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Exploring Climate Risk Effects on Financial Performance in Energy Sector

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Abstract

This study examines the impact of the Climate Change Performance Index (CCPI) on the financial performance of energy firms in Indonesia and Malaysia, with capital structure as a moderating factor, using panel data analysis. Data from 62 publicly listed energy firms over 2019–2023 were analyzed through fixed effects, random effects, and diagnostic tests (Chow, Hausman, and Lagrange Multiplier). Results reveal that CCPI does not significantly affect return on assets (ROA) (coefficient = -0.0065, p = 0.837), and capital structure shows no moderating effect (p = 0.806). Firm size exhibits a near-significant impact (p = 0.058) in the random effects model. Multicollinearity and time-invariant variables limit cross-country and sectoral analyses. Findings underscore the ASEAN context, where evolving climate regulations temper financial impacts, with firm size emerging as a critical resilience factor. Future research with broader datasets is recommended to address methodological constraints.

Keywords: CCPI, financial performance, capital structure, energy sector, ASEAN

1. Introduction

Global climate policies, such as carbon pricing and emission regulations, have reshaped the operational and financial landscapes of fossil fuel-based energy firms, particularly in developing economies like Indonesia and Malaysia. These policies aim to curb greenhouse gas emissions, impacting profitability and necessitating strategic adjustments for firms reliant on coal, oil, and gas. Carbon pricing mechanisms elevate operational costs tied to emissions, incentivizing firms to reduce their carbon footprint or transition to cleaner energy sources. Research indicates that firms are increasingly aware of climate-related financial risks, prompting a reevaluation of business models to align with regulatory frameworks and mitigate these risks (Al Frijat et al., 2025; Ashraf et al., 2020). In the ASEAN context, where energy sectors are pivotal yet heavily fossil fuel-dependent, understanding these dynamics is critical.

In Southeast Asia, climate policy frameworks, notably the Climate Change Performance Index (CCPI), significantly influence investor perceptions and corporate strategies. The CCPI assesses national climate performance across parameters like emissions, renewable energy adoption, and policy stringency, serving as a benchmark for investors evaluating firms' environmental commitments (Puertas & Martí, 2021). Firms in countries with higher CCPI rankings often gain better access to financing, as investors prioritize entities with robust environmental governance. The integration of environmental, social, and governance (ESG) factors into investment decisions correlates with enhanced financial performance, particularly in regions emphasizing sustainable practices (Lu et al., 2021; Lucia et al., 2020). For Indonesia and Malaysia, the CCPI not only reflects national climate commitments but also shapes energy firms' responses to regulatory and market pressures.

The climate policy landscapes in Indonesia and Malaysia reveal distinct approaches that affect the financial resilience of their energy sectors. Indonesia's heavy reliance on fossil fuel exports, particularly coal, coupled with slower transitions to renewables, poses significant challenges. Weaker regulatory enforcement and dependence on subsidized fossil fuel models hinder financial adjustments, especially as global capital markets increasingly favor low-carbon assets (Puertas & Martí, 2021). Conversely, Malaysia has adopted more progressive climate policies, supported by fiscal incentives and investments in green technologies, potentially bolstering financial stability in its energy sector (Dyah Sari & Sutopo, 2023; Hao, 2022). Despite these differences, both nations face barriers such as governance issues, limited capital access, and regulatory uncertainty, distinguishing them from developed

economies better equipped to absorb initial clean energy transition costs (Ariswati et al., 2025; Henrika et al., 2025; Siwiec & Karkowska, 2024). These variations result in differing adaptation costs, risk exposures, and financial outcomes for energy firms.

This study addresses a critical research gap: the scarcity of comprehensive empirical evidence on how CCPI influences the financial performance of energy firms in Indonesia and Malaysia, and the moderating role of capital structure. Given the energy sectoral's economic significance and vulnerability to climate policy pressures, this research is highly relevant. It aims to: (1) assess CCPI's impact on financial performance, and (2) investigate the moderating effect of capital structure. The novelty lies in employing CCPI as a climate policy proxy, offering a comparative ASEAN analysis, and focusing on fossil fuel subsectors sensitive to decarbonization policies. The study is confined to publicly listed energy firms in Indonesia and Malaysia (2019-2023), with limitations stemming from fossil fuel dominance and the use of firm size as a proxy for unavailable age data.

