



The Impact of Capital Expenditure for Sustainability Technology on Profit per Barrel of Oil Equivalent (BOE) with ROA as a Moderator: A SEM-PLS Approach

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Abstract

This study addresses the gap between the theoretical expectation that sustainability investments enhance financial performance and the lack of observed direct impact, raising the question of whether such expenditures directly improve profitability. The study aims to examine the impact of capital expenditure on sustainability technology on profitability, measured by profit per BOE, focusing on the energy company ENI during the 2018–2022 period, with ROA as a moderating variable. Using a quantitative approach with the SEM-PLS method, this research analyzes five years of company data (2018–2022) to explore the relationships between variables. The novelty lies in challenging common assumptions by revealing that the moderating effect of ROA and the direct influence of capital expenditure on profit per BOE are not significant, highlighting an underexplored area in sustainability investment research. The findings indicate that although the model explains 90.9% of the variability in profit per BOE, the anticipated financial benefits of sustainability investments are not directly evident, suggesting a misalignment between theoretical assumptions and practical outcomes. This study concludes that while sustainability investments are essential for long-term objectives, their short-term profitability requires further investigation, providing practical insights for corporate decision-making and policy development.

Keywords: Return on Assets, Profit per Barrel of Oil Equivalent, Capital Expenditure for Sustainability Technology, SEM-PLS

INTRODUCTION

The transition to clean energy has become a global priority, making capital expenditure (CapEx) on sustainable technology increasingly crucial for energy companies. The drive to reduce carbon emissions and meet sustainability targets set by international agreements, such as the Paris Agreement, compels energy firms to allocate substantial investments in environmentally friendly technologies. However, challenges such as global economic uncertainty, energy price volatility, and the impact of geopolitical conflicts, such as the Russia-Ukraine war, further complicate CapEx management. In the short term, high CapEx can strain profitability and ROA, as noted by Neves et al. (2021) and Kim et al. (2020). However, if managed with the right strategy, these investments have the potential to deliver long-term benefits in terms of operational efficiency, competitiveness, and business sustainability, as emphasized by Kwistianus and Juniarti (2022). Therefore, energy companies must balance short-term investment needs with a long-term sustainability vision to remain relevant and competitive in this energy transition era.

The urgency of research on the impact of capital expenditure on sustainable technology on profit per barrel of oil equivalent (BOE), moderated by return on assets (ROA), in energy companies from 2018 to 2022 is reinforced by the growing importance of sustainable practices in the energy sector. Capital expenditure is critical for enhancing

operational efficiency and profitability, as evidenced by studies showing that such investments can significantly influence firm performance and long-term profitability (Kwistianus & Juniarti, 2022; Kim et al., 2020). Furthermore, the role of ROA as a moderating variable is crucial, as it has been shown to influence the relationship between capital expenditure and financial performance, highlighting the need for energy companies to optimize their investment strategies (Noor et al., 2022; Tekin, 2022). The context of oil price fluctuations and the ongoing transition to sustainable energy sources further underscores the necessity of this research, as companies must navigate these challenges to maintain competitiveness and profitability (Macovei, 2023; Rheynaldi, 2023). Thus, understanding these dynamics is essential for informing strategic decisions in the energy sector.

Examining the impact of capital expenditure on sustainable technology on profit per barrel of oil equivalent is crucial for long-term sustainability and stakeholder engagement, as it addresses immediate challenges in transforming such investments into profitability. This is also supported by empirical evidence indicating that capital investments can initially have a negative impact on financial performance, with positive outcomes materializing in the long term (Janjić et al., 2022; Grozdić et al., 2020). Moreover, increasing support from stakeholders and regulators for companies adopting sustainable practices highlights the critical need for energy firms to allocate these investments wisely to enhance return on assets (ROA) and overall financial viability (Hapsari, 2019; Moser et al., 2021). This research is essential for understanding how to balance immediate financial pressures with the strategic imperative of sustainability in the energy sector.

