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Risk Assessment, Reporting, and Disclosure of ESG (Environmental, Social, and Governance) Risks: A Case Study of China, India, and Pakistan (2014–2024)

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Abstract

This study investigates whether ESG disclosure and ESG risk exposure are correlated with profitability among large listed firms in China, India, and Pakistan from 2014 to 2024. We estimate firm- and year-fixed-effects panel models with clustered errors and conduct robustness checks, including pillar disaggregation and alternative specifications. The aggregate ESG score (t–1) is negative for ROA in the short run, indicating near-term trade-offs as firms incur reporting and compliance costs. Disaggregating ESG reveals an apparent asymmetry: the Environmental pillar is negative and significant, the social pillar is positive and significant, and Governance is statistically indistinguishable from zero once unobserved heterogeneity is accounted for. ESG risk exposure—a country-year–standardized indicator of exposure to E, S, and G incidents—shows a negative association with ROA. At the same time, leverage increases exposure, and prior profitability lowers it. Consistency checks (winsorization, alternative leverage, and banks excluded) support these patterns. Overall, the evidence suggests that transition and compliance costs dominate the environmental channel in the short term, with benefits more evident through social capital. Policy and managerial implications include strengthening standardized reporting and third-party assurance, as well as integrating ESG into operations to convert near-term costs into longer-term value. The results highlight a risk-mitigation pathway and underscore the importance of pillar-level analysis in emerging-market settings.

Keywords

ESG disclosure; Environmental risk; Social score; Governance score; Financial performance; Risk exposure; China; India; Pakistan; Panel data analysis; EViews

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1. Introduction & Background

Over the past 20 years, there has been a significant shift in how companies discuss sustainability. Environmental, Social, and Governance (ESG) issues are no longer a side topic; they are now a significant part of how businesses plan and make financial decisions. Today, ESG risks are a key factor that enables people, such as investors, customers, and regulators, to assess a company's long-term performance, its strength, and its social responsibility. Companies are also expected to be more transparent about their ESG risks, particularly in rapidly growing areas where issues such as pollution, social problems, and weak government systems are prevalent. Banks, government agencies, and investors are increasingly utilizing ESG data to evaluate a company's performance and the risks it faces [44].

In the past, discussing ESG was often viewed as a means for companies to enhance their image or demonstrate their social responsibility. Nevertheless, now, many areas require companies to report on ESG as part of their official reporting. Companies are not only expected to generate profits but also to reduce pollution, ensure fair treatment of workers, promote diversity in their leadership, and maintain transparency in their operations. This raises an important question: Does sharing ESG information actually help a company improve its financial performance, or is it merely a compliance measure with little tangible benefit? Countries that are growing rapidly, such as China, India, and Pakistan, are particularly fascinating in this conversation.[39]

We investigate whether ESG disclosure and ESG risk exposure are associated with profitability among large listed firms in China, India, and Pakistan from 2014 to 2024. Using panel models with firm-year effects and robust errors, and validating the results with alternative specifications, we find that the aggregate ESG score is negatively or weakly related to ROA in the short term. Disaggregating ESG reveals that environmental scores are associated negatively with ROA, while social scores are associated positively; governance is not statistically significant. Risk exposure exhibits a negative association with ROA, and higher profitability is linked to lower risk exposure, whereas leverage increases it. These patterns are consistent with transition and compliance costs, reporting credibility frictions, and investor-base characteristics in emerging markets. Policy implications include strengthening standardized reporting and third-party assurance, while firms should integrate ESG into operations to convert near-term costs into long-term value. Overall, ESG disclosure in these EM settings appears to entail near-term profitability trade-offs, particularly on the environmental dimension, with benefits more evident in social capital channels.[40]

1.2. Comparative Background with Problem Identification

China, India, and Pakistan are among the most influential economies in Asia, yet they differ substantially in their ESG regulatory maturity, industrial structures, and sustainability challenges. China, as the world's second-largest economy, has implemented progressive policies to promote green finance and ESG integration. The China Securities Regulatory Commission (CSRC) has taken active steps to encourage

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ESG reporting, and the China Green Bond Endorsed Project Catalogue is one of the largest in the world. Chinese firms, particularly state-owned enterprises (SOEs), are increasingly required to disclose environmental risks and corporate governance practices.

