



Carbon risk and corporate financial resilience in Indonesia

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Article Info	ABSTRACT
Article history: Received May 31, 20xx Revised Aug 5, 20xx Accepted Sept 21, 2026	Empirical evidence linking carbon risk to corporate financial resilience largely comes from developed markets, leaving this relationship unexamined in emerging economies with still-developing carbon-regulatory regimes such as Indonesia's. This study addresses that gap, examining whether and through which mechanisms carbon exposure shapes financial resilience when disclosure and carbon pricing remain incomplete. The contribution is conceptual: explaining how carbon exposure becomes financial vulnerability through transition-cost, financing, governance, and stakeholder-legitimacy mechanisms, rather than treating the Indonesian context as the source of novelty. The argument is tested on nonfinancial firms listed on the Indonesia Stock Exchange from 2021–2024, using panel data regression across 857 firm-year observations; financial resilience is captured via the Altman Z-score, and carbon risk through emission intensity relative to revenue. Findings show a significant negative association between carbon risk and financial resilience ($\beta = -0.0365$, $p = 0.0492$), along with significant associations for profitability ($\beta = -5.5433$, $p = 0.0000$) and leverage ($\beta = -0.3339$, $p = 0.0000$); the model explains 24 percent of the variation (adjusted $R^2 = 0.2372$). The study integrates Transition Risk, Agency, and Stakeholder/Legitimacy Theory into a single framework explaining why carbon exposure weakens financial resilience absent mandatory disclosure. These results underscore embedding environmental considerations into corporate financial strategy and risk management as emerging economies develop their sustainability regulations.
Keywords: Carbon risk; Carbon exposure; Emerging markets; Financial stability; Sustainability.	

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1. INTRODUCTION

Corporate Financial Resilience is no longer determined solely by internal factors such as profitability and funding structure, but increasingly by external pressures from the transition to a low-carbon economy. Companies, especially in industrializing countries, face rising cost risks, shifting market preferences, and transparency demands affecting financial resilience. Firms more responsive to sustainability via carbon emissions disclosure and CSR tend to show better financial performance (Kristari & Teruna, 2022; Zhou et al., 2020; Fahad, & Busru, 2020).

The link between carbon disclosure and creditworthiness is also growing more prominent as financial institutions increasingly factor carbon risk into credit assessments. Companies with higher

emissions may face tighter financing conditions when creditors weigh emission profiles before approving credit (Chen et al., 2023), and as climate policies tighten, issuers seen as high-risk may face higher borrowing costs and weaker market competitiveness (Huang et al., 2022)

This shift is also reflected in growing use of sustainable investment instruments such as green bonds, signaling a market-wide move toward climate risk-based assessment. Integrating climate risk into credit ratings is now common practice in bond and loan markets, reinforced by rising green bond issuance as firms balance carbon risk while courting sustainability-conscious investors (Fatica & Panzica, 2021). Allocating capital toward sustainability is thus no longer just reputational signaling, but a strategic necessity for financial resilience against tightening regulation (Ozili, 2021; Zhang et al., 2022).

Carbon exposure is a well-established determinant of corporate risk shaping firm-level risk, capital costs, equity valuations, and investment, and reaching even structurally low-carbon banks through climate-induced shocks (Fu et al., 2023 ; Herold & Lee, 2019 ; Pfaffenbichler et al., 2024; Ding et al., 2023). This points to a systemic transmission mechanism, whereby carbon risk extends beyond direct emitters to become a broader vulnerability across credit and financial intermediation networks (Chen et al., 2023; Nurhayati et al., 2024; Oanh et al., 2025; Pfaffenbichler et al., 2024).

Developing economies tend to bear a disproportionate share of this vulnerability, since institutional strength, financial market depth, and technological capability jointly determine how carbon-related shocks translate into financial outcomes. According to Owusu et al., (2025), the impact of carbon risk on financial stability is uneven: firms with limited R&D capacity absorb a larger share of the shock, and the effect intensifies in settings marked by heavy emissions, weak rule of law, poor governance, and the absence of carbon-pricing mechanisms. A parallel argument comes from Farooq et al., (2024), who point to structural obstacles such as a shortage of green financial products and immature capital markets that hinder the flow of financing into green energy projects across developing economies, reinforcing the disproportionate concentration of carbon risk's costs in these settings.

