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SUSTAINABILITY AND EFFICIENCY: DO EFFECTS DIFFER BETWEEN *SHARIA* AND NON-*SHARIA* FIRMS?

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Abstract

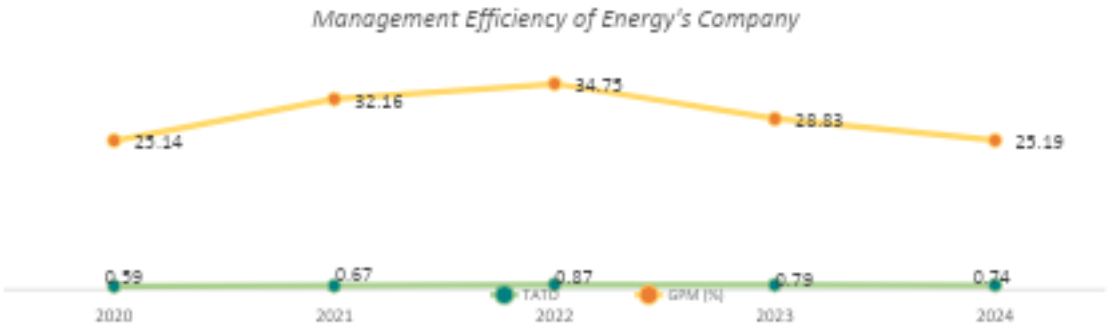
This study examines the impact of circular economy practices, environmental performance, and environmental investment on management efficiency, with financial risk as a moderating variable, while comparing sharia-compliant and non-sharia firms. This research employs a quantitative approach using panel data from energy sector companies listed on the Indonesia Stock Exchange during 2020–2024. Using purposive sampling, 185 observations were obtained, consisting of 160 sharia-compliant and 25 non-sharia firm observations. Data was analyzed using panel data regression and Moderated Regression Analysis (MRA) with E-Views 13. The results show that circular economy practices and environmental performance positively affect management efficiency, while environmental investment does not significantly influence efficiency outcomes. Financial risk moderates several sustainability and efficiency relationships, although the direction and significance of its effects vary across efficiency dimensions. The findings further indicate differences between sharia-compliant and non-sharia firms, suggesting that institutional characteristics influence how sustainability practices are translated into management efficiency. These findings support the Resource-Based View, legitimacy theory, and stakeholder theory by demonstrating that the effectiveness of sustainability practices depends on organizational capabilities, financial conditions, and firm characteristics. From a practical perspective, firms should integrate sustainability initiatives with financial risk management and resource allocation strategies to improve efficiency outcomes. The novelty of this study lies in integrating multiple sustainability dimensions and financial risk within a management efficiency framework while providing comparative evidence between sharia-compliant and non-sharia firms in the energy sector.

Keywords: Circular economy, environmental performance, environmental investment, financial risk, management efficiency

INTRODUCTION

The increasing pressure of climate change, resource scarcity, and the global transition toward sustainable energy systems has significantly reshaped corporate priorities, particularly in energy sector firms that are highly exposed to environmental risks and regulatory pressures. Firms are increasingly required to integrate sustainability into their operational strategies to maintain long-term performance and resilience in a rapidly changing environment. In this context, management efficiency becomes a critical indicator, reflecting a firm's ability to optimize resource utilization and control operating costs. This study conceptualizes management efficiency through two complementary dimensions: asset efficiency and operational efficiency. Asset efficiency, measured by Total Asset Turnover (TATO), reflects how effectively firms utilize their assets to generate revenue, while operational efficiency, measured by Gross Profit Margin (GPM), captures

the firm's ability to convert revenue into profitability (Al Frijat & Elamer, 2025; Erbetta et al., 2022; Kang et al., 2023). Empirical evidence from energy companies listed on the Indonesia Stock Exchange (IDX) during 2020–2024 shows that the average Total Asset Turnover (TATO) remains below the industry benchmark of 2 times and Gross Profit Margin (GPM) fluctuates below 30%, indicating that operational efficiency has not yet reached optimal levels (Brigham & Houston, 2022).



Source: www.idx.co.id
Figure 1. Management Efficiency of Energy's Company

Sustainability practices, including circular economic implementation, environmental performance, and environmental investment, enhance management efficiency through improved resource utilization and operational optimization. Circular economy practices promote resource recirculation, waste reduction, and process efficiency, enabling firms to improve asset productivity and reduce production costs, which ultimately enhances both asset efficiency (TATO) and operational efficiency (GPM) (Awan & Sroufe, 2022; Chaudhuri et al., 2022; Geissdoerfer et al., 2025; Kaewunruen et al., 2025; Peña et al., 2021). However, circular systems may also introduce operational complexity and inefficiencies, particularly due to reverse logistics and uncertainty in resource recovery processes (Arbolino et al., 2025; Hou et al., 2025; Naumov et al., 2025). Environmental performance, reflected in ESG practices and regulatory compliance, improves efficiency by enhancing operational stability, reducing environmental risk, and strengthening stakeholder trust (Ananzeh, 2022; Githaiga, 2025; Huang et al., 2023; Masditok et al., 2024; Moskovics et al., 2024; Rahman & Islam, 2023), although compliance costs and administrative burdens may weaken short-term efficiency (He & Jing, 2023; Rehman et al., 2024; Ren et al., 2024). Similarly, environmental investment enhances efficiency through innovation, energy savings, and optimized resource allocation, which supports both productivity and profitability (Dan et al., 2023; Larasati et al., 2023; Li et al., 2025; Rustam et al., 2025; Wang et al., 2024; Yu et al., 2025), yet may increase financial burden when investment decisions are not aligned with operational capacity or financial conditions (Arbolino et al., 2025; He & Jing, 2023; Hou et al., 2025; Patel et al., 2024; Tanveer et al., 2025).