Capital structure plays a pivotal role in mitigating climate policy risks, analyzed through Trade-Off Theory and Pecking Order Theory. Trade-Off Theory posits that firms balance debt's tax benefits against financial distress costs, which can be exacerbated by stringent climate regulations (Yildiz & Temiz, 2024). Rising regulatory burdens increase operational costs, potentially straining fossil fuel firms' finances (Irianto et al., 2025). Optimizing capital structure, balancing equity and debt, enables firms to maintain liquidity for compliance costs. Conversely, excessive leverage heightens vulnerability to economic shocks from climate policies, risking financial instability. Pecking Order Theory suggests firms prefer internal financing to avoid asymmetric information costs (Johnson et al., 2021). Facing climate pressures, energy firms may prioritize retained earnings for compliance or green investments, especially in emerging markets with constrained capital access. These theories highlight how capital structure decisions shape resilience to climate risks, optimizing financing flexibility and cost of capital.

Empirical evidence supports the link between climate policy indicators like CCPI and financial metrics such as Return on Assets (ROA). Studies show firms with strong climate performance, reflected in high CCPI rankings, often exhibit superior ROA, driven by appeal to environmentally conscious investors (Liu et al., 2024). This trend is amplified as stakeholders demand climate-related disclosures, pushing firms to align operations with sustainability goals. The moderating role of capital structure is equally critical. Firms with robust, equity-heavy structures are better equipped to absorb compliance costs, enabling sustainable investments without compromising stability (Dyah Sari & Sutopo, 2023). Conversely, high-debt firms may struggle under increased regulatory obligations, impacting operational performance and capital-raising capacity.

Sectoral sensitivities among fossil fuel subsectors, such as coal, oil, and gas further shape responses to climate policies. Coal firms face heightened vulnerability due to divestments and regulatory pressures to transition to cleaner energy. Oil and gas firms, while also affected, demonstrate greater flexibility by integrating renewable projects, balancing sustainability and financial performance. These distinctions underscore the need for industry-specific capital structure strategies. Empirical studies highlight that coal firms face greater financial stress from declining demand and scrutiny, while oil and gas firms leverage operational capabilities for smoother transitions (C. Liu et al., 2023). This variability emphasizes the importance of contextual factors in assessing climate policy impacts.

The interplay of climate policy, capital structure, and financial performance is complex. Trade-Off and Pecking Order theories provide a framework for understanding how energy firms navigate regulatory landscapes. Empirical findings confirm that superior climate performance enhances financial metrics, while sectoral sensitivities highlight diverse strategic responses. This study contributes to understanding financial strategies in emerging markets, offering insights for managers and policymakers amid the global energy transition.

2. Research Methods

This study employs a quantitative approach using panel data analysis to evaluate the impact of the Climate Change Performance Index (CCPI) on the financial performance of energy firms in Indonesia and Malaysia, with capital structure as a moderating variable. Data were sourced from annual reports of 62 publicly listed firms on the Indonesia Stock Exchange (IDX) and Bursa Malaysia, spanning 2019–2023, yielding 310 balanced observations. The sample targeted energi sector: coal, general mining, oil/gas production/services, upstream oil/gas, and mining support, with inclusion based on complete data availability (Alshahrani et al., 2022). Financial metrics included total assets, liabilities, equity, net income, while CCPI scores were obtained from Germanwatch reports.

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The dependent variable, financial performance, was measured by Return on Assets (ROA), calculated as net income divided by total assets, reflecting profitability and operational efficiency. The independent variable was the annual CCPI score per country, representing climate policy stringency. The moderating variable, capital structure, was proxied by the debt-to-equity ratio (DER), computed as total liabilities divided by total equity, consistent with Trade-Off and Pecking Order theories (Johnson et al., 2021; Yildiz & Temiz, 2024). Firm size, measured as the natural logarithm of total assets, served as a control variable to isolate CCPI's effect. The empirical model, incorporating an interaction term to test moderation, was specified as:

$$ROA_{it} = \beta_0 + \beta_1 CCPI_t + \beta_2 DER_{it} + \beta_2 (CCPI_t \times DER_{it}) + \beta_4 Control_{it} + \epsilon_{it} \quad (1)$$

Analysis utilized panel data regression with fixed effects and random effects models, with model selection guided by diagnostic tests. The Chow test compared fixed effects against pooled OLS, assessing firm-specific effects. The Hausman test determined the appropriateness of fixed versus random effects by testing for correlation between specific effects and independent variables (Gupta & Mahakud, 2020). The Breusch-Pagan Lagrange Multiplier test verified the presence of random effects over pooled OLS (Limazie & Woni, 2024). The random effects model (REM) was finalized based on these tests, with data processed using Stata 17.

3. Results and Discussions

This study investigates the effect of the Climate Change Performance Index (CCPI) on the financial performance of energy firms in Indonesia and Malaysia, with capital structure as a moderating factor, using panel data regression. The findings, supported by diagnostic tests and regression analysis, reveal key insights while highlighting the unique dynamics of the ASEAN energy sector.