Indonesia illustrates this urgency clearly: its economy still relies heavily on fossil-fuel-intensive sectors such as coal, cement, gas, and steel, which anchor national growth and employment, making strict emissions regulation a risk to economic stability (Al'amin & Lystianingrum, 2024 ; Hossain et al., 2024 ; Maheshwari & Naik, 2024). The government has introduced carbon economic value frameworks toward decarbonization, but capital and technological constraints continue to hinder this shift (OECD, 2022). Regulatory coverage also remains incomplete: the carbon tax under Law No. 7 of 2021 is still under debate, and POJK 51/2017 does not require carbon emissions disclosure, leaving open whether carbon risk still shapes financial resilience under such an immature regime.

Taken together, this literature reveals three gaps. Empirically, evidence on carbon risk and financial resilience remains concentrated in developed markets, leaving the mechanism untested under weaker regulatory regimes. Theoretically, prior studies have applied Risk Theory or Agency Theory in isolation, without integrating the stakeholder- and legitimacy-based motives that plausibly shape corporate responses where formal disclosure is absent. Contextually, Indonesia, despite its fossil-fuel dependence and incomplete disclosure regulation, remains largely absent from this body of work.

In short, the research problem is whether, and through which mechanisms, carbon exposure erodes financial resilience where carbon disclosure and pricing remain non-mandatory.

The 2021–2024 window follows the start of mandatory Sustainability Reporting in Indonesia, the first period with reasonably consistent carbon-related disclosure. The sample spans all nonfinancial IDX sectors, not one industry, so the carbon risk–resilience relationship can be tested across heterogeneous emission intensities, with sector differences absorbed via industry fixed effects (Table 8).

The theoretical foundation for this study comes from Risk Theory, under which the transition to a low-carbon economy is expected to generate sizeable macroeconomic and financial repercussions as regulation tightens, technology shifts, and market conditions evolve. Bolton & Kacperczyk (2019) locate the essence of transition risk in policy shifts and market sentiment surrounding

decarbonization, both of which feed into how financial markets price and assess risk. Building on this, Garcia-Jorcano & Sanchis-Marco (2025) note that changes in carbon regulation have a direct bearing on market performance, meaning investors need to factor this dimension into their portfolio decisions.

Rising transition risk can create financial strain for high-emission firms through higher compliance costs, potential sanctions, added transition-related investment, and shifting demand toward greener products. This aligns with literature linking carbon risk to firm risk (Amimakmur et al., 2024 ; Morshed, 2024), credit allocation (Li & Zhou, 2024), cost of debt (Prasad et al., 2024), equity valuations (Rupeika & Apoga et al., 2024) , financial distress probability (Saudicha & Kautsar, 2024), capital expenditure decisions (Darsani & Sukartha, 2021), and even banking-sector resilience, despite banks' relatively low direct emissions (Tolstov, 2024 ; Gao et al., 2023 ; Tedeschi et al., 2024).

This phenomenon can also be understood through a corporate governance lens, specifically Agency Theory, which explains the principal-agent frictions arising from divergent interests between management and shareholders. Conflicts can emerge when management prioritizes short-term profits over long-term sustainability commitments (Subhani et al., 2024), making transparent carbon disclosure a balancing mechanism that aligns management actions with stakeholder expectations while reducing financial risk exposure.

This governance perspective is complemented by Stakeholder Theory (Freeman, 1984) and Legitimacy Theory (Suchman, 1995), which suggest firms manage and disclose carbon risk not only to satisfy shareholders but to retain the support of investors, regulators, and the public whose expectations confer a company's social license to operate. Under weak carbon regulation, as in Indonesia, legitimacy-seeking behavior becomes an important, underexplored driver of carbon risk management, consistent with evidence that sustainability-aligned governance boosts investor confidence and capital access (Liu et al., 2024).

Financing channels matter too, as carbon risk assessment is increasingly embedded in credit and investment decisions: bank stability can be affected by carbon emissions, prompting financial institutions to factor this risk into creditworthiness assessments (Oanh et al., 2025), while more comprehensive corporate emissions disclosure can enhance credibility and capital access, improving reputation, lowering capital costs, and opening green financing channels (Fan & Gao, 2024).

This study's contribution spans three dimensions. Empirically, it offers early firm-level evidence on carbon risk and financial resilience among Indonesian nonfinancial firms, extending developed-market findings (Owusu et al., 2025) to a weaker-regulation context. Theoretically, its novelty is conceptual: integrating Transition Risk, Agency, and Stakeholder/Legitimacy Theory into one framework showing how carbon exposure becomes financial vulnerability through compliance costs, tightening financing, agency frictions, and legitimacy pressure even absent mandatory disclosure. Contextually, it measures carbon risk via emission intensity and resilience via the Altman Z-score, an approach extendable to other emerging markets with incomplete carbon regulation. Findings are intended to inform Indonesian regulators and to help managers, creditors, and investors factor carbon risk into their decisions.