Financial risk, proxied by leverage, reflects financial pressure that influences firms' ability to allocate resources toward sustainability initiatives. Excessive leverage may constrain sustainability investment and reduce efficiency outcomes, while optimal leverage can enhance managerial discipline and improve resource utilization (Sarfraz, Ozturk, et al., 2023; Wulandari et al., 2026). In addition, firm size is included as a control variable, as larger firms typically possess greater resources, more structured operational systems, and stronger capabilities to implement sustainability practices efficiently (Santos et al., 2026; Wang et al., 2024; Wulandari & Akbar, 2025). Moreover, this study introduces a comparative analysis between sharia-compliant and non-sharia

firms. Firms adhering to sharia principles face stricter financial and ethical constraints, including limitations on leverage and speculative activities, which may lead to more prudent resource allocation and risk management, thereby influencing the effectiveness of sustainability practices in enhancing management efficiency (Koh et al., 2025).

This study is grounded in legitimacy theory, stakeholder theory, and the resource-based view (RBV) to explain how sustainability practices influence management efficiency. Legitimacy theory suggests that firms engage in sustainability practices to align with societal expectations and regulatory requirements, thereby reducing external pressures, avoiding regulatory penalties, and minimizing operational disruptions, which ultimately enhances efficiency (Ananzeh, 2022; Nengzih, 2022; Rahman & Islam, 2023). From a stakeholder perspective, sustainability enhances trust and resource access, enabling firms to operate more efficiently (Githaiga, 2025; Seok et al., 2024; Tanjung & Lestari, 2025). Meanwhile, RBV posits that sustainability capabilities represent strategic resources that enable firms to optimize resource utilization, improve asset productivity, and achieve superior operational efficiency through competitive advantage (Kang et al., 2023; Martins & Eseosa, 2022). Together, these theories suggest that sustainability practices function not only as compliance mechanisms but also as strategic drivers of management efficiency through risk reduction, stakeholder alignment, and capability enhancement.

Despite the growing literature on sustainability and firm performance, important gaps remain. Prior studies largely focus on financial performance, with limited attention to management efficiency as a more direct outcome, particularly in terms of asset efficiency (TATO) and operational efficiency (GPM). In addition, sustainability dimensions are often examined separately, while the moderating role of financial risk and comparative differences between sharia-compliant and non-sharia firms remain underexplored. Therefore, this study aims to examine the effect of circular economy, environmental performance, and environmental investment on management efficiency, with financial risk as a moderating variable and firm size as a control variable, while also comparing results across sharia and non-sharia firms to identify how and under what conditions sustainability practices enhance efficiency.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

Circular Economy, Management Efficiency, Sharia Compliant Firms

Circular economy (CE) practices emphasize resource recirculation, waste minimization, and lifecycle optimization, enabling firms to improve operational processes and utilize resources more efficiently. From the resource-based view (RBV), CE represents a strategic capability that can enhance efficiency through better resource allocation and process optimization. By reducing material waste and reusing inputs, firms can lower production costs and streamline operations, thereby improving asset utilization and operational outcomes.

Empirical studies consistently show that CE practices improve efficiency and firm performance through improved resource utilization and operational effectiveness (Awan & Sroufe, 2022; Chaudhuri et al., 2022; Geissdoerfer et al., 2025; Kaewunruen et al., 2025; Peña et al., 2021). However, CE implementation may also introduce operational complexity, particularly due to reverse logistics, recycling uncertainty, and coordination challenges, which can reduce efficiency if firms lack sufficient capabilities (Arbolino et al., 2025; Hou et al., 2025; Naumov et al., 2025). In addition, firms operating under sharia principles tend to adopt more conservative financial strategies and emphasize ethical resource management, which may influence how CE practices are implemented. These characteristics may lead to differences in how CE contributes to operational efficiency between sharia and non-sharia firms. Therefore, circular economy practices are expected to enhance management efficiency, leading to the following hypotheses:

H1a: Circular economy affects asset efficiency (TATO).

H1b: Circular economy affects operational efficiency (GPM).

H1c: The effect of circular economy on management efficiency differs between sharia and non-sharia firms.

