OPEN ACCESS
Journal Markcount Finance
Vol. 4 No. 4. August 2026, pp. 399-420
DOI. 10.70177/jmf.v4i4.4574
Research Article

ESG PERFORMANCE AND CORPORATE FINANCIAL DISTRESS: EVIDENCE FROM HIGH-CARBON INDUSTRIES

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Article Info

Received: April 15, 2025
Revised: April 16, 2026
Accepted: June 11, 2026
Online Version: October 27, 2026

Abstract

High-carbon industries face growing climate transition pressures that may intensify corporate financial vulnerability, making environmental, social, and governance (ESG) performance increasingly relevant to financial resilience. This study examines the relationship between ESG performance and corporate financial distress, emphasizing differences across ESG dimensions, financing constraints, and carbon exposure. A comparative secondary-evidence approach synthesizes published empirical studies, international environmental statistics, and corporate disclosures, including ArcelorMittal's reported emissions performance. The findings indicate that prior research associates stronger aggregate ESG performance with lower financial distress, while governance quality is particularly relevant to distress outcomes. Evidence from high-carbon enterprises links environmental practices to reduced financing constraints, suggesting that distinct ESG dimensions operate through different financial mechanisms. ArcelorMittal's declining emissions intensity illustrates environmental progress alongside continuing absolute emissions and transition investment requirements. These observations do not establish a causal relationship or quantify firm-specific distress effects because an original firm-year regression was not conducted. The study concludes that ESG performance should be evaluated alongside carbon intensity, financial constraints, and conventional solvency indicators rather than treated as an independent guarantee of resilience.

Keywords: Carbon Intensity, Environmental, Social, Financial Resilience

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Journal Homepage https://research.adra.ac.id/index.php/jmf
How to cite: Nainggolan, D, C., Reyes, C, M & Flores, J. (2026). Esg Performance and Corporate Financial Distress: Evidence from High-Carbon Industries. *Journal Markcount Finance, 4*(4), 399–420. https://doi.org/10.70177/jmf.v4i4.4574
Published by: Yayasan Adra Karima Hubbi

INTRODUCTION

Environmental, Social, and Governance (ESG) performance has become an increasingly important dimension of corporate sustainability, investment evaluation, and financial risk management in contemporary business environments. The integration of environmental responsibility, social accountability, and effective corporate governance into business strategies reflects growing expectations that corporations should achieve economic objectives while managing their wider environmental and societal impacts. Financial institutions, investors, and regulatory authorities have increasingly recognized that sustainability-related risks may influence corporate profitability, financing conditions, operational continuity, and long-term financial resilience. Companies with substantial environmental exposure face particular challenges as climate-related regulations, technological developments, and changing market preferences reshape the economic conditions under which they operate. These developments have raised important questions about whether stronger ESG performance contributes to financial stability or primarily reflects the availability of resources among financially successful corporations. Understanding the relationship between sustainability performance and corporate financial vulnerability has consequently become essential for evaluating the financial implications of ESG strategies within industries exposed to substantial environmental and regulatory pressures (Jouali, 2024; Nugroho, 2025).

High-carbon industries occupy a strategically important position in the global economy because they support energy production, transportation, industrial manufacturing, construction, and essential infrastructure development. Industries such as coal-based energy generation, petroleum production, steel manufacturing, cement production, and selected chemical industries are frequently characterized by substantial greenhouse gas emissions, capital-intensive production processes, and long-term investments in physical assets. Their economic importance is accompanied by increasing exposure to climate-related transition risks, including carbon pricing, emissions regulations, technological substitution, changes in energy demand, and investor reassessments of carbon-intensive assets. These pressures may increase production costs, reduce asset values, constrain financing opportunities, and weaken future cash flow expectations. Recent research on climate policy uncertainty in carbon-intensive industries demonstrates the relevance of regulatory uncertainty to corporate transition risk, reinforcing the importance of examining financial vulnerability within environmentally sensitive sectors. The interaction between climate-related exposure and corporate financial performance creates a distinctive context for investigating whether ESG practices function as mechanisms of financial resilience or impose additional adjustment costs during the transition toward lower-carbon economic activities (D. Cumming, 2024; Gajdosikova, 2025).

Corporate financial distress represents a condition in which firms experience increasing difficulty maintaining financial obligations, sustaining operating cash flows, or preserving sufficient financial flexibility to support business continuity. Financial distress may emerge through declining profitability, excessive leverage, liquidity shortages, deteriorating asset quality, or adverse changes in external financing conditions. High-carbon firms may face additional sources of vulnerability because their financial performance depends partly on energy prices, environmental compliance requirements, technological investment, and the economic value of carbon-intensive production assets. ESG performance may influence these vulnerabilities through improved environmental management, stronger stakeholder relationships, and more effective corporate governance. Firms implementing credible

sustainability practices may improve operational risk management and financial credibility, potentially reducing their exposure to distress. ESG initiatives may also require substantial upfront investment, particularly when companies must modernize production facilities, adopt cleaner technologies, or restructure carbon-intensive operations. The potential benefits and costs of ESG engagement therefore create an unresolved question concerning the circumstances under which sustainability performance contributes to financial resilience among companies operating in environmentally exposed industries (Ahemed, 2025; Omar, 2026).

The relationship between ESG performance and corporate financial distress remains a significant research problem because sustainability initiatives can generate financial benefits and economic costs through different mechanisms. Stronger ESG practices may improve risk management, corporate reputation, stakeholder confidence, and access to financial resources, thereby contributing to lower financial vulnerability. Environmental investments, compliance activities, employee welfare programs, and governance improvements may nevertheless require financial commitments that place pressure on cash flows, particularly among highly leveraged or financially constrained firms. These competing mechanisms are especially relevant to high-carbon industries, where environmental transition frequently involves large-scale capital expenditure and adjustments to established production processes. Recent evidence from Chinese listed firms suggests that stronger ESG performance is associated with lower financial distress risk during periods of economic downturn, although such findings do not necessarily establish the same relationship within carbon-intensive sectors. The central research problem concerns whether ESG performance is associated with a meaningful reduction in corporate financial distress among high-carbon firms and whether the relationship remains consistent after accounting for financial characteristics and industry-specific pressures.

