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Green Financing and Energy Innovation Driving Firm Performance in Southeast Asian Energy Firms

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ABSTRACT

This research investigates the impact of sustainability initiatives and financial variables on Return on Assets (ROA) in Southeast Asian energy companies. **The study analyzes** the relationships between Renewable Energy Investment (REITI), Carbon Emission Disclosure (TCED), Fiscal Incentives for Renewable Energy Investment (FIREI), Green Financing (GFTF), and Green Energy Market Demand Growth (GEMDG), alongside financial variables like Debt-to-Equity Ratio (DER) and Dividend Payout Ratio (DPR). **Using regression analysis,** the research finds that REITI negatively affects ROA, while TCED positively correlates with it. Surprisingly, FIREI is negatively associated with ROA, suggesting market distortions or a focus on long-term investments. GFTF and GEMDG do not exhibit significant direct effects on ROA, and DER consistently shows a negative impact on ROA with a nuanced moderating role. DPR, however, lacks significant influence on ROA. These **findings** highlight the complex dynamics between sustainability efforts and financial performance, emphasizing the need for strategic financial management and careful evaluation of policy instruments to align long-term sustainability goals with financial outcomes.

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1. INTRODUCTION

Climate change has emerged as a central issue driving transformation across multiple sectors, particularly in [1]. As one of the world's fastest-growing economic regions, Southeast Asia faces significant challenges related to continuously increasing energy demand and its heavy dependence on fossil fuel sources, which contribute to rising carbon emissions. This situation directly relates to the global commitment to achieve Sustainable Development Goal (SDG) 7 (Affordable and Clean Energy) by ensuring access to reliable, sustainable, and modern energy, while also addressing SDG 13 (Climate Action) through urgent measures to combat climate change and its impacts [2].

Furthermore, accelerating the transition toward renewable energy and low-carbon technologies aligns with SDG 9 (Industry, Innovation, and Infrastructure), which emphasizes sustainable industrialization and tech-

nological innovation. At the same time, reducing dependence on fossil fuels and improving energy efficiency supports SDG 12 (Responsible Consumption and Production) by promoting more sustainable resource management and production patterns [3].

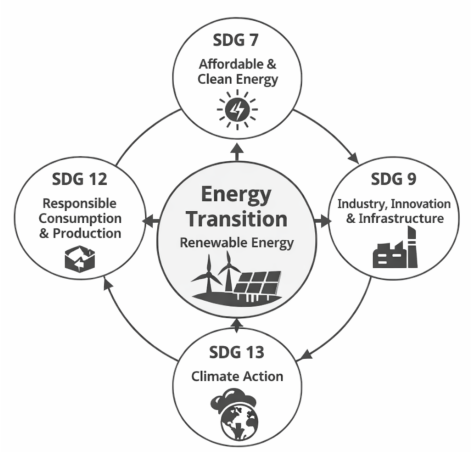


Figure 1. Relationship Between Energy Transition and SDG

Furthermore Figure 1, accelerating the transition toward renewable energy and low carbon technologies aligns with SDG 9 (Industry, Innovation, and Infrastructure), which emphasizes sustainable industrialization and technological innovation. At the same time, reducing dependence on fossil fuels and improving energy efficiency supports SDG 12 (Responsible Consumption and Production) by promoting more sustainable resource management and production patterns. This alignment demonstrates that the development of renewable energy systems and sustainable financing mechanisms plays a critical role in supporting global development priorities, particularly those related to clean energy accessibility, technological innovation, and environmentally responsible production practices.

In recent years, global pressures through international agreements such as the Paris Agreement, along with national commitments to the SDGs, have compelled energy companies to accelerate their transition toward environmentally sustainable business practices [4]. Thus, the transformation of Southeast Asia's energy sector is not only an economic necessity but also a strategic contribution to achieving SDGs 7, 9, 12, and 13 at both regional and global levels. Green energy investment has emerged as a primary solution to reduce carbon emissions and achieve sustainability targets. Green energy encompasses investments in renewable energy sources, including solar, wind, biomass, and hydroelectric power. Recent research demonstrates that companies investing in renewable energy not only contribute to environmental conservation but also enhance financial performance through operational cost efficiency and improved corporate reputation among investors and consumers [5]. However, these investments require substantial capital and well-planned financing strategies, necessitating support from green financing mechanisms.

Green financing represents a funding approach that integrates environmental considerations into financial decision-making processes. Green financing instruments, such as green bonds, green loans, and sustainability-linked loans, have experienced rapid development in recent years, particularly in Southeast Asia [6]. Green financing not only assists companies in obtaining more affordable and longer-term funding sources but also contributes to the development of more sustainable and environmentally conscious capital markets. Several studies indicate that companies with access to green financing tend to demonstrate more stable financial performance and gain greater confidence from institutional investors [7].

Furthermore, carbon emission disclosure has become a critical factor in evaluating corporate commitment to sustainability. Transparency in carbon emission reporting enhances corporate credibility and can significantly influence investment decisions by stakeholders. Reporting standards such as the Global Reporting Initiative (GRI) and the Task Force on Climate-related Financial Disclosures (TCFD) have been widely adopted by energy companies in Southeast Asia to improve accountability and transparency [8, 9]. Research by [10–12] found that companies with high levels of carbon emission disclosure tend to have better access to external financing sources and demonstrate superior financial performance compared to companies with low

disclosure levels.

Government economic and fiscal policies also play a crucial role in supporting green energy transition. Governments in Southeast Asia have implemented various fiscal incentives, including tax reductions, subsidies for renewable energy, and regulations that encourage investment in green energy sectors [3, 13]. Additionally, macroeconomic policies that support energy market stability can create conducive investment climates for energy companies to innovate and transform sustainably. A study by [14, 15] emphasizes that the success of green energy transition depends significantly on the synergy between economic policies, fiscal policies, and corporate commitment to implementing sustainable business practices.

Dynamic energy market demand also represents an external factor that cannot be overlooked. In Southeast Asia, middle-class growth and urbanization drive significant increases in energy consumption [16]. This demand stems not only from the industrial sector but also from household and transportation sectors. Energy companies are required to meet market demand while maintaining operational sustainability. Research by [4, 17, 18] demonstrates that companies capable of adapting their business portfolios to energy market demand that is shifting toward renewable energy tend to exhibit superior financial performance and lower business risks in the long term.

In addition to global sustainability commitments, public policy and regulatory frameworks have become key drivers shaping renewable energy development in Southeast Asia. Governments across the region have introduced various regulatory instruments, including renewable energy targets, sustainable finance frameworks, carbon reduction policies, and green investment incentives aimed at accelerating the transition toward low carbon energy systems. These policy initiatives, supported by government agencies and international organizations, provide institutional support for renewable energy investments and encourage energy firms to adopt sustainability oriented financial strategies. As a result, public policy frameworks play a critical role in influencing corporate decision making and shaping the financial performance of energy companies operating in the region.

Despite increasing attention to sustainability in the energy sector, the transition toward green energy still faces significant challenges, particularly related to financing mechanisms, corporate transparency, and market dynamics. Previous studies have examined the influence of individual factors such as green investment, carbon disclosure, or green financing on corporate performance. However, most of these studies analyze these factors separately and do not provide a comprehensive framework that integrates multiple determinants simultaneously.

Conversely, capital structure and dividend policy, as moderating variables, become highly relevant in analyzing the relationship between these factors and energy company financial performance. Capital structure, which reflects the proportion of debt and equity in corporate financing, can influence a company's capacity to invest in green energy sectors [19, 20]. A healthy capital structure enables companies to bear the risks associated with green energy investment and maximize the efficient use of external funding. Meanwhile, dividend policy plays a crucial role in determining profit distribution to shareholders and can influence investor preferences toward sustainability-oriented companies [21]. Research by [22–24] indicates that companies with consistent dividend policies and optimal capital structures tend to be more adaptive to energy policy changes and more capable of demonstrating superior financial performance.

Although various studies have examined the influence of one or two factors on energy company financial performance, limited research integrates the five primary factors green energy investment, carbon emission disclosure, green financing strategies, economic and fiscal policies, and energy market demand while simultaneously considering the moderating role of capital structure and dividend policy in the Southeast Asian context, [25]. This research endeavors to fill this literature gap through a more comprehensive approach based on the most recent empirical data from energy companies in the region.

