

Research Article

Exploring the Potential of Big Data Analytics in Enhancing CSR in the Oil and Gas Industry

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Abstract

The oil and gas industry are increasingly under pressure to prioritize Corporate Social Responsibility (CSR) due to heightened environmental concerns, social scrutiny, and evolving regulatory demands. Big Data Analytics (BDA) presents a transformative opportunity to enhance CSR performance within this sector. This study investigates how BDA can improve CSR outcomes in the oil and gas industry, focusing on three key areas: environmental sustainability, social impact, and governance. By leveraging large datasets to uncover patterns, BDA can aid companies in refining their CSR strategies, forecasting and managing risks, and measuring impact more effectively. The study made use of a panel dataset containing total assets of ten years, as well as measurements based on accounting on investments, financial performance, and activity disclosures. The findings reveal that multinational corporations operating in developing countries pay considerable attention to various critical aspects of their CSR policies. Notably, there was a significant positive correlation between the sustainability of financial performance and investments in CSR practices. However, no significant correlation was found between CSR disclosure and financial performance ($p = 0.792373 > 0.05$). The report concludes by providing empirical evidence supporting the hypothesis that effective CSR practices lead to long-term financial benefits for multinational oil and gas companies. Such practices are beneficial for poverty reduction programs and are crucial for achieving sustainable development goals in emerging economies where these companies operate.

Keywords

Big Data Analytics, Corporate Social Responsibility (CSR), Decision-making, Oil and Gas Sector, Oil Producing Communities

1. Introduction

Growing attention is being directed toward assessing the impact of greenhouse gas (GHG) emissions on both the current and future state of the environment. The release of greenhouse gases, particularly carbon dioxide (CO₂), has been linked to the intensification of the greenhouse effect, which subsequently affects Earth's temperature. This temperature

rise, often referred to as global warming, poses a significant threat to the environment [1]. Human activities are the primary drivers of the persistent increase in GHG levels in the atmosphere. To mitigate future environmental challenges, CO₂ emissions one of the main contributors to the greenhouse effect must be reduced to approximately 1.3 tonnes per person

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by 2050 [2]. However, in Malaysia, CO₂ emissions per capita have surged, projected to reach 12.1 tonnes per person, raising critical concerns about the sustainability of the ecosystem [8]. Therefore, reducing GHG emissions and promoting sustainable development should be a top priority for businesses and stakeholders across various sectors [3].

The use of fossil fuels is one of the primary contributors to CO₂ emissions. Many oil-rich countries, with their vast reserves of oil and gas, have leveraged these resources to drive economic growth and generate significant revenue. As the economy has expanded, the consumption of oil and gas has also surged, further fuelling the nation's growth [1, 3]. For instance, Malaysia's energy mix has become increasingly reliant on petroleum and oil, with fossil fuels dominating the country's energy supply. This dependence presents challenges, such as the depletion of fossil fuel reserves and inefficient energy usage [4]. Therefore, improving energy efficiency is critical as it can promote the sustainable and effective utilization of non-renewable resources. Enhancing efficiency will also play a vital role in addressing the rise in greenhouse gas emissions [5, 6].

Industry 4.0 is anticipated to play a key role in advancing energy efficiency. The adoption of smart technologies in areas such as energy generation, transmission, and distribution can lead to significant improvements in efficiency. Big data is considered a major enabler of these smart technologies making its integration crucial for enhancing energy efficiency. However, effectively contextualizing big data has proven challenging, and its full potential in driving energy efficiency improvements has yet to be fully realized [7, 8].