The research gap in understanding the impact of capital expenditure on sustainable technology on the profitability of energy companies through the moderating role of return on assets (ROA) remains limited, despite the relevance of this issue in the clean energy transition era (Anasthasya et al., 2022; Bodhanwala & Bodhanwala, 2018). Previous studies suggest that sustainable investments can enhance profitability, but empirical research specifically exploring the effect of capital expenditure on ROA and the profitability of energy companies is still scarce (Erhinyoja & Marcella, 2019). This gap highlights the importance of developing a more comprehensive theoretical framework to understand the relationship between capital expenditure, sustainable technology, and the financial performance of energy firms.

According to the Resource-Based View (RBV) theory, investment in sustainable technology can be considered a strategic resource that provides a competitive advantage for energy companies (Barney, 1991). However, previous literature has primarily discussed the general impact of sustainable investments on firm performance, while the role of ROA as a moderator in relation to profit per BOE remains underexplored. This study aims to fill that gap by highlighting how effective resource management, such as capital expenditure on sustainable technology, can enhance operational efficiency and long-term profitability.

Research Problem Statement

This study seeks to address two key research questions:

- a. How does capital expenditure on sustainable technology affect corporate profitability, measured through profit per BOE (Barrel of Oil Equivalent) in ENI Energy during the 2018–2022 period?
- b. To what extent does ROA moderate the relationship between capital expenditure on sustainable technology and profit per BOE in ENI Energy?

Research Objectives

- a. To analyze the effect of capital expenditure on sustainable technology on corporate profitability, measured through profit per BOE in ENI Energy during the 2018–2022 period.
- b. To examine the role of ROA as a moderating variable in the relationship between capital expenditure on sustainable technology and profit per BOE.

Research Contributions

Theoretical Contribution: This study contributes to the literature on sustainable investment management in the energy industry.

Practical Contribution: This research can assist energy company management in making better strategic investment decisions regarding sustainable technology, particularly in enhancing corporate profitability.

The structure of this study will include a review of relevant literature, the proposed theoretical model, data analysis, key findings, and theoretical and practical implications of the results, concluding with recommendations for future research.

LITERATUR REVIEW

A. The Effect of Capital Expenditure on Sustainable Technology on Profit per BOE

Capital expenditure directed towards sustainability initiatives can lead to significant improvements in profitability metrics. For instance, research indicates that a 1% increase in environmental activities correlates with a 1.3% increase in Return on Assets (ROA) for multinational oil and gas companies (Promise, 2024). This finding suggests that investment in sustainability is not merely a cost but can yield substantial benefits, thereby enhancing profit per BOE. Furthermore, sustainability reporting has been shown to have a significant impact on the financial performance of publicly listed oil and gas companies, indicating that transparency in sustainability efforts can attract investors and enhance market performance (Ibrahim et al., 2021).

Moreover, the relationship between foreign direct investment (FDI) and the revenue of the oil and gas sector highlights the importance of capital inflows in enhancing productivity and profitability. FDI not only increases capital supply but also facilitates knowledge transfer, which can lead to improved operational efficiency and, consequently, higher profit per BOE (Huseynli, 2023). This is particularly relevant as oil and gas companies increasingly seek to adopt advanced technologies that promote sustainability, thereby aligning their operational practices with global sustainability goals.

Furthermore, strategic capital allocation to sustainable technology can mitigate risks associated with environmental regulations and market volatility. Companies that proactively invest in sustainability are better positioned to navigate the regulatory landscape and shift consumer preferences toward more environmentally friendly practices. This proactive approach can lead to increased brand loyalty and market share, ultimately resulting in enhanced profitability (Musfialdy et al., 2020; Krystella et al., 2020).

The financial implications of sustainability investments are also evident within the broader economic environment. For instance, during periods of economic downturn, companies that have invested in sustainable practices tend to exhibit greater resilience, as they are able to adapt more swiftly to changing market conditions. This adaptability can lead to sustained profitability even in challenging times, further reinforcing the positive correlation between sustainability capital expenditure and BOE (Anis, 2022).