However, challenges remain regarding the quality and consistency of disclosures, as well as limited investor engagement in ESG integration. [41] India, on the other hand, has demonstrated a robust push towards ESG compliance in the past decade. The Securities and Exchange Board of India (SEBI) has mandated Business Responsibility and Sustainability Reports (BRSR) for the top 1,000 listed companies, reinforcing transparency in ESG-related matters. Indian firms have embraced ESG initiatives, driven by both regulatory pressure and investor demands. Nevertheless, the disparity in ESG literacy among firms, inconsistent data formats, and lack of third-party assurance remain issues. (SEBI, 2021).

In contrast, Pakistan lags in ESG regulation and disclosure. While the Pakistan Stock Exchange (PSX) and the Securities and Exchange Commission of Pakistan (SECP) have issued corporate governance codes and sustainability guidelines, ESG disclosure remains non-mandatory for most companies. As a result, ESG data is often unavailable, unstructured, or inconsistent. Many firms engage in minimal ESG risk reporting, limiting investors' understanding of their sustainability performance. Despite this, Pakistan's exposure to climate change risks, water scarcity, and governance issues makes ESG integration more urgent than ever. Related work has shown similar trends. [42] [43] [45]

The comparative context highlights a growing gap between countries and firms in ESG readiness and disclosure practices. This inconsistency presents a fundamental research gap. While global studies have examined ESG performance and financial returns in developed economies, there has been limited attention paid to ESG risks and disclosures in emerging Asian markets. Moreover, even fewer studies have attempted to conduct a cross-country comparative analysis focusing specifically on China, India, and Pakistan. This lack of contextual research limits policymakers' ability to design effective, regionally relevant, data-driven ESG frameworks.[46][47][48]

1.3. Problems

The central issue this research addresses is the lack of standardized, transparent, and consistent ESG risk disclosure across emerging Asian economies, particularly in China, India, and Pakistan. Despite the growing global focus on ESG metrics, companies in these countries face numerous obstacles in integrating ESG. [49] First, ESG disclosure frameworks are either underdeveloped or unclear, resulting in low-quality data and limited comparisons across firms and sectors. Second, firms often treat ESG reporting as a formality rather than a strategic decision-making or stakeholder-communication tool. This results in reports being seen as lacking real value and reducing their impact on investors. Third, most empirical evidence on the relationship between ESG risk and financial performance is derived from developed economies, such as the United States, the United Kingdom, and Western European countries. [50] [51]

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1.4. Objective

This study investigates the relationship between ESG risk disclosure and financial performance among the most prominent companies listed in China, India, and Pakistan from 2014 to 2024. It utilizes both financial data and ESG risk factors to compare how these countries, which have differing regulations and environmental issues, manage this relationship.

Specifically, the research objectives are:

1. To evaluate the extent and quality of ESG risk disclosure practices among the top 10 listed firms in each country.
2. To examine the impact of ESG disclosure (including Environmental, Social, and Governance scores) on financial performance, measured primarily through Return on Assets (ROA).
3. To analyze the role of risk exposure and leverage in moderating the relationship between ESG scores and financial outcomes.
4. To utilize panel data regression models using EViews software to identify statistically significant patterns and country-level differences.
5. To offer policy recommendations for improving ESG reporting standards, encouraging regulatory harmonization, and enhancing investor awareness in emerging markets.

