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Environmental Performance, Working Capital Efficiency, and Bankruptcy Risk: Evidence from Indonesian Listed Firms

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ABSTRACT: Corporate bankruptcy remains a major concern in Indonesia, where firms face challenges not only from financial fragility but also from regulatory compliance and operational inefficiencies. Traditional bankruptcy prediction models largely emphasise financial ratios, overlooking sustainability performance and liquidity management. This study examines the effect of environmental performance, measured by PROPER ratings, and working capital efficiency, measured by the cash conversion cycle, on the bankruptcy risk of non-financial firms listed on the Indonesia Stock Exchange between 2011 and 2023. Panel regression with firm and year fixed effects is employed. Bankruptcy risk is assessed through Altman Z-scores and validated with Ohlson O-scores. The results show that firms with higher PROPER ratings have significantly lower bankruptcy risk, while longer cash conversion cycles increase the probability of distress. The effects remain robust across alternative measures and industry sub-samples. Furthermore, environmental performance moderates the negative impact of inefficient working capital management. This study is among the first to integrate environmental ratings (PROPER) into bankruptcy prediction models in Indonesia and demonstrates that sustainability practices mitigate the risks associated with poor working capital management.
Keywords: bankruptcy risk; environmental performance; PROPER; working capital efficiency; Indonesia

INTRODUCTION

Corporate bankruptcy remains a pressing concern in emerging economies, where institutional quality, regulatory enforcement, and market volatility amplify the financial vulnerability of firms (Ren et al., 2025). In Indonesia, bankruptcy risk is particularly salient given the country's rapid economic growth, high dependence on resource-based industries, and exposure to global commodity price cycles. Episodes of corporate distress, including delistings from the Indonesia Stock Exchange (IDX) and restructurings under the Commercial Court, demonstrate the fragility of firms that fail to adapt to changing business environments (Wijantini, 2020). Understanding the determinants of bankruptcy risk in such a context is therefore essential for creditors, investors, regulators, and policymakers.

The literature on bankruptcy prediction has traditionally focused on financial ratios such as leverage, liquidity, and profitability, epitomised by Altman's discriminant model and Ohlson's probabilistic logit model, which remain standard baselines for empirical work (Altman, 1968; Balcaen & Ooghe, 2006; Ohlson,

1980; Zmijewski, 1984). While these models remain influential, recent studies argue that non-financial dimensions, including sustainability practices and managerial efficiency, may also shape firms' resilience to distress (Lasak, 2023). Environmental performance, in particular, has become increasingly relevant in emerging markets where governments promote sustainable industrial transformation. In Indonesia, the Ministry of Environment and Forestry operates the Program Penilaian Peringkat Kinerja Perusahaan dalam Pengelolaan Lingkungan Hidup (PROPER), which assigns firms ratings ranging from gold (highest) to black (lowest) based on compliance and proactive environmental initiatives. Despite its visibility, limited empirical evidence exists on whether PROPER ratings correlate with lower bankruptcy risk, especially in combination with financial indicators.

Parallel to sustainability performance, the efficiency of working capital management has been shown to influence firm survival. Inefficient management of receivables, payables, and inventories can constrain liquidity and increase the probability of financial failure (Vahid-Golpayegani, 2024). In Indonesia, where many firms face volatile supply chains and financing constraints, the cash conversion cycle (CCC) may serve as a critical determinant of resilience (Amaliah & Darmawan, 2019; Oktavianus Yusan & Edy Handoyo, 2023). Yet few studies integrate both environmental performance and working capital efficiency into a unified framework of bankruptcy risk analysis.

This study addresses this gap by examining whether environmental performance, as captured by PROPER ratings, and working capital efficiency, measured through the cash conversion cycle, jointly affect the risk of corporate bankruptcy among Indonesian listed firms from 2011 to 2023. Using panel regression with firm and year fixed effects, the analysis also incorporates three well-established controls: firm size, leverage, and profitability. The novelty of this research lies in integrating sustainability compliance data with classical financial predictors to provide a multidimensional view of bankruptcy risk in an emerging market context. By doing so, the study contributes to corporate finance and sustainability scholarship and offers policy-relevant insights for regulators and stakeholders seeking to strengthen both financial stability and environmental accountability in Indonesia. The remainder of the paper proceeds as follows. The next section reviews the theoretical and empirical literature on bankruptcy risk and develops the study's hypotheses. The subsequent section describes the data and empirical methods. This is followed by the presentation of results, a discussion of their implications, and a conclusion that outlines the study's limitations and directions for future research.

LITERATURE REVIEW

Theories of Bankruptcy Risk

Early research conceptualises bankruptcy risk as a function of financial statement fundamentals that proxy profitability, leverage, liquidity, and activity (Beaver, 1966). The seminal discriminant model by Altman and the probabilistic logit model by Ohlson established that combinations of accounting ratios predict failure with economically meaningful accuracy, and both remain standard baselines for empirical work (Altman, 1968; Ohlson, 1980).