Based on theoretical arguments and prior evidence, lower carbon risk is expected to correspond with higher financial stability (Owusu et al., 2025): firms effective at mitigating carbon risk tend to gain a better reputation, improving credit ratings and lowering debt costs (Ali et al., 2023), while firms facing higher carbon risk may incur higher capital costs that threaten financial viability (Chakrabarty & Nag, 2023).

H1. "Carbon risk has a negative impact on corporate Financial Resilience in Indonesia"

2. RESEARCH METHOD

Data and sample selection

Sample selection followed a careful, structured process aimed at generating reliable and consistent data for testing the association between carbon risk and corporate Financial Resilience.

Table 1. Sample step collection

Description	Amount companies
Total companies listing on IDX during 2021–2024 period	921
Excluded: Companies Operating in the Financial Sector	107
Excluded: Companies Listed After the Observation Period	283
Excluded: Companies Reporting Financial Losses During the Observation Period	298
Number of companies that passed the sample selection	233
Remaining Data (x 4 Years)	932
Excluded: Incomplete data / Outliers during specific years	75
Final Remaining Data (Observations)	857

Source: *Eviews 12*

This study uses financial statement and sustainability reporting data from non-financial companies listed on the Indonesia Stock Exchange during 2021–2024, reflecting the period since mandatory Sustainability Reporting began in Indonesia. The analysis focuses on profitable companies for a more reliable assessment of firms with relatively stable financial conditions. A further 75 observations were removed as outliers after an initial normality check, since extreme values would otherwise bias the regression residuals, leaving a final sample of 857 firm-year observations.

Empirical model intCO_2e

First, the study examined the association between corporate carbon risk and financial stability through regression analysis using the following empirical model:

$$\text{FRSLit} = \alpha_0 + \beta_1 \text{CRLit} + \text{eit} \quad \dots\dots\dots (1)$$

The empirical specification comprises a single dependent variable, one core explanatory variable, and a set of control variables designed to capture the relationship between carbon risk and financial resilience. Financial resilience enters the model as the natural log of the Altman Z-score (LNZ); a larger LNZ value signals that a firm is better positioned to absorb financial shocks (Owusu et al., 2025). The explanatory variable of interest, carbon risk (CRI), is constructed by dividing a firm's total greenhouse gas emissions by its revenue, so that it reflects emission intensity rather than raw emission volume (Lassoued et al., 2025). This intensity-based construction is chosen over either an unadjusted emissions figure or a simple binary disclosure indicator, since scaling by revenue neutralizes firm-size effects and makes the measure comparable across companies of different sizes.

To mitigate omitted variable bias, the model includes control variables selected on theoretical grounds: profitability (ROA), among the most consistent predictors of financial stability; leverage (DER), since higher leverage raises distress risk under capital structure theory; operational efficiency (TATO), since efficient asset use supports steadier cash flow; and firm size (FSIZE, logged total assets), which shapes financing access and resilience to shocks (Apriyanto & Soepriyanto, 2026).

Emission intensity, rather than raw emissions or a disclosure score, follows the transition-risk logic above: markets increasingly price carbon exposure relative to economic output, so an intensity measure better approximates compliance and stranded-asset risk (Lassoued et al., 2025). Institutional ownership is a control, not incidental: institutional investors can monitor management but may also exert short-horizon pressure against long-term resilience (Ali et al., 2023), so its inclusion isolates the carbon risk coefficient net of ownership-driven governance effects.

Panel data model selection

Rigorous diagnostic testing identified the optimal model specification via a sequential Chow, Hausman, and Breusch-Pagan LM procedure. The Chow Test (CEM vs. FEM) produced a non-significant F-statistic (1.0224, $p = 0.414$), supporting CEM. The Hausman Test (FEM vs. REM) was also

non-significant ($\chi^2 = 4.3695$, $p = 0.627$). Since Chow had already ruled out FEM, the LM Test compared CEM directly against REM, returning non-significant results across all effects ($p > 0.05$), confirming CEM as preferred (Table 2). Together the three tests converge on one conclusion: Chow rules out fixed effects in favor of pooling; since Hausman is only informative when fixed effects are credible, its non-significant result confirms REM adds nothing over pooling; and the LM test confirms random effects are unnecessary either. Each test simply fails to support the more complex alternative it examines, favoring CEM.