The oil and gas sector is known for operating in line with business ethics that prioritize sustainability [9]. The industry has increasingly embraced various codes of practice, such as corporate social responsibility (CSR), community engagement, environmental conservation, product stewardship, financial transparency, and the protection of stakeholder rights [4, 10]. According to the Global Reporting Initiative (GRI) and the United Nations Global Compact Report (UNGCR), state that multinational companies in this sector have taken the lead in establishing codes of conduct and responsible corporate practices by addressing key environmental and social concerns. Companies such as ChevronTexaco, ExxonMobil, Shell, BP-Amoco, ENI, Occidental, Tullow, and Total-Fina-Elf, which have significant interests and assets in emerging economies, are actively involved in these efforts. Their impact is especially noticeable in Africa, where they play a significant role in the region's economy as employers, providers of foreign direct investment (FDI), and intermediaries for the transfer of skills and technology [11]. Beyond their core business activities, these companies play a vital role in generating governmental revenue in the countries where they operate. Moreover, their development initiatives in areas such as infrastructure, education, and healthcare have a profound impact on emerging countries, where energy, transportation, trade, and

agriculture are crucial sectors. The significance of these industries cannot be overstated, as they are often the backbone of the local economy [12].

Although the "Acts of God" concept may suggest that oil and gas companies engage in responsible behavior out of goodwill, there is substantial evidence indicating that many multinational corporations prioritize highly profitable ventures at the expense of environmental integrity, using corporate social responsibility (CSR) as a façade for unethical practices. This view is supported by the stakeholder hypothesis, which posits that effective CSR enhances a company's reputation, allowing it to leverage superior marketing strategies to attract socially conscious stakeholders and customers. Over time, this strategy enables international corporations to maintain steady revenue streams [13]. There is compelling evidence that these corporations derive financial and other benefits from their CSR initiatives. While some advocates argue that CSR can boost business profitability, critics contend that when oil and gas multinationals become overly invested in CSR, they may lose sight of their core responsibility to operate sustainably. Instead, they may exploit CSR as a convenient cover for social neglect and environmental degradation in pursuit of economic gains [10, 13]. A substantial body of evidence indicates that Tullow Oil PLC, a global corporation, has empowered local businesses in Ghana and Uganda through large-scale expenditures on local content creation and education [13]. Similarly, international corporations such as Chevron Texaco and British Petroleum (BP) have made notable contributions to Angola by investing in the country's educational system and supporting the fight against AIDS. Companies such as Eni, Shell, Chevron Texaco, Total, and PetroChina have significantly influenced Nigeria's GDP growth trajectory. These corporations also oversee various community development projects in Nigeria, focusing on transportation, education, healthcare, and agriculture [14]. In South Africa, BP-Amoco and Shell have facilitated capital and technology transfers, created markets for exports, and ensured the supply of imports. In a similar vein, the economies of Chad, Gabon, Sudan, South Sudan, Algeria, and Libya have been dependent on earnings from ExxonMobil, Eni, and Petronas. Additionally, Eni and ExxonMobil have made significant financial contributions, created substantial employment, and boosted GDP in Equatorial Guinea and the Democratic Republic of the Congo [14].

Over 2 decades, corporate social responsibility (CSR) has gained considerable traction and is now widely recognized as a framework encouraging businesses to address social and environmental issues within their daily operations while voluntarily engaging with stakeholders [15]. According to Shayan et al, (2022) [10], CSR initiatives often reflect the societal obligations that accompany corporate success. However, the responsibility for executing these duties largely falls on the company itself and is often shaped by its financial performance. This underscores the mandated nature of CSR, holding firms accountable for actively involving society in

addressing pressing issues [13]. Another perspective frames CSR within the "triple bottom line" approach, which emphasizes people, planet, and profit (PPP). This approach broadens CSR's scope to include multiple factors useful in measuring the performance of companies engaged in CSR activities [16]. As a result, oil and gas multinationals are in a unique position to collaborate with communities within their operational regions to address social issues, with poverty alleviation being a key focus, rather than merely pursuing excess profits. Businesses increasingly view CSR as a strategic differentiator that can enhance value creation for both the company and its customers. In the long run, this approach may also contribute to improved financial outcomes for the firm itself [17].