Subsequent work reframed bankruptcy as a dynamic event process. Hazard and survival models incorporate time variation and forward-looking market information, which improves out-of-sample accuracy relative to single-period classifiers (Shumway, 2001). Shumway's (2001) hazard model shows that market size, prior returns, and return volatility add substantial predictive power when combined with accounting variables, and later evaluations confirm the superiority of hazard specifications in developed markets. Campbell, Hilscher, and Szilagyi further demonstrate that a dynamic failure probability built from market and accounting inputs tracks distress risk and pricing phenomena in equity markets, extending the hazard-model tradition to explain the well-documented anomalous returns of financially distressed stocks (Campbell et al., 2008); complementary work on single-index hazard specifications confirms that this class of models remains competitive in more recent data (Li et al., 2023).

A complementary structural perspective derives default risk from option-pricing theory. Distance-to-default from the Merton framework links equity volatility and leverage to the probability of default by modelling corporate equity as a call option on the firm's assets (Merton, 1974). Empirical comparisons show that market-based default measures contain information beyond accounting scores, and that simplified implementations of distance-to-default are competitive predictors of failure (Hillegeist et al., 2004).

These financial theories increasingly intersect with sustainability and stakeholder perspectives. Stakeholder and legitimacy theories argue that firms that meet salient stakeholder expectations and sustain legitimacy reduce exposure to regulatory sanctions, reputational losses, and operational disruptions, which can lower the likelihood of distress (Mahajan et al., 2023). Large evidence syntheses report a nonnegative, often positive, association between environmental, social, and governance practices and financial performance, and recent empirical studies link stronger ESG profiles to lower bankruptcy probabilities (Aydoğmuş et al., 2022; Friede et al., 2015).

Liquidity management provides a final bridge from theory to the variables examined in this study. Working capital efficiency, commonly summarised by the cash conversion cycle, affects the firm's ability to meet short-term obligations and sustain operations through shocks (Stavropoulos & Zounta, 2025). Evidence across settings shows that shorter cash conversion cycles and tighter management of receivables and inventories are associated with stronger performance, particularly during downturns, which implies a pathway from working capital policy to distress risk (Enqvist et al., 2014; Kiymaz et al., 2024).

Financial Determinants of Bankruptcy Risk

A substantial body of research demonstrates that financial structure and performance are central determinants of corporate bankruptcy. Among these, leverage is one of the most consistent predictors. Highly leveraged firms face higher fixed obligations, which increase the probability of distress when earnings decline. Empirical studies across developed and emerging economies confirm that the debt-to-asset ratio is positively associated with bankruptcy likelihood (Pathak et al., 2021). In Indonesia, evidence likewise shows that over-leveraged firms are more vulnerable to delisting and restructuring, especially during macroeconomic shocks (Njoku & Lee, 2024).

Profitability serves as a protective factor against distress. Firms with strong returns on assets or equity generate internal funds that reduce dependence on external financing. Higher profitability enhances resilience by supporting liquidity, investment, and debt-servicing capacity. Research in both developed and Asian emerging markets finds that low profitability consistently precedes corporate failures (Movsesyan & Seissian, 2025).

Firm size is another critical determinant. Larger firms typically enjoy economies of scale, easier access to capital markets, and more diversified cash flows, which reduces the volatility of earnings and lowers bankruptcy risk. Studies in emerging markets confirm that small and medium-sized enterprises are disproportionately exposed to failure due to limited financing channels and weaker bargaining power (Mokopanela, 2024).

Finally, working capital management reflects short-term financial health and liquidity control. The cash conversion cycle (CCC), measuring the average time between cash outflows for inputs and inflows from sales, captures the efficiency of managing receivables, inventories, and payables. A longer CCC implies greater cash tied up in operations and thus higher liquidity risk. International evidence shows that inefficient working capital management is associated with greater vulnerability to financial distress (Abdullah et al., 2022). Indonesian studies also document that shorter CCC values correlate with stronger performance and stability, highlighting its importance in emerging market contexts (Robiyanto et al., 2023). Together, these determinants provide a solid foundation for predicting bankruptcy risk. This study builds on this literature by incorporating not only traditional financial predictors but also environmental performance indicators, which remain underexplored in the Indonesian context.

Environmental Performance and Resilience

The relationship between corporate environmental responsibility and financial stability has gained increasing scholarly attention over the past two decades. Theoretical perspectives such as stakeholder theory and legitimacy theory suggest that firms engaging in sustainable practices can reduce regulatory risks, build stronger reputations, and secure legitimacy in the eyes of key stakeholders. These benefits may indirectly reduce the probability of financial distress by stabilising revenue streams and enhancing access to financing (Freeman et al., 2010; Suchman, 1995).

Meta-analyses of environmental, social, and governance (ESG) performance confirm a generally positive association with firm value and risk management outcomes (Singhania & Gupta, 2024). Firms with superior environmental ratings often face fewer compliance costs, lower litigation risk, and enhanced operational efficiency, all of which can strengthen financial resilience and reduce bankruptcy probability (Khalil et al.,

2024). Empirical studies in both developed and emerging economies show that proactive environmental management is linked to reduced default risk and better credit ratings, and Indonesia-specific evidence on the drivers of corporate bankruptcy risk reinforces the value of examining strategic, non-purely-financial explanations alongside classical accounting ratios (Agustia et al., 2020).

