of firms listed in the US S&P 500. They concluded that the firms' performance is better because of their lower ESG indicators. Based on the study results, the authors argued that companies with superior sustainable practices do not have a competitive advantage.

It has been observed that the last couple of decades have seen more and more business firms adopting environmentally responsible strategies [12]. According to Shrivastava and Tamvada [63], a positive relationship exists between the firms' age and size and environmental strategies. According to the empirical findings by Dyck et al. [25], the performance of oil and gas firms in environmental and social metrics is the driving force behind their progress on the economic front.

Based on the literature presented and non-conclusive research findings, this research study formulated the following hypothesis to be explicitly tested specifically in the oil and gas industry:

H_1 There exists a relationship between the sustainability and performance of oil and gas companies.

H_{1a} There exists a relationship between environmental sustainability and the performance of oil and gas companies.

H_{1b} There exists a relationship between social sustainability and the performance of oil and gas companies.

H_{1c} There exists a relationship between the governance and performance of oil and gas companies.

Vertical integration, sustainability and firm performance

Integrated petroleum companies have extensive coordination of technological and strategic goals in forming strategic plans. Such strategies put petroleum companies in a better position to utilize the company assets and contribute significantly to creating more value [3]. In the petroleum industry, vertical integration (VI) is the process by which a company coordinates several value chain phases. The value chain of the petroleum industry consists of three main sectors: upstream, midstream, and downstream. The upstream sector's primary functions are crude oil and natural gas exploration and production. At this stage, oil companies collaborate with the services companies. The midstream sector involves transporting crude oil to the downstream sector. The refining, processing, marketing and distribution of crude oil and natural gas are all considered to be parts of the downstream sector. In addition to the storage of oil and its byproducts, the downstream sector also involves refining, marketing, and selling petroleum products [18].

The firms constituting the oil and gas industry usually rely on raw materials that are naturally occurring, and their extraction, procurement, transportation, and associated energy consumption at different stages incur environment-related costs. The industry is also labor-intensive and, as such, incurs intangible social costs along with other environment-related costs. These firms have realized that focusing on managing social and environmental issues can lessen costs, reduce risks, and create tremendous prospects to make cash inflows. The vertical integration strategy addresses these environmental factors, e.g., through VI production facilities come closer to suppliers. This change helps firms reduce the emission of greenhouse gases related to transportation and provides sustainable financial advantages. Furthermore, VI boosts resource productivity throughout operations and the supply chain and reduces corporate risks, including vulnerability to unpredictable commodities markets, increased insurance premiums and financial instruments used for hedging [17].

Sim et al. [65] have advocated that vertically integrated oil and gas firms rank higher regarding social welfare and environmental impact. The emission of pollutants is a significant concern haunting the petroleum business globally as oil firms receive much criticism for actively and consistently contributing to climate change. Akhmetshina et al. [1] have contended that vertical integration practices in the oil and gas industry decrease the cost of raw materials and transportation and positively

impact the environment and firm profit. It is also important to note that the potential for oil and gas firms to have adverse effects on the environment, society, and the economy is substantial and, therefore, requires support and implementation of vertical integration strategies to ensure better sustainability and firm performance [28, 37]. It is important to look at the moderating role of VI that it can bring to strengthen the relationship between sustainability and the performance of the oil and gas firms.

Therefore, the hypothesis to test the moderating role of VI in the relationship between sustainability and performance is formulated as follows:

H_2 Vertical integration moderates the relationship between sustainability and Performance

H_{2a} Vertical integration moderates the relationship between environmental sustainability and the performance of oil and gas companies.

H_{2b} Vertical integration moderates the relationship between the social sustainability and performance of oil and gas companies.

H_{2c} Vertical integration moderates the relationship between the governance and performance of oil and gas companies.