This study adopts a quantitative approach utilizing secondary data from annual reports, sustainability reports, and official financial databases updated through 2025. Moderated regression analysis is employed to examine the role of capital structure and dividend policy in strengthening or weakening the influence of independent variables on corporate financial performance [26].

Regarding contributions, the results of this research are expected to provide both practical and theoretical benefits. From a practical perspective, the research findings can be utilized by government policymakers, energy industry practitioners, and investors to formulate more effective investment strategies, financing approaches, and risk management practices during the green energy transition era. From a theoretical perspective, this research enriches the knowledge base of financial management and sustainability science, particularly in

the context of emerging markets such as Southeast Asia [27].

Thus, this study examines how green energy investment, carbon emission disclosure, green financing strategies, economic and fiscal policies, and energy market demand influence the financial performance of energy companies in Southeast Asia. It also analyzes the moderating roles of capital structure and dividend policy in shaping these relationships, thereby highlighting how corporate financial decisions affect sustainability driven performance dynamics.

2. LITERATURE REVIEW

2.1. Renewable Energy Investment

Renewable energy investment refers to corporate expenditures allocated to developing and implementing renewable energy technologies such as solar, wind, and hydropower [28]. These investments contribute to reducing carbon emissions and improving environmental sustainability. From a business perspective, renewable energy investment may enhance operational efficiency and strengthen corporate reputation [29]. However, renewable energy projects generally require significant capital investment and long payback periods. As a result, the financial impact of such investments may not be immediately reflected in short-term financial performance. Nevertheless, firms that consistently invest in renewable energy may benefit from improved competitiveness and long-term sustainability [30].

In addition to the environmental and operational benefits, renewable energy investments also align with the global shift towards sustainability, which is increasingly prioritized by both consumers and investors. Firms that embrace renewable energy may attract a new segment of environmentally conscious customers, thereby expanding their market reach. Moreover, these investments can create cost-saving opportunities in the long run by reducing energy consumption and mitigating the risks associated with volatile fossil fuel prices. As governments around the world implement policies to support green energy initiatives, companies that are early adopters of renewable energy technologies may gain a competitive advantage in navigating the evolving regulatory and market landscapes.

2.2. Carbon Emission Disclosure

Carbon emission disclosure reflects the transparency of companies in reporting their greenhouse gas emissions and environmental impact [8]. Transparent disclosure enables stakeholders to evaluate a companys environmental responsibility and sustainability commitment [31]. By providing detailed and accurate emissions data, companies demonstrate their accountability and contribute to global efforts to address climate change. Such transparency is increasingly valued by consumers, investors, and regulatory bodies, who view it as an essential part of responsible corporate governance.

Companies that disclose carbon emissions are often perceived as more environmentally responsible, which may enhance corporate reputation and attract environmentally conscious investors [32]. This perception can lead to increased brand loyalty, improved market positioning, and a competitive advantage in industries where sustainability is a key differentiator. However, the relationship between disclosure and financial performance varies depending on regulatory environments and stakeholder expectations. In some regions, stricter regulations may require more detailed disclosures, while in others, companies may face less regulatory pressure, affecting the level of investment and the financial impact of such transparency.

In addition, the growing emphasis on sustainability reporting has led to increasing pressure from both regulators and investors for companies to improve their carbon emission disclosures. While the immediate financial benefits of such disclosures may not be obvious, long-term advantages include better risk management, access to green financing, and alignment with global sustainability goals. Companies that adopt robust disclosure practices may be better positioned to navigate the evolving regulatory landscape and meet increasing stakeholder demands for environmental accountability.

2.3. Green Financing

Green financing refers to financial mechanisms designed to support environmentally sustainable projects [33]. Examples include green bonds, green loans, and sustainability-linked financing instruments. These financing tools allow companies to access capital while supporting environmentally responsible investments. By adopting green financing, firms may improve their reputation, attract responsible investors, and support long-term sustainability objectives [34].

In addition to its financial benefits, green financing can also align companies with global sustainability trends, helping them meet regulatory requirements and investor expectations for environmental responsibility. Green bonds and loans, for instance, are increasingly being adopted by companies to fund renewable energy, energy efficiency, and other green projects. This not only allows firms to reduce their carbon footprint but also enhances their attractiveness to a growing segment of eco-conscious investors. As sustainability becomes a priority for both consumers and regulatory bodies, green financing offers companies a competitive edge in the marketplace.

The expansion of green financing is also supported by increasing government incentives and international agreements that promote sustainable development. By leveraging green financial instruments, companies can contribute to global sustainability goals, improve their operational efficiency, and ultimately achieve long-term financial success. The growing adoption of such instruments reflects the broader shift toward integrating environmental considerations into business strategies, making green financing a key element of corporate sustainability efforts.

2.4. Fiscal Incentives for Renewable Energy

Fiscal incentives are government policies aimed at encouraging companies to invest in renewable energy technologies [35], such as tax reductions, subsidies, and financial support programs. These incentives help reduce the financial burden associated with renewable energy investments, which often involve high initial capital and long payback periods [36]. By providing financial relief, these incentives can stimulate corporate participation in sustainable energy development, making green investments more attractive to companies. Furthermore, fiscal policies can accelerate the transition towards renewable energy by aligning corporate strategies with broader sustainability goals, as they lower the perceived risks and financial challenges tied to such investments.

However, while fiscal incentives may initially reduce investment costs, their impact on corporate financial performance is not always straightforward. In the short term, these incentives might not immediately translate into higher profitability for companies due to the long-term nature of renewable energy projects. In some cases, fiscal incentives could lead to market distortions by encouraging companies to invest in less profitable or less efficient projects [37]. Over time, though, companies that consistently leverage fiscal incentives may benefit from improved competitiveness and enhanced brand reputation as environmentally responsible firms. As governments continue to emphasize sustainability through policy tools, the long-term financial benefits of such incentives are likely to grow, supporting firms in achieving their green energy and profitability objectives simultaneously.

2.5. Green Energy Market Demand Growth

The increasing global demand for renewable energy creates new market opportunities for companies involved in sustainable energy industries [38]. As the push for environmental sustainability intensifies, demand for renewable energy sources like solar, wind, and hydropower grows significantly. This heightened demand encourages firms to expand their renewable energy production and adopt sustainable technologies, positioning themselves to meet the evolving needs of eco-conscious consumers and regulators. The growth of the green energy market represents a significant opportunity for companies to diversify their portfolios, attract environmentally conscious investors, and contribute to global sustainability goals. By capitalizing on these market dynamics, companies can position themselves as industry leaders in the transition towards cleaner energy.

As the market for green energy continues to expand, companies that actively participate in this sector may gain competitive advantages and improve long-term profitability [39]. These companies can benefit from a first-mover advantage, securing market share in emerging green technologies before competitors. Moreover, sustained participation in the green energy market not only improves profitability but also enhances a company's reputation, helping them attract both investors and customers who prioritize sustainability. However, the financial benefits of this growth may not be immediately apparent, as companies must navigate market constraints such as competition, regulatory hurdles, and the high initial costs associated with transitioning to renewable energy technologies. Nonetheless, in the long run, firms that embrace green energy are likely to experience improved financial performance, driven by market demand, innovation, and environmental responsibility.

2.6. Moderating Variables

Fiscal incentives, such as tax reductions and subsidies, are increasingly used by governments to encourage companies to invest in renewable energy technologies. These incentives aim to alleviate the financial

burden of investing in green energy projects, which often require significant capital upfront. As seen in the conceptual framework in Figure 2, fiscal incentives can stimulate corporate participation in sustainable energy development by improving the financial viability of these investments. However, while these incentives reduce investment costs, their direct impact on profitability may not be immediately realized, as renewable energy projects often involve long-term payback periods. This delay in profitability highlights the need for companies to adopt long-term financial strategies that account for the initial investment and future returns [14].