Environmental Performance, Management Efficiency, Sharia Compliant Firms

Environmental performance reflects a firm's ability to manage environmental risks, comply with regulations, and respond to stakeholder expectations. From the perspective of legitimacy theory, firms with strong environmental performance aim to align their operations with societal expectations and regulatory requirements. This alignment reduces regulatory risk and operational disruptions, thereby supporting more efficient operations. Additionally, stakeholder theory, improved environmental performance enhances stakeholder trust, strengthens relationships with regulators and investors, and facilitates access to critical resources. These advantages reduce transaction costs and improve coordination, ultimately enhancing both asset utilization and operational outcomes.

Empirical studies provide consistent evidence that environmental performance improves efficiency and firm performance through reduced risk and improved resource allocation (Ananzeh, 2022; Githaiga, 2025; Huang et al., 2023; Masditok et al., 2024; Moskovics et al., 2024; Rahman & Islam, 2023). However, achieving high environmental performance often requires significant compliance costs, monitoring efforts, and operational adjustments, which may reduce efficiency in the short term, particularly when firms lack sufficient capabilities or financial resources (He & Jing, 2023; Rehman et al., 2024; Ren et al., 2024). This indicates that the impact of environmental performance on efficiency is context dependent. Furthermore, firms operating under sharia principles may exhibit different environmental behaviour due to stronger ethical commitments and governance practices, potentially leading to different efficiency outcomes compared to non-sharia firms. Therefore, environmental performance is expected to influence management efficiency, leading to the following hypotheses:

H2a: Environmental performance affects asset efficiency (TATO).

H2b: Environmental performance affects operational efficiency (GPM).

H2c: The effect of environmental performance on management efficiency differs between sharia-compliant and non-sharia firms.

Environmental Investment, Management Efficiency, Sharia Compliant Firms

Environmental investment reflects a firm's commitment to sustainability through green innovation, energy efficiency, and process improvement. From the perspective of the Resource-Based View, such investments build valuable organizational capabilities that enhance resource utilization and operational performance. By adopting environmentally friendly technologies and improving production processes, firms can reduce waste, lower energy consumption, and optimize input usage, thereby enhancing asset utilization and operational efficiency. These investments create firm-specific capabilities that are difficult to imitate, enabling sustained efficiency improvements.

Empirical evidence shows that environmental investment enhances efficiency and firm performance through innovation and improved resource allocation (Dan et al., 2023; Larasati et al., 2023; Li et al., 2025; Rustam et al., 2025; Wang et al., 2024; Yu et al., 2025). However, environmental investment often requires substantial capital and long-term commitment, which may create financial pressure and reduce efficiency in the short term, especially when investment decisions are not aligned with firm capabilities or financial conditions (Arbolino et al., 2025; He & Jing, 2023; Hou et al., 2025; Patel et al., 2024; Tanveer et al., 2025). This suggests that the effectiveness of environmental investment depends on firms' ability to manage financial and operational constraints. Furthermore, firms operating under sharia principles may adopt more prudent investment strategies due to financial constraints and ethical considerations, which can

influence how environmental investments are implemented and translated into efficiency outcomes. Therefore, the following hypothesis:

H3a: Environmental investment affects asset efficiency (TATO).
H3b: Environmental investment affects operational efficiency (GPM).
H3c: The effect of environmental investment on management efficiency differs between sharia-compliant and non-sharia firms.

Financial Risk, Management Efficiency, Sharia Compliant Firms

Financial risk, commonly proxied by leverage, reflects the extent of financial pressure faced by firms in allocating resources and managing long-term investments. High financial risk may constrain firms' ability to invest in sustainability initiatives and reduce their effectiveness, as firms tend to prioritize short-term financial obligations over long-term efficiency improvements. In contrast, moderate leverage can enhance managerial discipline and improve resource allocation efficiency (He & Jing, 2023; Sarfraz, Ivascu, et al., 2023; Tanveer et al., 2025; Wulandari et al., 2026).

In the context of sustainability practices, financial risk acts as a boundary condition that influences how effectively firms can translate sustainability initiatives into management efficiency. Firms with high financial risk may face limitations in implementing circular economy practices, maintaining environmental performance, and sustaining environmental investments, thereby weakening their impact on efficiency. Conversely, firms with lower financial risk are more likely to allocate sufficient resources and fully realize the efficiency benefits of sustainability practices (Lei et al., 2024; Ning et al., 2023; Ren et al., 2024). Therefore, the following hypothesis:

H4a: Financial risk moderates the effect of circular economy on asset efficiency (TATO).
H4b: Financial risk moderates the effect of circular economy on operational efficiency (GPM).
H4c: The moderating effect of financial risk on circular economy differs between sharia and non-sharia firms.
H5a: Financial risk moderates the effect of environmental performance on asset efficiency (TATO).
H5b: Financial risk moderates the effect of environmental performance on operational efficiency (GPM).
H5c: The moderating effect of financial risk on environmental performance differs between sharia and non-sharia firms.
H6a: Financial risk moderates the effect of environmental investment on asset efficiency (TATO).
H6b: Financial risk moderates the effect of environmental investment on operational efficiency (GPM).
H6c: The moderating effect of financial risk on environmental investment differs between sharia and non-sharia firms.