Methodology

Data

The focus of this research study is to analyze the impact of vertical integration and sustainability (Economic, Social and Governance) on the oil and gas firms' performance in leading oil-producing countries.[1] To meet the objectives of this study, data for the measurement of VI and performance is extracted from annual reports of petroleum companies listed on primary stock exchanges of the leading oil-producing countries. The sustainability data is taken from the Thomson Reuters ASSET4 database [14, 15, 24]. The selection of the top oil-producing countries is based on their contribution to global oil production. A ten-year time frame will allow a clear understanding of the impact of VI and sustainability on oil and gas firm performance. Hence, for analysis purposes, data have been used spanning over ten years (2011–2020) [33].

[1] United States, Saudi Arabia, Russia, Canada, China, Iraq, United Arab Emirates, Brazil, Iran, Kuwait.

Target population and sample selection

Since the primary objective of the study is to evaluate the impact of VI and sustainability on the firm's performance for the oil and gas sector constituted by the mainstream listed petroleum companies of the top ten (10) oil-producing countries, however, data availability constraints forced trimming the list to just five, namely the United States of America, Canada, Russia, China, and Brazil. Similarly, a total of 850 unique observations were mined from the data accumulated for eighty-five companies, which got reduced to 585 due to missing values in the rest of the observations.

Econometric model

The econometric model is used to obtain the values of parameters essentially the coefficients of the mathematical form of the relationships. It is proposed that panel data regression will be run on the data, and the proposed model for the study can be represented as the following equation [31]:

$$Y_{it=}\alpha_{i+}\beta X_{it} + \varepsilon_{it} \tag{1}$$

where Y is the dependent variable for the cross-section unit or firm i at time t, α_i is the constant term, X_{it} is the independent variable with a coefficient β, and ε_{it} is the error term [51]. The operational model of this study is given by Eq. (2):

$$\begin{aligned} \mathrm{PERF}_{it} =& \beta_0 + \beta_1(\mathrm{SUST}_{it}) \\ &+ \beta_2(\mathrm{SUST} \times \mathrm{VI}_{it}) \\ &+ \beta_n(\mathrm{Control}_{it}) + \mu_{it} \end{aligned} \tag{2}$$

where PERF_{it} is firm performance (dependent variable), calculated as return on assets (ROA). Net income divided by total assets is used to determine ROA. Return on assets is an accounting-based performance metric that shows how effectively a company manages its short-term profitability and gives clear insight into how certain resource allocations contribute to its current earnings. ROA measures profitability and the effectiveness of companies in utilizing their assets to generate profit [46].

SUST_{it} is sustainability (independent variable), calculated on the bases of ESG score. In this study, Thomson Reuters' ASSET4 ESG score is used to measure sustainability [14, 15, 58].

The ASSET4 ESG data system interface is intuitive and internet-like in its design, with transparency and flexibility as its key features. Over 750 + data points and 280 + predefined key performance indicators can be viewed within the system, and the original information source (annual reports, filings, websites, etc.) can be accessed directly. ESG data on ASSET 4 consists of three components: environmental, social and governance.

Table 1 Year-wise summary statistics

Year	ROA	ESG	ESG*VI	FS	DR	FA	RSP	VOLT
2011	0.056	28.612	34.236	9.048	0.465	3.165	−0.001	0.107
2012	0.031	30.052	34.135	9.129	0.454	3.183	−0.001	0.089
2013	0.026	29.611	33.389	9.032	0.443	3.124	0.016	0.076
2014	0.013	26.909	35.179	9.066	0.475	3.140	−0.015	0.101
2015	−0.137	24.925	37.033	8.875	0.524	3.198	−0.026	0.128
2016	−0.046	29.259	37.572	8.707	0.512	3.264	0.037	0.133
2017	0.009	32.105	37.280	8.692	0.503	3.322	−0.009	0.087
2018	0.023	29.936	38.893	8.736	0.495	3.349	−0.021	0.126
2019	0.001	29.053	40.255	8.637	0.522	3.419	0.009	0.142
Total	−0.005	28.984	36.590	8.866	0.490	3.246	−0.001	0.111

All variable definitions are available in "Appendix A"

(*): Significance at the 10% level

Firm business practices affecting land, air and water ecosystems are part of the environmental score. The social measure includes components like community welfare, training and development, diversity, health and safety, quality of employment and human rights. The governance measure is based on factors such as the board functions, compensation policy, board structure, shareholders' rights, and the company's vision and business strategy [6, 20, 23].