Recent research based on the enlightened shareholder (ES) approach suggests that companies can gain both financially and in other ways through their CSR efforts. For oil and gas multinationals to maximize long-term financial returns, they must consider a broad spectrum of social and environmental issues [14]. However, CSR critics argue that companies engaging in such initiatives risk losing focus on their core business objectives, dismissing these efforts as mere superficial gestures. Their theory suggests that strict compliance intended to maintain returns may falter due to the risk associated with the cost of equity capital when CSR is not factored into pricing [18]. Another viewpoint by Ismael and Yesiltas (2020) [13] supports this, asserting that CSR issues cannot be accurately priced based solely on theoretical grounds. This study aligns with the proponents of this perspective, emphasizing that the outcome will be determined by how investors perceive the importance and impact of CSR's goals and principles.

The CSR Instrumental Theory (IT), which emphasizes how companies can achieve financial objectives through social efforts, serves as the foundation for this study. Proponents of this theory aim to maximize long-term shareholder value by positioning social investments within a competitive framework. They highlight the strategic marketing and resourcefulness of oil and gas companies in their ability to capitalize on natural resources like hydrocarbons [19, 20]. This could explain why some believe that investing in and disclosing CSR efforts can enhance a company's financial performance. According to Gutterman (2024) [19], multinational corporations' approach to Corporate Social Responsibility (CSR) is shaped by ethical and integrative CSR theories, influencing their investment decisions, definitions of social responsibility, and commitment to human rights, labor rights, and environmental sustainability. Ethical theories emphasize fundamental rights and the common good, urging businesses to act morally. According to Ashrafi et al, (2020) [21], companies have a fiduciary duty to prioritize the interests of their stakeholders, which includes upholding labor and civil rights, safeguarding the environment, and promoting sustainable practices that benefit both business and society. Balancing human growth with intergenerational needs is the

aim, ensuring a sustainable future for all. The integrative perspective, meanwhile, focuses on how companies respond to political and social challenges, adhere to policies, and manage social performance. It builds on a firm's public responsibilities, stakeholder management, and corporate social performance, ensuring a balance between social legitimacy, business interests, and appropriate responses to societal challenges [22].

This study seeks to explore the factors motivating major oil and gas companies to invest heavily in corporate social responsibility (CSR) disclosures. It aims to provide empirical insights into the CSR practices and activities of multinational corporations operating in developing countries. The research will employ accounting-based methods to assess how CSR disclosure and investment influence the financial performance of these companies in emerging markets. This study will examine the Corporate Social Responsibility (CSR) initiatives of international oil and gas companies in Africa, evaluating how these strategies impact the long-term financial success of their investments on the continent. The findings are expected to enhance understanding of the linkages between CSR investments, disclosures, and the financial sustainability of multinational oil and gas operations. This research aims to bridge the knowledge gaps in CSR initiatives and offer actionable guidance for managers and decision-makers to develop transparent social performance strategies, enhancing the long-term sustainability of multinational oil and gas companies.

2. Methodology

This study utilized a mixed-methods approach, combining both qualitative and quantitative research techniques. Qualitative data were analyzed through inductive methods to understand the CSR practices of major oil and gas multinational corporations operating in emerging markets. Quantitative data were used to evaluate the CSR investments and financial performance of nine multinational oil and gas firms operating in Africa to test the premise that CSR initiatives improve financial success. This strategy sought to explore how these businesses' CSR actions affect the long-term viability of their financial results [23]. Using secondary data, the study investigated the effects of CSR investments and disclosures on financial performance in a descriptive manner. It also explored correlations and interactions between the variables. A comparative analysis and contextual framework were developed using various secondary data sources focusing on the impact of CSR disclosures on the financial performance of enterprises in developing countries. Nine companies were selected based on data availability for the period 2014–2024, given the numerous global oil and gas firms with significant operations in Africa [24]. A 10-year panel dataset was created by integrating data on CSR investments and disclosures, financial performance, and sustainability indicators from

audited financial statements, sustainability reports, and annual reports. This dataset was used to develop and evaluate a behavioral model based on [25, 26]. The regression model statement is provided below.

