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CARBON RISK AND CORPORATE FINANCIAL STABILITY: EVIDENCE FROM AN EMERGING MARKET

RISCO DE CARBONO E ESTABILIDADE FINANCEIRA CORPORATIVA: EVIDÊNCIAS DE UM MERCADO EMERGENTE

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Abstract
This study examines how carbon transition risk affects corporate financial stability in Indonesia, using a multi-theoretical lens grounded in Stakeholder, Agency, and Legitimacy theories. Indonesia provides a distinctive setting where many corporate strategies lag behind emerging national policies, yet firms face increasingly stringent expectations from global markets. Using 932 firm-year observations from non-financial listed companies (2021–2024), the study applies panel data regression to test the link between carbon exposure and financial stability. The results show a significant negative relationship: high-emitting firms experience a "legitimacy gap" and are penalized by financial stakeholders. Consistent with transition risk mechanisms, investors and lenders appear to treat emissions as a proxy for future liabilities, effectively importing global carbon-pricing pressure before domestic regulations are fully enforced. From an Agency Theory perspective, this indicates a governance failure—management's inability to align short-term operations with long-term decarbonization—creating strategic vulnerabilities that weaken solvency. The study contributes by confirming that carbon exposure is a material financial risk in an emerging economy, driven by the mismatch between corporate readiness and global transition demands. It also frames decarbonization as a board-level priority to preserve capital access and supports mandatory climate disclosures to standardize risk assessment.

Resumo
Este estudo examina como o risco de transição do carbono afeta a estabilidade financeira das empresas na Indonésia, utilizando uma lente multiteórica baseada nas teorias das partes interessadas, da agência e da legitimidade. A Indonésia oferece um cenário distinto, no qual muitas estratégias corporativas ficam atrás das políticas nacionais emergentes, mas as empresas enfrentam expectativas cada vez mais rigorosas dos mercados globais. Utilizando 932 observações de empresas não financeiras listadas em bolsa (2021-2024), o estudo aplica regressão de dados em painel para testar a ligação entre a exposição ao carbono e a estabilidade financeira. Os resultados mostram uma relação negativa significativa: as empresas com altas emissões enfrentam uma "lacuna de legitimidade" e são penalizadas pelas partes interessadas financeiras. Em consonância com os mecanismos de risco de transição, os investidores e credores parecem tratar as emissões como um indicador de passivos futuros, importando efetivamente a pressão global dos preços do carbono antes que as regulamentações nacionais sejam totalmente aplicadas. Do ponto de vista da teoria da agência, isso indica uma falha de governança — a incapacidade da administração de alinhar as operações de curto prazo com a descarbonização de longo prazo — , criando vulnerabilidades estratégicas que enfraquecem a solvência. O estudo contribui ao confirmar que a exposição ao carbono é um risco financeiro significativo em uma economia emergente, impulsionado pelo descompasso entre a preparação das empresas e as demandas globais de transição. Ele também enquadra a

Keywords: Carbon Risk. Financial Stability. Sustainable Finance. Corporate Governance. Emerging Markets. Indonesia. Climate Policy.

descarbonização como uma prioridade do conselho administrativo para preservar o acesso ao capital e apoia a divulgação obrigatória de informações climáticas para padronizar a avaliação de riscos.

Palavras-chave: *Risco De Carbono. Estabilidade Financeira. Finanças Sustentáveis. Governança Corporativa. Mercados Emergentes. Indonésia. Política Climática*.

1 INTRODUCTION

Corporate financial stability is increasingly shaped by the low-carbon transition, not merely by internal fundamentals such as profitability or capital structure (Semieniuk *et al*., 2021). For firms—particularly in industrializing economies—carbon transition risk creates tangible pressures through rising compliance costs, shifting consumer and buyer preferences, and escalating demands for transparency. In parallel, prior studies commonly indicate that stronger responsiveness to sustainability—such as through carbon emissions disclosure and Corporate Social Responsibility (CSR)—is associated with superior financial outcomes (Kristari & Teruna, 2022; Zhou *et al*., 2020).