Table 2. Model of selection

Test	Comparison	Result	Decision
Chow Test	CEM vs FEM	$F=1.0224$ ($p=0.4142$)	CEM preferred
Hausman Test	FEM vs REM	$\chi^2=4.3695$ ($p=0.6268$)	REM preferred over FEM
Breusch-Pagan LM Test	CEM vs REM	$p=0.8282$ (both)	CEM preferred

Source: *Eviews 12*

This paper therefore reports results exclusively from the Common Effect Model. Classical assumption tests confirmed the model's fitness: residuals, initially non-normal (Jarque-Bera $p = 0.000$, $n = 932$), achieved normality after removing 75 outliers ($p = 0.834$, $n = 857$), alongside no multicollinearity ($r = 0.246$), constant residual variance (Glejser, all $p > 0.05$), and no autocorrelation (Durbin-Watson = 2.038). Two caveats remain: reverse causality (weaker firms may cut production and emit less) and omitted variables such as management quality. As the data cannot support an instrumental-variable or System GMM correction, these are treated as limitations rather than resolved statistically. As an additional diagnostic, the Pesaran CD test was applied to check for cross-sectional dependence in the model residuals (857 firm-year observations, 230 cross-sections, $T = 4$).

The result is significant ($CD = 8.18$, $p < 0.001$), suggesting residuals remain correlated across firms within the same year – most likely reflecting shared macroeconomic or sector-wide shocks the current controls do not fully capture. Given the panel's short time dimension, a standard correction such as Driscoll-Kraay would itself be unreliable here, so this is reported as a diagnostic finding and an explicit limitation rather than corrected for; the standard errors in Table 8 may therefore understate the true uncertainty around the coefficients. An alternative carbon-risk proxy and an instrumental-variable or System GMM approach to endogeneity are left for future research, and the carbon risk coefficient is accordingly read as an association rather than a causal effect.

Table 3. Normality test (jarque-bera)

Stage	N	Skewness	Kurtosis	Jarque-Bera	Prob.
Before outlier elimination	932	–	5.2000	192.0740	0.0000
After outlier elimination	857	-0.0487	3.0253	0.3623	0.8343

Source: *Eviews 12*

Table 4. Heteroskedasticity test (glejser)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.321088	0.316569	1.014274	0.3107
CRI	-0.015826	0.011643	-1.359296	0.1744
INSTOWN	-0.049837	0.077063	-0.646708	0.5180
ROA	-0.231427	0.262258	-0.882440	0.3778
DER	-0.002055	0.020002	-0.102723	0.9182
TATO	-0.003216	0.026732	-0.120300	0.9043
FSIZE	0.014395	0.010679	1.347937	0.1780

Dependent variable: *ARESID*. Source: *Eviews 12*

Table 5. Autocorrelation test (durbin-watson)

Durbin-Watson stat	dU	4 – dU	Conclusion
2.0376	1.812	2.188	No autocorrelation

Source: *Eviews 12*

3. ESULTS AND DISCUSSIONS

Descriptive statistics

Table 6 summarizes the descriptive statistics of the research variables. Financial Resilience (LNZ) averages 3.5696 (SD = 0.9545, range 0.9832–6.3253). Carbon exposure (CRI) shows substantial dispersion (mean = 0.1035, SD = 1.5453, max = 32.3352), indicating a subset of highly carbon-intensive outliers. Institutional ownership (Instown) is relatively concentrated (mean = 0.6407), while the remaining fundamentals show expected variation: profitability (ROA) averages 0.0801, leverage (DER) 0.8457, asset utilization (TATO) 0.8562, and Firm Size 29.2521.

Table 6. Statistics descriptive

Variable	CRI	INSTOWN	ROA	DER	TATO	FSIZE	LNZ
Average	0.1035	0.6407	0.0801	0.8457	0.8562	29.2521	3.5696
Median	0.0000	0.6868	0.0623	0.5672	0.6507	29.1600	3.5710
Maximum	32.3352	0.9998	0.5926	8.4535	4.4275	33.7900	6.3253
Minimum	0.0000	0.0000	0.0001	0.0020	0.0009	24.6830	0.9832
Std. dev	1.5453	0.2369	0.0723	0.9490	0.7088	1.75094	0.9545

Source: Eviews 12

Correlation

Table 7 presents the correlation matrix. All pairwise correlation coefficients remain well below conventional thresholds of concern, indicating no severe multicollinearity among the explanatory variables.