In Indonesia, the Program Penilaian Peringkat Kinerja Perusahaan dalam Pengelolaan Lingkungan Hidup (PROPER), administered by the Ministry of Environment and Forestry, provides a formal evaluation of corporate environmental performance. Companies are ranked on a five-tier system: gold (leading in sustainability innovation), green (beyond compliance), blue (compliant), red (below compliance), and black (severe violation). PROPER ratings are published annually and cover major industries such as mining, energy, manufacturing, and plantations. While the programme has been widely recognised for promoting compliance and transparency, empirical research linking PROPER scores to financial outcomes remains limited. The novelty of incorporating PROPER ratings into bankruptcy prediction models lies in testing whether environmental compliance and sustainability initiatives are not only reputational signals but also determinants of financial resilience. If stronger PROPER ratings are associated with lower bankruptcy risk, this would provide robust evidence that environmental responsibility has tangible financial consequences in emerging markets.

Hypothesis Development

Drawing on the theoretical and empirical strands reviewed above, this study advances three hypotheses. First, because superior environmental performance is theorised to reduce regulatory, reputational, and operational risks and to signal long-term sustainability to investors and creditors, firms with higher PROPER ratings are expected to exhibit lower bankruptcy risk (H1). Second, because inefficient working capital management ties up cash in operations and weakens firms' ability to meet short-term obligations, longer cash conversion cycles are expected to be associated with higher bankruptcy risk (H2). Third, consistent with the view that environmentally responsible firms enjoy reputational capital and more favourable access to financing that can buffer operational shocks, environmental performance is expected to moderate the adverse effect of working capital inefficiency, such that the positive relationship between the cash conversion cycle and bankruptcy risk is attenuated among firms with higher PROPER ratings (H3).

METHODS

This study applies a quantitative research design based on secondary panel data of non-financial firms listed on the Indonesia Stock Exchange between 2011 and 2023. The primary objective is to examine how environmental performance and working capital efficiency affect the risk of corporate bankruptcy. Financial sector firms such as banks and insurance companies are excluded from the sample because they operate under different accounting standards and regulatory structures, consistent with standard practice in the bankruptcy prediction literature. The data are drawn from two main sources. Environmental performance is measured using annual PROPER ratings published by the Ministry of Environment and Forestry, where ratings are assigned on a five-point ordinal scale ranging from black, indicating severe violation, to gold, indicating exemplary performance. Financial data are collected from the official reports and annual filings of listed companies on the Indonesia Stock Exchange. These data are used to calculate working capital efficiency, bankruptcy risk measures, and firm-level controls.

Bankruptcy risk is operationalised primarily through the Altman Z-score, which is computed from accounting ratios related to liquidity, profitability, leverage, and activity; firms with low Z-scores are considered at higher risk of financial distress (Altman, 1968). The Ohlson O-score is employed as an alternative measure for robustness (Ohlson, 1980). Working capital efficiency is proxied by the cash conversion cycle, which captures the average length of time required to convert investments in receivables and inventory back into cash flows after settling payables. To account for other firm characteristics that may influence bankruptcy risk, three control variables are included: firm size, measured as the natural logarithm of total assets; leverage, expressed as the ratio of total debt to total assets; and profitability, represented by return on assets. These controls are consistently identified in the literature as primary determinants of corporate survival and failure. Table 1 summarises the definition, measurement, and expected sign of each variable used in the analysis.

Table 1. Variable Definitions and Measurement

Variable	Measurement	Expected Sign
Altman Z-score (dependent)	Composite index of liquidity, profitability, leverage, and activity ratios (Altman, 1968); higher values indicate lower bankruptcy risk.	—
Ohlson O-score (robustness dependent)	Probabilistic logit-based distress score (Ohlson, 1980); higher values indicate higher bankruptcy risk.	—
PROPER rating	Ordinal environmental performance rating, 1 (black) to 5 (gold), Ministry of Environment and Forestry.	+ (Z-score) / − (O-score)
Cash Conversion Cycle (CCC)	Days sales outstanding + days inventory outstanding – days payables outstanding.	− (Z-score) / + (O-score)
Firm Size	Natural logarithm of total assets.	+ (Z-score) / − (O-score)
Leverage	Total debt divided by total assets.	− (Z-score) / + (O-score)
Profitability (ROA)	Net income divided by total assets.	+ (Z-score) / − (O-score)
PROPER × CCC (interaction)	Product of the PROPER rating and the cash conversion cycle.	+ (Z-score)

Note. Expected signs are stated relative to the Altman Z-score (higher = financially healthier) and, where applicable, the Ohlson O-score (higher = greater distress probability).

The relationship between bankruptcy risk and the explanatory variables is estimated using panel regression. The econometric model is specified as:

$$BankruptcyRisk_{it} = a + \beta 1\ PROPER_{it} + \beta 2\ CCC_{it} + \beta 3\ Size_{it} + \beta 4\ Leverage_{it} + \beta 5\ Profitability_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where i denotes the firm and t denotes the year, μ_i represents firm fixed effects that capture unobserved heterogeneity across companies, λ_t represents year fixed effects that control for time-specific macroeconomic shocks, and ε_{it} is the error term. Estimation is carried out using the fixed effects (within) estimator, which is preferred in this setting because it controls for unobservable firm-level characteristics that are constant over time and may bias the coefficients. The appropriateness of the fixed effects approach is confirmed through a Hausman test that compares it with random effects. Standard errors are clustered at the firm level to mitigate concerns of heteroskedasticity and serial correlation in the residuals. To ensure robustness, additional analyses include the use of Ohlson O-scores as an alternative dependent variable and sub-sample estimations by industry group. The possibility that environmental performance and working capital efficiency interact in shaping bankruptcy risk, as anticipated in H3, is tested by including an interaction term between the PROPER rating and the cash conversion cycle.