To provide a clearer illustration of the proposed relationships in this study, here is the research model which presented in Figure 2.

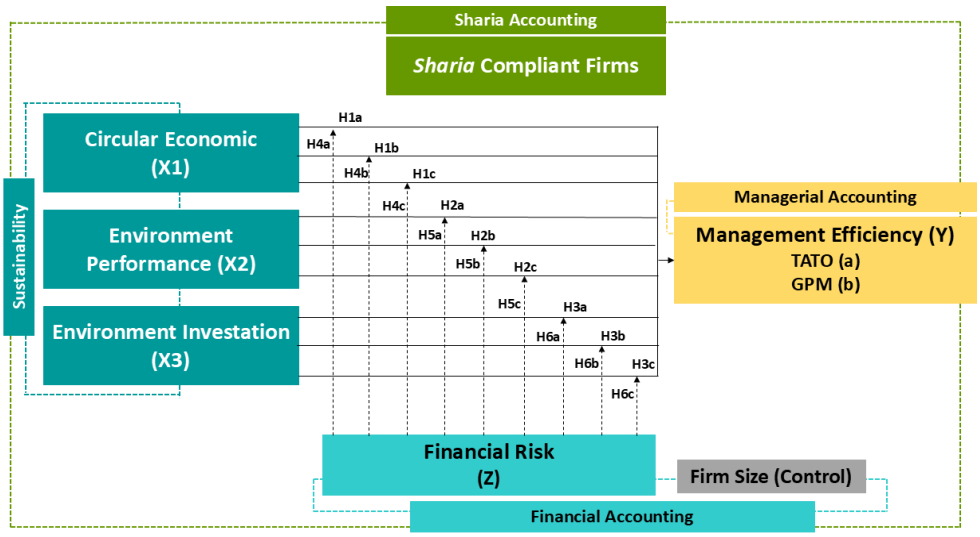


Figure 2. Research Construct

RESEARCH METHODS

This study employs a quantitative causal design to examine the effect of circular economy, environmental performance, and environmental investment on management efficiency, with financial risk as a moderating variable and firm size as a control variable, while comparing sharia and non-sharia firms. The focus on the energy sector is motivated by its high environmental impact, intensive resource utilization, and strong regulatory pressure, making it highly relevant for sustainability and efficiency analysis. The sample consists of energy companies listed on the Indonesia Stock Exchange (IDX) during 2020–2024, selected using purposive sampling, resulting in 185 data observations (160 data observation with sharia, and 25 data observation non-*sharia*). Management efficiency is measured using asset and operational efficiency, proxied by TATO and GPM. Independent variables include CEI, PROPER ratings, and environmental costs, with financial risk measured by DER. Data is analyzed using panel regression and moderated regression with EViews 13.

Table 1. Operational Definition

Variable	Definition	Indicator	Scale
Management Efficiency (Asset Efficiency)	Firm's ability to utilize assets to generate revenue (Ridwan & Alghifari, 2025)	TATO = Sales / Total Assets	Ratio
Management Efficiency (Operational Efficiency)	Firm's ability to control costs and generate profit from operations (Fadhillah et al., 2024)	GPM = Gross Profit / Sales	Ratio
Circular Economy	Firm's implementation of resource recirculation, waste reduction, and sustainable production practices (Vitolla et al., 2023)	CEI = Total Score Disclosure/30 CEI Index	Ratio
Environmental Performance	Firm's ability to manage environmental impact and comply with environmental regulations (Wulandari & Akbar, 2025)	PROPER Rank (1 = Black, 2 = Red, 3 = Blue, 4 = Green, 5 = Gold)	Ordinal
Environmental Investment	Firm's allocation of resources toward environmental protection and	EnI = Environmental Cost/Earning Before Tax	Ratio

	sustainability initiatives (Mustafa et al., 2025)		
Financial Risk	Firm's level of financial pressure due to leverage (Brigham & Houston, 2022)	DER = Total Debt / Total Equity	Ratio
Firm Size	Scale of the firm's operations and resources (Douziech & Joulain, 2025)	SIZE = Ln (Total Assets)	Ratio
Sharia Classification	Firm's compliance with Islamic financial principles	1 = Sharia, 0 = non-Sharia	Dummy

Source: Data processed by researchers, 2026.

The Circular Economy Index (CEI) is constructed based on content analysis of company disclosures related to circular economy practices. The index consists of 10 indicators covering resource recirculation, waste management, reuse, recycling, and sustainable production processes. Each indicator is scored on a scale of 0 to 3, where 0 indicates no disclosure and 3 indicates comprehensive implementation. The total score is then normalized by dividing it by the maximum possible score (30), resulting in an index ranging from 0 to 1, where higher values indicate a greater level of circular economy implementation. The PROPER rating is an environmental performance assessment issued by the Indonesian Ministry of Environment and Forestry, evaluating firms' compliance with environmental regulations and their environmental management performance. The rating is categorized into five levels: Black (very poor), Red (poor), Blue (compliant), Green (beyond compliance), and Gold (excellent). Higher PROPER ratings indicate better environmental performance and stronger commitment to sustainability practices.