Table 7. Correlation variable

Variable	Carbon Risk (CRI)	Institutional Ownership (INSTOWN)	Return on Asset (ROA)	Debt to Equity Ratio (DER)	Total Asset Turnover (TATO)	Firm Size (FSIZE)
CRI	1.000000					
Instown	0.025535	1.000000				
ROA	0.064154	0.155100	1.000000			
DER	-0.048555	-0.043139	-0.155373	1.000000		
TATO	-0.029113	0.148792	0.240499	0.097219	1.000000	
Firm Size	-0.063608	-0.055573	-0.008515	0.246390	-0.099397	1.000000

Source: Eviews 12

Robust regression results

Carbon Risk (CRI)

The results show a negative, statistically significant relationship between Carbon Risk (CRI) and financial stability ($\beta = -0.0365$, $p = 0.0492$), indicating that higher emission intensity relative to revenue is associated with lower financial stability. This suggests higher carbon exposure elevates transition risk, which in turn harms financial resilience, consistent with (Owusu et al., 2025).

This mechanism reflects the transition-risk logic outlined earlier: firms with heavier emission intensity face steeper compliance costs, carbon-pricing liabilities, and mounting pressure from investors and creditors increasingly pricing in climate risk, all of which erode the buffer the Altman Z-score is meant to capture (Bolton & Kacperczyk, 2019 ; Chen et al., 2023). Agency Theory adds that the negative coefficient may signal managers accounting for carbon exposure only once it becomes an actual cost. The effect size here is notably smaller than in developed-market studies, likely because Indonesia's carbon-pricing regime, with the Law No. 7/2021 tax still unenforced and POJK 51/2017 disclosure not yet required, has not fully priced carbon exposure into the market.

The estimated coefficient ($\beta = -0.0365$) is directionally consistent with Owusu et al. (2025) but smaller than developed-market, disclosure-based estimates (e.g., Ding et al., 2023; Fan & Gao, 2024) plausibly because Indonesia's carbon-pricing and disclosure regime remains only partially implemented, leaving the market less standardized information with which to price carbon exposure than in jurisdictions with binding carbon markets or mandatory disclosure.

Institutional Ownership shows a significant negative effect on financial stability ($\beta = -0.3113$, $p = 0.0114$), implying that higher institutional ownership concentration is linked to lower financial stability in this sample. This may reflect principal-agent frictions or short-term pressures from institutional investors misaligned with long-term resilience, consistent with evidence that ownership structure and board characteristics shape investment efficiency in emerging markets (Ali et al., 2023).

A highly significant negative relationship emerges between profitability (ROA) and financial stability ($\beta = -5.5433$, $p = 0.0000$). This runs counter to conventional theory, which typically ties higher profitability to greater stability; instead, the pattern observed here implies that, among the sampled firms, pushing net income higher relative to assets may come bundled with risk exposures that end up dragging the Altman Z-score down.

This counterintuitive result deserves scrutiny. One explanation lies in the Altman Z-score's construction, which weighs working capital and retained earnings alongside profitability: a firm could post solid profits while drawing down cash reserves to fund carbon-intensive operations, pulling the Z-score lower even as ROA climbs. Alternatively, profitable firms in carbon-intensive sectors may face tighter margins from compliance costs, so profitability here reflects short-term performance rather than solvency. This aligns with Agency Theory's prediction that short-term incentives can undermine resilience (Subhani et al., 2024), echoing similar effects in other emerging-market carbon risk studies.

In line with expectations, the Debt to Equity Ratio (DER) exerts a highly significant negative effect on financial stability ($\beta = -0.3339$, $p = 0.0000$). This confirms that as firms take on relatively more debt, their exposure to financial distress climbs, which in turn pulls their stability score downward. Total Asset Turnover (TATO) positively and significantly influences financial stability ($\beta = 0.0840$, $p = 0.0486$), showing that firms more effective at generating sales from their asset base tend to have stronger financial stability and lower bankruptcy risk. Firm Size (FSIZE) also shows a positive, significant relationship with financial stability ($\beta = 0.0343$, $p = 0.0439$), supporting the premise that larger firms benefit from economies of scale, better market access, and greater resource buffers that enhance stability and resilience to shocks.