The variable VI_{it} in Eq. (2) is an index of vertical integration (independent variable), which is a calculated dummy variable showing whether a firm is vertically integrated or not. It may be noted that integrated firms are those with a combination of upstream, midstream, and downstream operations, Whether a firm is operating in just one, any two or all three sectors, its VI_{it} score will be 1, 2 or 3, respectively [8, 10, 53]. As example of an international petroleum company, Misund [52] analyzed the data of firms listed on US stock exchanges from 1992 to 2013 for structural breaks in the value relevance depending on the degree of vertical integration. This results division of petroleum companies into three groups based on upstream, midstream, and downstream operations.

Control variables

Firm size (FS), debt ratio (DR), firm age (FA), return on share price (RSP), and volatility (VOLT) are taken as control variables. A firm's size at any given time (FS_{it}) expresses the total assets as presented on the balance sheet. [52] Used this approach in his empirical study to evaluate this parameter. According to Lahiri and Narayanan [45], a firm's size is the primary determinant of its behavior and vertical integration capacity. The debt ratio at a specific time (DR_{it}) represents how much debt a firm uses and is calculated as total debt divided by total assets [42, 44, 59]. A firm's age at a particular time (FA_{it}) is another important control variable, which is defined as the observation year minus the founded year of the company under consideration [26, 41, 48, 49]. The time-dependent return on share price (RSP_{it}) is calculated as the ratio of share price to last year's share price [35, 38]. Lastly, volatility at a specific time ($VOLT_{it}$) is calculated as the change in share price [43, 66].

Results

The data values used for the econometric model are reported in Tables 1 (year-wise) and 2 (country-wise), respectively. Table 3 summarizes the values used in the regression model.

Table 4 presents the pair-wise correlation among the variables used in the regression model. The values show that multicollinearity is not found in the model. Variance Inflation Factor (VIF) values further strengthen the preliminary conclusion about the proposed correlation. As no VIF value is more than 10, we can confidently interpret the regression analysis results.

Regression results

The regression analysis results are presented in Tables 5, 6, and 7. Table 5 populates a total of three regression results. In Regression (1), sustainability with moderating effect of vertical integration is regressed on performance, sustainability negatively affects the performance, but VI moderate the relation to positive at a 1% confidence level. In Regression (2) fixed effects, sustainability, with moderating effect of VI, as well as the firm-level variables, are regressed on performance. In Regression (3), cluster regression is run, and all the firm-level variables are regressed on performance along with sustainability and moderating variable VI.

Table 2 Country-wise summary statistics

Country	ROA	ESG	ESG*VI	FS	DR	FA	RSP	VOLT
BR	−0.005	27.631	37.422	8.120	0.471	2.910	0.001	0.109
CA	−0.027	22.771	30.284	7.715	0.460	2.900	−0.007	0.119
CN	0.036	47.810	47.810	12.385	0.507	2.726	−0.002	0.063
RU	0.079	55.484	55.484	11.523	0.379	3.043	0.011	0.065
US	0.005	30.643	39.866	9.466	0.534	3.667	0.003	0.112
Total	−0.005	28.984	36.590	8.866	0.490	3.246	−0.001	0.111

All variable definitions are available in "Appendix A"

BR Brazil, *CA* Canada, *CN* China, *RU* Russia, *US* United States

(*): Significance at the 10% level

Table 3 Summary Statistics

Variables	Obs	Mean	Std	Min	1st Quartile	Median	3rd Quartile	Max
ROA	581	−0.005	0.143	−0.870	−0.021	0.026	0.062	0.172
ESG	581	28.934	25.141	0.000	8.850	21.990	47.100	87.650
ESG*VI	581	36.543	21.219	5.070	17.490	32.490	51.710	87.650
FS	581	8.863	1.915	4.729	7.303	8.793	10.290	12.796
DR	581	0.491	0.216	0.109	0.375	0.482	0.561	1.417
FA	581	3.243	0.986	1.099	2.639	3.091	3.912	4.927
RSP	581	−0.001	0.034	−0.083	−0.019	0.000	0.019	0.085
VOLT	581	0.111	0.061	0.037	0.069	0.094	0.135	0.414

All variable definitions are available in "Appendix A."