RESULTS AND DISCUSSION

Table 1. Statistic Descriptive

Variable	Model 1			Model 2			Model 3		
	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.
TATO	0,730	0,532	185	0,766	0,554	160	0,501	0,277	25
GPM	29,214	19,266	185	30,028	19,152	160	24,006	19,572	25
CEI	0,705	0,250	185	0,721	0,249	160	0,599	0,235	25
PROPER	2,114	2,046	185	2,319	2,032	160	0,800	1,633	25
ENC	1,324	3,614	185	1,432	3,595	160	0,630	3,733	25
DER	1,329	2,601	185	1,142	2,668	160	2,520	1,734	25
SIZE	30,641	2,983	185	30,529	2,962	160	31,352	3,079	25

Source: Output EViews 13 (processed by researchers, 2026).

The descriptive statistics indicate that the mean value of TATO is 0,730 (Model 1), 0,766 (Model 2), and 0,501 (Model 3), suggesting that firms have not yet achieved optimal asset efficiency, as the values remain below the industry benchmark of 2 times (Brigham & Houston, 2022; Kieso et al., 2020). The mean GPM is 29,214, 30,028, and 24,006, respectively, indicating that gross profit margins are around or below the industry standard of 30% (Brigham & Houston, 2022), reflecting suboptimal operational efficiency, particularly among non-sharia firms. The CEI shows mean values of 0,705, 0,721, and 0,599, indicating a moderate to high level of circular economic implementation, with sharia firms demonstrating relatively stronger adoption. The PROPER scores average 2,114, 2,319, and 0,800, which are below the "green" standard (4), indicating that most firms have not yet achieved beyond-compliance environmental performance and remain at basic compliance levels, with non-sharia firms exhibiting lower environmental performance (Sormin et al., 2026; Wulandari & Akbar, 2025). Environmental investment (ENC) shows variation across firms, with higher values in sharia firms, indicating stronger commitment to sustainability. Meanwhile, DER has mean values of 1,329, 1,142, and 2,520, indicating that non-sharia firms tend to have higher leverage, exceeding the generally acceptable threshold of 2 and thus facing greater financial risk

(Kieso et al., 2020). Firm size (SIZE) shows relatively similar values across models, although non-sharia firms tend to be slightly large (Fahmi, 2020).

Following the descriptive analysis, panel model selection tests were conducted in Table 2. In TATO models, the Chow and Hausman tests are significant, indicating that the Fixed Effect Model (FEM) is most appropriate. For GPM, while the Chow test supports FEM, the Hausman test favors the Random Effect Model (REM), supported by the LM test. Therefore, FEM is used for TATO and REM for GPM, ensuring robust estimation.

Table 2. Selection Panel Test

Model	Testing	Prob.	Sig.	Conclusion	Result
TATO	Chow	0,000	0,050	(0,000<0,050)	FEM
	Hausman	0,004	0,050	(0,004<0,050)	FEM
	LM	0,000	0,050	(0,000<0,050)	REM
GPM	Chow	0,000	0,050	(0,000<0,050)	FEM
	Hausman	0,180	0,050	(0,180>0,050)	REM
	LM	0,000	0,050	(0,000<0,050)	REM

Source: Output EViews 13 (processed by researchers, 2026).

After determining the appropriate panel models, classical assumption tests were conducted to ensure the robustness of the regression results, as shown in Table 3. The multicollinearity test shows that all correlation values are below 0,80, indicating no multicollinearity among the independent variables. In addition, the *Breusch–Pagan* test results show probability values above 0,05 for all models, suggesting the absence of heteroscedasticity. These findings confirm that the regression models meet the classical assumptions and are suitable for further hypothesis testing.

Table 3. Classic Assumption Test

Test	Results	Conclusion
Multicollinearity	All models < 0,80	No multicollinearity
Heteroscedasticity (Breusch-pagan)	All models > 0,50	No heteroscedasticity

Source: Output EViews 13 (processed by researchers, 2026)

After confirming that the regression models meet the classical assumptions, hypothesis testing is conducted to examine the relationships among variables. Table 4 presents the regression results. The R-squared values indicate that the independent variables show TATO has 64,2% and GPM has 62,7% of the variation in Model 1, then TATO has 66,7% and GPM has 59,1% in Model 2, while TATO has 95,4% and GPM has 82,3% in Model 3, suggesting strong explanatory power. In addition, the F-statistic values are significant with 0,000 lower than 0,05 (0,000<0,05) across all models, indicating that the models are jointly significant and suitable for hypothesis testing.