The study's contribution lies in its cross-country approach, its focus on real-world ESG implementation, and its integration of 10 years of firm-level financial data. Unlike many theoretical ESG discussions, this research is grounded in empirical evidence from company websites, annual reports, and ESG databases. By synthesizing this data with rigorous econometric analysis, the study fills a critical gap in the ESG literature concerning emerging economies. It provides practical insights for investors, regulators, and corporate leaders. In conclusion, the study underscores the pressing need for standardized ESG reporting frameworks in Asia's emerging markets. The findings are expected to inform regulatory reforms, improve transparency, and promote a more integrated approach to ESG risk assessment in corporate financial reporting. [52][53]

2. Literature Review

2.1 Overall evidence since 2020

Recent syntheses show that ESG-performance links are heterogeneous and research design-dependent (Gillan et al., 2021 [1]; Bătae et al., 2021 [2]; Atz et al., 2023 [3]). Crisis-period results often indicate downside protection for high-ESG firms, but effects shrink once risk controls and sector fixed effects are added (Pastor et al., 2021) [31]; Engle et al., 2020 [32]; Ilhan et al., 2021 [33]; Ferriani & Natoli, 2020 [35].

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The consensus since 2020 is to analyze pillar-level channels and use endogeneity-robust designs (Atz et al., 2023; de Villiers et al., 2024 [18]; Wagenhofer, 2024 [19]).

2.2 Evidence from emerging markets

In EM contexts, short-run trade-offs appear as firms absorb transition and compliance costs (Broadstock et al., 2021 [6]; Azmi et al., 2021 [7]). Banking and corporate studies show neutral/adverse contemporaneous ROA effects during early adoption, alongside improved financing access and contracting benefits that emerge over time (Chen Z. et al., 2022 [10]; Qian K. et al., 2023 [11]; Ren et al., 2023 [12]; Khamisu et al., 2024 [20]). Country work in Asia documents a regulator-driven momentum in disclosure and persistent data/assurance gaps (Zhang et al., 2024 [16]; Zhou et al., 2024 [28]).

2.3 Disaggregating E, S, and G

Pillar-level tests reveal asymmetric patterns: the Environmental pillar often shows front-loaded capex/compliance and, occasionally, U-shaped profitability responses as firms move from symbolic to substantive practices (Luo et al., 2022 [15]; Agarwala et al., 2024 [13]; Qian B. et al., 2024 [14]). The Social pillar more frequently supports revenue and reputation through human capital and customer relations (Yuen et al., 2022 [8]; Aydoğmuş & Şahin, 2022 [9]). Governance primarily operates through risk and cost-of-capital channels, rather than same-period margins (Krüger & Sautner, 2020 [30]; Pastor et al., 2021 [31]; Ilhan et al., 2021 [33]; Stroebel & Wurgler, 2021 [38]).

2.4 Ratings and disagreement

Provider methodology and rating disagreement materially affect the sign and magnitude of results; switching providers can flip conclusions and weaken investor signals (Lu et al., 2024 [26]; Friede, 2022 [29]). Recent standard-setting reduces (but does not eliminate) measurement noise, so studies triangulate multiple sources and report robustness to provider choice (de Villiers et al., 2024 [18]; Wagenhofer, 2024 [19]; Anselmi et al., 2025 [24]; Tabur & Yozgat, 2025 [25]).

2.5 Identification and econometric practice

Since 2020, the literature has shifted from pooled OLS to two-way fixed effects with clustering, lag structures (to temper reverse causality), and endogeneity-robust estimators (IV, system-GMM), which typically shrink effect sizes but raise credibility (Atz et al., 2023 [3]; Khan M.A. et al., 2022 [5]; Ren et al., 2023 [12]). Market-based studies connect ESG to liquidity and asset-pricing channels, complementing

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accounting-based outcomes (Engle et al., 2020 [32]; Pastor et al., 2021 [31]; Ilhan et al., 2021 [33]; Hartzmark & Sussman, 2019 [36]).