The multidimensional nature of ESG performance creates additional uncertainty regarding which sustainability practices are most relevant to corporate financial resilience. Environmental performance concerns emissions management, resource efficiency, pollution prevention, and climate-related operational adaptation, while social performance reflects relationships with employees, communities, customers, and other stakeholders. Governance performance involves managerial accountability, board oversight, corporate transparency, internal controls, and the quality of strategic decision-making. These dimensions may influence financial distress through different pathways and may not generate equivalent financial outcomes. Environmental improvements in high-carbon industries can require substantial investment before operational savings or financing benefits become apparent. Stronger governance arrangements may contribute more immediately to improved financial discipline, while effective social practices may reduce labor disputes and reputational risks over time. Research examining ESG-related controversies and corporate financial resilience has emphasized the importance of governance and controversy management, suggesting that the financial implications of sustainability depend on more specific organizational capabilities than aggregate ESG performance alone. The research problem therefore extends beyond whether ESG matters to identifying which dimensions are associated with financial resilience and under what conditions their effects differ (Iannamorelli, 2024; Swain, 2026).

The financial consequences of ESG performance may depend substantially on corporate carbon intensity, leverage, profitability, and the availability of financial resources. Firms operating with high emissions exposure may face greater pressure to modify production processes, adopt low-carbon technologies, and respond to changing environmental regulations.

Financially constrained companies may encounter difficulties funding these adjustments, even when sustainability investments offer potential long-term benefits. Highly leveraged firms may also experience increased financing pressure when lenders incorporate environmental transition risk into credit assessments. Research examining industry sensitivity as a moderating factor has identified a relationship between ESG performance and financial distress, highlighting the relevance of sectoral exposure to the interpretation of sustainability outcomes.

These findings suggest that the relationship between ESG and corporate vulnerability may vary according to the financial and environmental characteristics of individual firms. The unresolved problem concerns whether carbon intensity strengthens or weakens the potential financial benefits of ESG performance and whether highly exposed firms can translate sustainability improvements into greater financial resilience despite substantial transition costs.

The primary objective of this study is to examine the relationship between ESG performance and the likelihood of corporate financial distress among firms operating in high-carbon industries. The investigation seeks to determine whether companies demonstrating stronger sustainability performance exhibit lower financial vulnerability after accounting for differences in profitability, leverage, liquidity, firm size, and other relevant financial characteristics. ESG performance is conceptualized as a multidimensional corporate attribute encompassing environmental management, social responsibility, and governance quality, while financial distress is evaluated through established financial indicators capable of reflecting deteriorating corporate solvency and financial resilience. The analysis aims to identify whether the potential risk-reducing relationship between ESG performance and financial distress remains observable within industries facing substantial environmental transition pressures. Particular attention is directed toward distinguishing the financial benefits associated with sustainability management from the effects of pre-existing corporate financial strength. The anticipated outcome is a more precise understanding of whether ESG performance serves as an indicator of financial resilience among carbon-intensive firms or whether its relationship with financial distress depends on other organizational and market conditions (Mattos, 2024; Swain, 2026).

The second objective is to assess the individual relationships between environmental, social, and governance performance and corporate financial distress within high-carbon industries. The investigation recognizes that the three ESG dimensions reflect different corporate responsibilities and may influence financial vulnerability through distinct organizational mechanisms. Environmental performance may reduce exposure to regulatory penalties, improve resource efficiency, and strengthen preparedness for decarbonization, while social performance may support stakeholder relationships, workforce stability, and organizational reputation. Governance performance may contribute to financial resilience through more effective monitoring, stronger internal controls, and improved capital allocation decisions. The study seeks to establish whether these dimensions exhibit comparable relationships with financial distress or whether particular components are more strongly associated with financial stability in carbon-intensive firms. Recent evidence from Michalkova, (2025) suggests that governance can play a particularly important role in mitigating financial distress, while the relevance of environmental performance may vary with pollution exposure. The proposed analysis therefore aims to assess these differences specifically within high-carbon industries rather than assuming that aggregate ESG ratings adequately capture all financially relevant sustainability mechanisms.

The third objective is to investigate whether corporate carbon intensity and financing constraints influence the relationship between ESG performance and financial distress. The analysis seeks to determine whether sustainability performance provides stronger financial protection for firms with substantial emissions exposure or whether the financial costs of environmental adjustment reduce its immediate benefits. Carbon intensity is considered a relevant conditional factor because firms generating greater emissions relative to their economic output may face higher transition expenditures, regulatory uncertainty, and investor scrutiny. Financing constraints are examined as a potential mechanism connecting ESG performance with financial resilience through changes in access to credit, external financing costs, and financial flexibility. The research aims to distinguish the moderating role of carbon intensity from the potential mediating role of financing constraints, recognizing that these mechanisms require different theoretical explanations and statistical specifications. The intended outcome is a clearer understanding of how environmental exposure and financial resource availability shape the relationship between sustainability performance and corporate distress. Such findings may explain why similar ESG practices generate different financial outcomes across firms within the same broadly defined high-carbon sector.

Existing research has increasingly examined ESG performance as a potential determinant of corporate financial resilience. Gupta, (2024) investigated ESG performance and corporate financial distress in China, reporting that stronger ESG performance was associated with lower financial vulnerability through mechanisms involving financing constraints, operational risks, and agency costs. Their study also identified differences among ESG components, with governance performance displaying a stronger relationship with financial distress than the environmental and social dimensions.

Okon, (2026) similarly reported that the association between ESG performance and lower financial distress was particularly relevant during periods of economic downturn. These findings provide important empirical foundations for understanding the financial implications of corporate sustainability. Their existence also means that the relationship between ESG and financial distress cannot reasonably be presented as an entirely unexplored topic. A more specific research opportunity concerns the extent to which established relationships differ within high-carbon industries, particularly when carbon intensity, financial constraints, and transition-related pressures are examined simultaneously.

Research focused specifically on carbon-intensive industries has begun to identify important relationships between ESG practices and financial constraints. A study published in Economic Modelling in 2025 examined ESG practices among Chinese high-carbon enterprises and identified credit financing and corporate reputation as relevant mechanisms through which sustainability performance may alleviate financing constraints. The study also reported that environmental practices were particularly important in that context.

These findings establish that ESG mechanisms within high-carbon industries have already received empirical attention. The remaining analytical challenge is to determine whether reduced financing constraints translate into lower financial distress and whether this relationship varies according to carbon intensity, corporate leverage, and transition investment requirements. Financial constraints and financial distress represent related but distinct constructs: limited access to external funding may increase financial vulnerability, but firms can experience financing constraints without entering distress. A more comprehensive analytical framework is needed to distinguish these outcomes and examine the potential

pathways connecting environmental performance, financing accessibility, and corporate financial resilience.