Moreover, the effectiveness of fiscal incentives can vary depending on a company's financial structure and the overall regulatory environment. Firms with solid capital structures may be better positioned to absorb the initial costs of renewable energy projects, thus maximizing the benefits of fiscal incentives [40]. Conversely, companies with weaker financial foundations might struggle to leverage these incentives effectively, potentially limiting their ability to make impactful green investments. Therefore, the role of fiscal incentives in driving corporate financial performance is not only contingent upon government policies but also on how companies manage their financial risks and long-term investment strategies.

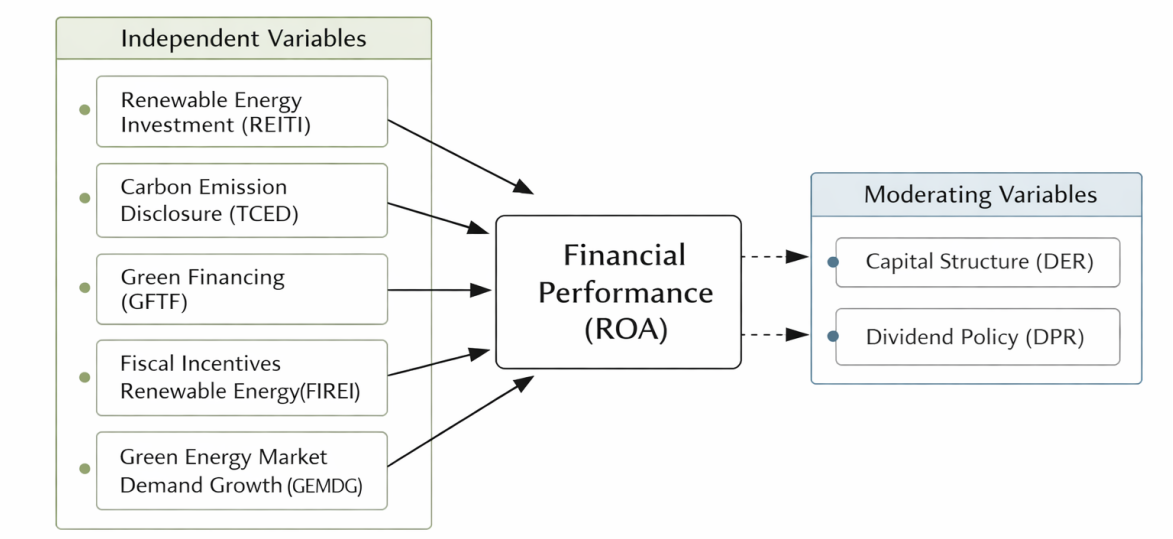


Figure 2. Research Conceptual Framework

Figure 2 illustrates the research conceptual framework, depicting the relationships between independent variables, the dependent variable, and moderating variables. This framework suggests that sustainability investments and practices, such as Renewable Energy Investment (REITI), Carbon Emission Disclosure (TCED), Green Financing (GFTF), Fiscal Incentives for Renewable Energy Investment (FIREI), and Green Energy Market Demand Growth (GEMDG), have the potential to influence corporate financial performance, as measured by Return on Assets (ROA). These independent variables are hypothesized to directly affect ROA, highlighting the importance of sustainability efforts in shaping a company's financial outcomes.

However, the framework also acknowledges that Capital Structure (DER) and Dividend Policy (DPR) act as moderating variables that could either amplify or mitigate the effects of sustainability initiatives on financial performance. These internal financial policies reflect a firm's approach to managing debt and equity as well as how it distributes profits to shareholders. As shown in Figure 2, the relationship between sustainability factors and ROA is not solely influenced by external market conditions but is also shaped by the company's financial strategies, making it crucial to consider both sustainability initiatives and financial policies when evaluating a firm's overall performance.

3. METHODOLOGY

This study employs a quantitative explanatory approach to examine causal relationships among variables using panel data analysis [23]. Panel Data Regression with the Fixed Effects Model (FEM) and Random Effects Model (REM) is employed to control for unobserved heterogeneity across firms and over time, thereby

producing more robust and consistent estimates. The selection between FEM and REM is determined through appropriate statistical tests, such as the Chow and Hausman tests, to ensure model suitability and validity [41]. The study utilizes secondary data from published reports which, although standardized and accessible, may present limitations such as reporting bias, data inconsistency, and limited disclosure depth. All variables are operationalized using established proxies from prior literature to ensure construct validity and replicability.

The study population comprises energy companies listed on stock exchanges across Southeast Asia, representing the target group for analysis [42]. The sampling process involves selecting firms based on the availability of relevant financial and sustainability data to ensure adequate representation and support generalizability. Data are collected from secondary sources, including annual reports, sustainability reports, and financial databases, which provide comprehensive information on investment, emissions, financing, policy, market demand, and financial performance indicators relevant to the research variables [43].

The research instruments consist of standardized measurement formulas and indices derived from established literature and institutional reports [44]. These instruments operationalize abstract constructs such as green energy investment, carbon emission disclosure, green financing strategy, fiscal policy incentives, market demand, financial performance, capital structure, and dividend policy into quantifiable metrics. Data analysis employs Moderated Regression Analysis (MRA) using statistical software to test both direct and moderating effects among variables. This approach enables the examination of the primary relationships as well as the interaction effects of capital structure and dividend policy on the financial performance of energy companies [45, 46]. To ensure validity and reliability, the study relies on well-documented secondary data sources, consistent operational definitions, and standardized measurement formulas. The use of established indicators and adherence to international reporting standards further enhance data credibility [47].

The independent variables include REITI,Carbon Emission Disclosure TCED, GFTF, FIREI, and GEMDG. Financial performance is measured using ROA, while DER and DPR are incorporated as moderating variables. Data analysis is conducted using MRA to evaluate both direct and moderating effects of the variables on financial performance [48].

4. RESULT AND DISCUSSION

This report summarizes the descriptive statistics for eight variables, each observed across 170 entities, providing insights into their central tendencies, dispersions, and ranges [49]. While the TCED exhibited remarkable homogeneity with a mean of approximately 14.27 and a low standard deviation of 1.01, indicating consistent values, the remaining variables demonstrated varying degrees of significant variability. Specifically, the REITI (mean: 21.31, Std.dev: 22.82), GFTF (mean: 14.21, Std.dev: 15.95), FIREI (mean: 46.82, Std.dev: 22.09), ROA (mean: 4.37, Std.dev: 4.56), Debt-to-Equity Ratio (DER) (mean: 97.80, Std.dev: 59.09), and DPR (mean: 53.32, Std.dev: 41.01) all displayed substantial dispersion, characterized by large standard deviations relative to their means and broad ranges, including negative values for ROA and values exceeding 100 for FIREI, GEMDG, DER, and DPR. Notably, the GEMDG variable presented the highest variability (mean: 14.31, Std.dev: 23.37, range: 0.001-150), suggesting extreme heterogeneity within its observations. Overall, the analysis reveals a diverse set of variables, with TCED standing out for its stability, while others exhibit considerable spread, indicating significant differences among the observed entities that warrant further inferential investigation [50].

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std.Dev	Min	Max
REITI	170	21.31235	22.82467	1.0000	93.0000
TCED	170	14.27194	1.01685	8.5500	15.8500
GFTF	170	14.20946	15.95200	0.0000	80.0000
FIREI	170	46.82361	22.09225	0.0010	100.0000
GEMDG	170	14.31291	23.37947	0.0010	150.0000
ROA	170	4.37666	4.565533	-6.7461	27.1441
DER	170	97.80362	59.09168	10.7962	261.2410
DPR	170	53.32752	41.01031	0.0000	278.2793

Table 1 presents the descriptive statistics for eight variables across 170 entities, including the mean,

standard deviation, minimum, and maximum values for each variable. The statistics reveal significant variability in most variables, with REITI, GFTF, FIREI, and GEMDG showing broad ranges, while TCED demonstrates stability. The Debt-to-Equity Ratio (DER) and Dividend Payout Ratio (DPR) also exhibit considerable dispersion, indicating diverse financial structures and payout strategies across the firms. These values provide a foundation for understanding the relationship between sustainability initiatives and financial performance in the study.