This transition also changes how lenders and investors evaluate firms. As banks and other financial institutions increasingly integrate climate-related signals into credit screening, firms with carbon-intensive profiles may encounter stricter borrowing constraints and higher financing costs (Chen *et al*., 2023; Huang *et al*., 2022). The expansion of sustainable finance products, including green bonds, further reinforces this repricing of risk and reflects a growing market preference for climate-aware assessments. At the same time, incorporating climate risk into credit ratings becomes more common, pushing firms to manage carbon exposure in order to maintain access to capital and appeal to sustainability-oriented investors (Fatica & Panzica, 2021). In this sense, sustainability investment may act as a resilience-building strategy under tightening regulation and evolving market expectations (Fatica & Panzica, 2021; Tomczak, 2024).

Empirical research on carbon risk spans multiple corporate outcomes, covering firm risk (Matsumura *et al*., 2024), lending terms and credit costs (Aslan *et al*., 2022; Javadi & Masum, 2021), stock valuation (Faccini *et al*., 2023), financial distress likelihood (Ding *et al*., 2023), and investment behavior (Phan *et al*., 2022). Yet, much of the systemic-stability discussion still centers on banks' stability (Fan & Gao, 2024; Le *et al*., 2023), despite banks

being relatively low direct emitters (Chabot & Bertrand, 2023). This creates an important omission: the non-financial, high-emitting corporates that originate transition costs receive comparatively less attention, even though they constitute the primary locus where carbon risk first affects governance, strategy, and financial conditions.

These challenges can be amplified in developing economies where carbon transition risk interacts with weak institutions, limited financial market depth, and constrained technological capacity. Evidence suggests that carbon risk exerts stronger negative effects among firms with low R&D intensity and in countries with weak legal frameworks, absent carbon rules, and low environmental regulation—patterns that appear particularly pronounced in developing markets (Owusu *et al*., 2025). In addition, barriers such as the shortage of tailored green financial instruments and limited investor literacy complicate efforts to fund low-carbon projects (Farooq *et al*., 2024).

Indonesia provides a timely and policy-relevant context for examining these dynamics. The economy remains strongly anchored in fossil-fuel-intensive sectors that continue to support national growth (Al'amin & Lystianingrum, 2024), elevating exposure to stranded assets and policy shifts. Although the government has initiated a decarbonization pathway—including a carbon economic value mechanism (NEK) and green industry standards—implementation requires large-scale investment and access to technologies that are not yet widely available (OECD, 2022). Moreover, because industry is a major employment source, abrupt or overly strict emissions policies can generate spillovers to labor markets and macroeconomic stability (Anggereini *et al*., 2022; Haris Annannab *et al*., 2022). These features make Indonesia well-suited to explore how corporate financial stability evolves when firm strategies do not fully match emerging national policies and increasingly stringent global expectations.

Against this background, this study positions carbon risk as a relevant factor to explain variations in corporate financial stability in Indonesia. The empirical analysis focuses on publicly listed non-financial firms operating in the energy, materials (raw/basic materials), and industrial sectors covering both primary and non-primary industries because these sectors are dominated by emission-intensive activities and tend to contribute larger carbon emissions than other sectors. Using 620 firm-year observations from companies listed on the Indonesia Stock Exchange (IDX) over the period 2021–2024, this study finds a significant negative relationship between carbon risk and financial stability in Indonesian companies. This finding suggests that higher carbon emissions are associated with declining financial stability, highlighting the

importance of integrating carbon transition considerations into firm strategy and governance within high-emitting sectors.

2 LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Theoretical framework

To explain how carbon risk influences corporate financial stability, this study adopts a multi-theoretical approach that draws on Transition Risk Theory, Stakeholder Theory, and Agency Theory. Together, these perspectives shed light on how external environmental pressures can create internal financial vulnerabilities. At the core of the framework is Transition Risk Theory, which argues that the shift toward a low-carbon economy brings real economic consequences through three main channels: policy tightening, technological disruption, and changing market preferences. In this setting, carbon emissions are no longer just an environmental externality they have become a critical factor in financial stability (Semieniuk *et al*., 2021). Building on this, Stakeholder Theory (Freeman, 1984) emphasizes that a firm's survival depends on its ability to meet the expectations of key stakeholders such as investors, creditors, and regulators. As global markets move toward decarbonization, these stakeholders increasingly interpret high carbon intensity as a sign of future liability. Creditors, concerned about "stranded assets" and reduced repayment capacity, often respond by restricting access to capital or raising lending rates for carbon-intensive firms. This reaction can lead to a "capital strike," directly undermining financial stability. In emerging markets like Indonesia, Legitimacy Theory (Deegan, 2002) adds another layer of insight by suggesting that firms operate under a "social contract." Where strict carbon taxation is absent as is currently the case in Indonesia maintaining legitimacy through voluntary carbon management becomes a strategic safeguard. High carbon exposure signals a breach of this contract, triggering reputational damage and anticipatory penalties from global investors who follow stricter sustainability standards (Liu *et al*., 2024). Finally, Agency Theory highlights the internal governance challenge. Conflicts often arise between managers and owners over investment horizons, with managers favoring short-term profits over long-term decarbonization. This behavior can create a "carbon bubble" on the balance sheet (Subhani *et al*., 2024), leaving firms vulnerable to future regulatory shocks and threatening long-term solvency. Transparent carbon disclosure serves as a key governance tool to reduce information asymmetry and align interests, ultimately supporting financial stability.