$$YP_{xt} = \alpha_0 + \alpha_1 CSRIV_{xt} + \alpha_2 CSRDC_{xt} + \alpha_3 TAST_{xt} + \varepsilon_{xt} \quad (1)$$

where YP_{xt} is the financial outlook (dependent variable) for oil and gas multinational business x at time t , as measured by turning on assets [17]. Oil and gas multinational business x 's CSR investments are shown in $CSRIV_{xt}$, and its CSR disclosures are indicated in $CSRDC_{xt}$ at time t . $CSRIV_{xt}$ and $CSRDC_{xt}$ are the intrinsic variables in the model [25]. To regress the firms' current year's financial performance and represent their true impact on the operations, the natural log of actual spending on CSR activities that were published in prior annual reports were examined. From [25], it can be inferred that the impact of the companies' present CSR investments are anticipated to have a real impact on their financial performance in the next year. If firm ' x ' clearly discloses CSR activities in its annual report, then $CSRDC_{xt}$ a dummy variable in this model is assigned a value of '1'. If not, the company receives a value of '0'. The natural logarithm of the assets at period t is used to calculate $TAST_{xt}$ or total assets of oil and gas multinational firm x . This operationalization is considered crucial to control variance in the dependent variable. The model defines the error for company x at time t as ε_{xt} , the intercept as α_0 , and the coefficients for the firms' explanatory variables, $CSRIV_{xt}$ and $CSRDC_{xt}$ as $\alpha_1 - \alpha_9$.

2.1. The Impact of CSR on Financial Risk and Return

For businesses to disclose their CSR activities, the legitimacy theory (LT) of CSR serves as the cornerstone and according to this theory, multinational oil and gas corporations are expected to operate within a framework that implies a social contract, which is crucial for their continued existence. Their involvement in CSR activities and the extensive disclosure of these initiatives act as signals of their legitimacy within society. As noted in [27, 28], such disclosures also serve as a platform for these multinational corporations to enhance their public image, encourage competition, make sure things are sustainable, and keep the public's opinion favorable. Essentially, CSR disclosures assist businesses acquire access to capital markets, reduce the risk of adverse selection, and win over the community and consumers by making their goods and services more visible. All of these international oil and gas firms that operate in developing countries, especially in Africa, have proven this potential.

There are two main methods to measure the relationship between corporate social responsibility (CSR) and business financial success, as mentioned in [29]: the accounting

method and the market-based approach. Every approach has advantages and disadvantages of its own. To investigate the relationships between CSR , financial performance (FP), and firm size, profitability across various enterprises can be evaluated. Other financial metrics such as profit margin (PM), return on equity (ROE), return on sales (ROS), and return on investments (ROI) are also applicable, though [30] prefer to use the return on assets (ROA) ratio for these kinds of analyses. These metrics help assess the internal operational efficiency of a company, claims [31]. Accounting metrics are widely utilized because they are simple to compute and understand, but because they rely on past performance data, managerial judgment and variations in accounting procedures may have an impact on them [32].

Moreover, market-based indicators can be used to evaluate the connection between business financial performance and social responsibility, specifically by evaluating a company's share performance. Many Studies found no significant benefit from CSR efforts when analyzing stock market performance through a mix of individual stocks and overall buy-and-hold portfolios for socially responsible companies. However, other research compared the share price fluctuations of multinational corporations that engage in CSR with those that do not, based on the impact of CSR [32]. The findings indicated that companies practicing effective stakeholder management saw improvements in their share prices. In short, market-based metrics are advantageous as they are less susceptible to administrative manipulation. Additionally, this approach has the benefit of evaluating perceptions of a company's future performance rather than focusing solely on past events. Consequently, stock performance offers valuable insight into how investors are likely to view a company's future activities.