The Table 2, yielded a statistically significant Breusch Pagan chi square statistic, with a corresponding probability value (Prob chi square) below the 5% significance level, leading to the rejection of the null hypothesis. This rejection unequivocally indicates the presence of significant individual effects within the panel data, thereby rendering the Pooled Ordinary Least Squares model inappropriate due to its failure to account for such unobserved heterogeneity. Consequently, the Random Effects model is identified as the more suitable regression approach, acknowledging the strong panel characteristics of the data that necessitate consideration of both inter individual and inter temporal variations. This outcome establishes the Random Effects model as the preferred alternative to Pooled OLS, setting the stage for further refinement in model selection through the subsequent application of the Hausman Test to distinguish between Random Effects and Fixed Effects specifications.

Table 2. Lagrange Multiplier Test

	Var	**SD = sqrt (Var)**
ROA	20.84409	4.56553
e	18.56767	4.30902
u	0	0

Based on the findings from the Hausman Test, as presented in Table 3, the Chi-square (X^2) statistic yielded a statistically significant result, indicated by a probability value (Prob $> X^2$) less than the conventional 5% significance level. This outcome necessitates the rejection of the null hypothesis, which posits no systematic difference between the coefficients estimated by the Fixed Effects (FE) and Random Effects (RE) models.

The rejection of the null hypothesis carries a crucial implication it confirms the presence of systematic differences in coefficients between the FE and RE models [51]. This discrepancy suggests that the unique, unobserved individual effects pertinent to each firm are indeed correlated with the independent variables incorporated into the research model. Consequently, the assumption of exogeneity required for the consistency of the Random Effects model is violated. Therefore, the Random Effects estimator is deemed inconsistent, rendering the Fixed Effects model the more appropriate and robust choice for the subsequent panel data analysis [52].

Table 3. Hausman Test

	Coefficients			
	(b)	**(B)**	**(b-B)**	$\mathbf{Sqrt(diag(v_b - V_B))}$
	fe	**re**	**Difference**	**Std.err**
REITI	.0343498	.0209332	.0134166	.
TCED	.760767	.8620719	-.1013049	.
GFTF	-.0172962	-.0090606	-.0082356	.0011996
FIREI	-.0844436	-.0426502	-.0417934	.012699
GEMDG	.0198437	.0237683	-.0039246	.0041166

Table 3 the selection of the Fixed Effects model is advantageous as it effectively controls for unobserved heterogeneity that is specific to each firm and remains constant across the observation period. By accounting for these time-invariant, firm specific characteristics, the Fixed Effects model enhances the validity and reliability of the estimated coefficients [53]. This methodological choice is critical for accurately assessing the influence of variables such as REITI, TCED, GFTF, FIREI, and GEMDG on ROA, ensuring that unmeasured firm level attributes do not confound the observed relationships. Table 4 presents the results of the Fixed Effect Model for various variables tested across multiple models (M1 to M24). The variables analyzed include REITI, TCED, GFTF, FIREI, GEMDG, DER, and others. The results from this model indicate the relationship

between the independent variables and the dependent variable being analyzed [54].

Table 4. Fixed Effect Model

Model	Variable	Coefficient	Std. Err	t	P>t	[95% conf.	Interval]	Sig
M1	REITI	0.0343498	0.1914730	1.79	0.075	-0.0034735	0.0721731	
M2	TCED	0.7607670	0.3674235	2.07	0.040	0.0349633	1.4865710	
M3	GFTF	-0.0172962	0.0238457	-0.73	0.469	-0.0644006	0.0298082	
M4	FIREI	-0.0844436	0.0217787	-3.88	0.000	-0.0108757	-0.0414221	
M5	GEMDG	0.0198437	0.0155511	1.28	0.204	-0.0108757	0.0505631	
	_Cons	-3.2973240	5.4715180	-0.50	0.548	-14.10569	7.5110420	

Table 4 show significant results across multiple models, indicating that these variables have a statistically significant effect on the dependent variable. For instance, in model M4, the FIREI variable has a negative coefficient of 0.0844436, with a t statistic of 3.88 and a p value of 0.000, meaning that FIREI is negatively associated with the dependent variable and is statistically significant at the 1% level. This suggests that an increase in FIREI is associated with a decrease in the dependent variable. This result is highly significant, as denoted by the, which indicates a high level of significance (1%). REITI and DER also show significant results, with p values of 0.000, indicating a strong influence of these two variables on the dependent variable (Model 6). The negative coefficient for REITI (-0.0964505) suggests that an increase in REITI will be associated with a decrease in the dependent variable [46].

TCED has a positive coefficient of 2.013155, with a p-value of 0.011, indicating a positive and significant relationship between TCED and the dependent variable (M7) [55]. This result is significant at the 5% level, meaning that an increase in TCED will lead to an increase in the dependent variable. Model M8 shows that GFTF has a relatively large negative coefficient of -0.1295448, with a p-value of 0.000, indicating a very strong negative relationship at the 1% significance level [56]. This suggests that an increase in GFTF will decrease the dependent variable. Additionally, in model M9, both FIREI and DER have p-values below 0.05, indicating that both have a significant negative impact on the dependent variable. Model M10 demonstrates that DER has a very strong negative effect on the dependent variable, with a p-value of 0.000, indicating significance at the 1% level [57]. This result reinforces the idea that DER plays a crucial role in influencing the dependent variable.

Overall, the findings from this table suggest that several variables such as REITI, DER, FIREI, and GFTF contribute significantly to the dependent variable being analyzed. Some variables have negative coefficients, indicating an inverse relationship with the dependent variable, while others show a positive relationship. These models provide important insights into the influence of various economic and financial factors on the dependent variable under investigation.

5. DISCUSSION

5.1. Analysis of Regression Models on Return on Assets (ROA)

This analysis examines the relationship between various sustainability factors and financial performance, measured by Return on Assets, through several regression models (M1 to M5). The independent variables analyzed include renewable energy investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy investment, and green energy market demand growth.

Model M1 shows a positive relationship between REITI and ROA, but this relationship is statistically insignificant (p-value = 0.075). This suggests that while renewable energy investments can enhance financial performance in the long term through energy savings and mitigating fossil fuel price risks, their positive impact may be delayed due to high initial costs and long payback periods. On the other hand, Model M2 reveals a statistically significant positive relationship between TCED and ROA (coefficient = 0.761, p-value = 0.040). Higher carbon emissions disclosure tends to indicate transparency and accountability, which can improve a companys reputation and investor trust, subsequently boosting its financial performance.

Model M3 indicates that green financing (GFTF) does not significantly affect ROA (coefficient = -0.017, p-value = 0.469). Despite the potential for green financing to reduce capital costs and enhance a companys reputation, its financial benefits may not materialize immediately due to the high upfront costs of green projects and the lack of clear standards in green finance reporting. In contrast, Model M4 reveals a significant negative relationship between fiscal incentives for renewable energy investment (FIREI) and ROA

(coefficient = -0.084, p-value = 0.000). This suggests that fiscal incentives might attract investments in less profitable projects or create market distortions, ultimately suppressing short-term ROA. However, long term benefits from fiscal incentives may be more apparent in the firms value rather than immediate profits.

Model M5 shows that green energy market demand growth (GEMDG) does not significantly affect ROA (p-value = 0.204). While the growth in the green energy market provides new opportunities for companies, it may also lead to increased competition, which could compress profit margins and limit the expected financial benefits. Overall, while carbon emissions disclosure demonstrates a significant positive relationship with ROA, other sustainability factors, such as renewable energy investments and fiscal incentives, require further investigation to understand their long term impact on profitability. These findings highlight the importance of considering both short-term and long-term effects, as well as the interactions between variables, when evaluating the role of sustainability in financial performance. Further research is needed to clarify the mechanisms underlying these findings.

5.2. Regression Analysis of Sustainability and Financial Variables on Return on Assets Moderated by Debt to Equity Ratio

This analysis examines the impact of various sustainability and financial variables on Return on Assets, considering the moderating role of the Debt to Equity Ratio. The independent variables include renewable energy investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy, and green energy market demand growth, with DER acting as a moderating factor.