RESULTS

Descriptive Statistics

The descriptive statistics provide an overview of the characteristics of the sample firms. The average Altman Z-score is 2.15, which falls within the "grey zone" between financial health and distress. The minimum value of −1.50 indicates that some firms in the sample experienced extreme financial difficulties, while the maximum of 6.80 suggests that other firms maintained strong financial stability. This variation highlights the heterogeneity in bankruptcy risk across Indonesian listed firms.

Table 2. Descriptive Statistics of Variables

Variable	Mean	Std. Dev.	Min	Max
Altman Z-score	2.15	1.10	−1.50	6.80
PROPER rating	3.20	0.85	1.00	5.00
Cash Conversion Cycle (days)	85.40	40.20	−20.0	220.0
Firm Size (log assets)	14.25	1.25	11.00	18.10
Leverage (debt/assets)	0.48	0.22	0.05	0.95
Profitability (ROA)	0.065	0.045	−0.12	0.21

The average PROPER rating is 3.20, corresponding to the "blue" to "green" categories, which implies that most firms are at least compliant with environmental regulations, with a small number achieving exemplary "gold" performance. The minimum rating of 1 reflects that some firms were sanctioned with a "black" rating due to severe environmental violations, while the maximum rating of 5 shows that sustainability leaders are also present in the sample. The cash conversion cycle (CCC) has a mean of 85.4 days, indicating that on average firms require nearly three months to convert resource inputs into cash flows. The relatively wide standard deviation of 40.2 and the range from −20 days to 220 days suggest significant variation in working capital efficiency. Negative values imply that some firms are able to collect revenues before settling their obligations, while longer cycles point to potential liquidity pressures.

The average firm size, measured as the natural logarithm of total assets, is 14.25 with values ranging from 11.00 to 18.10, confirming that the sample consists of both medium-sized and very large corporations. Leverage has a mean of 0.48, meaning that on average almost half of the firms' assets are financed through debt. The maximum leverage ratio of 0.95 illustrates that some firms rely heavily on debt financing, increasing their vulnerability to financial distress. Finally, profitability as measured by return on assets averages 6.5 percent, but the negative minimum of −12 percent indicates that some firms have experienced losses, while the positive maximum of 21 percent shows that other firms operate with strong profitability. Taken together, these descriptive statistics demonstrate that the sample contains firms with widely differing levels of environmental performance, working capital efficiency, financial structure, and profitability. This diversity strengthens the suitability of panel regression analysis to identify systematic relationships between these characteristics and bankruptcy risk.

Correlation Analysis

The correlation matrix provides preliminary evidence of the relationships among the key variables. As expected, the Altman Z-score is negatively correlated with leverage (−0.520), indicating that firms with higher debt relative to assets are more likely to face financial distress. Conversely, the Z-score shows a positive correlation with profitability (0.460) and firm size (0.280), which suggests that more profitable and larger firms enjoy greater financial stability. These findings are consistent with prior literature that emphasises the protective role of profitability and scale, and the vulnerability associated with excessive leverage.

Table 3. Correlation Matrix of Variables

Variable	Altman Z	PROPER	CCC	Size	Leverage	ROA
Altman Z-score	1.000	0.210	−0.305	0.280	−0.520	0.460
PROPER rating	0.210	1.000	−0.180	0.330	−0.220	0.250
Cash Conversion Cycle	−0.305	−0.180	1.000	−0.100	0.280	−0.270
Firm Size (log assets)	0.280	0.330	−0.100	1.000	−0.250	0.310
Leverage (debt/assets)	−0.520	−0.220	0.280	−0.250	1.000	−0.410
Profitability (ROA)	0.460	0.250	−0.270	0.310	−0.410	1.000

The relationship between environmental performance (PROPER rating) and bankruptcy risk is positive (0.210), suggesting that firms with better environmental compliance and sustainability practices are less likely to fall into financial distress. This supports the theoretical expectation that environmental responsibility enhances resilience by reducing regulatory, reputational, and operational risks. The correlation between

PROPER and firm size (0.330) also indicates that larger firms tend to achieve higher PROPER ratings, likely due to greater resources available for compliance and sustainability initiatives. The cash conversion cycle (CCC) is negatively correlated with the Z-score (−0.305), implying that longer working capital cycles are associated with higher bankruptcy risk. This confirms the argument that inefficient liquidity management erodes firm stability. CCC also shows a negative correlation with profitability (−0.270), consistent with the view that efficient working capital practices support stronger financial performance. Overall, the correlations align well with theoretical expectations. Importantly, none of the coefficients approach values that would indicate severe multicollinearity (e.g., above 0.80), suggesting that the variables can be jointly included in the regression model without biasing the results. These descriptive associations provide the foundation for the panel regression analysis, which formally tests the effect of environmental performance and working capital efficiency on bankruptcy risk after controlling for firm characteristics.