Table 4. Hypothesis Test

Variable	Model 1				Model 2				Model 3			
	TATO		GPM		TATO		GPM		TATO		GPM	
	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.
C	0,355	0,278	81,787	0,000	0,416	0,241	68,697	0,000	1,672	0,000	144,442	0,013
CEI	0,306	0,078*	-28,136	0,000***	0,076	0,723	-17,098	0,045**	-1,507	0,000***	-45,286	0,206
PROPER	0,068	0,002***	3,965	0,000***	0,095	0,001***	3,887	0,002***	0,234	0,000***	3,074	0,546
ENC	0,009	0,302	0,257	0,407	0,009	0,317	-0,499	0,235	0,003	0,856	-0,448	0,830
SIZE	-0,004	0,673	-1,352	0,000	-0,003	0,793	-1,056	0,008	-0,026	0,009	-2,872	0,033
DER	0,163	0,000	-3,977	0,000	0,154	0,000	-3,182	0,003	-0,063	0,333	-12,247	0,125
CEIDER	-0,134	0,031**	4,337	0,063*	0,078	0,540	-3,392	0,524	0,359	0,002***	14,651	0,231
PROPERDER	-0,021	0,038**	-0,304	0,432	-0,064	0,006***	-0,036	0,971	-0,041	0,008***	-0,907	0,591
ENCDER	-0,007	0,075*	-0,096	0,491	-0,013	0,010***	0,835	0,029**	0,004	0,370	0,130	0,790
R-Square	0,642		0,627		0,667		0,591		0,954		0,823	
F-Statistic	0,000		0,000		0,000		0,000		0,000		0,000	

Notes: *(p<0,10), **(p<0,05), ***(p<0,01)

Model 1 = all firms
Model 2 = sharia firms
Model 3 = non-sharia firms

Source: Output Eviews 13 (processed by researchers, 2026)

Circular economy (CEI) shows varying effects on management efficiency. For asset efficiency (TATO), CEI significantly affects Model 1 (β = 0,306; p < 0,10) and Model 3 (β = −1,507; p < 0,01) but does not affect Model 2 (β = 0,076; p = 0,723). Thus, H1a is accepted in Model 1 and Model 3, but rejected in Model 2. For operational efficiency (GPM), CEI significantly affects Model 1 (β = −28,136; p < 0,01) and Model 2 (β = −17,098; p < 0,05) but not Model 3 (β = −45,286; p = 0,206). Therefore, H1b is accepted in Model 1 and Model 2, but rejected in Model 3. Furthermore, the difference in results between Model 2 (insignificant) and Model 3 (significant) suggest that H1c is supported, indicating that the effect of circular economy differs between sharia and non-sharia firms. These findings suggest that circular economy practices influence management efficiency, but the effects are not consistently positive. From the resource-based view (RBV), circular economy is expected to enhance efficiency through improved resource utilization and process optimization. This is supported by prior studies showing that circular practices improve operational performance and efficiency (Awan & Sroufe, 2022; Chaudhuri et al., 2022; Geissdoerfer et al., 2025). However, the negative and inconsistent results indicate that circular economy implementation may also generate short-term inefficiencies due to higher operational complexity, reverse logistics, and coordination costs, particularly when firms lack sufficient capabilities (Arbolino et al., 2025; Naumov et al., 2025). In addition, the differences between sharia and non-sharia firms suggest that institutional characteristics play an important role. Sharia firms tend to adopt more conservative financial policies and structured resource management, which may stabilize the implementation of circular practices but also limit their immediate impact. In contrast, non-sharia firms may experience greater variability, leading to stronger but less stable effects. This finding confirms that the relationship between circular economy and management efficiency is context-dependent and aligns with the hypothesis development that emphasizes the role of firm characteristics in shaping sustainability outcomes.

Environmental performance (PROPER) shows consistent effects on management efficiency. For asset efficiency (TATO), PROPER significantly affects Model 1 (β = 0,068; p < 0.01), Model 2 (β = 0,095; p < 0.01), and Model 3 (β = 0,234; p < 0,01). Thus, H2a is accepted in all models. For operational efficiency (GPM), PROPER significantly affects Model 1 (β = 3,965; p < 0,01) and Model 2 (β = 3,887; p < 0,01) but does not affect Model 3 (β = 3,074; p = 0,546). Therefore, H2b is accepted in Model 1 and Model 2, but rejected in Model 3. Furthermore, the difference between Model 2 (significant) and Model 3 (insignificant) indicates that H2c is supported, suggest that the effect of environmental performance differs between sharia and non-sharia firms. These findings support legitimacy theory, which suggests that firms improve environmental performance to comply with regulatory and societal expectations, thereby reducing operational risks and enhancing efficiency. The consistent positive effect on asset efficiency indicates that firms with higher environmental performance are better able to utilize resources and maintain operational stability. This is in line with prior studies showing that strong environmental performance improves firm efficiency through risk reduction and improved stakeholder trust (Ananzeh, 2022; Githaiga, 2025; Huang et al., 2023; Masditok et al., 2024; Moskovics et al., 2024; Rahman & Islam, 2023). However, the insignificant effect on operational efficiency in non-sharia firms suggests that the benefits of environmental performance are not uniformly realized across all firm types. This may be due to differences in governance structures, commitment to sustainability, and resource allocation. Sharia firms, which emphasize ethical compliance and financial discipline, may be better positioned to translate environmental performance into operational gains. In contrast, non-sharia firms may treat environmental compliance as a regulatory obligation rather than a strategic initiative, limiting its impact on efficiency. Overall, these findings confirm that environmental performance is a more

consistent driver of management efficiency, but its effectiveness remains contingent on firm characteristics, as proposed in the hypothesis development.