Model M6 reveals that REITI has a significant negative effect on ROA, implying that increased investment in renewable energy tends to reduce profitability. However, the interaction between REITI and DER shows that higher financial leverage mitigates the negative impact of renewable energy investments on ROA. This suggests that firms with higher debt levels may manage the costs and risks associated with green investments more effectively, enhancing their long-term financial sustainability. Model M7 finds that carbon emissions disclosure has a positive effect on ROA, indicating that companies transparent about their emissions tend to have better financial performance. However, this positive effect is moderated negatively by DER, suggesting that highly leveraged firms benefit less from carbon disclosure. This could be due to the pressure on such firms to prioritize short-term profitability, diminishing the reputational advantages of emissions transparency.

In Model M8, green financing (GFTF) also has a negative effect on ROA, suggesting that the initial costs of green projects may outweigh the short term financial returns. However, the negative effect is moderated positively by DER, indicating that firms with higher leverage may better absorb the initial costs associated with green financing. Model M9 shows a surprising negative relationship between fiscal incentives for renewable energy (FIREI) and ROA, implying that such incentives may not lead to immediate profitability improvements. This could be due to market distortions or long-term investment horizons. DER does not significantly moderate this relationship, suggesting that fiscal incentives operate independently of a firms capital structure in terms of their immediate financial impact.

Model M10 indicates that the growth of the green energy market (GEMDG) has a positive effect on ROA, confirming that expanding market opportunities drive profitability. However, DER does not significantly moderate this relationship, implying that market growth influences all firms in the sector similarly, regardless of their financial leverage.

In conclusion, while some sustainability practices positively impact financial performance, such as carbon emissions disclosure and market growth, others like green financing and fiscal incentives show mixed results. The moderating effect of DER reveals that a firm's capital structure plays a critical role in determining how sustainability investments impact profitability, with highly leveraged firms experiencing different outcomes compared to less leveraged firms. Further research is needed to explore these dynamics in more detail.

5.3. Regression Analysis of Sustainability and Financial Variables on Return on Assets Moderated by Dividend Payout Ratio

This analysis explores the effects of various sustainability and financial variables on ROA, considering the moderating role of the dividend payout ratio. The study uses several regression models (M11 to M15) to examine the relationships between ROA and independent variables such as renewable energy investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy investment, and green energy market demand growth, while also considering the moderating role of DPR.

Model M11 finds that REITI does not significantly affect ROA, with neither REITI nor DPR statistically significant. This suggests that renewable energy investments, which often entail high upfront costs and long payback periods, do not immediately affect ROA. Similarly, DPR does not moderate the relationship between REITI and ROA, indicating that a firm's dividend policy does not significantly influence the financial outcomes of renewable energy investments. Prior research suggests that such investments may have long-term benefits, but their immediate impact is often negligible.

Model M12 shows a marginally significant positive effect of TCED on ROA, suggesting that carbon emissions disclosure might enhance financial performance due to improved reputation and access to sustainable financing. However, DPR does not significantly moderate this relationship. This lack of moderation indicates that dividend policies do not alter the reputational and financial benefits associated with transparency in emissions disclosure.

Model M13 indicates that GFTF has no significant impact on ROA, reinforcing the notion that green financing, while aimed at sustainability, may come with higher upfront costs and may not immediately boost profitability. Again, DPR does not significantly moderate this relationship, suggesting that firms can manage green financing without being significantly affected by their dividend policies. Model M14 reveals a significant negative relationship between FIREI and ROA, implying that fiscal incentives may not lead to immediate profitability gains, possibly due to market distortions or long-term investment horizons. However, DPR does not moderate this effect, indicating that dividend policies do not influence the impact of fiscal incentives on profitability.

Lastly, Model M15 shows that GEMDG does not significantly affect ROA, suggesting that while market demand for green energy may provide opportunities, it may not immediately translate into higher profitability. DPR again does not moderate this relationship, highlighting that external market factors are more influential than dividend policies in this context. The study finds that while some sustainability factors, like FIREI, have a measurable impact on ROA, DPR does not significantly moderate these relationships. These findings suggest that sustainability investment decisions and market responses are more influenced by factors such as capital structure and market conditions rather than profit distribution policies. Further research is needed to explore other potential moderators in this context.

5.4. Regression Analysis of Sustainability and Financial Variables on ROA with Dual Moderation by Debt to Equity Ratio and Dividend Payout Ratio

This analysis investigates the impact of various sustainability and financial variables on Return on Assets, while considering the dual moderating roles of the Debt-to-Equity Ratio and the Dividend Payout Ratio. The independent variables under study include renewable energy investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy investment, and growth in green energy market demand. ROA serves as the dependent variable, while DER and DPR are moderating factors that reflect a firm's financial leverage and dividend distribution policy, respectively.

Model M16 reveals that REITI has a statistically significant negative effect on ROA, suggesting that increased renewable energy investments reduce short-term profitability, likely due to high upfront costs and long payback periods. Additionally, DER has a significant negative effect on ROA, consistent with financial leverage theory, which holds that excessive debt reduces profitability. However, the interaction between REITI and DER shows a significant positive moderation, indicating that higher financial leverage can mitigate the negative effects of renewable energy investments on ROA. Conversely, DPR does not significantly moderate this relationship, implying that dividend policy does not substantially impact the effect of REITI on ROA.

In Model M17, TCED shows a positive effect on ROA, indicating that firms disclosing more carbon emissions tend to experience better financial performance. However, the interaction between TCED and DER reveals that higher leverage reduces the positive impact of carbon disclosure on ROA. This suggests that highly leveraged firms may face greater pressure to prioritize short-term profitability, diminishing the reputational benefits of carbon transparency. DPR continues to show no significant moderating effect on this relationship. Model M18 finds that GFTF has a significant negative impact on ROA, again likely due to the initial costs of green financing, which may not yield immediate financial returns. Yet, the interaction between GFTF and DER reveals that higher leverage can reduce the negative impact of green financing on ROA. DPR remains insignificant in moderating this relationship.

In Model M19, FIREI exhibits a negative but non-significant effect on ROA, suggesting that fiscal incentives for renewable energy investment may not immediately enhance profitability. Neither DER nor DPR

significantly moderates this relationship, indicating that fiscal incentives might have broader macroeconomic implications rather than being influenced by a firms capital structure or dividend policy. Lastly, Model M20 shows that GEMDG has a positive but non-significant effect on ROA, implying that while market demand for green energy may present growth opportunities, it does not immediately translate into higher profitability. The interactions between GEMDG and both DER and DPR are not statistically significant, highlighting that market growth affects firms uniformly regardless of their financial leverage or dividend policy.

In conclusion, the study finds that financial leverage plays a crucial role in moderating the impact of sustainability practices on ROA, while dividend payout policies do not significantly influence these relationships. Further research is necessary to explore the underlying mechanisms of these moderating effects and examine additional contextual factors.

5.5. Regression Analysis of Sustainability and Financial Variables on Return on Assets (ROA)

This analysis examines the impact of various sustainability and financial variables on Return on Assets, focusing on the influence of renewable energy investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy, and green energy market demand growth. The study also investigates how these relationships are moderated by the Debt to Equity Ratio and Dividend Payout Ratio.

Model M21 reveals that renewable energy investment does not significantly impact ROA, with its positive effect being statistically insignificant. This aligns with the understanding that renewable energy investments often involve substantial upfront costs and long payback periods, which may suppress short-term profitability. Similarly, green financing (GFTF) shows no statistically significant impact on ROA, suggesting that the benefits of such financing might be long-term and not immediately apparent.

In contrast, the disclosure of carbon emissions) is positively and significantly associated with ROA, indicating that firms transparent about their environmental impact may benefit from enhanced reputations, better access to sustainable financing, and improved operational efficiency. This finding supports the theory that environmental transparency can increase investor confidence and reduce information asymmetry, leading to better financial performance.

Surprisingly, fiscal incentives for renewable energy investment show a significant negative relationship with ROA, indicating that such incentives may not always lead to immediate profitability improvements. This could be due to market distortions or the long-term nature of the investments these incentives promote, which might not yield substantial returns within the analysis period.

The growth rate of the green energy market shows a positive but statistically insignificant relationship with ROA. While the growth of the green energy market should theoretically drive profitability through increased market opportunities, the effect is not strong enough to result in significant short-term financial gains, possibly due to increased competition and market constraints.