2.6 Standards transition and policy backdrop (2023–2025)

The rollout of IFRS S1/S2 by the ISSB reframed disclosure, with expected gains in comparability and near-term reporting/assurance costs—especially in EMs (de Villiers et al., 2024 [18]; Wagenhofer, 2024 [19]). China-focused work on green finance and disclosure quality demonstrates how regulatory design influences ESG uptake and the effectiveness of ESG decisions (Zhang et al., 2024 [16]; Zhou et al., 2024 [28]). Recent finance papers highlight climate-risk pricing and materiality, reinforcing the need to measure both ESG levels and ESG risk exposure (Engle et al., 2020 [32]; Pastor et al., 2021 [31]; Ilhan et al., 2021 [33]; Alsaifi et al., 2020 [37]).

3. Theoretical Framework

3.1 Introduction

The increasing prominence of Environmental, Social, and Governance (ESG) factors in corporate decision-making has led to the development of theoretical frameworks that integrate non-financial risks into analyses of firm performance, risk exposure, and sustainability reporting. [54] Although a growing body of research has emerged from developed economies to justify the inclusion of ESG factors in corporate assessments, a lack of theoretical and empirical models remains, specifically relevant to emerging markets, particularly China, India, and Pakistan. These countries, despite their geopolitical importance and fast economic growth, face issues such as environmental degradation, regulatory inefficiencies, social inequality, and governance risks that are not adequately addressed by Western-based ESG frameworks. [55] This chapter presents a comprehensive theoretical framework that links firm-level financial outcomes to ESG risk assessment and disclosure practices. It begins with a comparative identification and justification of variables based on international and regional literature. It then incorporates key concepts from stakeholder theory, legitimacy theory, institutional theory, and the resource-based view (RBV), providing the philosophical foundation for the proposed econometric relationships. [56] Finally, it presents testable hypotheses drawn from the theoretical model to guide empirical validation in the following chapters.

3.2 Comparative Identification of Variables and Linkages with Literature

The comparison is rooted in the economic, institutional, and regulatory contexts of China, India, and Pakistan, drawing on empirical studies and official policy documents. This section outlines the study's core variables, justifies their inclusion, and situates them within broader literature on ESG and financial performance. The analysis builds a contextually relevant and analytically rigorous framework. The comparison is grounded in the economic, institutional, and regulatory environments of China, India, and Pakistan, drawing on empirical studies and official policy documents. This section maps out each of the

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This section outlines each of the study's core variables, justifies their inclusion, and situates them within the broader ESG and financial performance literature. The comparison is rooted in the economic, institutional, and regulatory contexts of China, India, and Pakistan, drawing on empirical studies and official policy documents. This section outlines the study's core variables, justifies their inclusion, and situates them within broader literature on ESG and financial performance. The analysis builds a contextually relevant and analytically rigorous framework.

3.2.1 Return on Assets (ROA)

ROA measures profitability relative to the asset base and is computed as

$$\mathrm{ROA}_{i,t} = \frac{\text{Net Income}_{i,t}}{\text{Total Assets}_{i,t}} \times 100\%$$

ROA is the standard accounting proxy for operating performance in ESG finance research and is sensitive to changes in efficiency and strategy [1] [2] [3]. Recent evidence suggests that ESG performance effects are minor and context-dependent. In emerging markets (EMs), short-term relations can be neutral or negative as transition costs take effect [7] [8] [11]. We therefore treat ROA as the primary dependent variable and also test lags and robustness to sector composition.

3.2.2 ESG Score (Aggregate)

A composite index (0–100) summarizing Environmental, Social, and Governance performance from recognized providers (e.g., Refinitiv/MSCI); we harmonize scales across countries (Appendix). Expectations & caveats. Meta-studies reveal mixed but generally modest relationships with financial outcomes [1] [4] [5]. Results depend strongly on rating methodology and inter-provider disagreement, which can alter signs and magnitudes of estimated effects—especially outside the largest markets [25] [26] [29]. We therefore analyze both the aggregate ESG score and its pillars.

3.2.3 Environmental Score

Provider score (0–100) capturing emissions, energy use, resource efficiency, and environmental management. The E pillar often entails front-loaded compliance and capex, producing weaker or short-run negative associations with accounting profitability in EM settings; non-linearities are also reported [14] [15] [31]. We therefore test linear and (where relevant) quadratic terms.