Environmental investment (ENC) does not show a significant effect on management efficiency across all models. For asset efficiency (TATO), ENC is insignificant in Model 1 (β = 0,009; p = 0,302), Model 2 (β = 0,009; p = 0,317), and Model 3 (β = 0,003; p = 0,856). Similarly, for operational efficiency (GPM), ENC is insignificant in Model 1 (β = 0,257; p = 0,407), Model 2 (β = −0,499; p = 0,235), and Model 3 (β = −0,448; p = 0,830). Therefore, H3a and H3b are rejected in all models. Furthermore, the insignificant coefficient in Model 3 indicates that the relationship between environmental investment and management efficiency does not differ between sharia-compliant and non-sharia firms, so H3c is also rejected. These findings do not support the Resource-Based View (RBV), which suggests that environmental investment enhances efficiency through innovation, process improvement, and better resource utilization. Instead, the results indicate that environmental investment does not immediately generate efficiency gains in either asset utilization or operational performance. One possible explanation is that environmental projects often require substantial capital expenditures, long implementation periods, and delayed economic returns. Consequently, the benefits of environmental investment may not be reflected in short-term efficiency measures such as TATO and GPM. Prior studies report that environmental investment may create financial pressure and reduce short-term performance when firms face implementation costs and uncertain returns (Arbolino et al., 2025; He & Jing, 2023; Hou et al., 2025; Patel et al., 2024; Tanveer et al., 2025). Moreover, the absence of significant differences between sharia and non-sharia firms suggests that compliance status does not materially alter the effectiveness of environmental investment in improving management efficiency. Overall, environmental investment should be viewed as a long-term strategic commitment whose benefits may emerge gradually rather than as an immediate driver of management efficiency.

The moderating effect of financial risk on the relationship between circular economy (CEI) and management efficiency shows mixed results. For asset efficiency (TATO), the interaction term CEI*DER is significant in Model 1 (β = −0,134; p < 0,05) and Model 3 (β = 0,359; p < 0,01), but not in Model 2 (β = 0,078; p = 0,540). Thus, H4a is accepted in Model 1 and Model 3, while rejected in Model 2. The negative interaction coefficient in Model 1 indicates that financial risk weakens the positive effect of circular economy practices on asset efficiency, whereas the positive interaction coefficient in Model 3 suggests that financial risk strengthens the relationship. For operational efficiency (GPM), CEI*DER is marginally significant in Model 1 (β = 4,337; p < 0,10), but insignificant in Model 2 (β = −3,392; p = 0,524) and Model 3 (β = 14,651; p = 0,231). Therefore, H4b is strength supported in Model 1 and rejected in Model 2 and Model 3. Furthermore, the difference between Model 2 (insignificant) and Model 3 (significant for TATO) indicates that H4c is supported, suggesting that the moderating effect of financial risk differs between sharia and non-sharia firms. These findings suggest that financial risk acts as a boundary condition in determining the effectiveness of circular economy practices. Consistent with the financial constraint perspective, higher leverage may limit firms' ability to allocate resources toward circular initiatives, thereby reducing the efficiency benefits generated from such practices. This argument is reflected in Model 1, where the negative interaction coefficient indicates that financial pressure weakens the contribution of circular economy implementation to asset efficiency. Previous studies similarly report that high financial risk constrains sustainability investments and weakens performance outcomes (He & Jing, 2023; Sarfraz, Ivascu, et al., 2023; Tanveer et al., 2025; Wulandari et al., 2026). However, the positive and significant interaction in Model 3 suggests that financial risk does not always reduce efficiency gains. Under certain conditions, financial pressure may encourage firms to allocate resources more carefully, improve managerial discipline, and maximize asset utilization, thereby strengthening the efficiency benefits of circular economy practices. This finding is consistent with the argument that moderate leverage can improve resource allocation efficiency and organizational discipline. The differing results between sharia and non-sharia firms further

indicate that institutional characteristics influence how financial risk shapes the effectiveness of sustainability initiatives. Overall, these findings confirm that the impact of circular economy practices on management efficiency depends on firms' financial conditions and organizational context, as proposed in the hypothesis development.