Tabel 1: Hasil Uji Chow

Fixed-effects (within) regression — Number of obs = 310
Group variable: perusahaan — Number of groups = 62

R-squared:
Within = 0.0065
Between = 0.0824
Overall = 0.0638

Obs per group:
min = 5
avg = 5.0
max = 5

F(4,244) = 0.40
corr(u_i, Xb) = -0.5342 — Prob > F = 0.8077

roa	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
ccpi	-.0064993	.0329193	-0.20	0.844	-.0713416	.0583431
der	.0607134	.1744794	0.35	0.728	-.2829647	.4043914
ccpider	-.0006552	.004383	-0.15	0.881	-.0092886	.0079781
fs	.3789251	.4139798	0.92	0.361	-.436505	1.194355
_cons	-4.355265	5.680882	-0.77	0.444	-15.54509	6.834562
sigma_u	4.8450999					
sigma_e	2.2869599					
rho	.81779645	(fraction of variance due to u_i)				

F test that all u_i=0: F(61, 244) = 15.37 — Prob > F = 0.0000

Sumber : Diolah dari Stata 17

The Chow test, comparing fixed effects to pooled OLS, yielded an F (61, 244) = 15.37 with $p < 0.0000$, indicating significant firm-specific effects and favoring the fixed effects model over pooled OLS. The Hausman test, assessing fixed versus random effects, produced a χ^2 (4) = 7.58 with $p = 0.1081$, supporting the random effects model due to no significant correlation between specific effects and independent variables. The Breusch-Pagan Lagrange Multiplier test further confirmed random effects with χ^2 (1) = 326.02 and $p < 0.0000$, validating the use of the Random Effects Model (REM) for final analysis.

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Tabel 2: Hasil Uji Hausman

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
ccpi	**-.0064993**	**-.0064887**	**-.0000105**	**.0095393**
der	**.0607134**	**.0950478**	**-.0343344**	**.0234714**
ccpider	**-.0006552**	**-.0010642**	**.0004089**	**.0006077**
fs	**.3789251**	**-.2643916**	**.6433167**	**.3897148**

b = Consistent under H0 and Ha; obtained from **xtreg**.
B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

chi2(**4**) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= **7.58**
Prob > chi2 = **0.1081**

Sumber : Diolah dari Stata 17

Tabel 3: Hasil Uji Lagrange Multiplier

Breusch and Pagan Lagrangian multiplier test for random effects

roa[perusahaan,t] = Xb + u[perusahaan] + e[perusahaan,t]

Estimated results:

	Var	SD = sqrt(Var)
roa	**22.09854**	**4.700908**
e	**5.230185**	**2.28696**
u	**15.38379**	**3.922217**

Test: Var(u) = 0
chibar2(01) = **326.02**
Prob > chibar2 = **0.0000**

Sumber : Diolah dari Stata 17

The REM analysis indicates that CCPI does not significantly impact Return on Assets (ROA), with a coefficient of -0.0065 and p = 0.837. This finding rejects the hypothesis that CCPI negatively affects financial performance due to compliance costs, a common assumption in prior studies (L. Liu et al., 2024). The result aligns with the ASEAN context, where developing regulatory frameworks and inconsistent enforcement may reduce financial pressures on energy firms (Kesuma et al., 2025). Firm adaptability, through operational diversification or cost management, likely mitigates short-term financial burdens. The early stage of climate policy implementation in Indonesia and Malaysia further weakens CCPI's immediate impact, contrasting with developed markets where stringent regulations significantly affect profitability.

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Tabel 4: Hasil Regresi Random Effect Model (REM)

Random-effects GLS regression — Number of obs = 310
Group variable: **perusahaan** — Number of groups = 62

R-squared:
Within = **0.0005**
Between = **0.1074**
Overall = **0.0855**

Obs per group:
min = 5
avg = 5.0
max = 5

Wald chi2(**4**) = 5.70
corr(u_i, X) = **0** (assumed) — Prob > chi2 = 0.2225

roa	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ccpi	-.0064887	.0315069	-0.21	0.837	-.0682411	.0552636
der	.0950478	.1728935	0.55	0.582	-.2438172	.4339128
ccpider	-.0010642	.0043407	-0.25	0.806	-.0095717	.0074434
fs	-.2643916	.1396484	-1.89	0.058	-.5380975	.0093142
_cons	4.472364	2.069172	2.16	0.031	.4168619	8.527866
sigma_u	3.9222173					
sigma_e	2.2869599					
rho	.74627961	(fraction of variance due to u_i)				

Sumber : Diolah dari Stata 17

The interaction term between CCPI and debt-to-equity ratio (DER) is also insignificant (p = 0.806), suggesting that capital structure does not moderate the CCPI-financial performance relationship. This challenges expectations that equity-heavy structures enhance resilience against regulatory pressures (Dang et al., 2024). Limited variation in DER across the sample or the nascent stage of climate policy enforcement in ASEAN may explain this outcome, indicating that capital structure's role is less pivotal in this context. Other factors, such as operational scale, appear more dominant in shaping firm responses to climate policies.