Comparisons of CSR disclosures across different industries may vary significantly, with emerging economies showing notably low levels of CSR reporting. For example, Ghana's breweries and Nigeria's listed companies provided minimal CSR disclosures. A survey by [11] revealed that global company disclosure of CSR initiatives increased from 50% in 2015 to 95% in 2020, evolving into a key standard for ensuring sustainability in the extractive industries. This rise in reporting is largely attributed to stakeholder expectations and pressure for environmental sustainability, particularly within the multinational oil and gas sector. However, the limited number of companies that undergo independent verification of their reports makes it challenging to empirically determine whether CSR performance data in the oil and gas industry is over-reported or underreported, despite the increased prevalence of CSR disclosures. Moreover, there is a dearth of information regarding the relationship between corporate financial success and CSR disclosure, particularly in developing countries. This gap highlights the need for additional study on the subject at hand.

2.2. Data Analysis

The data panel was examined using SPSS (24th edition), commencing with a descriptive analysis to calculate means and standard deviations for each variable. Subsequently, multiple regression analysis was employed to assess the impact of CSR disclosure and actions on financial sustainability. Additionally, Pearson correlation analysis was utilized to investigate the empirical relationship between the variables, and potential multicollinearity issues among the independent variables were also assessed. To evaluate the study's hypotheses, the Wallace and Hussain estimator of component variances was utilized. Panel data analysis is thought to be better than conventional cross-sectional or time-series data sets because it can test intricate behavioral models, decrease collinearity between explanatory factors, and increase data points, which improves the degrees of freedom. Content analysis was done on purpose-selected secondary data and annual reports of multinational oil and gas companies to look at their CSR policies. A sustainability benchmarking methodology was then selected, based on [25]

to assess the CSR efforts of the sampled organizations across seven key areas: commitment to CSR, CSR spending, community, environmental considerations, workplace, marketplace, and CSR reporting. The benchmark assessment was conducted using a Likert scale ranging from 1 to 5, where 1 represented no activity highlights, 2 low activity highlights, 3 some activity highlights, 4 high activity highlights, and 5 very high activity highlights in Table 2. Table 1 outlines the main CSR practice areas and corresponding evaluation criteria.

No major ethical issues are anticipated due to the broad usage of publicly available secondary data from multinational oil and gas businesses. The data for this study was sourced from publicly accessible channels, including websites, annual reports, and other publications from multinational corporations operating in Africa [33]. Additionally, all ethical considerations related to the lawful access and use of books, articles, and other referenced materials have been appropriately addressed through in-text citations and proper referencing throughout the study.

Table 1. A Comprehensive Assessment of CSR Practices in Oil and Gas Multinationals.

Essential CSR procedures	Criterion for Assessment
Commitment to CSR activities	Considering how global oil and gas corporations incorporate corporate social responsibility (CSR) into their business plans and their fervent commitments to CSR practices
Environmental aspects	The evaluation is predicated on how transnational oil and gas corporations handle environmental concerns associated with their primary operations, namely energy usage and emissions, biodiversity, noise pollution, dust, depletion of water supplies, climate change, and recycling.
CSR spending	evaluates the amount of money that oil and gas multinational corporations spend on CSR initiatives as well as their claimed financial commitments.
Work environment	Multinational oil and gas businesses' commitment to their workers' evaluation is based on issues related to child labor, health and safety, human rights, equal opportunity, diversity, work-life balance, training and development, pay and benefits, and these areas.
Market environment	evaluates the effects that a company's goods and services have on society and the economy, as well as how the firm uses CSR initiatives to boost its brand and competitive edge and its relationships with outside organizations.
The Community	evaluates corporate social responsibility (CSR) efforts that are centered on stakeholder engagement and the communities where multinational oil and gas corporations operate.
CSR reporting	The foundation for assessing CSR reporting is how frequently international oil and gas companies publish information about their CSR initiatives and make them accessible to the public through print and digital media.

Table 2. CSR Benchmarking Assessment Scale.