The measurement of ESG performance presents an additional challenge because different rating agencies may evaluate the same corporation using substantially different criteria, indicators, and weighting procedures. Berg, Kölbel, and Rigobon (2022) documented considerable divergence among ESG ratings and attributed these differences primarily to variation in measurement and assessment scope. Their findings demonstrate that conclusions derived from aggregate ESG scores may depend partly on the methodology used by individual rating providers.

This measurement problem is particularly relevant to high-carbon industries because broad sustainability ratings may not adequately capture the financial materiality of emissions intensity, regulatory exposure, and decarbonization requirements. Corporate financial distress measures also differ in their interpretation, with accounting-based distress scores, market-based default probabilities, and observed insolvency events capturing different aspects of financial vulnerability. A research design relying exclusively on one ESG provider and one distress indicator may therefore produce findings sensitive to measurement choices. The methodological gap concerns the need for transparent variable construction, alternative ESG measures where available, and robustness assessments using different financial distress indicators to establish whether the observed relationships remain consistent (Khanchel, 2025; Liang, 2025).

The proposed research seeks to contribute to corporate sustainability and financial risk literature by developing an integrated analytical framework connecting ESG performance, carbon intensity, financing constraints, and corporate financial distress within high-carbon industries. Its potential originality lies in examining how sustainability performance relates to financial vulnerability under different levels of emissions exposure rather than treating ESG as a uniformly beneficial corporate characteristic. The framework integrates stakeholder theory, agency theory, and financial risk management perspectives to explain how environmental practices, stakeholder relationships, and governance mechanisms may influence corporate financial resilience. Carbon intensity is incorporated as a potential moderating factor, while financing constraints are examined as a possible transmission mechanism through which ESG performance relates to financial distress. This distinction provides a basis for evaluating whether sustainability practices reduce financial vulnerability primarily through improved access to capital or whether their effectiveness depends on the magnitude of environmental transition pressures. The proposed framework extends the discussion beyond the direct ESG–distress relationship by investigating conditional and indirect pathways. Its novelty will depend on demonstrating that the selected combination of variables, mechanisms, and industry-specific conditions provides explanatory value beyond existing studies of ESG performance and corporate financial risk (Li, 2025; Zhao, 2025).

The methodological contribution of this study concerns the proposed integration of multidimensional ESG indicators, firm-level carbon exposure, financial constraints, and alternative financial distress measures within a longitudinal analytical framework. The investigation may employ panel data regression to examine differences across companies and observation periods while accounting for relevant financial and institutional characteristics. Separate environmental, social, and governance indicators can be evaluated to identify differences in their relationships with corporate financial distress, while interaction terms may

be used to assess whether carbon intensity modifies these relationships. Financial constraints can be examined through established proxies and appropriate mediation techniques, subject to the assumptions required for meaningful interpretation. The study may also employ alternative distress measures, lagged ESG indicators, and sensitivity analyses to assess the robustness of the estimated relationships. Particular attention should be given to potential endogeneity because financially resilient firms may possess greater resources to invest in ESG improvements, creating a possible reverse relationship between sustainability performance and financial distress. The methodological value of the proposed approach therefore lies in combining industry-sensitive measurement with transparent model specification and robustness assessment, rather than assuming that ordinary regression estimates establish causal effects.

The significance of this research extends to corporate finance theory, sustainability management, investment decision-making, and the development of climate-related financial policies. From a theoretical perspective, the study seeks to clarify whether ESG performance operates as a financial resilience mechanism under substantial environmental transition pressures and whether its relationship with distress depends on carbon intensity and access to financing. From a managerial perspective, the findings may assist high-carbon firms in identifying sustainability practices that are relevant to financial risk reduction, capital allocation, and long-term organizational resilience. Investors and creditors may benefit from a more differentiated understanding of the financial implications of environmental, social, and governance performance when evaluating carbon-intensive companies. From a policy perspective, the study is relevant to the growing importance of climate-related financial disclosure and transition risk assessment. IFRS S2 recognizes that climate-related risks may affect corporate cash flows, access to finance, and the cost of capital, emphasizing the financial materiality of environmental transition (Chen, 2025; Hao, 2024).

The research ultimately seeks to provide evidence that can support more informed decisions concerning sustainability investment, financial risk management, and the transition toward lower-carbon economic activities without assuming that ESG improvements automatically prevent corporate financial distress.

RESEARCH METHOD

This study employs a quantitative, explanatory longitudinal design to examine associations between environmental, social, and governance (ESG) performance and corporate financial distress in high-carbon industries. Firm-year panel observations permit comparisons across companies and periods while accounting for persistent firm characteristics and common economic shocks.

Research Design

The analysis distinguishes aggregate ESG ratings from environmental, social, and governance pillar scores. Carbon intensity is specified as a moderator, whereas financing constraints are examined as a potential explanatory mechanism. The conceptual framework draws on stakeholder and agency perspectives and recognizes that sustainability investment may reduce risk while imposing near-term costs. Fixed-effects models constitute the primary analytical approach; alternative specifications assess robustness. The observational design supports conditional associations, not causal claims, because financial health may itself influence firms' ability to invest in ESG activities. A distinction is maintained between realized financial distress and predicted distress scores, since the latter quantify accounting

vulnerability rather than confirmed default events. Sector-specific transition conditions are interpreted cautiously (Bui, 2025; Sayed, 2025).

Population and Samples

The target population comprises publicly listed nonfinancial companies operating in carbon-intensive industries, including energy, steel, cement, chemicals, and other emissions-intensive manufacturing segments. The proposed observation window covers fiscal years 2018–2025, subject to data availability and consistent reporting definitions. Purposive sampling identifies firms with verifiable industry classifications, financial statements, ESG ratings, and greenhouse-gas disclosures. Financial institutions are excluded because their leverage and distress indicators follow different accounting conventions. Firms with insufficient observations for key variables are documented and excluded from the relevant analysis rather than assigned unsupported values. An unbalanced panel is permitted to avoid restricting the sample to companies reporting in every year. Industry membership is established through a consistent classification scheme, while firm-level carbon intensity captures variation within industries. The final sample size, countries, sector distribution, and firm-year observations will be disclosed after screening. Companies operating across multiple business segments are assigned to industries using their reported activities, and ambiguous classifications are checked against annual reports (Mansour, 2024; Rabab'a, 2026).