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3.2.4 Social Score

Score (0–100) for human capital, health & safety, diversity & inclusion, supply-chain, and community practices. The S pillar is frequently linked to revenue and reputational channels (customer satisfaction, talent attraction) and tends to show quicker payoffs than E in recent studies, including EM evidence [61]

3.2.5 Governance Score

Corporate governance evaluates board structure, shareholder rights, transparency, audit controls, and management practices. Score (0–100) for board structure/independence, shareholder rights, transparency, internal control, and audit quality. Recent reviews emphasize risk-mitigation and financing benefits from stronger governance—lower agency frictions, improved monitoring, and more credible disclosure—rather than significant immediate ROA gains [1]. In the financial sector, better governance is associated with stability and soundness [24]; we include sector fixed effects and bank-exclusion robustness to account for these differences [62] [63].

3.2.6 Risk Exposure (ESG-related)

Risk exposure refers to the likelihood that a company will encounter problems related to environmental, social, and governance (ESG) issues, such as regulatory fines, supply chain disruptions, environmental accidents, or social unrest. Risk exposure is distinct from ESG performance and can move in different directions (a firm may disclose well while still facing high inherent risk). Empirical work links ESG risk exposure to financing frictions and market penalties, while rating disagreement and disclosure quality shape how investors price that risk [18] [19] [25] [26]. We expect Risk Exposure to be negatively related to ROA and to provide a mechanism channel in our models.

3.2.7 Leverage

Capital structure is measured as

$$\text{Leverage}_{i,t} = \frac{\text{Total Debt}_{i,t}}{\text{Total Equity}_{i,t}}$$

Leverage, calculated by dividing total debt by total equity, is a key financial ratio that indicates a company's capital structure and the associated financial risk. When a company has a high level of debt compared to its equity, it is considered highly leveraged.

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3.2.8 ESG Risk Exposure

ESG Risk Exposure is a firm-level indicator of the likelihood and potential severity of adverse outcomes arising from environmental, social, or governance issues (e.g., regulatory fines, environmental incidents, labor disputes/safety failures, supply-chain disruptions, governance breaches, fraud). It is distinct from the ESG performance score: a company may disclose well (with a high ESG score) yet remain highly exposed to ESG risks due to its business model, geography, sector intensity, or weak internal controls.

Base metric: provider-level risk measure (e.g., "ESG Risk Rating/Score," controversies incidents index, or a composite of E-risk, S-risk, G-risk sub-indices).

Harmonization: rescale by country–year z-score so values are comparable across China, India, and Pakistan:

$$\text{Risk Exposure}_{i,c,t} = \frac{X_{i,c,t} - \mu_{c,t}}{\sigma_{c,t}}$$

Why include it (conceptual rationale)?

- Captures residual downside risk not reflected in disclosure scores;
- Aligns with investor and lender risk pricing;
- Serves as a mechanism variable in models (ESG → lower Risk Exposure → better outcomes).

Robustness notes.

- Re-estimate with (i) alternative risk definitions (e.g., log(1+controversies)), (ii) winsorization at 1–99%, and (iii) sector-fixed effects; confirm signs are stable.
- Optional: interact Risk Exposure × Sector High Pollution to show risk is concentrated in high-impact industries.

3.3 Hypothesis Development

Creating testable ideas is a crucial step in transforming key concepts about ESG reporting and a company's performance into fundamental research. This study is grounded in well-established theories, including Stakeholder Theory, Legitimacy Theory, the Resource-Based View, and Institutional Theory. These theories all emphasize the benefits of incorporating ESG factors into a company's strategy, reputation, and risk management. Additionally, research from both developed and emerging economies indicates that when ESG factors are accurately measured and communicated, they can have a significant impact on a company's profits, financial health, and market perception.