In conclusion, the findings suggest that while carbon emissions disclosure positively impacts ROA, other sustainability variables such as REITI, GFTF, and GEMDG do not show significant effects in this model. The negative relationship between FIREI and ROA highlights the complexity of sustainability investments, indicating that their financial impact is not always straightforward. Further research is needed to explore the underlying mechanisms behind these relationships and to identify other factors that may moderate or mediate these effects.

5.6. Impact of Debt to Equity Ratio on Sustainability-Financial Performance Dynamics

This analysis investigates the impact of various sustainability and financial variables on Return on Assets, with a focus on how the Debt to Equity Ratio moderates these relationships. The independent variables considered include the percentage of renewable energy investment relative to total investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy investment, and the growth rate of green energy market demand. DER is incorporated as a moderating variable to examine how a company's capital structure influences these dynamics.

Model M22 finds that REITI does not have a statistically significant impact on ROA, suggesting that renewable energy investments, which typically involve substantial upfront costs, do not immediately affect profitability. Similarly, the disclosure of carbon emissions (TCED) shows no significant effect on ROA, challenging the idea that increased transparency in environmental matters directly boosts financial performance. Green financing (GFTF) also shows a non-significant relationship with ROA, indicating that green projects, while potentially beneficial, may require long payback periods that do not immediately translate into financial returns. Conversely, fiscal incentives for renewable energy investment (FIREI) have a significant negative

effect on ROA, implying that these incentives may not lead to immediate profitability improvements. This negative impact could be due to market distortions or the long-term nature of the investments they encourage. The growth rate of the green energy market (GEMDG) also shows no significant impact on ROA, suggesting that while market demand for green energy may increase opportunities, it does not directly translate into higher profitability in the short term.

A crucial finding is the significant negative impact of the Debt to Equity Ratio on ROA, supporting the theory that higher financial leverage increases financial risk, thereby reducing profitability. However, the interaction between REITI and DER does not significantly moderate the relationship between renewable energy investments and ROA, indicating that financial leverage does not substantially alter the effect of such investments on profitability.

In conclusion, this analysis highlights the complexity of the relationships between sustainability variables, financial leverage, and profitability. While some factors, such as fiscal incentives and financial leverage, have clear direct impacts, others like renewable energy investments and carbon emissions disclosures require more nuanced consideration. Further research is needed to explore the long-term effects and other moderating factors that could influence these relationships.

5.7. Regression Analysis of Sustainability and Financial Variables on Return on Assets with Dividend Payout Ratio as a Moderator

This analysis explores the impact of sustainability and financial variables on Return on Assets, with a focus on the moderating role of the Dividend Payout Ratio. The study examines variables such as the percentage of renewable energy investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy investment, and green energy market demand growth, with the DPR incorporated as a moderator.

Model M23 reveals that REITI does not significantly affect ROA, suggesting that renewable energy investments, while potentially beneficial in the long term, do not immediately influence profitability due to high initial costs and long payback periods. Similarly, TCED, despite being associated with a negative coefficient, does not significantly impact ROA, indicating that carbon emission disclosures do not directly translate into improved financial performance in this model. Green financing also shows no significant impact on ROA, likely due to the long-term nature of green projects, which may not provide immediate financial benefits.

Fiscal incentives for renewable energy investment have a statistically significant negative effect on ROA. This finding is counterintuitive, as fiscal incentives are typically expected to stimulate investment and enhance profitability. The negative relationship may stem from market distortions, long-term investment horizons, or inefficient investments in projects that would not be profitable without government support. The growth rate of green energy market demand (GEMDG) shows a marginally positive but statistically insignificant effect on ROA. This suggests that while market growth presents opportunities, its impact on profitability is tempered by competition and other constraints.

DPR, the moderating variable, consistently shows no statistically significant direct effect on ROA across all models. Additionally, the interaction term between REITI and DPR is not significant, suggesting that the firms dividend policy does not significantly influence the relationship between renewable energy investments and profitability. The constant term is statistically significant, indicating a meaningful baseline ROA when all other variables are zero. The findings emphasize the complexity of sustainability variables and their financial impacts. While fiscal incentives and market demand growth show some influence, other variables like REITI, TCED, and GFTF do not have immediate or significant effects on ROA. The role of DPR as a moderator is also limited, indicating that dividend policies may not substantially alter the outcomes of sustainability investments. Further research is needed to explore these relationships over longer time periods or in different contexts.

5.8. Regression Analysis of Sustainability and Financial Variables on Return on Assets with Dual Moderation by Debt to Equity Ratio and Dividend Payout Ratio

This analysis explores the impact of various sustainability and financial variables on Return on Assets, with a focus on the moderating roles of the Debt to Equity Ratio and the Dividend Payout Ratio. The independent variables under examination include renewable energy investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy investment, and green energy market demand growth. The study integrates DER and DPR as moderating variables to understand their influence on the relationship between these factors and ROA.

Model M24 shows that REITI does not have a statistically significant impact on ROA, suggesting that renewable energy investments, despite their potential long-term benefits, do not immediately enhance profitability due to high initial costs. Similarly, TCED and GFTF also do not exhibit significant effects on ROA. The lack of significance for these sustainability variables may reflect the long-term nature of their benefits, which are not fully realized within the analysis period. In contrast, FIREI has a statistically significant negative impact on ROA, indicating that fiscal incentives for renewable energy investments may not lead to short-term profitability improvements. This counterintuitive finding may result from market distortions, long-term investment horizons, or inefficient projects funded by these incentives. GEMDG shows a marginal positive but statistically insignificant effect on ROA, suggesting that while the growth in green energy market demand may provide opportunities, its direct impact on profitability is limited by factors such as competition and capacity constraints.

Both DER and DPR show interesting results. DER has a significant negative effect on ROA, which aligns with the financial leverage theory, suggesting that higher leverage increases financial risk, suppressing profitability. However, the interaction terms between REITI and DER, and REITI and DPR, do not significantly moderate the relationships between renewable energy investments and ROA. This implies that a firm's capital structure and dividend distribution policy do not substantially alter the impact of sustainability investments on profitability. The constant term is statistically significant, indicating a baseline ROA when all independent and moderating variables are zero. Overall, the study highlights the complexity of sustainability initiatives and financial leverage in affecting financial performance. While some factors like fiscal incentives and financial leverage have clear impacts, the roles of DER and DPR require further exploration, especially in understanding their moderating effects on sustainability investments.

6. MANAGERIAL IMPLICATIONS

The findings offer important managerial implications for energy sector leaders in Southeast Asia, particularly in aligning sustainability strategies with financial performance objectives. Strategic investment in renewable energy should be managed with a long-term orientation, as such investments may exert short-term pressure on Return on Assets due to high upfront capital requirements. Accordingly, managers should adopt financing structures and capital budgeting frameworks that accommodate delayed returns while maintaining financial stability. The results further indicate that an optimal capital structure plays a buffering role, as financial leverage can help absorb the initial costs of green investments when managed prudently.

Transparency in carbon emission disclosure is shown to positively influence financial performance, underscoring the importance of strengthening environmental reporting practices to enhance corporate credibility and attract sustainability oriented investors. However, fiscal incentives for renewable energy do not automatically translate into higher profitability, implying that managers must rigorously evaluate project feasibility and avoid overreliance on policy driven advantages. Meanwhile, dividend policy appears to have limited moderating influence, suggesting that payout decisions can be determined primarily by liquidity conditions, growth opportunities, and long-term reinvestment strategies rather than concerns over sustainability related profitability effects. These findings emphasize that successful green energy transition requires not only environmental commitment but also disciplined financial strategy, integrated risk management, and adaptive corporate governance to balance sustainability goals with shareholder value creation.

7. CONCLUSION

This research provides a thorough analysis of the complex relationships between sustainability and financial variables and their impact on Return on Assets (ROA) in the energy sector of Southeast Asia. The study highlights how factors such as renewable energy investment, carbon emissions disclosure, green financing, fiscal incentives for renewable energy, and green energy market demand growth influence corporate profitability. The findings suggest that while renewable energy investments (REITI) are crucial for long-term sustainability, their high initial costs and long payback periods reduce short-term profitability. Similarly, the Debt to Equity Ratio (DER) negatively affects ROA, indicating that firms with higher debt levels face greater financial challenges.