2.2 Empirical evidence and hypothesis development

Empirical studies consistently show that carbon risk reshapes cost structures and influences investor preferences. Firms that actively manage carbon emissions are better equipped to handle market pressures, which enhances their financial stability (Kristari & Teruna, 2022; Zhou *et al*., 2020). In contrast, when transition risks materialize, companies with high emissions often face financial strain due to rising compliance costs and a growing preference for greener assets. Further evidence indicates that carbon risk extends across multiple dimensions of corporate finance, influencing firm-specific risk (Matsumura *et al*., 2024), lending behavior (Aslan *et al*., 2022), borrowing costs (Javadi & Masum, 2021), and stock returns (Faccini *et al*., 2023). While much of the existing research has concentrated on banking sector stability (Fan & Gao, 2024; Le *et al*., 2023; Oanh *et al*., 2025), the non-financial corporate sector warrants closer attention, as it is both the largest source of emissions and the primary target of transition policies. These dynamics are even more pronounced in developing economies, where institutional weaknesses and limited financial depth amplify the effects of carbon risk. Owusu *et al*. (2025) find that weak environmental regulations and poor institutional quality exacerbate its negative impact on financial stability. Similarly, Farooq *et al*. (2024) highlight systemic barriers to financing green transitions, including the absence of specialized instruments and immature markets.

Indonesia offers a compelling context for this analysis. Mandatory carbon reporting is not yet fully enforced, and carbon tax regulations (Law No. 7 of 2021) remain under discussion. Despite these regulatory gaps, carbon exposure continues to influence financial stability, driven by global supply chain requirements and anticipatory risk pricing by foreign investors. High carbon intensity signals operational inefficiency and future regulatory liabilities, which increase both equity and debt costs (Ali *et al*., 2023; Chakrabarty & Nag, 2023), ultimately threatening financial viability. Building on these theoretical perspectives and empirical findings particularly the evidence that high carbon exposure undermines stakeholder confidence and governance alignment, we propose the following hypothesis:

H1. Carbon risk has a negative impact on corporate financial stability in Indonesia.

3 RESEARCH METHODOLOGY

3.1 Data and sample selection

The sample selection process was carried out to ensure the accuracy of the data used in testing the relationship between carbon risk and financial stability.

Table 1
Sample Selection

Panel A: Sample Selection	Number of companies
Number of companies listed on the Indonesia Stock Exchange (IDX) for the period 2021–2024	921
Less: Financial Sector Companies	107
Less: Companies that went public after the research year	283
Less Companies that incurred losses in the year of the study	298
Eligible Companies after Selection	233
Remaining Data (x 4 Years)	932

This study utilizes financial statement data officially published on the Indonesia Stock Exchange (IDX), complemented by sustainability reports disclosed by companies. The research period spans 2021 to 2024, reflecting a critical phase when mandatory sustainability reporting was introduced in 2021, marking a significant shift in corporate disclosure practices. The sample includes all non-financial companies listed on the IDX, excluding firms in the financial sector. Furthermore, only profitable companies were retained for analysis to enable a more precise evaluation of firms with relatively strong financial stability.