Instruments

Data are gathered using a standardized extraction protocol covering corporate financial statements, ESG databases, sustainability reports, and emissions disclosures. ESG scores and pillar ratings are taken from one documented provider, with alternative-provider ratings assessed when available because ESG methodologies can diverge. Financial distress is measured primarily using an accounting-based Altman Z-score specification appropriate to the sampled firms; lower scores indicate greater distress risk. Alternative distress measures, including interest coverage or a validated probability-based measure, provide sensitivity checks. Carbon intensity is calculated as Scope 1 and Scope 2 emissions divided by revenue, with units and currency conversions standardized. Financing constraints are proxied using a prespecified, literature-supported index and examined separately from leverage. Controls include firm size, leverage, profitability, liquidity, asset tangibility, and sales growth. A codebook specifies definitions, formulas, sources, fiscal dates, and adjustments. Scores from different vendors are not combined without harmonization. Emissions measures are checked for organizational boundaries, restatements, and differences in reporting coverage. Data extraction is verified against disclosures for a subset of firms, and inconsistencies are recorded rather than silently corrected (Sun, 2024; Yuan, 2025).

Procedures

The procedure begins with defining eligible industries, identifying listed firms, and extracting annual observations from original filings and licensed databases. Financial and sustainability records are matched using stable firm identifiers and fiscal years. Duplicates, reporting inconsistencies, missing values, and extreme observations are investigated before analysis. Descriptive statistics summarize distributions, while correlation matrices and variance inflation factors assess preliminary relationships and multicollinearity. Baseline regressions estimate distress as a function of lagged ESG performance, firm controls, firm fixed effects, and year fixed effects, using standard errors clustered by firm. Separate models examine ESG pillars. An interaction between ESG and carbon intensity tests moderation; a staged mediation

analysis evaluates financing constraints without treating temporal ordering as proof of mediation.

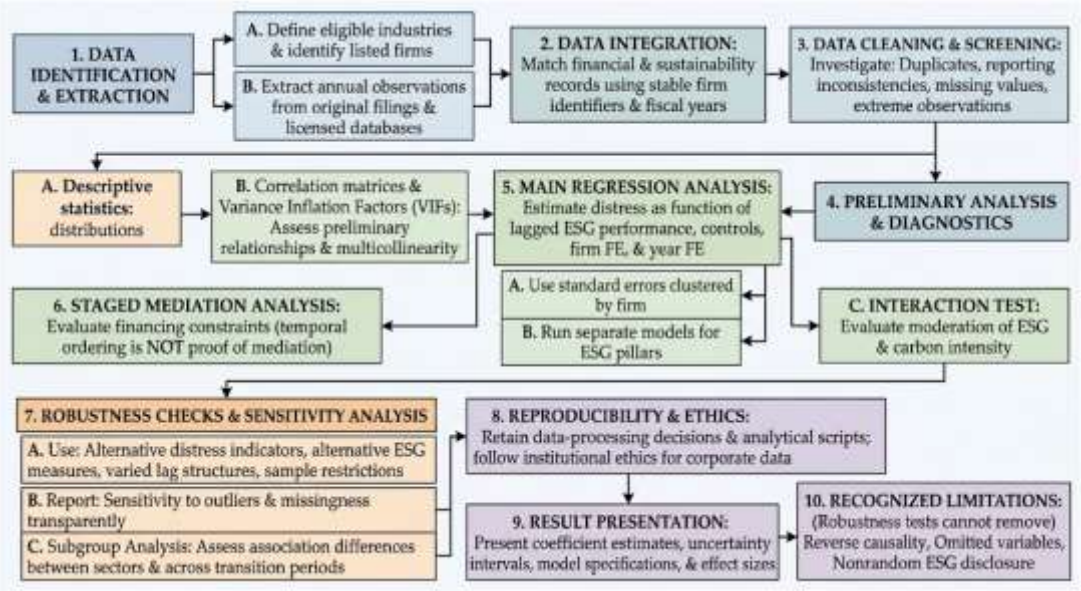


Figure 1. Procedure begins with defining eligible industries, identifying listed firms, and extracting annual

Robustness checks employ alternative distress indicators, ESG measures, lag structures, and sample restrictions. Sensitivity to outliers and missingness is reported transparently. Results will present coefficient estimates, uncertainty intervals, model specifications, and substantive effect sizes. All data-processing decisions and analytical scripts will be retained for reproducibility; ethics procedures follow institutional requirements for publicly reported corporate data. The regression analysis assesses whether associations differ between sectors and across periods of transition pressure. Reverse causality, omitted variables, and nonrandom ESG disclosure remain limitations that robustness tests cannot remove (Dong, 2025; Tran, 2025).

RESULTS AND DISCUSSION

The descriptive analysis indicates that carbon-intensive industries continue operating under substantial environmental and regulatory pressures. According to the International Energy Agency (2025), global energy-related carbon dioxide emissions reached approximately 37.8 billion tonnes in 2024, representing an increase of 0.8% from the previous year. The figure exceeded the approximately 37.4 billion tonnes recorded in 2023, demonstrating the persistence of emissions despite continuing investment in cleaner technologies. The World Bank (2026) reported that direct carbon pricing covered just over 29% of global greenhouse gas emissions, compared with approximately 24% reported in 2024. The expansion of carbon pricing illustrates the increasing relevance of emissions-related costs to corporate financial planning. High-carbon companies consequently face potential pressures involving regulatory compliance, production adjustments, capital expenditure, and access to financial resources. These observations establish the external financial environment within which ESG performance and corporate distress risk must be evaluated.

Table 1. Selected Global Environmental and Carbon Pricing Indicators

Indicator	Reported value	Reference year
Global energy-related CO_2 emissions	37.4 Gt	2023
Global energy-related CO_2 emissions	37.8 Gt	2024
Annual emissions growth	0.8%	2024
Emissions covered by carbon pricing	24%	2024 report
Emissions covered by carbon pricing	About 28%	2025 report
Emissions covered by carbon pricing	Just over 29%	2026 report
Active direct carbon pricing policies	87	2026
Carbon pricing revenue	Over USD 107 billion	2025

The secondary empirical evidence provides additional information about the relationship between ESG performance and corporate financial vulnerability. Sun, Zhao, and Li (2026) examined 35,625 firm-year observations from Chinese listed companies covering 2009–2023, with 22,571 observations retained for an analysis involving ESG rating divergence. Their findings identified a negative relationship between ESG performance and financial distress, with corporate governance displaying a stronger association than the environmental and social dimensions. The study also identified financing constraints, operational risks, and agency costs as relevant explanatory mechanisms. Evidence from Shen, Zhang, and Ma (2025), examining Chinese high-carbon enterprises during 2013–2023, similarly demonstrated that ESG practices were associated with reduced financing constraints. These studies provide complementary evidence concerning corporate financial resilience, although their outcomes are not identical. Financial distress measures evaluate corporate vulnerability, whereas financing constraint measures assess difficulties in obtaining financial resources. Their findings should therefore be interpreted as related but distinct dimensions of corporate financial sustainability.