On the other hand, carbon emissions disclosure (TCED) has a significant positive effect on ROA, highlighting that transparency in environmental disclosures enhances corporate reputation and attracts investors. The study also finds that fiscal incentives for renewable energy have a negative relationship with ROA, poten-

tially leading to market distortions or investments in less profitable projects. Green Energy Market Demand Growth (GEMDG) shows no significant immediate financial benefits, indicating that while market demand for green energy may provide future opportunities, it does not directly translate into higher profitability in the short term.

Furthermore, the research reveals that neither the Debt to Equity Ratio (DER) nor the Dividend Payout Ratio (DPR) significantly moderates the relationships between sustainability variables and ROA. This suggests that a firm's financial structure and dividend policy have limited influence on the effectiveness of sustainability investments. In conclusion, the analysis emphasizes the need for a deeper understanding of how sustainability investments impact financial performance, guiding stakeholders in making informed decisions that balance both environmental and financial goals.

8. DECLARATIONS

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Conceptualization: EP; Methodology: DS; Software: EP; Validation: DS and UR; Formal Analysis: EP. RD and DS; Investigation: UR.; Resources: EP, SL; Data Curation: DS. Writing Original Draft Preparation: DS and EP; Writing Review and Editing: UR, RD, and EP; Visualization: UR All authors, EP, UR, DS, SL, and RD, have read and agreed to the published version of the manuscript.

8.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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8.5. Declaration of Conflicting Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

REFERENCES

[1] International Energy Agency (IEA), "World energy investment 2025," International Energy Agency, Paris, Tech. Rep., 2025, license: CC BY 4.0. [Online]. Available: https://www.iea.org/reports/world-energy-investment-2025

[2] United Nations, "Sustainable development goals," 2025, accessed: 2026-02-07. [Online]. Available: https://sdgs.un.org/goals

[3] I. Abdullah, D. Warviyan, R. Safrina, N. A. Utama, A. Tirta, I. Veza, and I. Irianto, "Green fiscal stimulus in indonesia and vietnam: a reality check of two emerging economies," *Sustainability*, vol. 15, no. 3, p. 2174, 2023.

[4] Z. Adiguzel and F. Sonmez Cakir, "Empowering sustainability: green entrepreneurial orientation, innovative strategies, culture and operational performance," *Management decision*, vol. 63, no. 11, pp. 3934–3966, 2025.
[5] D. Wuisan, J. W. Manurung, C. Wantah, and M. E. Yuliana, "Entrepreneurial self-employment and work engagement in msmes through autonomy and rewards," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 7, no. 1, pp. 264–281, 2025, https://doi.org/10.34306/att.v7i1.448.
[6] M. Akbar and C. Fauziah, "The effect of current ratio, debt to equity ratio, and total asset turnover ratio on return on assets," *Indonesian Journal of Multidisciplinary Science*, vol. 4, no. 11, pp. 1036–1050, 2025.
[7] M. R. Sultanuzzaman, C.-C. Lee, and S. Akther, "Unlocking sustainable development: the asymmetric impact of green finance on energy efficiency in developing countries," *Economic Change and Restructuring*, vol. 59, no. 1, p. 8, 2026.
[8] S. Anwar, E. Rusanti, and D. R. Maulidiyah, "Women, global reporting initiative standards (gri), and carbon emission disclosure: Are women eco-friendly? evidence from banking in indonesia," *The International Journal of Financial Systems*, vol. 3, no. 1, pp. 49–80, 2025.
[9] T. H. Nguyen, M. M. Abu Afifa, L. T. L. Nguyen, T. H. T. Tran, and N. T. Dao, "Sustainability report quality with moderating impact of carbon emissions index: evidence from asean region," *Pacific Accounting Review*, 2025.
[10] D. Lestari, M. Mutiarani, N. Azzahra, and S. E. Pratiwi, "Planet or profit? the effect of carbon emission disclosure and carbon tax on financial performance: Evidence from indonesia's green stock index," *International Conference on Sustainable Economics, Management, and Accounting (ICSEMA 2025)*, 2025.
[11] Y.-T. Hsieh and H.-H. Fu, "Does carbon disclosure matter? corporate finance and bank lending evidence from taiwan," *Journal of Applied Finance & Banking*, vol. 15, no. 4, pp. 13–40, 2025.
[12] A. Rehman, H. Gonenc, and N. Hermes, "Carbon disclosure policy, external financing needs and the cost of capital: Does financial market quality matter?" *Business Strategy and the Environment*, vol. 32, no. 8, pp. 5854–5872, 2023.
[13] A. Halimatussadiah, R. Kurniawan, A. Farah Mita, A. Amanda Siregar, W. Al Kautsar Anky, R. Farah Maulia, and D. Hartono, "The impact of fiscal incentives on the feasibility of solar photovoltaic and wind electricity generation projects: The case of indonesia." *Journal of Sustainable Development of Energy, Water and Environment Systems*, vol. 11, no. 1, pp. 1–16, 2023.
[14] J. P. Braga and E. Ernst, "Financing the green transition. the role of macro-economic policies in ensuring a just transition," *Frontiers in Climate*, vol. 5, p. 1192706, 2023.
[15] D. Chatzinikolaou and C. M. Vlados, "On a new sustainable energy policy: exploring a macro-meso-micro synthesis," *Energies*, vol. 18, no. 2, p. 260, 2025.
[16] P. X. Hoa, V. N. Xuan, and N. T. P. Thu, "Determinants of renewable energy consumption in the fifth technology revolutions: evidence from asean countries," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 10, no. 1, p. 100190, 2024.
[17] L. D. Gitelman, M. V. Kozhevnikov, and M. K. Ditenberg, "Financial sustainability of energy business development: The unregulated activity phenomenon," *Sustainability*, vol. 17, no. 2, p. 505, 2025.
[18] R. Verma and A. A. Shroff, "Esg risks and market valuations: Evidence from the energy sector," *International Journal of Financial Studies*, vol. 13, no. 2, p. 113, 2025.
[19] W. Ning, U. F. Saeed, and M. Kongkuah, "Saving the environment in emerging markets: The synergistic roles of corporate ownership structure, financing strategy, and innovation capacity," *Business Strategy and the Environment*, vol. 34, no. 4, pp. 5114–5138, 2025.
[20] Q. Rahmah, D. Priantinah *et al.*, "The influence of green investment and corporate social responsibility on company financial performance with capital structure as a mediating variable," *American Journal of Economic and Management Business (AJEMB)*, vol. 4, no. 9, pp. 1563–1580, 2025.
[21] M. R. Perdana, A. Sudiro, K. Ratnawati, and R. Rofiaty, "Does sustainable finance work on banking sector in asean?: The effect of sustainable finance and capital on firm value with institutional ownership as a moderating variable," *Journal of Risk and Financial Management*, vol. 16, no. 10, p. 449, 2023.
[22] F. Balli, H. O. Balli, I. Hoxha, H. Nguyen, and T. H. N. Dang, "Energy market deregulation: A new perspective on dividend smoothing," *Journal of International Financial Markets, Institutions and Money*, vol. 106, p. 102260, 2026.
[23] S. Dow and Y. Shi, "How climate change shapes capital structure and corporate payout decisions," in *Corporate Finance Under Climate Crisis: Sustainability Transitions in Theory and Practice*. Springer,