Regression Results

The fixed effects regression results in Table 4 provide evidence on how environmental performance, working capital efficiency, and firm characteristics influence corporate bankruptcy risk among Indonesian listed firms.

Table 4. Fixed Effects Regression Results (Baseline Model)

Variable	Coefficient	Std. Error	t-Statistic	p-Value
PROPER rating	0.185	0.072	2.57	0.011
Cash Conversion Cycle (CCC)	−0.012	0.004	−3.00	0.003
Firm Size (log assets)	0.210	0.095	2.21	0.027
Leverage (debt/assets)	−1.480	0.220	−6.73	0.000
Profitability (ROA)	3.150	0.510	6.18	0.000
Constant	0.950	0.480	1.98	0.048

Note. Within $R^2 = 0.47$. Standard errors clustered at the firm level. Firm and year fixed effects included.

The coefficient for PROPER rating is positive and statistically significant ($\beta = 0.185$, $p = 0.011$). This finding indicates that firms with higher environmental performance scores, as measured by PROPER ratings, tend to have higher Altman Z-scores, implying lower bankruptcy risk, supporting H1. The result is consistent with the theoretical argument that environmental responsibility enhances resilience by reducing regulatory penalties and reputational risks while signalling long-term sustainability to investors. The cash conversion cycle (CCC) is negatively associated with the Z-score ($\beta = -0.012$, $p = 0.003$), supporting H2: firms with longer working capital cycles, reflecting inefficiencies in managing receivables, payables, and inventory, are more likely to face financial distress. This finding supports prior empirical evidence that inefficient liquidity management weakens firm stability and increases vulnerability to bankruptcy.

Turning to the control variables, firm size shows a positive and significant coefficient ($\beta = 0.210$, $p = 0.027$), confirming that larger firms are generally more financially stable due to economies of scale, diversification of activities, and better access to external financing. Leverage is strongly negative ($\beta = -1.480$, $p < 0.001$), reaffirming that high debt burdens substantially increase bankruptcy risk by raising fixed obligations and financial fragility. Finally, profitability (ROA) has a large positive effect on the Z-score ($\beta = 3.150$, $p < 0.001$), highlighting that more profitable firms are significantly less likely to fall into distress because internal cash generation strengthens their ability to meet obligations. The overall explanatory power of the model is meaningful, with a within R-squared of 0.47, indicating that nearly half of the variation in bankruptcy risk across firms and years is explained by the included variables. The inclusion of firm and year fixed effects ensures that unobserved heterogeneity and macroeconomic shocks are controlled for, strengthening the credibility of the results. In summary, the baseline regression supports H1 and H2, while the control variables behave in line with well-established financial distress theory.

Robustness Check

The robustness test with the Ohlson O-score largely reinforces the results obtained with the Altman Z-score. The coefficient for PROPER rating is negative and statistically significant ($\beta = -0.095$, $p = 0.013$), confirming that firms with stronger environmental performance face a lower probability of financial distress.

This aligns with the theoretical expectation that sustainability practices reduce exposure to regulatory penalties and reputational risks.

Table 5. Robustness Regression Results Using the Ohlson O-score

Variable	Coefficient	Std. Error	t-Statistic	p-Value
PROPER rating	−0.095	0.038	−2.50	0.013
Cash Conversion Cycle (CCC)	0.008	0.003	2.67	0.008
Firm Size (log assets)	−0.145	0.060	−2.42	0.016
Leverage (debt/assets)	0.920	0.150	6.13	0.000
Profitability (ROA)	−2.250	0.380	−5.92	0.000
Constant	1.420	0.320	4.44	0.000

Note. Within $R^2 = 0.44$. Higher Ohlson O-scores indicate greater distress probability. Standard errors clustered at the firm level.

The cash conversion cycle (CCC) has a positive and significant coefficient ($\beta = 0.008$, $p = 0.008$), suggesting that longer cycles, which reflect weaker liquidity management, increase the likelihood of distress. This result mirrors the negative association between CCC and the Z-score in the baseline model, thus providing consistent evidence across two different bankruptcy measures. The control variables also behave as expected: firm size is negatively associated with the O-score ($\beta = -0.145$, $p = 0.016$), indicating that larger firms are less prone to failure; leverage is positively and strongly significant ($\beta = 0.920$, $p < 0.001$), reaffirming that heavy debt burdens heighten distress risk; and profitability exerts a large negative effect ($\beta = -2.250$, $p < 0.001$), highlighting that more profitable firms have substantially lower failure probabilities. The overall explanatory power of the model (within R-squared = 0.44) is similar to that of the baseline regression, confirming the robustness of the specification. Taken together, these results strengthen the reliability of the study by showing that the negative effect of environmental performance and the positive effect of working capital inefficiency on bankruptcy risk are not sensitive to the choice of distress measure.

Industry Sub-Sample Analysis

The sub-sample analysis reveals that the relationship between environmental performance, working capital efficiency, and bankruptcy risk is not uniform across industries.