1	2	3	4	5
No highlight activities	Low extent	Some extent	High extent	Very high extent

3. Results and Discussions

3.1. Sustainable Operations in Oil and Gas Multinationals' Environmental CSR Practices

Table 3 illustrates the performance of multinational oil and gas firms operating in Africa over the past decade, evaluated across seven benchmarked categories: A. Commitment, B. Spending, C. Community, D. Environment, E. Workplace, F. Marketplace, and G. CSR reporting. These domains reflect the firms' dedication and outcomes related to their CSR agendas. The sustainability benchmarking framework, adapted from [25] was used to assess the CSR practices and activities of these corporations within these seven key areas. The study's conclusions show that all multinational oil and gas businesses in the sample, especially those with operations in underdeveloped nations like Africa, are dedicated to making CSR efforts in these key areas. The data largely shows a strong focus on environmental considerations in their operational contexts.

Other CSR factors, such as expenditure, community involvement, workplace conditions, marketplace engagement, and reporting, were also given substantial attention, each achieving scores above 30 as shown in Table 3. The marketplace, with a score of 37 out of a possible 47, was the lowest-priority CSR area (Sum = 37) while the environment had the highest score. This lower score could be attributed to the oil and gas sector's long-standing focus on environmental protection, community engagement, and employee welfare, which often takes precedence in their CSR efforts. The data lends strong support to the argument made by [34] that the oil

and gas sector is uniquely positioned to prioritize corporate social responsibility and business ethics, particularly in areas such as sustainability, stakeholder engagement, environmental protection, employee rights, human rights, and transparency. Furthermore, additional research reinforces this notion, showcasing the proactive efforts of oil and gas corporations in engaging with local communities and leading the development of robust corporate practices and workplace codes of conduct that set industry standards.

The CSR benchmarking assessment scale in Table 2 was utilized to evaluate, aggregate, and rank the CSR practices and activities of multinational corporations in Table 1. The findings reveal that ExxonMobil and Shell's overall scores were separated by two points 37 and 35 respectively as shown in Table 3. Despite this close result, ExxonMobil secured the top position as shown in Figure 1 as both companies achieved scores ranging from "to a very high extent" of 5 points to "to a high extent" of 4 points in their CSR practices and activities, as outlined in their sustainability reports. Meanwhile, Eni, BP, Chevron, and Tullow each earned 32, 33, 34, and 35 points respectively out of 37 points in CSR activity and practice performance. Using the same benchmarking framework, they were assessed on a scale of 1 to 5 (1 = Does not highlight activities, 2 = To a low extent, 3 = To some extent, 4 = To a high extent, and 5 = To a very high extent) across six key assessment areas as shown in Figure 1, and Table 3. These firms were ranked third, fourth, fifth, and sixth, respectively. Conversely, Total, Sinopec, and Petronas ranked lowest, placing seventh, eighth, and ninth, respectively. This outcome suggests that these companies may need to reassess their CSR investments and consider reallocating resources to improve their impact and performance.

Table 3. Core CSR ratings activities and practices. Source: Based on field data.

Oil and gas company	Core CSR activities and practices rating							Cumulative aggregate score	Ranking
	A	B	C	D	E	F	G		
Chevron	5	4	5	6	5	4	5	34	Fifth
BP	5	5	5	6	4	4	5	34	Fourth
Tullow Oil	5	5	4	5	5	4	4	32	Sixth
ExxonMobil	5	6	5	6	5	5	5	37	First
Eni	5	5	5	6	4	4	4	33	Third
Shell	5	5	5	5	5	5	5	35	Second
Total oil	5	3	4	6	4	5	4	31	Seventh
Petronas	5	4	4	5	4	3	4	29	Ninth
Sinopec	5	5	4	4	4	4	4	30	Eighth
Sum	45	43	41	47	40	37	41		

A= commitment, B = spending, C = community, D= environment, E = workplace, F= market place, G = CSR reporting