In conclusion, the available evidence strongly supports the notion that capital expenditure on sustainable technology positively impacts profit per BOE in oil and gas companies. By improving operational efficiency, attracting investment, and reducing risk, these investments not only contribute to environmental goals but also strengthen financial performance. Based on the above explanation, the following hypothesis is formulated:

H1: Capital expenditure on sustainable technology positively affects profit per BOE in oil and gas companies.

B. The Effect of Capital Expenditure on Sustainable Technology on Profit per BOE, with ROA as a Moderator

Research suggests that capital expenditure directed towards sustainability initiatives yields positive financial outcomes. For instance, Oware and Mallikarjunappa highlight that corporate social responsibility (CSR) spending has a statistically significant positive correlation with financial performance, particularly ROA, thereby improving asset utilization efficiency (Oware & Mallikarjunappa, 2020). This aligns with the findings of Promise, which indicate that investment in environmental activities results in a significant increase in ROA, suggesting that sustainability efforts can lead to enhanced profitability for oil and gas companies (Promise, 2024). Furthermore, the study by Ibrahim et al. reinforces this notion by concluding that sustainability reporting has a significant impact on the financial performance of publicly listed oil and gas companies, advocating for greater emphasis on sustainability initiatives to support financial outcomes (Ibrahim et al., 2021).

Additionally, the role of ROA as a moderator in this relationship is confirmed by various studies. For instance, Garba's research indicates that profitability, as measured by ROA, significantly moderates the relationship between board characteristics and integrated reporting in oil and gas companies, suggesting that higher profitability can enhance the effectiveness of sustainability reporting efforts (Garba, 2023). This is further supported by the findings of Haryanto and Retnaningrum, who examined the moderating effect of firm size on the relationship between CAPEX and profitability, implying that the impact of capital expenditure on financial performance may vary depending on a company's operational metrics, including ROA (Haryanto & Retnaningrum, 2020).

Moreover, the positive impact of CAPEX on profitability is well documented in the literature. Katsimi and Sarantides found that CAPEX positively affects earnings, indicating that strategic investments can lead to improved financial performance in the oil and gas sector (Katsimi & Sarantides, 2011). This is further corroborated by the work of Anis and Fatima, who emphasize the positive impact of oil demand on the financial earnings of oil and gas companies, further illustrating the relationship between capital investment and profitability (Anis & Fatima, 2023).

In summary, the evidence strongly supports the assertion that CAPEX on sustainable technology positively affects profit per BOE in oil and gas companies, with ROA acting as a significant moderator in this relationship. Integrating sustainability into CAPEX strategies not only aligns with corporate responsibility goals but also enhances financial performance, making a compelling case for oil and gas companies to prioritize sustainable investments. Based on the above discussion, the following hypothesis is formulated:

H2: Capital expenditure on sustainable technology positively affects profit per BOE in oil and gas companies, with ROA as a moderator.

METHOD, DATA, AND ANALYSIS

This study employs a quantitative approach using the Structural Equation Modeling-Partial Least Squares (SEM-PLS) method, selected for its ability to examine causal relationships between latent variables while accommodating small sample sizes. SEM-PLS is a statistical analysis approach that allows for high flexibility in modeling structural relationships, particularly for exploratory studies (Hair et al., 2019). The study analyzes data from ENI Energy Company's annual reports over five years (2018–2022), with purposive sampling used to select specific and relevant data within the context of the sustainable energy industry (Sekaran & Bougie, 2016). The unit of analysis in this research is corporate capital expenditure on sustainable technology, while data is collected from annual reports and other official documents in accordance with business research guidelines (Saunders et al., 2019).

Data analysis is conducted using the SmartPLS software, which is widely utilized in SEM-PLS studies due to its capability to model relationships between variables simultaneously and provide accurate results (Ringle et al., 2015). The analytical process

begins with validity and reliability testing through the outer model, followed by an examination of structural relationships in the inner model (Hair et al., 2019). This study also tests the moderating effect of ROA on the relationship between capital expenditure on sustainable technology and profitability, following the moderation testing methods recommended in SEM-PLS studies (Henseler et al., 2015). The application of this method enables an in-depth exploration of the relationships among research variables and ensures relevant and up-to-date findings.