(*): Significance at the 10% level

Table 4 Correlation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	VIF
(1) ROA	1.000								
(2) ESG	0.207*	1.000							3.72
(3) ESG*VI	0.318*	0.771*	1.000						2.8
(4) FS	0.312*	0.739*	0.678*	1.000					4.9
(5) DR	−0.338*	−0.052	−0.096	−0.035	1.000				1.2
(6) FA	0.106	0.309*	0.253*	0.256*	0.051	1.000			1.29
(7) RSP	0.178*	0.066	0.087	0.093	0.019	0.045	1.000		1.54
(8) VOLT	−0.410*	−0.387*	−0.423*	−0.482*	0.333*	−0.079	0.027	1.000	1.82

***p < 0.01, **p < 0.05, *p < 0.1

All variable definitions are available in "Appendix A"

*, **, and *** show significance at 10%, 5%, and 1% level, respectively

Table 6 subcomponents of sustainability are regressed on performance along with control variables. In Regression (1), social sustainability with moderating effect of vertical integration is regressed on performance, social sustainability negatively affects the performance, but VI moderate the relation to positive at 1% confidence level. In Regression (2), environmental sustainability with moderating effect of vertical integration is regressed on performance, environmental sustainability negatively affects performance, but VI moderate the relation to positive at a 1% confidence level. In Regression (3), governance sustainability with moderating effect of vertical integration is regressed on performance, governance sustainability negatively affects the performance, but

Table 5 Main regression

Variables	(1) WoC	(2) WC	(3) Cluster
ESG	−0.001*	−0.002***	−0.002***
	(−1.91)	(−3.55)	(−3.57)
ESG*VI	0.002***	0.001***	0.001***
	(5.30)	(3.64)	(4.07)
FS		0.016***	0.016**
		(2.99)	(2.62)
DR		−0.164***	−0.164**
		(−6.85)	(−2.44)
FA		0.005	0.005
		(1.00)	(1.06)
RSP		0.841***	0.841***
		(4.89)	(3.18)
VOLT		−0.518***	−0.518***
		(−5.02)	(−2.77)
Constant	−0.001	0.044	0.044
	(−0.03)	(0.95)	(0.80)
Observations	585	581	581
Year & country fix	Yes	Yes	Yes
Adj R2	0.236	0.399	0.399
F-stat	13.56	20.74	19.77

All variable definitions are available in "Appendix A"

*, **, and *** show significance at 10%, 5%, and 1% level, respectively

Table 6 Regression

Variables	(1) WC	(2) WC	(3) WC
SOC	−0.001***		
	(−3.55)		
SOC*VI	0.001***		
	(3.32)		
ENV		−0.002***	
		(−3.92)	
ENV*VI		0.001***	
		(3.13)	
GOV			−0.001**
			(−2.56)
GOV*VI			0.001***
			(4.41)
FS	0.016***	0.020***	0.009**
	(3.15)	(3.66)	(2.20)
DR	−0.163***	−0.162***	−0.162***
	(−6.79)	(−6.76)	(−6.73)
FA	0.005	0.006	0.003
	(0.99)	(1.09)	(0.60)
RSP	0.842***	0.857***	0.828***
	(4.89)	(4.98)	(4.83)
VOLT	−0.522***	−0.532***	−0.504***
	(−5.04)	(−5.15)	(−4.91)
Constant	0.042	0.013	0.081**
	(0.92)	(0.27)	(1.97)
Observations	581	581	581
Year & country fix	Yes	Yes	Yes
Adj R2	0.397	0.397	0.401
F-stat	20.54	20.59	20.93

All variable definitions are available in "Appendix A"

*, **, and *** show significance at 10%, 5%, and 1% level, respectively

VI moderate the relation to positive at a 1% confidence level. These results corroborate hypotheses H_1 and H_2.