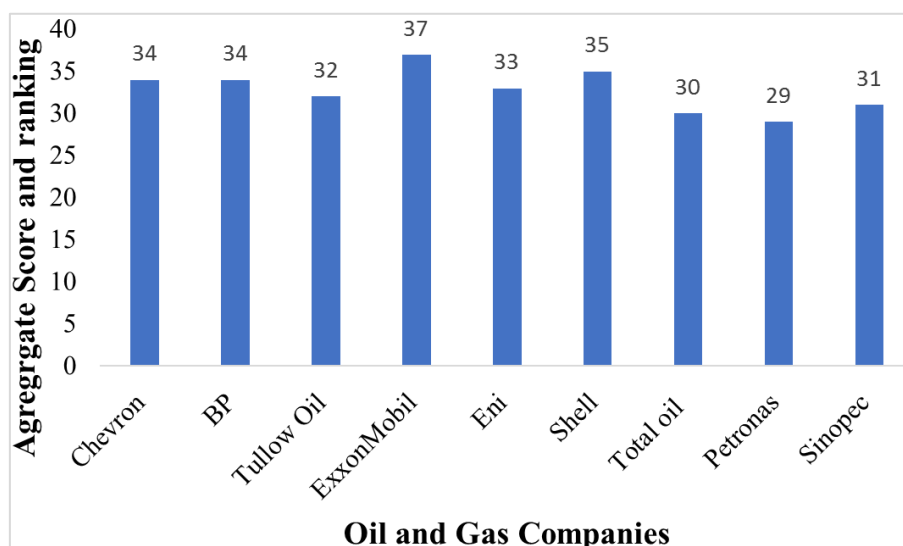


Figure 1. Ranking of CSR activities and practices.

3.2. Descriptive Analysis

The model's dependent and independent variables are described by their mean scores, standard deviations, and skewness distributions. A negatively skewed distribution has a left tail, while a positively skewed distribution has a right tail. According to this study Table 4 shows the profitability margin (YP) of multinational corporations with interests in Africa has a mean score of 16.01, reflecting a healthy margin. This variable shows a flattened peak with right-tailed skewness (Skewness = 0.21). The mean CSR investment score (CSRIV) is 2.98, indicating consistent CSR investments over time. CSRIV exhibits a pronounced peak with a negatively skewed distribution (Skewness = -1.41). The mean CSR disclosure score (CSRDC) is 1.00, suggesting ongoing reporting of CSR activities. This score is expected to improve progressively as multinationals enhance their reporting quality and extent each year.

The total assets (TAST) have a mean value of 5.98, characterized by a flattened peak distribution and, negative skewness (Skewness = -0.58)

To assess the correlation between the model's variables and to check for collinearity disturbances, the correlation matrix was calculated in Table 5. The results reveal a significant correlation between CSR investment (CSRIV) and both the scale of multinational corporations (TAST) and financial performance (YP), with p-values of 0.0048 and 0.0031, respectively. Table 5 also indicates a negative correlation between YP and both TAST and CSRIV, with correlation coefficients of -0.3028 and -0.3164, respectively. According to [35], the regression estimates are considered reliable since no significant correlation was observed among the independent variables (TAST, CSRIV, and CSRDC). This finding suggests that multi-collinearity is not a concern in this analysis.

Table 4. Descriptive analysis of variables. Source: Based on field data.

Descriptive analysis	YP	CSRIV	CSRDC	TAST
Mean	16.01	2.98	1.00	5.98
Median	17.20	2.89	1.00	5.87
Maximum	3.10	3.01	1.00	5.89
Minimum	4.90	2.97	1.00	6.01
Std. Dev	8.21	0.20	0.00	0.31
Skewness	0.21	- 1.41	0.00	- 0.58
Sum	1498.4	2914.49	98	598.98
Observations	98	98	98	98

Table 5. Correlation and collinearity analysis. Source: Based on field data.