Table 6. Industry Sub-Sample Regression Results (Fixed Effects Models)

Variable	Manufacturing	Mining	Other Sectors
PROPER rating	0.220 (0.008)	0.110 (0.210)	0.180 (0.025)
Cash Conversion Cycle	−0.015 (0.001)	−0.010 (0.120)	−0.009 (0.045)
Firm Size (log assets)	0.240 (0.032)	0.195 (0.088)	0.180 (0.041)
Leverage (debt/assets)	−1.520 (0.000)	−1.330 (0.002)	−1.410 (0.000)
Profitability (ROA)	3.420 (0.000)	2.950 (0.004)	3.080 (0.000)
Constant	0.810 (0.076)	1.020 (0.093)	0.920 (0.055)
Observations	1,420	680	760
R-squared (within)	0.49	0.41	0.45

Note. p-values in parentheses. Standard errors clustered at the firm level.

In the manufacturing sector, the coefficient for PROPER rating is positive and highly significant ($\beta = 0.220$, $p = 0.008$), suggesting that improvements in environmental performance are strongly associated with reduced bankruptcy risk. This likely reflects the fact that manufacturing firms are closely monitored under the PROPER programme and that their environmental practices directly affect their regulatory compliance, reputation, and operational continuity. The cash conversion cycle (CCC) is also negative and significant ($\beta = -0.015$, $p = 0.001$), indicating that working capital efficiency is a critical determinant of financial stability in this sector, where supply chain and inventory management are central to operations.

In the mining sector, however, the effect of PROPER rating on bankruptcy risk is weaker and statistically insignificant ($\beta = 0.110$, $p = 0.210$). This suggests that environmental performance, while important for compliance, does not translate as directly into bankruptcy risk for mining firms, possibly because global commodity price fluctuations overshadow environmental compliance in determining financial survival. Similarly, the cash conversion cycle is negative but not significant ($\beta = -0.010$, $p = 0.120$), reflecting that

liquidity management is less central in mining, where capital intensity and resource dependence play a larger role.

For other sectors such as services, plantations, and energy, the results are broadly consistent with manufacturing. PROPER ratings show a positive and significant association with the Altman Z-score (β = 0.180, p = 0.025), indicating that environmental compliance contributes to resilience outside of mining. The CCC is also negative and significant (β = −0.009, p = 0.045), confirming that inefficient working capital cycles increase distress risk even in non-manufacturing industries. Across all industries, the control variables behave consistently with theoretical expectations: firm size is positively related to financial health, leverage strongly increases bankruptcy risk, and profitability provides a significant protective effect. These results demonstrate that while the core financial determinants of bankruptcy risk are stable across sectors, the influence of environmental performance and working capital management is more pronounced in manufacturing and other industries than in mining.

Interaction Effects: Environmental Performance and Working Capital Efficiency

The inclusion of an interaction term between environmental performance (PROPER rating) and working capital efficiency (CCC) provides additional insight into how these two factors jointly influence bankruptcy risk, directly testing H3.

Table 7. Regression Results with Interaction Term (Fixed Effects Model)

Variable	Coefficient	Std. Error	t-Statistic	p-Value
PROPER rating	0.160	0.075	2.13	0.034
Cash Conversion Cycle (CCC)	−0.018	0.006	−3.00	0.003
PROPER × CCC (interaction)	0.006	0.002	2.90	0.004
Firm Size (log assets)	0.190	0.092	2.07	0.039
Leverage (debt/assets)	−1.420	0.230	−6.17	0.000
Profitability (ROA)	3.050	0.500	6.10	0.000
Constant	0.880	0.470	1.87	0.061

Note. Within R^2 = 0.50. Standard errors clustered at the firm level.

The coefficient for PROPER rating remains positive and significant (β = 0.160, p = 0.034), which confirms that firms with stronger environmental performance exhibit higher Altman Z-scores and thus lower distress risk. Similarly, the cash conversion cycle maintains a negative and significant coefficient (β = −0.018, p = 0.003), indicating that inefficient working capital management increases bankruptcy risk. Importantly, the interaction term PROPER × CCC is positive and statistically significant (β = 0.006, p = 0.004), supporting H3: environmental performance moderates the adverse effect of inefficient working capital cycles on bankruptcy risk. In other words, firms with higher PROPER ratings are better able to withstand the risks associated with longer cash conversion cycles, plausibly because environmentally responsible firms enjoy reputational capital, stronger stakeholder support, and better access to financing, which can buffer them against liquidity pressures stemming from working capital inefficiency.

The control variables behave consistently with prior models: firm size continues to show a positive relationship with financial stability, leverage remains a strong negative predictor of bankruptcy risk, and profitability exerts a large positive effect on the Altman Z-score. The overall explanatory power of the model improves slightly compared with the baseline regression, with a within R-squared of 0.50, indicating that the interaction term adds meaningful explanatory value. Taken together, these findings highlight that environmental performance not only directly reduces bankruptcy risk but also strengthens firms' resilience against operational inefficiencies in working capital management, reinforcing the argument that sustainability practices can act as a strategic resource that enhances financial stability in emerging market contexts.

DISCUSSION

The findings of this study provide compelling evidence that both environmental performance and working capital efficiency play significant roles in shaping bankruptcy risk among Indonesian listed firms. The baseline regression shows that higher PROPER ratings are associated with higher Altman Z-scores,

indicating lower bankruptcy risk, while longer cash conversion cycles are linked to greater financial vulnerability. These relationships remain robust across alternative measures of financial distress and across sub-samples, confirming their consistency and providing support for H1 and H2.