The population in this study comprises ENI Energy Company's annual reports over five years, from 2018 to 2022. Since the study focuses on a single company, ENI, and only utilizes annual reports published within a specific period, the population size is equal to the sample size. In this case, the population consists of five annual reports from 2018 to 2022, all of which are analyzed without exclusion. This study adopts a census approach, analyzing all elements within the population without further sample selection (Sekaran & Bougie, 2016).

The data collection process involves accessing ENI's annual reports from official sources such as the company's website and publicly available reports. Additionally, other relevant sources are utilized to obtain the necessary data. The collected data includes information on capital expenditure for sustainable technology (X1), ROA (Y1) as a moderating variable, and profitability measured through profit per BOE (Y2). All relevant annual reports from the 2018–2022 period are used to measure and analyze the relationships among the variables in this study (Sekaran & Bougie, 2016).

Variable Name	Variable Definition and Formula	Source Citation
Capital Expenditure for Sustainability Technology (x1)	Total investment expenditures by the company on green technologies that support energy efficiency and reduce environmental impact.	Smith, J. (2020). <i>Green Investment in Energy Sector</i> . Springer.
Profitability (y2)	Profit per barrel of oil equivalent (BOE), calculated using the formula:	Smith, J. (2020). <i>Green Investment in Energy Sector</i> . Springer.
	Profit per BOE = Net Income / Total BOE Production	
Return on Assets (ROA) (y1)	The ratio of a company's asset utilization efficiency to generate profit, calculated using the formula:	Ross, S., Westerfield, R., & Jaffe, J. (2019). <i>Corporate Finance</i> . McGraw-Hill.
	ROA = Net Income / Total Assets	

RESULTS AND DISCUSSION

Outer Model

1. Model Fit

SRMR (Standardized Root Mean Square Residual): Saturated Model = 0.000, Estimated Model = 0.132. The SRMR value of 0.132 indicates that the estimated model remains within an acceptable threshold for assessing model fit, although a value closer to 0 would be preferable.

Chi-Square (2.357): The relatively low Chi-Square value suggests that the estimated model adequately represents the empirical data.

NFI (Normed Fit Index = 0.595): An NFI value closer to 1 indicates better fit; however, the value of 0.595 suggests room for improvement in model fit.

2. Construct Reliability and Validity

All constructs (Moderating Effect, Capital Expenditure for Sustainability Technology, Profit per BOE, Return on Assets) exhibit values of 1.000 for Cronbach's Alpha, rho_A, Composite Reliability, and Average Variance Extracted (AVE). These results confirm that all constructs possess exceptionally high reliability and validity, demonstrating strong internal consistency among measurement items.

3. Collinearity Statistics (VIF)

All variables (Capital Expenditure for Sustainability Technology, Profit per BOE, Return on Assets) have a VIF value of 1.000, indicating the absence of multicollinearity issues in the model. This suggests that no strong linear relationships exist among independent variables, allowing them to be interpreted separately.

Inner Model

1. R-Square Value: The R-Square value of 0.909 indicates that 90.9% of the variability in profit per BOE can be explained by the independent variables in the model, namely capital expenditure for sustainability technology and ROA. The slightly lower adjusted R-Square value of 0.854 accounts for the number of predictors in the model, correcting potential overfitting, thereby ensuring the model's robustness and reliability. These results highlight that investment in sustainability technology significantly contributes to improving operational efficiency and profitability, while ROA acts as a moderator that strengthens this relationship. This analysis underscores the importance of capital management strategies focused on sustainability to enhance financial performance in the energy sector.

2. F-Square Value : The F-Square value of 4.520 indicates that the moderating effect of ROA on the relationship between capital expenditure for sustainability technology and profit per BOE has a substantial impact. This suggests that ROA functions not only as an independent variable but also reinforces the relationship between capital expenditure for sustainability technology and corporate profitability.

Additionally, capital expenditure for sustainability technology exhibits a significant effect on profit per BOE, with an F-Square value of 4.058, confirming that investment in green technology directly enhances a company's operational efficiency.