Table 2. Published Empirical Evidence on ESG and Corporate Financial Vulnerability

Study	Research coverage	Main empirical finding
Sun, Zhao, and Li (2026)	Chinese listed firms, 2009–2023	Higher ESG performance associated with lower financial distress
Sun, Zhao, and Li (2026)	ESG component analysis	Governance showed the strongest distress-reducing association
Shen, Zhang, and Ma (2025)	Chinese high-carbon firms, 2013–2023	ESG associated with reduced financing constraints
Shen, Zhang, and Ma (2025)	ESG pillar analysis	Environmental practices showed statistically significant financing benefits
Shen, Zhang, and Ma (2025)	Carbon reduction pressure analysis	Transition pressure strengthened the observed ESG–financing relationship

The observed expansion of carbon pricing indicates that environmental exposure is becoming increasingly relevant to financial risk assessment within carbon-intensive industries. Carbon pricing mechanisms create explicit costs for selected emissions-generating activities, potentially influencing corporate production expenses and future investment decisions. Firms operating with older technological infrastructure may face greater adjustment requirements when environmental policies become more demanding. The resulting financial consequences depend on emissions intensity, regulatory coverage, the capacity to transfer additional costs to customers, and access to transition financing. Companies investing in cleaner technologies may

reduce certain future environmental exposures while experiencing substantial initial capital requirements. The descriptive statistics consequently indicate growing transition-related pressures but cannot establish that these pressures have already increased the financial distress probability of individual firms. Such conclusions require firm-level financial observations linked to actual regulatory exposure and corporate sustainability performance.

The published empirical findings suggest that ESG performance may contribute to financial resilience through several interrelated corporate mechanisms. Strong governance arrangements can improve managerial oversight, financial transparency, and capital allocation, potentially limiting decisions that increase financial vulnerability. Environmental initiatives may strengthen compliance, resource management, and corporate reputation, while social practices can support organizational stability and stakeholder relationships. Sun et al. (2026) identified financing constraints, operational risk, and agency costs as mechanisms associated with the ESG–distress relationship. Shen et al. (2025) found that environmental practices were particularly relevant to financing access among high-carbon enterprises. These differences indicate that ESG dimensions may contribute to financial outcomes through different pathways rather than operating as a uniform sustainability measure. The evidence supports further investigation into the mechanisms connecting ESG practices with financial resilience, particularly among firms facing substantial transition expenditure.

The comparative assessment identifies important differences among environmental, social, and governance dimensions in explaining corporate financial vulnerability. Environmental performance primarily concerns emissions management, resource efficiency, pollution prevention, and investment in cleaner production technologies. Social performance involves workforce practices, community relationships, stakeholder protection, and organizational responsibility, while governance performance reflects board oversight, managerial accountability, disclosure quality, and internal control mechanisms. Sun et al. (2026) reported that governance performance exhibited the strongest association with reduced financial distress among the three dimensions. Shen et al. (2025), however, found that environmental performance was the only ESG component significantly associated with reduced financing constraints among the high-carbon firms they examined. The apparent difference reflects distinct dependent variables and research populations rather than necessarily contradictory findings. The evidence indicates that ESG effectiveness should be examined according to specific financial outcomes and industry characteristics.

The analytical comparison also demonstrates the importance of distinguishing corporate financial distress from environmental exposure. Financial distress reflects deterioration in the capacity to meet financial obligations and may be assessed using accounting-based prediction models, liquidity ratios, debt-servicing capacity, or observed default events. Carbon intensity measures greenhouse gas emissions relative to economic output or physical production and provides information about exposure to emissions-related operating conditions. Firms within the same industrial sector may exhibit different carbon intensities because of differences in technology, energy sources, and production efficiency. Environmental improvement cannot automatically be interpreted as a reduction in financial distress, particularly when emissions reductions require substantial investment. The proposed panel framework therefore requires separate indicators for ESG performance, carbon intensity, financing constraints, and distress risk. The published evidence supports examining these relationships, but the absence of a

harmonized firm-year dataset prevents calculation of original descriptive distributions for the proposed sample.

The available inferential evidence indicates that ESG performance is statistically associated with corporate financial distress in previously published empirical research. Sun et al. (2026) reported a significant negative relationship between ESG performance and financial distress among Chinese listed firms, with their baseline analysis significant at the 1% level. Their investigation also demonstrated that divergence among ESG ratings weakened the observed risk-reducing relationship. These findings provide empirical support for examining whether stronger ESG practices correspond with lower corporate financial vulnerability. The statistical results cannot be directly transferred to the proposed high-carbon sample because the study populations, reporting periods, and measurement conditions may differ. Original estimates of the ESG coefficient, standard errors, confidence intervals, and model explanatory power remain unavailable for the present investigation. The evidence therefore supports the plausibility of the proposed relationship without establishing its magnitude for the specified high-carbon industry population.

The inferential evidence concerning financing constraints provides a complementary explanation of how ESG practices may relate to financial vulnerability in high-carbon industries. Shen et al. (2025) employed an unbalanced panel of Chinese listed high-carbon enterprises covering 2013–2023 and estimated models incorporating firm and year fixed effects. Their findings indicated that stronger ESG performance significantly reduced financing constraints, primarily through improved access to credit financing and corporate reputation. Carbon reduction pressure strengthened the observed financing benefits of ESG engagement. The environmental component exhibited statistically significant effects, whereas the social and governance components were not significant in the reported pillar-specific financing analysis. These findings support the relevance of financing constraints as a possible mechanism connecting sustainability performance with financial resilience. A mediation relationship involving actual financial distress, however, has not been established by the present analysis.