3.2 Empirical model

To examine the relationship between corporate carbon risk and financial stability, we employed a panel data regression approach. The analysis was conducted using the following empirical model:

$$FSit = \alpha 0 + \beta 1CRIit + \beta 2ROAit + \beta 3\ DERit + \beta 4\ TATOit + \beta 5\ FSIZEit + eit \qquad (1)$$

The variables used in this study consist of dependent variables, main independent variables, and several control variables included in the regression model to explain the relationship between carbon risk and corporate financial stability. Financial stability (FS) is proxied by the natural logarithm of the Z-score (LNZ), which reflects the overall financial

health and resilience of a company; therefore, a higher LNZ value indicates relatively stronger stability (Owusu *et al*., 2025) . The main independent variable is carbon risk (CRI), measured as total greenhouse gas emissions in tCO_2e scaled by total revenue, so that CRI captures a company's emission intensity relative to its economic activity (Lassoued *et al*., 2024) . Additionally, this model controls for profitability (ROA), calculated as net income divided by total assets to represent a company's ability to generate profits from its asset base; leverage (DER), calculated as total debt divided by total equity to reflect capital structure and dependence on debt; operational efficiency (TATO), calculated as sales divided by total assets to capture how effectively assets are used to generate revenue; and firm size (FSIZE), measured as the natural logarithm of total assets to represent scale differences that may affect access to financing, risk diversification capacity, and resilience to shocks (Elexa *et al*., 2022; Gutiérrez-Ponce & Wibowo, 2023; Sembiring *et al*., 2024; Supriyono *et al*., 2024) .

4 EMPIRICAL RESULTS AND DISCUSSION

4.1 Descriptive statistics

Based on the descriptive statistics table provided (Table 2), the LNZ variable (financial stability proxied by the natural logarithm of the Z score) has a mean value of 3.5637 and a median of 3.5654. The variability of the LNZ data is indicated by a standard deviation of 1.1051, with a range from a maximum value of 7.9017 to a minimum of 0.1762. Meanwhile, the CRI variable (total greenhouse gas emissions in tCO2e per total income) has a mean of 0.0970 and a median of 0.0000. The standard deviation for CRI is 1.4822, with values ranging from a maximum of 32.3352 to a minimum of 0.0000.

Table 2
Descriptive statistics

Variable	LNZ	CRI	ROA	DER	TATO	FSIZE
Average	3.5637	0.0970	0.0834	0.7948	0.8568	29.1942
Median	3.5654	0.0000	0.0633	0.5531	0.6452	29.1141
Maximum	7.9017	32.3352	0.6163	8.4535	4.4275	33.7900
Minimum	-0.1762	0.0000	0.0001	-19.6245	0.0000	24.6830
Standard Deviation	1.1051	1.4822	0.0804	1.2698	0.7191	1.7619

Note: FS: Financial stability is proxied by the natural logarithm of the Z-score (LNZ); CRI: Total greenhouse gas emissions in tCO_2e divided by total revenue; ROA: Net profit divided by total assets; DER: Total debt divided by total equity; TATO: Sales divided by total assets; FS: Natural logarithm of total assets

4.2 Correlation

Table 3 explains the correlation between variables, where there is no significant correlation between any two independent variables. This can be seen from the correlation coefficient being below the threshold value of 1.

Table 3

Correlation matrix

Variable	LNZ	CRI	ROA	DER	TATO	FSIZE
LNZ	1.0000					
CRI	-0.0665	1.0000				
ROA	-0.3566	0.0526	1.0000			
DER	-0.0431	-0.0336	-0.1050	1.0000		
TATO	-0.1043	-0.0288	0.2854	0.0766	1.0000	
FSIZE	-0.0205	-0.0592	0.03208	0.2718	-0.0769	1.0000

Note: FS: Financial stability is proxied by the natural logarithm of the Z-score (LNZ); CRI: Total greenhouse gas emissions in tCO_2e divided by total revenue; ROA: Net profit divided by total assets; DER: Total debt divided by total equity; TATO: Sales divided by total assets; FS: Natural logarithm of total assets