Firm size, measured as the natural logarithm of total assets, shows varying effects across models. In the fixed effects model, it has a positive coefficient, but in the random effects model, it exhibits a near-significant negative effect (p = 0.058). This variability supports the notion that larger firms, with broader operational scale and better capital market access, are better positioned to absorb regulatory costs (C. Liu et al., 2023). In Indonesia and Malaysia, large firms leverage economies of scale to invest in compliance or diversify operations, reducing vulnerability to climate policy shifts. However, the near-significant negative effect in the random effects model suggests that larger firms may face higher regulatory scrutiny or operational costs in certain contexts, warranting further exploration (Matemane et al., 2024).

Multicollinearity and time-invariant variables posed analytical challenges. Variance Inflation Factor (VIF) tests detected multicollinearity, leading to the exclusion of time-invariant variables like country and subsector dummies in fixed effects models, which limited cross-country and subsectoral analyses. This constraint prevented testing whether CCPI's impact is stronger in fossil fuel-dependent Indonesia compared to Malaysia's more progressive policies (Martí et al., 2022). Such limitations reflect challenges in panel data analysis in developing contexts, where secondary data may lack granularity (Rehan et al., 2023). Future studies could employ principal component analysis to address multicollinearity while retaining information (Nyangchak, 2023).

The ASEAN context, characterized by high fossil fuel reliance and evolving regulations, likely dilutes CCPI's financial impact. Unlike developed markets with stringent climate policies, Indonesia's coal dependence and weaker enforcement delay financial adjustments, while Malaysia's renewable energy support offers greater stability (Puertas & Martí, 2021). These findings suggest that financial pressures may intensify as regulations

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mature. The near-significant firm size effect underscores scale's strategic importance, enabling firms to navigate regulatory changes without compromising stability (Dang et al., 2024).

The near-significant firm size effect offers practical insights for energy firm managers. Large-scale operations provide a strategic advantage, facilitating investments in green technologies or portfolio diversification. Policymakers should strengthen climate regulatory frameworks to support sustainable energy transitions, particularly in fossil fuel-reliant nations. Theoretically, this study enriches the literature by highlighting regional context's role in shaping climate policy outcomes. The insignificance of CCPI and capital structure challenges assumptions of universal negative financial impacts, emphasizing contextual factors like regulatory maturity and firm adaptability (Dyah Sari & Sutopo, 2023).

Methodological constraints, such as multicollinearity and a fossil fuel focus, suggest avenues for future research. Including renewable energy firms could elucidate differential impacts across subsectors. More granular data on subsector-specific regulatory exposures would enhance sectoral insights (Dyah Sari & Sutopo, 2023). Advanced techniques, like quantile regression or principal component analysis, could improve model stability (Yang et al., 2023). Incorporating time-specific variables, such as annual policy changes, would better capture temporal dynamics.

This study illuminates the unique dynamics of ASEAN energy markets, where regulatory development stages temper climate policy impacts. The lack of CCPI significance reflects early-stage enforcement, while firm size underscores scale's role in adaptation, providing a foundation for strategic and policy advancements in emerging markets.

4. Conclusion

This study finds that the Climate Change Performance Index (CCPI) does not significantly influence the financial performance of energy firms in Indonesia and Malaysia, with a coefficient of -0.0065 ($p = 0.837$). Capital structure, measured by the debt-to-equity ratio, does not moderate this relationship ($p = 0.806$). Firm size shows a near-significant effect in the random effects model ($p = 0.058$), highlighting its role in enhancing resilience to regulatory pressures. Multicollinearity and time-invariant variables limit cross-country and subsectoral analyses, reflecting the ASEAN context's reliance on fossil fuels and evolving regulations. These findings suggest that current climate policies have limited immediate financial impacts, with scale emerging as a key adaptation factor. Managers should leverage operational scale to support compliance, while policymakers must strengthen regulatory frameworks to drive sustainable transitions. Future research should include renewable energy firms, incorporate time-specific variables, and adopt advanced methodologies to deepen insights into energy transitions in developing economies.

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