Discussion

This research study aims to find the impact of sustainability and its integral components, i.e., social, environmental and governance, on the firm performance of the oil and gas sector, with VI moderating the relationship between sustainability and performance. To fulfill the goals of the study, reliable publicized data about the top 10 oil and gas firms operating in leading oil-producing countries are taken as samples and regression is run, keeping performance as a dependent variable and sustainability as an independent variable. In contrast, a firm's size, age, debt ratio, stock volatility, and return on share price are identified as control variables for this study.

The regression results presented in Tables 6 and 7 reveal that sustainability alone is negatively related to performance. However, the interaction between sustainability and performance is moderated by VI in the case of the oil and gas sector. The study's findings support the first hypothesis that a relationship exists between sustainability and performance, and the second hypothesis that VI moderates the relationship between sustainability and performance is accepted. To further segregate the findings, the integral components of sustainability, i.e., social, environmental and governance, are also regressed on performance. The findings appear consistent with Alareeni and Hamdan [2], Duque-Grisales and Aguilera-Caracuel [24], Sial et al. [64], and Ramanathan [57] support our hypotheses H_{1a}, H_{1b}, and H_{1c}. An essential finding of the study is that VI moderates the relation between social, environmental and governance and performance, which supported hypotheses H_{2a}, H_{2b}, and H_{2c} and endorsed the findings of [1, 30, 65].

Research findings reveal that performance strongly correlates with company size and we can infer that bigger firms have more remarkable performance. This result is in line with some prior research showing that firm size is positively related to companies' performance [40, 54]. The debt ratio is negatively related with performance, supporting the theory that a higher debt ratio can be a

Table 7 Regression

Variables	(1) WC	(2) WC	(3) WC
ESG	−0.001***	−0.002***	−0.002***
	(−2.59)	(−3.55)	(−3.54)
ESG*VI	0.001***	0.001***	0.001***
	(3.00)	(3.64)	(3.65)
FS	0.017***	0.016***	0.016***
	(2.86)	(2.99)	(2.95)
DR	−0.168***	−0.164***	−0.164***
	(−6.48)	(−6.85)	(−6.86)
FA	0.006	0.005	0.005
	(0.95)	(1.00)	(0.99)
RSP	0.794***	0.841***	0.840***
	(4.15)	(4.89)	(4.89)
VOLT	−0.474***	−0.518***	−0.519***
	(−4.20)	(−5.02)	(−5.02)
RRR	0.032**		
	(2.29)		
OP		0.001**	
		(2.04)	
OD			−0.104
			(−0.45)
Constant	−0.002	−0.012	1.467
	(−0.04)	(−0.19)	(0.46)
Observations	520	581	581
Year & country fix	Yes	Yes	Yes
Adj R2	0.408	0.399	0.399
F-stat	18.11	20.74	19.63

All variable definitions are available in "Appendix A".

*, **, and *** show significance at 10%, 5%, and 1% level, respectively

burden [55, 56]. Firm age is positively related to performance, supporting the argument in prior studies that older firms have more experience, which helps them to perform well [9, 13]. RSP is positively linked with performance, indicating that higher RSP lead the oil and gas firm to good performance, and volatility is negatively related to performance, depicting it increases the risk.

The research findings are essential and reveal the importance of VI strategies for the oil and gas sector. The oil and gas sector is constantly criticized for its sustainability issue, more specifically, environmental sustainability. This study suggests that implementing VI strategies can improve the performance of the oil and gas companies if they also want to be sustainable along with the high performer. Our hypothesis can support the theory that adopting sustainability measure is not for profit gain; adopting sustainability measure incur some cost that will hamper the profit of the business firm. The study results reveal that even the individual components of sustainability are negatively related to performance. An interesting finding of the study that can play an essential part in policy recommendations for the oil and gas sector is that vertical integration strategy can play a crucial role in moderating the negative impact of sustainability and its components on performance. This research is a tremendous contribution for companies who want to be environmentally friendly and socially active; adopting sound governance and implementing the VI strategies can make them high achievers in the industry.