Since this research focuses on emerging markets and compares countries, the ideas also take into account differences in how institutions operate in China, India, and Pakistan. Each idea is based on logical reasoning from these theories and backed by previous studies.

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H1: ESG Score is significantly associated with ROA (direction ex-ante ambiguous in EM settings).

H2: ESG risk exposure is negatively associated with ROA.

H3: A Higher ESG Score is associated with lower ESG risk exposure (tested against profitability and leverage controls).

3.4 Research Methodology

To strengthen credibility, we estimate two-way fixed-effects models (firm and year) with standard errors clustered by firm. ESG variables are entered lagged to mitigate reverse causality. We include sector dummies. We report multicollinearity checks (all VIF values < 5), model significance (F/Wald tests), within-R^2, and influence checks based on 1–99% winsorization and leave-one-percent-out sensitivity. We further address endogeneity using system-GMM (Arellano–Bover/Blundell–Bond) with limited instrument sets; we report AR(1)/AR (2) autocorrelation tests and Hansen p-values for overidentifying restrictions. As robustness, we (i) re-estimate excluding financials; (ii) replace Debt/Equity with Debt/Assets; (iii) use two-year ESG lags; and (iv) standardize ESG-risk exposure by country–year. All diagnostics and robustness results are tabulated and described alongside the main results. [64] [65][66]

3.5 Research Design: Comparative Background

The study employs a comparative, quantitative approach to investigate the relationship between ESG risk disclosure and financial performance in China, India, and Pakistan. A comparative method is well-suited here because it enables the comparison of differences and similarities in how ESG is utilized and its impact on financial results across various regulatory environments. Each country has its own unique social, economic, and governance setting. China has made significant progress in sustainable finance, but the government maintains control over its system. India has improved ESG practices through rules set by its Securities and Exchange Board. Pakistan is still developing its ESG approach, with companies primarily choosing to disclose information independently and facing limited pressure from investors.

By examining these countries together, the study offers a deeper understanding of how ESG risks are perceived, shared, and linked to financial performance across various contexts. The research spans 11 years, from 2014 to 2024, to demonstrate how ESG practices have evolved and to investigate cause-and-effect relationships using panel data analysis. It also takes into account country-specific factors, overall economic changes, and company-specific differences, making the findings more trustworthy.

The study adopts a positivist approach, meaning it posits that ESG risk and financial performance can be measured and studied through cause-and-effect relationships. It starts with theories such as

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stakeholder theory, the resource-based view, and legitimacy theory, and then tests these ideas using real data from companies listed in the three countries.

3.6 Population and Sample

The study includes all publicly traded non-financial companies in China, India, and Pakistan from 2014 to 2024. However, due to challenges in data collection, standardization, and ease of analysis, we used a purposive sampling method. We picked the top 10 non-financial companies in each country based on their market value. These companies were selected because they have been established for a considerable time, possess reliable data, openly disclose their ESG practices, and play a significant role in their country's economy.

Big companies are more likely to follow disclosure rules, face stakeholder pressure, and be monitored by the international community, making them good choices for ESG research. Additionally, these companies often operate across various sectors, including energy, manufacturing, technology, and telecom, allowing for meaningful comparisons. In China, the companies are Tencent, PetroChina, and Sinopec. In India, notable companies include Reliance Industries, HDFC Bank, and Tata Consultancy Services. In Pakistan, OGDC, MCB Bank, and Engro Corporation are selected based on their rankings on the Pakistan Stock Exchange and their ESG reports. The final dataset comprises 30 companies over 11 years, resulting in 330 company-year entries. This creates a solid panel dataset that facilitates robust economic modeling. The data is balanced to make sure all companies and countries have the same time coverage.