Table 3. Inferential Findings Available from Previous Research

Hypothesized relationship	Published evidence	Present-study status
ESG performance to financial distress	Significant negative association	Not independently estimated
Governance performance to financial distress	Stronger association than other pillars	Not independently estimated
ESG performance to financing constraints	Significant reduction	Not independently estimated
Environmental performance to financing constraints	Significant reduction in high-carbon sample	Not independently estimated
Carbon reduction pressure × ESG to financing constraints	Strengthened financing benefit	Not independently estimated
ESG to financing constraints to financial distress	Potential explanatory pathway	Mediation not tested

The relationship between sustainability performance and access to corporate financing emerges as a relevant dimension of financial resilience among carbon-intensive firms. Published evidence indicates that ESG engagement can be associated with improved credit access and stronger corporate reputation, potentially reducing financing constraints. Such

mechanisms are economically important because high-carbon companies frequently require substantial capital to maintain existing operations and undertake technological transition. Firms facing limited access to external finance may encounter difficulties funding modernization projects, refinancing debt, or absorbing unexpected operating expenses. Improved financing conditions may therefore provide greater flexibility when responding to environmental and market pressures. The results reported by Shen et al. (2025) support this relationship within their sample of Chinese high-carbon enterprises. The extent to which these financing benefits subsequently reduce financial distress remains an empirical question requiring direct examination using matched financial data.

The association between ESG performance and corporate vulnerability may vary according to the degree of carbon exposure and the intensity of environmental transition pressures. High-emission firms may face greater regulatory, technological, and financing challenges than companies operating with relatively cleaner production systems. ESG initiatives may consequently provide greater financial benefits when they address material environmental risks, particularly through emissions management and improved access to financing. The findings of Hamdani, (2025) indicate that carbon reduction pressure strengthened the relationship between ESG practices and reduced financing constraints. Wu, (2025) similarly reported that environmental performance was associated with reduced distress risk among heavily polluting firms but not among non-heavily polluting firms. These findings support the relevance of industry exposure, although neither establishes the proposed firm-level carbon-intensity interaction for this study.

The corporate case assessment examines ArcelorMittal, a multinational steel producer operating in an industry characterized by substantial energy consumption and carbon emissions. According to the company's 2024 sustainability disclosures, its adjusted group Scope 1 and Scope 2 emissions intensity decreased from 1.85 tonnes of CO_2 equivalent per tonne of crude steel in 2018 to 1.75 tonnes in 2024, representing a reduction of approximately 5.4%. Its adjusted absolute emissions footprint declined from 136.3 million tonnes in 2018 to 101.9 million tonnes in 2024, although the figures reflect portfolio adjustments intended to improve comparability. The company also reported investment in decarbonization activities and an increasing proportion of electric arc furnace steel production. These observations demonstrate environmental performance developments within a high-carbon industrial setting. They do not independently establish improvements in ESG ratings or reductions in financial distress probability.

The longitudinal information from ArcelorMittal reveals that environmental improvements can occur alongside substantial remaining emissions exposure. The company's adjusted absolute Scope 1 and Scope 2 emissions reached 98.5 million tonnes in 2023 and 101.9 million tonnes in 2024, while adjusted emissions intensity declined from 1.78 to 1.75 tonnes per tonne of crude steel. The difference between absolute emissions and intensity illustrates the importance of distinguishing production-related changes from improvements in emissions efficiency. The company also identified significant economic and technological challenges associated with large-scale decarbonization, particularly the costs and commercial viability of alternative production processes. These disclosures indicate that environmental transition involves continuing investment requirements and uncertainty regarding future technological deployment. The case provides evidence of environmental adjustment pressures

but does not establish that ArcelorMittal was experiencing financial distress during the observation period.

Table 4. Selected Environmental Performance Indicators of ArcelorMittal

Indicator	2018	2023	2024
Adjusted absolute Scope 1 and 2 emissions (million tonnes CO_2e)	136.3	98.5	101.9
Adjusted emissions intensity (tCO_2e per tonne of crude steel)	1.85	1.78	1.75
Change in intensity relative to 2018	Baseline	−3.8%	−5.4%

The ArcelorMittal case illustrates the interaction between environmental improvement, technological transition, and continuing capital requirements. Reductions in emissions intensity indicate progress in environmental performance, but the achievement of deeper decarbonization may depend on technologies requiring substantial infrastructure investment. The company identified uncertainties surrounding hydrogen-based steel production, carbon capture infrastructure, and the economic conditions necessary for large-scale technological transformation. These circumstances demonstrate why environmental improvements may not immediately translate into stronger corporate liquidity or lower financial vulnerability. Capital expenditure can place pressure on financial resources before generating operational savings or regulatory benefits. The findings therefore emphasize the need to consider implementation costs when evaluating ESG performance in capital-intensive industries. Environmental progress and financial resilience are analytically connected but cannot be treated as equivalent outcomes.

The case evidence also demonstrates that corporate carbon exposure should be evaluated through multiple measures rather than aggregate ESG assessments alone. Absolute emissions provide information about the scale of environmental exposure, while emissions intensity indicates the carbon efficiency of production. Changes in either measure may reflect technological improvements, production fluctuations, acquisitions, or divestments. ArcelorMittal's adjusted reporting illustrates the importance of accounting for portfolio changes when interpreting emissions trends. Financial distress analysis would require these environmental observations to be matched with indicators of profitability, leverage, liquidity, and debt-servicing capacity. The available case information does not provide sufficient evidence to attribute changes in financial stability to environmental performance. The case nevertheless identifies relevant measurement considerations for evaluating carbon-intensive corporations within a broader firm-year panel dataset.

The combined secondary evidence suggests that ESG performance is relevant to corporate financial resilience, although the relationship varies according to the financial outcome examined and the characteristics of carbon-intensive industries. Published empirical research identifies negative associations between ESG performance and financial distress, while separate evidence demonstrates that environmental practices can reduce financing constraints among high-carbon enterprises. The relative importance of ESG dimensions differs across these outcomes, indicating that governance effectiveness and environmental transition practices may contribute through distinct financial mechanisms. The ArcelorMittal case illustrates the practical complexity of environmental improvement within capital-intensive operations. These findings support an integrated interpretation in which ESG practices, financing conditions, and carbon exposure are considered together. The evidence does not

establish a newly estimated causal effect of ESG performance on distress within the proposed study population.

The overall results indicate that assessing corporate financial distress in high-carbon industries requires a multidimensional approach combining sustainability performance, environmental exposure, and financial condition. Existing empirical findings provide support for examining financing constraints as a potential explanatory mechanism and carbon intensity as a relevant conditional factor. Corporate disclosures demonstrate that environmental improvements can coexist with continuing transition costs and emissions exposure, reinforcing the importance of evaluating financial outcomes separately. The proposed longitudinal analysis would provide a stronger empirical foundation by examining firm-specific ESG indicators alongside financial distress measures and relevant control variables. A definitive conclusion regarding the magnitude, statistical significance, or causal direction of the relationship cannot be established without the completed firm-year dataset and regression estimates. The present findings therefore provide source-grounded contextual and comparative evidence rather than a completed test of the proposed research hypotheses.