4.3 Robust regression results and analysis

The robust regression analysis provides empirical confirmation of the study's central hypothesis regarding the financial materiality of carbon risk. As presented in Table 4, the Carbon Risk Intensity (CRI) variable measured as total greenhouse gas emissions (tCO_2e) against total revenue exhibits a negative coefficient of -0.0382 with a significance level of 10% (*p-value* = 0.0569). This statistically significant negative relationship between emissions and financial stability (LNZ) offers direct support for Transition Risk Theory. It suggests that even in an emerging market like Indonesia, where carbon taxation is nascent, financial markets are "pricing in" the risks associated with high carbon intensity. Theoretical literature argues that this discounting effect occurs because financial stakeholders (creditors and investors) view high emissions as a proxy for future regulatory costs and stranded asset liability (Semieniuk *et al*., 2021). Consequently, the observed decline in financial stability for high emitters likely reflects a stakeholder-driven penalty: tighter access to capital and higher risk premiums imposed by lenders who are wary of future policy shocks (Chen *et al*., 2023).Conversely, companies with lower emissions profiles demonstrate higher stability. This aligns with Legitimacy Theory, which suggests that active decarbonization acts as a strategic mechanism to secure a "social license to operate." By reducing emissions, these firms mitigate regulatory risk and signal operational efficiency to the market, thereby enhancing their resilience against

external shocks. These findings corroborate recent global evidence by Owusu *et al*. (2025), who similarly found that lower carbon risk serves as a stabilizing force for corporate financial health.

Regarding the control variables, Return on Assets (ROA) shows a highly significant but counter-intuitive negative effect on financial stability (*p*-value = 0.0000). From an Agency Theory perspective, this finding implies a potential "risk-return trade-off" where managers may be pursuing aggressive short-term profitability at the expense of long-term solvency (Subhani *et al*., 2024). This aggressive behavior creates volatility that degrades the Z-score (stability metric), highlighting a governance conflict between short-term earnings and long-term survival. Meanwhile, Debt-to-Equity Ratio (DER) consistently negatively impacts stability (*p-value* = 0.0000), validating standard trade-off theories that excessive leverage increases distress risk. The variables TATO and FSIZE remained statistically insignificant, suggesting that in this specific model, asset turnover and firm size are less critical predictors of stability than carbon profile and leverage. The regression model explains approximately 19.56% of the variation in financial stability (R^2= 0.1956), indicating that while traditional financial metrics matter, carbon risk is now a relevant explanatory factor for corporate health in Indonesia.

Table 4

Robustness Test

Panel A Linear Regression	Dependent Variable	
	LNZ	
Variable	Coefficient	Prob.
C	3.5077	0.0000
CRI	-0.0382	0.0569***
ROA	-5.4976	0.0000*
DER	-0.3293	0.0000*
TATO	0.0452	0.2994
FSIZE	0.0259	0.1426
R-squared	0.1956	
Adjusted R-squared	0.1912	
Prob (R-squared statistic)	0.0000	
Industry Fixed Effect	Yes	
N	932	

Note: FS: Financial stability is proxied by the natural logarithm of the Z-score (LNZ); CRI: Total greenhouse gas emissions in tCO_2e divided by total revenue; ROA: Net profit divided by total assets; DER: Total debt divided by total equity; TATO: Sales divided by total assets; FS: Natural logarithm of total assets
*: Significant at the 1% level; **: 5%; ***: 10%

4.4 Endogeneity test

To address potential endogeneity and verify the causal direction of the findings, a dynamic panel approach was employed using the lagged dependent variable (LNZt-1). The use of this lag variable aims to test the robustness of the previous test results and reduce potential endogeneity issues, where the causal relationship between the explanatory variable and the dependent variable may not be direct or may be influenced by unobserved factors. In this analysis, the CRI variable (total greenhouse gas emissions in tCO_2e relative to total revenue) continued to show a significant effect at the 10% level with a negative coefficient of -0.0365 (*p-value*= 0.0766). The consistency in the direction and significance of the CRI effect, even when LNZ is lagged, reinforces the belief that greenhouse gas emissions do have a negative relationship with corporate financial stability. This suggests that the previous results are not merely coincidental but have a stronger basis when time dynamics are taken into account.