2025, pp. 223–243.
[24] O. E. Njoku and Y. Lee, "Debt capital and dividend policy as complementary indicators of firm valuation," *International Journal of Financial Studies*, vol. 13, no. 1, p. 18, 2025.
[25] M. Ai, F. Luo, and Y. Bu, "Green innovation and corporate financial performance: Insights from operating risks," *Journal of Cleaner Production*, vol. 456, p. 142353, 2024.
[26] M. Hardini, H. Hetilaniar, S. E. E. Girsang, S. N. W. Putra, and I. N. Hikam, "Advancing higher education: Longitudinal study on ai integration and its impact on learning," *International Journal of Cyber and IT Service Management (IJCITSM)*, vol. 5, no. 1, pp. 23–30, 2025, https://doi.org/10.34306/ijcitsm.v5i1.185.
[27] M. M. Siahaan, A. Sijabat, H. Samosir, R. Purba, and R. F. Terizla, "Enhancing hots and entrepreneurial competencies through avnet academic applications in english learning," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 7, no. 1, pp. 206–216, 2025, https://doi.org/10.34306/att.v7i1.496.
[28] D. Amiarti and Y. FAHRUNA, "Boosting profitability through green finance, csr, and capital structure: The moderating of the board of directors," *ILOMATA INTERNATIONAL JOURNAL OF MANAGEMENT : Yayasan Ilomata*, vol. 6, no. 2, pp. 587–599, 2024.
[29] T. H. Nguyen, L. Huynh, and N. M. Nguyen, "Green innovation capability and firm value: The moderating role of esg rating and energy transition in asean countries," *Corporate Social Responsibility and Environmental Management*, 2026.
[30] R. Sivaraman, M.-H. Lin, M. I. C. Vargas, S. I. S. Al-Hawary, U. Rahardja, F. A. H. Al-Khafaji, E. V. Golubtsova, and L. Li, "Multi-objective hybrid system development: To increase the performance of diesel/photovoltaic/wind/battery system." *Mathematical Modelling of Engineering Problems*, vol. 11, no. 3, 2024.
[31] U. Askiah and R. H. Valdiansyah, "Carbon emission disclosure and profitability on firm value," *Accounting and Finance Studies*, vol. 5, no. 3, pp. 296–310, 2025.
[32] G. D. Caesaro, C. H. T. Rahmawati, and L. Purwoto, "Stock returns: Effect of return on assets, return on equity, debt to equity ratio, and dividend payout ratio," *Manajemen Dewantara*, vol. 7, no. 3, pp. 535–547, 2023.
[33] H.-C. Vo Thai and S. H. T. Thu, "How technological innovation and management practices shape green economic practices: Evidence from southeast asian manufacturing smes," *Business Strategy and the Environment*, 2026.
[34] W. Dong, Y. Li, P. Gao, and Y. Sun, "Role of trade and green bond market in renewable energy deployment in southeast asia," *Renewable Energy*, vol. 204, pp. 313–319, 2023.
[35] I. K. Bagiana, R. M. Y. D. Rengganis, L. P. M. Mirayani, and L. P. E. Setiawati, "Impact of dividend policy on firm performance: Moderating role of credit risk," *Jurnal Akuntansi Dan Bisnis*, vol. 5, no. 1, pp. 276–284, 2025.
[36] D. Azhgaliyeva, J. Beirne, and R. Mishra, "What matters for private investment in renewable energy?" *Climate Policy*, vol. 23, no. 1, pp. 71–87, 2023.
[37] W. Bai, L. Zhang, S. Lu, J. Ren, and Z. Zhou, "Sustainable energy transition in southeast asia: Energy status analysis, comprehensive evaluation and influential factor identification," *Energy*, vol. 284, p. 128670, 2023.
[38] J. Li, "The impact of green credit policy on the corporate value of high-polluting enterprises," *FinTech and Sustainable Innovation*, 2025.
[39] F. Batool, I. A. Alhidary, J. R. Boda, B. M. Alwadi, K. Khudoykulov, and M. Haseeb, "Balancing sustainability and profitability: the financial effect of green innovation in chinese high-pollution industries," *Sustainability*, vol. 17, no. 8, p. 3610, 2025.
[40] T. Hidayat, D. Manongga, Y. Nataliani, S. Wijono, S. Y. Prasetyo, E. Maria, U. Raharja, I. Sembiring *et al.*, "Performance prediction using cross validation (gridsearchcv) for stunting prevalence," in *2024 IEEE International Conference on Artificial Intelligence and Mechatronics Systems (AIMS)*. IEEE, 2024, pp. 1–6.
[41] I. G. P. SD and M. N. Majid, "Optimising green industry development to strengthen the national economy," *Jurnal Lemhannas RI*, vol. 12, no. 3, pp. 373–390, 2024.
[42] E. Makeeva, K. Popov, and O. Teplova, "Patenting for profitability: Green energy innovations and firm performance in brics countries," *Frontiers in Environmental Science*, vol. 12, p. 1332792, 2024.
[43] H. N. Mutiara, A. M. Hidayat, and P. N. Madiawati, "The impact of green accounting, capital structure, liquidity, good corporate governance and gdp on profitability in energy sector companies in 2012-2022.

economics and finance, volume 12, issue 3, 51-64," *Economics and Finance*, p. 51, 2024.
[44] J. Moolman and C. C. Shuttleworth, "Qualitatively pre-testing a tailored financial literacy measurement instrument for professional athletes," *Journal of Risk and Financial Management*, vol. 18, no. 6, p. 317, 2025.
[45] D. Ramadhan, A. Indrabudiman, M. Akuntansi, F. Ekonomi, and D. Akuntansi, "Understanding the effects of liquidity, profitability, and sales growth on capital structure: The moderating role of company size," *Jurnal Comparative: Ekonomi Dan Bisnis*, vol. 6, no. 1, pp. 140–161, 2024.
[46] D. Sunaryo, E. P. Lestari, S. Puryandani, and H. Hersugondo, "Driving shareholder value through technopreneurship innovation," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 7, no. 3, pp. 751–765, 2025, https://doi.org/10.34306/att.v7i3.642.
[47] S. C. Hashim, "The role of international financial reporting standards (ifrs) in enhancing the quality of financial reporting applied research in a sample of iraqi banks listed on the iraq stock exchange," *Jurnal Anggaran: Jurnal Publikasi Ekonomi dan Akuntansi*, vol. 2, no. 3, 2024.
[48] P. Negi, A. Jaiswal, and I. Rekunenko, "Green bonds and corporate value creation: a review of financial, market, and environmental performance," *Discover Sustainability*, vol. 6, no. 1, p. 1106, 2025.
[49] L.-T. Nguyen, "The relationship between green product innovation and accounting-based financial performance: insights from non-linear modeling," *Meditari Accountancy Research*, vol. 33, no. 3, pp. 910–928, 2025.
[50] L. Operato, A. Gallo, E. A. E. Marino, and D. Mattioli, "Navigating csrd reporting: Turning compliance into sustainable development with science-based metrics," *Environmental Development*, vol. 54, p. 101138, 2025.
[51] S. Zheng and S. Jin, "Is corporate green investment a determinant of corporate carbon emission intensity? a managerial perspective," *Heliyon*, vol. 9, no. 12, 2023.
[52] T. Hariguna, U. Rahardja, and Q. Aini, "The antecedent e-government quality for public behaviour intention, and extended expectation-confirmation theory," *Computer Science and Information Technologies*, vol. 4, no. 1, pp. 33–42, 2023.
[53] O. Zarrad and N. Gafsi, "Green finance and economic growth in emerging markets: A swot analysis," *Journal of Ecohumanism*, vol. 4, no. 2, pp. 2579–2595, 2025.
[54] H. H. Trinh, "How do firms cope with climate change exposure? evidence from capital structure and corporate policies," *Evidence from Capital Structure and Corporate Policies (May 24, 2024)*, 2024.
[55] L. P. Dewanti, L. Sitoayu, and A. Idarto, "Digital tele-counseling for sustainable maternal health services in indonesia focus on telelactation," *IAIC Transactions on Sustainable Digital Innovation (ITSDI)*, vol. 6, no. 1, pp. 10–20, 2024.
[56] A. A. Brohi, W. Ali, and Y. Suzuki, "The role of green finance and renewable energy consumption in promoting environmental sustainability in south asia," *Discover Sustainability*, 2026.
[57] N. Anwar, A. M. Widodo, B. A. Sekti, M. B. Ulum, M. Rahaman, and H. D. Ariessanti, "Comparative analysis of nij and nist methods for microsd investigations: A technopreneur approach," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 6, no. 2, pp. 169–181, 2024, https://doi.org/10.34306/att.v6i2.407.