The findings indicate that environmental, social, and governance (ESG) performance is an important consideration in understanding corporate financial vulnerability within high-carbon industries. The secondary evidence identifies associations between stronger ESG performance and lower financial distress, particularly through improved financing conditions, operational risk management, and corporate governance. These relationships suggest that sustainability performance may contribute to financial resilience, although the magnitude of its association with distress remains dependent on institutional and industry characteristics.

The comparative findings reveal differences in the financial relevance of individual ESG dimensions. Published research by Ma, (2025) identifies governance as a particularly important dimension associated with lower corporate financial distress. Evidence from D. J. Cumming, (2024), however, indicates that environmental performance is more closely associated with reduced financing constraints among Chinese high-carbon enterprises. These differences suggest that the financial benefits of sustainability practices depend partly on the specific financial outcome being examined.

The environmental evidence demonstrates that carbon-intensive industries continue to face substantial transition pressures despite improvements in selected sustainability indicators. ArcelorMittal's adjusted emissions intensity declined from 1.85 tonnes of carbon dioxide equivalent per tonne of crude steel in 2018 to 1.75 tonnes in 2024. The improvement illustrates measurable environmental progress, although substantial emissions exposure remains. Environmental improvements therefore cannot automatically be interpreted as evidence of reduced financial distress.

The overall findings suggest that ESG performance and financial resilience are connected through multiple potential mechanisms rather than a single uniform relationship. Stronger governance may improve financial discipline, environmental management may reduce transition-related exposure, and favorable sustainability practices may strengthen access to external financing. The evidence is nevertheless drawn from published studies and institutional disclosures. Original regression estimates for the proposed high-carbon firm-year sample remain unavailable, limiting conclusions concerning causal effects and statistical significance.

The findings correspond with Shetty, (2024), who reported an inverse relationship between ESG performance and corporate financial distress among Chinese listed companies.

Their research identified financing constraints, operational risks, and agency costs as mechanisms associated with this relationship. The present analysis reinforces the relevance of these mechanisms while emphasizing that conclusions established for broader corporate populations cannot be transferred directly to high-carbon industries without examining their distinctive environmental and financial characteristics.

The evidence also aligns with Butt, (2024), who found that ESG performance was associated with reduced financing constraints among Chinese high-carbon enterprises. Their findings identified improved credit access and corporate reputation as important explanatory mechanisms, with environmental practices providing particularly significant benefits. The present discussion extends this interpretation by distinguishing financing constraints from financial distress. Improved financing access may support corporate resilience, but it does not necessarily demonstrate that financial distress has declined.

The differences between the findings of Thi, (2025) highlight the importance of separating ESG dimensions and financial outcomes. Governance performance may be particularly relevant to distress through managerial oversight and agency-cost reduction, whereas environmental performance may influence financing access in industries exposed to substantial carbon reduction pressure. These results are not necessarily contradictory because financial distress and financing constraints capture different aspects of corporate vulnerability.

The measurement implications are consistent with Özer, (2024), who documented substantial divergence among ESG rating agencies. Their research attributed differences in ratings primarily to measurement approaches and assessment scope. This evidence challenges the assumption that aggregate ESG scores provide uniform representations of corporate sustainability. The present analysis consequently emphasizes separate ESG dimensions, transparent measurement procedures, and alternative indicators when interpreting relationships between sustainability performance and financial distress.

The findings signify that sustainability performance is increasingly relevant to corporate financial management rather than remaining exclusively an environmental or reputational concern. High-carbon companies operate under conditions in which emissions exposure, regulatory requirements, and technological transformation may influence their financial position. ESG practices can therefore be understood as part of broader organizational efforts to manage uncertainty. Their financial significance depends on whether sustainability initiatives address material risks and strengthen corporate resilience.

The contrasting importance of governance and environmental performance signifies that ESG dimensions serve different economic functions. Governance arrangements may support financial stability through stronger oversight, accountability, and investment decisions. Environmental initiatives may improve preparedness for regulatory changes and access to transition-related financing. These relationships indicate that aggregate sustainability ratings can conceal differences in the financial relevance of individual practices. Corporate ESG strategies should consequently reflect industry-specific risks rather than assume identical benefits from every sustainability dimension.

The ArcelorMittal case signifies that environmental transition is a gradual process involving technological, financial, and operational adjustments. The company's reported reduction in emissions intensity demonstrates progress toward improving carbon efficiency. The continuing scale of absolute emissions also indicates the difficulty of transforming capital-intensive production systems. These observations suggest that environmental progress and

financial resilience may develop at different rates, particularly when decarbonization requires substantial investment before generating measurable economic benefits.

The broader evidence signifies that ESG performance should not automatically be interpreted as proof of financial strength. Financially stable corporations may possess greater resources to implement sustainability programs, creating potential reverse causality between ESG investment and financial performance. ESG ratings may also reflect differences in disclosure practices rather than underlying operational improvements. The findings therefore support a conditional interpretation in which sustainability performance represents a potentially important financial characteristic whose effects require careful empirical identification.

The theoretical implications concern the relationship between stakeholder management, corporate governance, and financial resilience. Stakeholder theory suggests that responsible corporate practices may strengthen relationships with employees, investors, creditors, and communities. Agency theory emphasizes how effective governance can reduce managerial conflicts and improve resource allocation. The findings indicate that these perspectives may complement one another in explaining financial distress, particularly when environmental transition creates additional demands on corporate resources and decision-making.

The managerial implications highlight the importance of integrating ESG considerations into corporate financial planning. Managers of high-carbon firms should evaluate environmental investments alongside liquidity, leverage, operating cash flows, and long-term financing requirements. Sustainability initiatives may provide financial benefits when they address material exposure, improve efficiency, or strengthen stakeholder confidence. Their implementation should nevertheless reflect available financial resources and investment priorities. Effective ESG management requires balancing environmental objectives with the capacity to maintain financial obligations.

The implications for investors and creditors involve the assessment of sustainability performance as one component of corporate risk evaluation. ESG indicators may provide information about governance quality, transition preparedness, and relationships with financial stakeholders. These measures should complement rather than replace conventional indicators of solvency, profitability, liquidity, and debt-servicing capacity. The evidence concerning ESG rating divergence further suggests that financing decisions should consider underlying sustainability indicators and disclosure quality rather than rely exclusively on composite ratings (Hajek, 2024; Nguyen, 2024).