The positive association between environmental performance and financial stability supports theoretical arguments from stakeholder and legitimacy theory, which posit that firms engaging in proactive sustainability practices build stronger reputations, reduce exposure to regulatory sanctions, and enhance legitimacy in the eyes of regulators and investors (Freeman et al., 2010; Suchman, 1995). The result also echoes global evidence that environmental, social, and governance performance contributes to financial resilience (Khalil et al., 2024) and is consistent with meta-analytic evidence that ESG disclosure is, on balance, associated with lower rather than higher firm risk (Singhania & Gupta, 2024). In the Indonesian context, this study is among the first to demonstrate empirically that PROPER ratings, a nationally standardised environmental performance metric, can serve not only as a compliance signal but also as a predictor of reduced bankruptcy risk. This finding suggests that sustainability compliance has material financial implications, which reinforces the importance of the PROPER programme for regulators and firms alike, and complements Indonesia-focused bankruptcy research that has emphasised earnings quality and business strategy as non-purely-financial correlates of distress risk rather than environmental performance (Agustia et al., 2020).

The negative effect of working capital inefficiency on bankruptcy risk aligns with prior evidence that inefficient liquidity management reduces firms' ability to meet short-term obligations and exposes them to higher distress probabilities (Dainelli et al., 2024; Tarighi et al., 2024). The significance of the cash conversion cycle across models indicates that, in an emerging market characterised by volatile supply chains and financing constraints, liquidity management remains a critical determinant of survival. The sub-sample analysis further demonstrates that this effect is particularly strong in manufacturing and service-related industries, where operations are highly dependent on efficient inventory and receivables management. By contrast, in the mining sector, the effect of both PROPER ratings and the cash conversion cycle is weaker, suggesting that external shocks such as commodity price fluctuations play a more dominant role in shaping bankruptcy risk than either sustainability compliance or liquidity management, a pattern broadly consistent with commodity-exposed emerging market evidence on the primacy of macro and sector-level shocks in mining-sector distress (Movsesyan & Seissian, 2025).

The interaction model adds an important nuance and provides direct support for H3: environmental performance mitigates the negative consequences of inefficient working capital cycles. Firms with higher PROPER ratings appear better able to buffer themselves against liquidity pressures, possibly due to improved access to capital markets, stronger stakeholder support, and enhanced reputation that accompanies environmental compliance. This finding extends prior literature by showing that sustainability practices do not simply operate as independent determinants of firm value but can also strengthen resilience to operational inefficiencies, a moderating role for non-financial performance that has received little direct empirical attention in the working-capital literature to date (Kiymaz et al., 2024). Theoretically, this moderating pattern is consistent with a structural reading of distress risk in which environmentally compliant firms behave, in effect, as lower asset-volatility borrowers in the sense of the Merton (1974) framework: to the extent that PROPER compliance reduces the likelihood of costly regulatory or reputational shocks, it narrows the effective distribution of asset-value outcomes that determines distance-to-default, which would rationalise why the same liquidity shock (a longer CCC) translates into a smaller increase in distress risk for highly rated firms.

The control variables, firm size, leverage, and profitability, behave consistently with long-established theories of financial distress. Larger and more profitable firms enjoy greater financial stability, while highly leveraged firms face increased bankruptcy risk. The consistency of these results across different models and against the dynamic, market-augmented perspective on distress risk associated with hazard-model and option-pricing traditions (Campbell et al., 2008; Hillegeist et al., 2004) confirms the robustness of the estimation and validates the theoretical framework underpinning the study.

Taken together, the findings contribute to the literature in three important ways. First, they extend the bankruptcy prediction literature in Indonesia, which has traditionally emphasised financial ratios in the tradition of Altman (1968) and Ohlson (1980), by introducing environmental performance as an explanatory factor grounded in a nationally administered, verifiable rating rather than a self-reported or third-party ESG composite score. This addresses a measurement concern that has complicated cross-country ESG-risk

studies, where score methodologies differ widely across providers (Aydoğmuş et al., 2022; Friede et al., 2015). Second, the results show that working capital efficiency, often studied in relation to profitability rather than solvency (Enqvist et al., 2014; Robiyanto et al., 2023), also has a direct and measurable impact on financial distress risk, extending this literature from a performance outcome to a survival outcome. Third, the study identifies and tests a moderating role for environmental performance in buffering liquidity risk, offering a novel perspective on the interaction between sustainability and operational efficiency that, to the authors' knowledge, has not previously been documented for an emerging Southeast Asian market.

Compared with hazard-model evidence from developed markets, where market-based predictors such as prior returns and return volatility substantially improve out-of-sample accuracy over accounting-ratio models (Campbell et al., 2008; Shumway, 2001), the present study relies on accounting-based Z- and O-scores because firm-level market microstructure data of comparable quality are not consistently available across the full 2011–2023 window for all sample firms; this is a deliberate scope choice rather than an oversight, and future work could test whether market-augmented hazard specifications preserve the PROPER effect documented here. Relative to studies of financial distress in other emerging and transitional economies, where bankruptcy business environment reforms and institutional quality shape firm risk-taking and survival (Ren et al., 2025), the Indonesian evidence suggests that a sector-specific regulatory instrument like PROPER can function as a comparable institutional signal, operating alongside rather than in place of conventional financial fundamentals. Relative to Indonesia-specific work on earnings management and business strategy as correlates of Altman Z-scores, which finds that generic competitive strategy, rather than accounting manipulation, is the more reliable non-financial predictor of distress (Agustia et al., 2020), this study identifies environmental compliance as a further, largely orthogonal non-financial channel, suggesting that Indonesian bankruptcy prediction models stand to gain from incorporating multiple non-financial dimensions rather than any single one in isolation.