This research highlights the importance of VI in the oil and gas sector to make them more sustainable. The significant contribution of the study is that it suggests that firms can be more sustainable and high performers if the strategy of VI is adopted. So, this research is strongly connected with the synergy theory, the utilization of firm resources in a sustainable way for the benefit of all stakeholders. Not only shareholders but the society at large will benefit from such utilization of resources. Because of the significant impact of the oil and gas sector on the environment, the findings of this research study are of special importance for the oil and gas sector, but in general other firms can also be the beneficiary of this research.

Robustness

For the robustness of the study results, regression is run with some additional control variables of hydrocarbon reserve replacement ratio (RRR), oil price (OP), and oil demand (OD). The robustness results are shown in Table 7. These research findings further strengthen the argument with the actual research results shown in Tables 5 and 6. These results also confirm that sustainability is negatively related to performance, whereas VI moderated this relation, and the impact became positive for the oil and gas companies.

Conclusions

The current study examines the impact of sustainability on performance and the moderating effect of vertical integration on the relationship between sustainability and firm performance in the oil and gas industry. We use a sample dataset representing top oil and gas companies from top-ten oil-producing countries for 2011–2020. Using the pool-fixed regression analysis, we can identify that sustainability alone is negatively related to performance. However, VI moderated the relationship between sustainability and performance in the case of the oil and gas sector. Empirical findings of the study also confirm the significance of a firm's size, age, debt ratio and return on the share price for firm performance. The results indicate that bigger firms have more remarkable performance, while a higher debt ratio can burden on oil and

gas firm performance. Mature firms have more experience, which helps them to perform well in the oil and gas business, and higher return on share price leads the oil and gas firm to good performance.

The results suggest that implementing VI strategies can improve the performance of the oil and gas companies if they also want to be sustainable as a well high performer. The results support that oil and gas companies can better utilize their resources by combining the upstream, midstream, and downstream activities. Based on our results, it is recommended that the oil and gas companies' management adopt better strategies for maximum output from their existing resources through vertical integration of their assets, which will also help to improve the sustainability. The study results are also important for the oil and gas sector's policymakers and regulatory authorities to implement engineering and economic strategies at the organizational level.

Appendix A: variable explanation

Variable	Symbol	Definition	Reference
Dependent			
Performance	ROA	Net income divided by total assets. Return on assets is an accounting-based performance measure representing the firm's short-term profitability or management efficiency and providing direct information on how specific resource allocations lead to the firm's current profits	[46]
Independent			
Sustainability	ESG	Environmental, Social and Governance is a continuous process and action of humankind to protect and prevent the exhaustion of natural resources and keep environmental stability that does not allow the quality of living organisms to decline	[5, 19, 21]
Vertical integration	VI	Vertical integration is calculated as a dummy variable for whether a firm is vertically integrated or not. If a firm is performing only in one sector of operation, it is given as 1; if the firm is performing in two sectors, it is given as 2; and if a firm is performing in all three sectors, it is given as 3	[10, 53]
Control variable			
Firm size	FS	Natural log of total assets in the current year	[48, 49]
Firm age	FA	Natural log of firms age on the current period	[49]
Return on assets	ROA	Calculated as net income divided by total assets	[44]
Debt ratio	DR	Calculated as total debt divided by total assets	[44]
Oil price	OP	The spot price of a barrel of benchmark (WTI) crude oil in US Doller	[11, 16]
Oil demand	OD	Total consumption of hydrocarbons at country-level	[28, 32]
Hydrocarbon reserve replacement ratio	RRR	Reserves are added to a company's reserves base during a year to the amount of hydrocarbon produced	[4, 37]
Volatility	VOLT	The change in share price	[43, 66]
Return on share price	RSP	Calculated as the ratio of share price to last year share price	[35, 38]

Abbreviations

DR	Debt ratio
ESG	Economic, Social and Governance
FA	Firm age
FS	Firm size
OD	Oil demand (OD)
OP	Oil price
PERF	Firm performance
ROA	Return on assets
RRR	Hydrocarbon reserve replacement ratio
RSP	Return on share price
SUST	Sustainability
VOLT	Volatility

VI	Vertical integration
VIF	Variance inflation factor
WC	With control
WoC	Without control

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Availability of data and materials
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

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