The moderating effect of financial risk on the relationship between environmental performance (PROPER) and management efficiency shows consistent patterns for asset efficiency but not for operational efficiency. For asset efficiency (TATO), the interaction term PROPER*DER is significant in Model 1 (β = −0,021; p < 0,05), Model 2 (β = −0,064; p < 0,01), and Model 3 (β = −0,041; p < 0,01). Thus, H5a is accepted in all models. The negative on coefficient shows that financial risk weakens the effect of environmental performance on asset efficiency. For operational efficiency (GPM), the interaction is insignificant in Model 1 (β = −0,304; p = 0,432), Model 2 (β = −0,036; p = 0,971), and Model 3 (β = −0,907; p = 0,591), indicating that H5b is rejected in all models. Furthermore, because the interaction is consistently significant for TATO in both Model 2 and Model 3, there is no difference between sharia and non-sharia firms, and therefore H5c is not supported. These findings indicate that financial risk consistently weakens the positive effect of environmental performance on asset efficiency. In line with legitimacy theory, environmental performance is expected to improve efficiency through reduced regulatory risk and enhanced operational stability. However, high leverage creates financial pressure that limits firms' ability to allocate resources effectively, thereby reducing the efficiency gains from environmental performance. This supports prior studies showing that financial constraints weaken the benefits of sustainability practices (He & Jing, 2023; Ren et al., 2024; Sarfraz, Ozturk, et al., 2023). The absence of moderating effects on operational efficiency suggests that financial risk does not directly influence how environmental performance translates into profitability. This may indicate that cost structures and profit margins are influenced by broader operational factors beyond financial leverage. Overall, these results confirm that while environmental performance improves efficiency, its effectiveness is significantly constrained by financial risk, particularly in terms of asset utilization, as proposed in the hypothesis development.

The moderating effect of financial risk on the relationship between environmental investment (ENC) and management efficiency shows conditional results. For asset efficiency (TATO), the interaction term ENC*DER is marginally significant in Model 1 (β = −0,007; p < 0,10) and significant in Model 2 (β = −0,013; p < 0,01), but not in Model 3 (β = 0,004; p = 0,370). Thus, H6a is accepted in Model 1 and Model 2 but rejected in Model 3. The negative coefficient on Model 1 and 2 shows that financial risk weakens the effects of environmental investment on asset efficiency. For operational efficiency (GPM), the interaction is significant only in Model 2 (β = 0,835; p < 0,05), but insignificant in Model 1 (β = −0,096; p = 0,491) and Model 3 (β = 0,130; p = 0,790). Therefore, H6b is accepted in Model 2, while rejected in Model 1 and Model 3. The positive coefficient value on Model 2 shows that financial risk strength the environmental investment on operational efficiency. Furthermore, the difference between Model 2 (significant) and Model 3 (insignificant) suggest that H6c is supported, indicating that the moderating effect of financial risk differs between sharia and non-sharia firms. These findings suggest that financial risk conditionally influences the effectiveness of environmental investment. From the resource-based view (RBV), environmental investment is expected to enhance efficiency through innovation and improved resource utilization. However, under high financial pressure, firms may face constraints in sustaining such investments, thereby weakening their impact on efficiency. This is reflected in the negative interaction for asset efficiency, indicating that leverage reduces the benefits of environmental investment. Prior studies also highlight that financial constraints and high leverage can limit the effectiveness of sustainability investments (He & Jing, 2023; Patel et al., 2024; Tanveer et al., 2025)Interestingly, the positive interaction for operational efficiency in Model 2 suggests that, under certain conditions, financial pressure may encourage more efficient allocation of environmental investment, particularly in sharia firms with stricter financial discipline. This indicates that the role of financial risk is not

uniform and depends on firm characteristics and governance structures. Overall, these results confirm that the impact of environmental investment on efficiency is contingent upon financial conditions and institutional context, as proposed in the hypothesis development.

CONCLUSION

This study investigates the effect of circular economy practices, environmental performance, and environmental investment on management efficiency, measured by asset efficiency (TATO) and operational efficiency (GPM), with financial risk serving as a moderating variable. The results indicate that circular economy practices and environmental performance generally improve management efficiency, while environmental investment does not significantly affect efficiency outcomes. Furthermore, financial risk acts as a contextual factor that influences the effectiveness of sustainability practices. The moderating effects are not uniform, as financial risk weakens, strengthens, or does not significantly alter the relationship between sustainability practices and management efficiency depending on the efficiency dimension examined and the type of firm. The findings also suggest that several sustainability–efficiency relationships differ between sharia-compliant and non-sharia firms, highlighting the importance of institutional context.

These findings imply that sustainability initiatives should be integrated into operational and strategic decision-making rather than being treated solely as compliance mechanisms. From an environmental accounting perspective, the results emphasize the importance of measuring environmental performance and evaluating sustainability-related expenditures based on their contribution to efficiency outcomes. From a management accounting perspective, firms should incorporate financial risk considerations into sustainability planning and resource allocation decisions to maximize efficiency gains. Accordingly, environmental accounting and management accounting systems should provide relevant information for environmental cost control, performance evaluation, risk management, and sustainable value creation. The study also extends Resource-Based View, legitimacy, and stakeholder perspectives by demonstrating that the effectiveness of sustainability practices depends not only on their implementation but also on firms' financial conditions and organizational context.

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