The policy implications concern the development of financial and environmental frameworks that recognize differences in corporate transition capacity. High-carbon companies may experience unequal adjustment costs depending on technological maturity, emissions intensity, and access to financing. Regulatory arrangements that improve disclosure comparability and encourage credible transition planning may support better financial risk assessment. Policymakers should also recognize that environmental compliance expenditure can create short-term financial pressure, particularly among firms with limited liquidity or substantial existing debt obligations.

The negative association between ESG performance and corporate financial distress identified in previous studies may arise because sustainability practices support more effective identification and management of organizational risks. Companies maintaining stronger governance structures may demonstrate greater financial transparency, internal accountability, and investment discipline. Environmental management may reduce exposure to operational

inefficiencies and compliance-related disruptions, while social responsibility can support stakeholder relationships. These mechanisms provide plausible explanations for why firms with stronger ESG performance may exhibit lower financial vulnerability.

The stronger relevance of governance to financial distress may reflect its direct relationship with financial decision-making and organizational oversight. Effective boards and internal control systems can influence debt management, capital expenditure, financial disclosure, and managerial accountability. These functions are closely connected with corporate solvency and liquidity management. Sun et al. (2026) identified reduced agency costs and operational risks among the mechanisms associated with ESG performance, supporting the interpretation that governance quality may influence corporate vulnerability through established financial management processes.

The importance of environmental practices in high-carbon industries can be explained by their direct connection with emissions exposure and transition-related financing requirements. Carbon-intensive firms face pressure to modernize production systems, improve resource efficiency, and demonstrate credible environmental performance. Lenders and investors may evaluate these practices when assessing future operating risks and financing needs. Wang, (2025) found that ESG practices alleviated financing constraints through credit access and corporate reputation, while carbon reduction pressure strengthened the observed benefits.

The absence of an automatically beneficial relationship between ESG investment and financial stability can be explained by substantial implementation costs and differences in organizational capabilities. Decarbonization projects may require new equipment, infrastructure adjustments, employee training, and technological development. Financially constrained firms may struggle to absorb these expenditures before realizing potential benefits. Changes in market demand, energy prices, and regulatory conditions may further influence project outcomes. ESG performance therefore produces financial implications that depend on implementation timing, capital availability, and the materiality of the risks being addressed.

The findings indicate that future research should prioritize longitudinal firm-level analysis linking ESG performance with measurable indicators of financial distress. Such investigations should incorporate carbon intensity, financing constraints, leverage, profitability, liquidity, and industry-specific characteristics within consistent analytical frameworks. Fixed-effects models may help control for persistent differences across firms, while time effects can account for common economic shocks. Alternative distress indicators and lagged ESG measures would strengthen robustness assessments, although these procedures alone cannot establish causality.

The methodological direction should also involve more detailed examination of individual ESG dimensions and their conditional relationships with financial vulnerability. Separate environmental, social, and governance scores could clarify whether particular sustainability practices are more relevant within high-carbon industries. Interaction models could evaluate how firm-level carbon intensity modifies ESG–distress associations. Mediation analysis could investigate financing constraints as a potential pathway, provided that the research design supports appropriate temporal ordering and explicitly considers confounding relationships.

The strategic response for corporate managers involves treating ESG performance as an integrated component of risk management and capital allocation. High-carbon companies should prioritize credible environmental initiatives, effective governance, and transparent

financial disclosures while monitoring the consequences of transition investment for liquidity and leverage. Sustainability performance should be evaluated alongside financial resilience rather than through ratings alone. This approach may help companies identify investments that address material environmental exposure without creating disproportionate short-term financial pressure.

The overall direction emerging from this study is the development of an industry-sensitive understanding of ESG performance and corporate financial distress. The secondary evidence indicates that sustainability practices can be associated with improved financing conditions and reduced vulnerability, although the importance of individual ESG dimensions differs across outcomes. The analysis contributes a comparative interpretation linking governance, environmental exposure, financing constraints, and financial resilience. Its conclusions remain bounded by the absence of original firm-level regression estimates. Future empirical investigation is therefore necessary to determine whether these relationships persist across high-carbon industries and under changing economic and regulatory conditions.

CONCLUSION

The central finding of this study is that the financial relevance of environmental, social, and governance (ESG) performance in high-carbon industries differs across sustainability dimensions and financial outcomes. Published evidence associates stronger overall ESG performance with lower corporate financial distress, while governance quality appears particularly relevant to distress exposure and environmental performance to financing constraints. Carbon-intensive research indicates that transition pressure can strengthen the relationship between ESG engagement and access to finance. ArcelorMittal illustrates that reductions in emissions intensity may occur alongside substantial absolute emissions and continued investment requirements. These patterns challenge assuming that an aggregate ESG score provides a sufficient measure of corporate financial resilience. They suggest that sustainability practices should be evaluated alongside carbon exposure, liquidity, leverage, and transition costs across firms facing different regulatory and technological transition conditions. No original causal effect was established.

This study contributes a conceptual synthesis rather than new econometric estimates. Its comparative synthesis connects three perspectives that are often examined separately: multidimensional ESG performance, corporate financial distress, and the financing pressures associated with industrial decarbonization. The framework distinguishes governance-related financial discipline from environmentally driven transition adjustments and identifies financing constraints as a plausible explanatory pathway and carbon intensity as a potentially important moderator. This offers a basis for evaluating financial materiality in carbon-intensive sectors than treating ESG performance as a uniform protective factor. Methodologically, the study specifies a route for future firm-year analysis using separate ESG pillars, comparable emissions measures, alternative distress indicators, and tests sensitive to institutional heterogeneity. Practically, it encourages managers, lenders, and investors to assess the financial consequences of particular sustainability practices rather than relying exclusively on composite ratings.

The study relies on published secondary statistics, earlier empirical studies, and a single corporate illustration instead of an independently assembled firm-year dataset. It cannot report original regression coefficients, quantify mediation or moderation effects, or determine whether improved ESG performance precedes reductions in financial distress. Differences in ESG

rating methodologies, reporting boundaries, sector composition, and accounting-based distress measures limit comparability. ArcelorMittal cannot represent all high-carbon firms or establish default risk. Future research should construct longitudinal samples across energy, steel, cement, and chemicals, harmonize emissions and financial measures, and compare results across ESG providers. Studies should address reverse causality, omitted variables, disclosure selection, and the timing of transition expenditures. Such work could determine when sustainability investment strengthens financial resilience, when it imposes short-term financing pressure, and which governance or environmental mechanisms explain those differences.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used Chat GPT to assist inimproving grammar, language quality, and overall readability of the text. After using this tool, the author(s) Carefully reviewed and edited the content as necessary and take full responbility for the content of the publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

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

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