Correlation probability	TAST	CSRIV	CSRDC	YP
TAST	1.00			
CSRIV	0.4028	1.00		
CSRDC	0.2009	0.1988	1.00	
YP	- 0.3028	- 0.3164	- 0.132	1.00

3.3. Effect of CSR and CSR Disclosure on Financial Performance

To provide empirical evidence on how CSR investment

and disclosure impact the financial sustainability of oil and gas multinationals in Africa, the study used model estimation analysis to assess how CSR disclosure affected financial performance. Initially, the research assessed whether funding CSR initiatives had a positive or negative effect on financial performance. It then looked into how financial performance would be affected by revealing such activities.

In Table 6, a two-way panel model with fixed and random effects was used, with the Wallace and Hussain estimator of component variances applied at the 0.05 significant level. To determine the appropriate model, the Hausman specification test was conducted based on [36], with recommendations to use the fixed effects model if $p < \text{chi-square} < 0.05$, and the random effects model if $p > \text{chi-square} > 0.05$. Using this method, the impact of CSR investment and disclosure (independent factors) during ten years on financial performance (dependent variable) could be measured. The Hausman test confirmed the suitability of the random effects

model, as it showed no significant correlation ($p = 0.792373 > \alpha = 0.05$) between the person-specific random effects and the independent variables in Table 6, indicating that the random effects model is appropriate for analyzing the data. The study's assumptions were subsequently validated using the Wallace and Hussain panel analysis, with the results presented in Table 6. These findings suggest that the model effectively explains the variations in the dependent variable (YP), demonstrating a strong fit. Additionally, the Durbin-Watson Test was employed to examine the autocorrelation of the predictor variables, ensuring the robustness of the analysis. The test has a range of zero to four, with a score of two denoting no autocorrelation, according to the reference [25]. A result of 2.0 indicated that the model satisfied the independent residuals assumptions and that there was no substantial problem with collinearity among the predictor variables.

Table 6. Hausman test with fixed and random effects.

Test Summary	Chi. Sq. statistic	Chi. Sq. df	Probability
Random cross-section	1.39867	2	0.4995
Period random	0.000013	2	1.00000
Cross-section and Period random	0.90654	2	0.792373

4. Conclusions and Recommendations

This study has examined the extensive potential of Big Data Analytics (BDA) in advancing Corporate Social Responsibility (CSR) within the oil and gas industry. By harnessing BDA, companies can refine their CSR strategies, anticipate and address risks, and evaluate their impact more precisely. The findings reveal that global oil and gas corporations operating in developing countries, especially in Africa, are deeply committed to all aspects of CSR. These businesses have established themselves as leaders in the industry by upholding international standards and best practices in the seven benchmarked key areas of corporate social responsibility. The study highlights that these corporations are continuously enhancing their CSR initiatives each year, which positively affects their stakeholder interactions and environmental performance. Despite this progress, companies that performed poorly on the CSR scale are facing increasing pressure to align with international standards to rebuild investor confidence. A significant positive correlation was found between CSR investments by multinational corporations in emerging markets and their financial performance. The consistent

application of CSR policies over the ten-year study period suggests that CSR has positively influenced financial success, contributing to performance and sustainability. Effective CSR investments also allow businesses to focus on their primary business oil and gas production possibly increasing output and financial performance in addition to building strong relationships with host communities and stakeholders. The study recommends that oil and gas multinationals, especially those in less developed emerging economies, continue to invest in CSR to maximize their impact on local communities. To provide a more comprehensive evaluation, future research should expand the model to include additional CSR dimensions such as environmental impact, community engagement, marketplace conduct, and workplace issues. Incorporating market-based performance metrics alongside accounting measures could offer a clearer picture of the true effects of effective CSR practices on multinational oil and gas firms.

Abbreviations

BDA	Big Data Analytics
CSR	Corporate Social Responsibility
LT	Legitimacy Theory

PM	Profit Margin
FP	Financial Performance
ROE	Return on Equity
ROS	Return on Sales
ROI	Return on Investments

Data Statement

No/Not applicable (this manuscript does not report data generation or analysis).35

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Conflicts of Interest

The authors declare no conflicts of interest.

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