From a practical perspective, the results carry significant implications for managers, investors, and regulators. Managers are encouraged to view environmental compliance not merely as a regulatory obligation but as a strategic investment that can enhance financial resilience, particularly for firms that also carry elevated working capital risk, given the buffering role identified in the interaction model. Investors may use PROPER ratings as an additional, low-cost screening tool to identify firms with lower distress risk, complementing conventional leverage- and profitability-based screens (Pathak et al., 2021). Regulators, in turn, can view the strengthening of the PROPER programme, for example through more frequent rating updates or finer-grained disclosure, as contributing not only to environmental governance but also to broader financial system stability, extending the rationale for environmental regulation beyond compliance and into prudential policy.

CONCLUSION

This study examined the relationship between environmental performance, working capital efficiency, and bankruptcy risk among Indonesian listed firms from 2011 to 2023. Using panel regression with firm and year fixed effects, the findings reveal that higher PROPER ratings are consistently associated with lower bankruptcy risk, while longer cash conversion cycles increase the likelihood of financial distress. The results remain robust across alternative measures of financial failure and across industry sub-samples, with the strongest effects observed in manufacturing and service-related sectors. Furthermore, the interaction analysis demonstrates that environmental performance moderates the negative impact of working capital inefficiency, supporting all three hypotheses advanced in this study and suggesting that sustainability practices enhance resilience to liquidity pressures. These findings extend the bankruptcy prediction literature in emerging markets by integrating a nationally standardised environmental compliance indicator with classical financial determinants, and they highlight that sustainability practices and operational efficiency are complementary, rather than competing, dimensions of corporate resilience.

This research is subject to several limitations that qualify its conclusions and point to productive avenues for future work. First, the analysis relies on secondary data drawn from PROPER disclosures and listed companies' official financial filings; while these are the authoritative public sources for each series, they inherit any reporting lags or measurement conventions embedded in the underlying disclosures, and the study does not independently audit firm-level financial statements. Second, the sample is restricted to non-financial firms listed on the Indonesia Stock Exchange, which excludes unlisted firms, financial institutions,

and state-owned enterprises operating under distinct governance and disclosure regimes; the results should accordingly be generalised to the broader Indonesian corporate sector with caution. Third, although the fixed effects specification, Hausman test, clustered standard errors, and dual bankruptcy measures address several sources of bias, the accounting-based nature of both the Altman and Ohlson scores means the study does not capture the forward-looking, market-based information shown elsewhere to improve distress prediction (Campbell et al., 2008; Hillegeist et al., 2004; Shumway, 2001); the PROPER effect documented here should therefore be interpreted as evidence from an accounting-based prediction framework rather than as a claim about market-priced default risk. Fourth, the ordinal PROPER rating, while nationally standardised and independently assigned, aggregates a range of underlying environmental practices into a single five-point scale, which may obscure heterogeneity in the specific compliance or sustainability activities driving the observed relationship with bankruptcy risk.

Future research could extend the analysis in several directions. Incorporating governance variables and qualitative disclosure measures, for example board independence, ownership concentration, or the granularity of sustainability reporting, would help disentangle which dimensions of non-financial performance are most responsible for the resilience effects identified here. Extending the sample to unlisted firms or to a cross-country comparison with other Southeast Asian markets that operate comparable environmental rating programmes would help establish whether the PROPER–bankruptcy risk relationship generalises beyond the Indonesian listed-firm context. Future work could also combine the accounting-based measures used here with market-based hazard or distance-to-default specifications (Campbell et al., 2008; Merton, 1974) to test whether the environmental performance effect persists once forward-looking market information is taken into account, and could disaggregate the PROPER rating into its constituent compliance and beyond-compliance components to identify which specific environmental practices contribute most to reduced bankruptcy risk. For managers, the results suggest that investment in environmental compliance can deliver both regulatory legitimacy and financial stability; for regulators and policymakers, the study underscores the dual role of the PROPER programme in promoting environmental responsibility and strengthening financial system robustness.

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CONFLICT OF INTEREST
The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

DATA AVAILABILITY
The PROPER environmental performance ratings analyzed in this study are publicly available from the Indonesian Ministry of Environment and Forestry. The financial data were compiled from official annual reports and filings published by non-financial firms listed on the Indonesia Stock Exchange (IDX), which are publicly accessible through IDX and company disclosure channels. The compiled panel dataset and estimation code used for the analysis are available from the corresponding author upon reasonable request.

AUTHORS' CONTRIBUTION
Ihsan Ro'is: conceptualization, methodology, formal analysis, writing – original draft, writing – review and editing, project administration, corresponding author. Benjamin Chadwick: literature review, data curation, validation, writing – review and editing. Tz-Li Wang: methodology, formal analysis, visualization, writing – review and editing. All authors have read and agreed to the published version of the manuscript.

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