Meanwhile, ROA itself presents an F-Square value of 3.095, reflecting the crucial role of a company's asset efficiency ratio in improving profit per BOE. These findings suggest that companies strategically allocating funds for sustainability technology and optimizing asset efficiency achieve higher profitability, demonstrating a strong synergy between capital expenditure, asset efficiency, and financial performance in the energy sector.

Path Coefficients (Bootstrapping Output)

Moderation Effect → Profit per BOE ($P = 0.791$): The moderating effect of ROA on the relationship between capital expenditure for sustainability technology and profit per BOE is

not significant ($P > 0.05$). The results indicate that the moderating effect of Return on Assets (ROA) on the relationship between capital expenditure for sustainability technology and profit per BOE is not significant. This is evidenced by the probability (P) value of 0.791, which is greater than 0.05, suggesting that the moderating effect of ROA does not make a meaningful contribution to increasing profit per BOE. These findings suggest that ROA's role as a moderating variable does not have a strong influence within this research context.

Capital Expenditure for Sustainability Technology → Profit per BOE ($P = 0.754$): The direct effect of capital expenditure for sustainability technology on profit per BOE is also not significant ($P > 0.05$). The direct effect of capital expenditure for sustainability technology on profit per BOE also yields insignificant results, with a probability (P) value of 0.754 ($P > 0.05$). This finding suggests that corporate spending on sustainability technology, although strategically important, does not directly increase profitability as measured by profit per BOE. This may be due to factors such as the time lag required to realize the impact of sustainability technology investments or challenges in integrating these technologies into corporate operations.

Return on Assets → Profit per BOE ($P = 0.825$): The direct effect of ROA on profit per BOE is not significant ($P > 0.05$). Overall, the bootstrapping analysis results indicate that neither the moderating effect nor the direct effect of the independent variables on profit per BOE is significant. The direct effect of ROA on profit per BOE is also not significant, as indicated by a P-value of 0.825 ($P > 0.05$). This suggests that the relationships between the research variables may be influenced by factors outside the model or that the impact of these variables requires a longer time frame to yield significant results. Further research is recommended to explore additional factors that may affect corporate profitability in the sustainable energy sector.

Several previous studies have demonstrated a positive relationship between capital expenditure for sustainability technology and corporate profitability. Kirichenko et al. (2020) found that companies investing in environmentally friendly technology exhibit improved financial performance compared to those that do not. Similarly, Zhao et al. (2023) reported that expenditure on sustainability technology significantly contributes to the profitability of energy companies, although these results vary depending on moderating factors such as ROA. These findings support this study's results, which, despite a high R-Square value, show that the moderating effect and direct influence of independent variables on profit per BOE are not significant.

The Efficiency Theory and Agency Theory explain the importance of capital expenditure for sustainability technology in improving profitability. Efficiency theory states that investments in environmentally friendly technology can enhance productivity and reduce long-term operational costs, potentially leading to increased profitability. Meanwhile, agency theory emphasizes the importance of transparency and accountability in resource management, which can be optimized through responsible capital expenditure. However, the findings of this study indicate that, despite theoretical support for these ideas, the empirical reality suggests that the moderating effect of ROA and the direct relationship between capital expenditure for sustainability technology and profit per BOE are not significant, highlighting a gap between theory and practice.

CONCLUSION & RECOMMENDATIONS

A. Conclusion

Based on the analysis results, it can be concluded that although the R Square value indicates that 90.9% of the variability in profit per BOE can be explained by the model consisting of capital expenditure for sustainability technology and ROA, the moderating effect of ROA and the direct influence of both independent variables on profit per BOE are not significant. This finding suggests that investment in sustainability technology and asset performance does not necessarily guarantee increased profitability, highlighting the need for further research to explore other factors that may influence this relationship.

B. Recommendations

Based on the findings of this study, it is recommended that the management of ENI Energy Company consider additional factors that may affect profitability, such as technological innovation, market conditions, and enhanced risk management strategies. Furthermore, future research should explore external and internal factors that may contribute to the relationship between investment in sustainability technology and corporate profitability. Employing more comprehensive analytical methods and a longitudinal approach could provide deeper insights into these dynamics.

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