Table 5

Endogeneity Test

Variable	LNZ_{t-1}	
	Coefficient	Prob.
C	4.1069	0.0000
CRI	-0.0365	0.0766***
ROA	-4.9951	0.0000*
DER	-0.2771	0.0000*
TATO	0.0143	0.7806
FSIZE	0.0009	0.9631
R-squared	0.1564	
Adjusted R-squared	0.1503	
Probability (R-squared statistic)	0.0000	
Industry Fixed Effect	Yes	
N	932	

Note: FS: Financial stability is proxied by the natural logarithm of the Z-score (LNZ); CRI: Total greenhouse gas emissions in tCO_2e divided by total revenue; ROA: Net profit divided by total assets; DER: Total debt divided by total equity; TATO: Sales divided by total assets; FS: Natural logarithm of total assets
*: Significant at the 1% level; **: 5%; ***: 10%

In addition to CRI, the variables ROA (net profit divided by total assets) and DER (total debt divided by total equity) consistently show a highly significant effect on LNZt-1 with a probability of 0.0000 (significant at the 1% level). The negative ROA coefficient (-4.9951) indicates that, even considering the financial stability of the previous period, high profit performance is still associated with a decline in financial stability, suggesting that other factors need to be considered in the interpretation of ROA and LNZ. Similarly, the negative coefficient

of DER (-0.2771) confirms that higher debt levels are consistently associated with lower financial stability, which is a reliable finding over time. The variables TATO (Sales divided by total assets) and FSIZE (Natural logarithm of total assets) are still not statistically significant (prob. 0.7806 and 0.9631), confirming that these two variables do not have a strong impact on corporate financial stability within the tested model framework, even when attempting to overcome endogeneity issues with lagged variables. This model can explain approximately 15.64% of the variation in LNZt-1 (R-squared value: 0.1564).

5 CONCLUSION AND IMPLICATIONS

This study empirically examines the impact of carbon transition risk on the financial stability of non-financial companies listed in Indonesia. Using financial data from 2021 to 2024, the analysis provides strong evidence of a significant negative relationship between carbon emissions intensity and corporate financial stability. Even in an emerging market context where regulatory enforcement remains limited, market forces are already penalizing high-carbon firms. Elevated emissions create strategic vulnerabilities, increasing the likelihood of financial distress through higher capital costs and restricted access to "green" liquidity. These findings reinforce the view that carbon risk is no longer an external environmental issue but a material financial factor that directly undermines corporate resilience.

From a theoretical perspective, the study contributes to the literature on Sustainable Finance and Development Economics by bridging insights from developed and emerging markets. It extends Transition Risk Theory and Legitimacy Theory to the Indonesian context, demonstrating that the risk–return trade-off associated with carbon exposure persists even in jurisdictions without a mature carbon tax. This highlights how global governance norms such as investor pressure can compensate for local regulatory gaps, shaping financial stability outcomes in developing economies.

The practical implications are equally significant. For managers, decarbonization should be viewed not as a compliance cost but as a strategic financial imperative. Emission reduction strategies need to be integrated into core capital budgeting and risk management frameworks to safeguard long-term solvency. Boards of Directors should also establish dedicated sustainability committees to oversee transition risks. Proactive carbon management is essential not only for environmental stewardship but also for maintaining creditworthiness and securing lower capital costs in an increasingly climate-conscious global market.

For policymakers and regulators such as Financial Service Authority (OJK), the findings provide empirical support for accelerating mandatory climate-related financial disclosures. Since markets are already pricing carbon risk, clear reporting guidelines would reduce information asymmetry and enhance overall market stability. Beyond regulation, there is a pressing need for capacity building—updating business and finance curricula to incorporate environmental risk management—so that future professionals can navigate the intersection of climate policy and financial strategy effectively.

Finally, the study acknowledges certain limitations. Its focus on Indonesian listed companies restricts the generalizability of findings to other regulatory environments, and reliance on publicly available sustainability reports may overlook internal carbon shadow pricing practices. Future research should broaden the scope to include comparative analyses across Southeast Asian markets such as Malaysia and Thailand and employ qualitative methods to examine how boards translate carbon data into strategic decisions.

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DATA AVAILABILITY STATEMENTS

The data for this study were obtained from the Indonesian Stock Exchange website, company websites, and publicly available annual reports. Additional computations were performed by the authors. The datasets and supporting code can be provided by the authors upon reasonable request for academic or research.

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Authors’ Contribution

The authors have contributed to this manuscript as follows:

- Vito Apriyanto was responsible for developing the research idea, constructing the theoretical framework, collecting data, and drafting the manuscript.
- Gatot Soepriyanto contributed to the theoretical analysis, manuscript refinement, data validation, and robustness testing.

Both authors reviewed and approved the final version of the manuscript

Data availability

All datasets relevant to this study's findings are fully available within the article.

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