Table 8. Robustness test

Panel A Linear Regression		Dependent Variable LNZ	
Variable	Coefficient		Prob.
C	3.4236		0.0000
CRI	-0.0365		0.0492***
INSTOWN	-0.3113		0.0114*
ROA	-5.5433		0.0000*
DER	-0.3339		0.0000*
TATO	0.0840		0.0486*
FSIZE	0.0343		0.0439*
R-squared		0.2425	
Adjusted R-squared		0.2372	
Prob (R-squared statistic)		0.0000	
Industry Fixed Effect		Yes	
N		857	

*: Significant at the 1% level; **: 5%; ***: 10%

Source: Eviews 12

Table 8 re-estimates the Common Effect Model with industry fixed effects. Even after accounting for time-invariant industry characteristics such as sector-specific emission intensity or regulatory exposure, Carbon Risk remains negative and significant ($\beta = -0.0365$, $p = 0.0492$), with control variables retaining their signs and significance. This suggests the carbon risk-financial resilience link is not merely an artifact of unobserved industry differences; a finer-grained heterogeneity analysis was not feasible with this dataset and is left for future research. A full heterogeneity and sensitivity analysis by sector, firm size, or alternative specifications was beyond the scope of the present dataset and revision window, and is flagged as a priority for future work.

The adjusted R^2 of 0.2372 indicates carbon risk and the controls explain roughly a quarter of the variation in financial resilience; other factors such as governance quality or green-financing access likely also contribute but are not captured here. Theoretically, this negative effect supports the transition-risk and agency-based reasoning developed earlier, extending (Owusu et al., 2025) findings to a weaker-regulation emerging market. For managers, reducing emission intensity directly affects bankruptcy risk. For policymakers, that carbon risk matters without mandatory disclosure under POJK 51/2017 suggests room to strengthen Indonesia's reporting requirements. Other theoretically relevant omitted factors—board environmental expertise, supply-chain emission exposure, and climate-adaptation capacity likely also shape financial resilience and merit attention once suitable data become available.

4. CONCLUSION

This study's principal contribution is showing that carbon risk is negatively and significantly associated with financial resilience among Indonesian nonfinancial firms ($\beta = -0.0365$, $p = 0.0492$), even under an immature regulatory regime extending developed-market evidence to an emerging market and to the rarely used Altman Z-score. Theoretically, it shows Transition Risk, Agency, and Stakeholder/Legitimacy mechanisms operate jointly rather than in isolation. Managerially, emission intensity carries a financial consequence the market appears to price before disclosure rules make it compulsory. For policymakers, that carbon risk matters even absent mandatory disclosure strengthens the case for closing Indonesia's regulatory gap. Practically, embedding carbon risk management in corporate strategy is warranted: lower emission intensity is associated with stronger resilience, though this design does not establish causation. For investors and creditors, emission intensity is a financially material signal. For policymakers, four priorities follow: standardizing carbon-emission measurement and reporting; strengthening enforcement of the Law No. 7/2021 carbon-pricing mechanism; expanding POJK 51/2017 to require, not merely encourage, disclosure; and integrating climate-related risk into financial-sector supervision. The findings also carry implications for education: academic institutions could incorporate sustainability, environmental risk, and carbon management into business and finance curricula, building awareness of how environmental issues shape corporate performance and preparing future professionals for sustainability-responsive, responsible business practice. Several limitations deserve mention. The sample is confined to nonfinancial companies in Indonesia, which constrains how broadly the findings can be generalized. Carbon risk relies on an emission-intensity proxy that may miss some scope 1–3 emissions, given that disclosure remains voluntary under POJK 51/2017. Because instrumental-variable techniques such as 2SLS or System GMM were not employed, the reported associations should be understood as robust correlations rather than proof of causation. The relatively modest R^2 (0.2372) also points to other unmeasured drivers, such as governance quality or access to green financing, that plausibly influence financial resilience alongside carbon risk. Additionally, because ROA is itself embedded in the Altman Z-score used here, the negative ROA coefficient may partly reflect construct overlap rather than a fully independent effect—a limitation future studies could address with a non-overlapping resilience measure. Future research could extend this study through cross-country comparisons of carbon-pricing and disclosure regimes, or by incorporating ESG ratings, green innovation, carbon disclosure quality, or climate governance as additional variables. Instrumental-variable or System GMM approaches, where data permit, would strengthen causal identification, and sector-specific heterogeneity analyses comparing emission-

intensive industries against less exposed sectors could yield more targeted policy insights. Future work could also test alternative, non-overlapping measures of financial resilience that do not embed profitability directly, in order to isolate the carbon risk channel more cleanly from firm profitability.

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