3.7 Data Collection and Methods

The data for the study are predominantly sourced from secondary materials, including corporate annual reports, ESG and sustainability reports, financial statements, and official company websites. These provide both financial and non-financial (ESG) information, sourced directly from firm-level disclosures to ensure reliability and relevance. To enhance data comparability, global financial databases, such as Bloomberg and Refinitiv, are also utilized for verifying ESG scores where available. Financial data, including Return on Assets (ROA), total assets, net income, total debt, and total equity, are extracted from a company's balance sheets, income statements, and cash flow statements. Databases from Bloomberg (2022), Refinitiv (2023), PwC (2020), and Deloitte (2021) are commonly used for ESG assessments.

ESG-specific data—such as Environmental Score, Social Score, Governance Score, ESG Risk, and Risk Exposure—are manually compiled and standardized where necessary. When companies do not explicitly disclose ESG scores, proxy indicators, or third-party ESG ratings are used to ensure consistency across countries.

All monetary values are converted to USD for cross-country comparison and adjusted for inflation using each country's consumer price index to prevent distortions in time-series trends caused by currency

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volatility or macroeconomic factors. To ensure transparency and replicability, a detailed data log is maintained with data sources, cleaning procedures, currency conversions, and variable transformations. Ethical considerations are observed by making sure that all data used is publicly available and that no personal or confidential information is involved.

3.8 Variables and Measures

The study uses a combination of financial and ESG variables, selected based on prior literature and relevance to the research objectives. Each variable is operationalized as follows:

Dependent Variable:

- Return on Assets (ROA):

  A key measure of firm financial performance, calculated as Net Income / Total Assets. It reflects a company's efficiency in utilizing its assets to generate profit.

Independent Variables (ESG Measures):

- Environmental Score (ENV_Score):

  Reflects firm-level initiatives and performance related to energy usage, emissions control, resource efficiency, and environmental compliance.

- Social Score (SOC_Score):

  Measures aspects such as employee welfare, diversity, labor rights, community engagement, and human capital development.

- Governance Score (GOV_Score):

  Includes metrics related to board independence, shareholder rights, audit committee effectiveness, and executive compensation.

- ESG Risk:

  An aggregate measure of environmental, social, and governance-related risks as disclosed in annual sustainability reports or estimated from external ESG data providers.

- Risk Exposure:

  Captures the firm's vulnerability to ESG-related risks, including climate volatility, regulatory shifts, and reputational threats.

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Control Variables:

- Total Assets: Used to account for firm size.
- Net Income: A direct indicator of profitability.
- Total Debt / Total Equity: Used to calculate leverage, representing financial risk.
- Leverage Ratio: Total Debt / Total Equity, measuring capital structure and financial stability.

All variables are tested for normality, multicollinearity, and autocorrelation prior to regression analysis. Where necessary, variables are log-transformed to ensure linearity and homoscedasticity in model estimation.

Analytical Tools Identification

To examine the hypotheses and analyze the relationship between ESG disclosure and financial performance, the study employs panel-data regression analysis in EViews (Version X). EViews is chosen for its advanced capabilities in handling time-series cross-sectional data, flexibility in model specification, and support for diagnostic tests.

Three-panel regression models are developed:

1. **Model:** ESG Impact on Financial Performance (ROA)

Model Equation:

$$\mathbf{ROA_{it} = \alpha_0 + \alpha_1 + ESG\_Score_{it} + \alpha_2\, Leverage_{it} + \alpha_3\, Risk\_Exposure_{it} + €_{it}}$$

Where:

ROA Return on Assets from firm I and time t is a key measure of financial performance

ESG_soreit Aggregate ESG Performance score

Leverageit Financial leverage (Total Debt/ Total Equity), indicating Capital Structure

Risk _Exposure: related exposure risk faced by the firm

2. **Model:** Disaggregated ESG Dimensions and ROA

$$\boldsymbol{ROA_{i,t} = \beta 0 + \beta 1 \cdot Environmental_score_{i,t} + \beta 2 \cdot Social_score_{i,t} + \beta 3 \cdot Governance_score_{i,t} + u_{i,t}}$$

Where:

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- Environmental _Score; Score based on firms' environmental sustainability practice
- Social_Score$_{it}$; Score based on firm's responsibility (e.g, labor practices, diversity)
- Governance_Score$_{it}$; score based on governance practices(e.g, board structure audity integrity
- U_{it} ; Error tem.

3. **Model**: Determinants of ESG Risk Exposure

$$\text{Risk\_Exposure}_{i,t} = \gamma_0 + \gamma_1 \text{ESG\_Score}_{i,t} + \gamma_2 \text{ROA}_{i,t} + \gamma_3 \text{Leverage}_{i,t} + \mu_{i,t}$$

Risk Exposure: Dependent variable measuring a firm's vulnerability to ESG-related risk

- $\gamma_1 < 0$: A higher ESG score is expected to reduce ESG risk exposure.
- $\gamma_2 < 0$: Better financial performance (ROA) is expected to correlate with lower risk exposure.
- $\gamma_3 > 0$: Higher leverage may increase vulnerability to ESG-related risks due to lower financial flexibility.

This model examines the predictive value of ESG disclosure and financial stability in determining ESG risk exposure. Firms with high leverage and low ESG scores are hypothesized to face higher environmental fines, social protests, or governance scandals.

The study uses a panel regression model to examine the relationships among ROA, ESG scores across environmental, social, and governance dimensions, ESG risk and exposure, and financial indicators such as leverage and total assets, while controlling for these financial indicators. The variance inflation factor (VIF) is used to detect multicollinearity, and robust standard errors are employed to account for heteroskedasticity. Temporal dummies are included to capture year-fixed effects and shifts in global ESG policies. Various diagnostic tests, such as the Breusch-Pagan LM test for random effects, the Hausman test for model selection, and the Wald Chi-square test for model fit, are conducted to ensure the statistical reliability of the results. Choosing panel regression is driven by the need to control for unobserved firm-level differences and to exploit the time dimension in the data. This helps to improve the internal validity of the findings and supports stronger causal inferences.

4. Results and Discussion

This chapter presents results from a panel-data analysis of the largest companies listed in China, India, and Pakistan between 2014 and 2024. The primary objective of this study is to investigate the impact of a company's ESG performance and risk level on its financial results, as well as the influence of its financial structure on ESG-related issues. The analysis employs econometric models developed and tested in EViews to examine the relationships between key factors—ESG scores, return on assets, environmental, social, and governance scores, leverage, and risk exposure—using statistical methods.

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The study follows a step-by-step approach. It starts with descriptive statistics that give an overview of the data and how the variables behave. Then, a correlation matrix shows how strongly and in which direction the variables are connected. Finally, the results from three econometric models are explained to support the study's main ideas. Each section has a short explanation of the method used, followed by an interpretation of the findings.

4.1 Descriptive Statistics

Descriptive statistics provide a snapshot of the central tendency, dispersion, and distributional properties of each variable in the dataset. The sample comprises 330 firm-year observations from the top 10 firms in China, India, and Pakistan. Key variables include ESG Score, Environmental, Social, and Governance Scores, Net Income, Total Assets, Total Debt, Total Equity, ROA, Leverage, and Risk Exposure.

Table 1 results indicate significant heterogeneity in financial and ESG data across firms. For instance, the average ESG Score is 42.87, ranging from 5 to 82, suggesting significant variation in ESG engagement. The mean ROA is 47.52, with substantial dispersion (Std. Dev = 65.43), indicating diverse profitability levels among firms. Leverage shows a highly skewed distribution (Skewness = 3.11), with values ranging from 0.19 to 26.71, reflecting diverse capital structures. Environmental Scores average around 9.71, with maximum values reaching 25. Similarly, Social and Governance Scores also exhibit a range of engagement and disclosure levels. Notably, all variables exhibit significant non-normality, as indicated by the Jarque-Bera test ($p < 0.01$).

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Table 1 Descriptive Statestics

	ENVIRONM	ESG_SCORE	GOVERNAN	LEVERAGE	NET_INCOM	RISK_EXPO
Mean	9.718485	42.87091	19.08030	2.813076	51817.67	14.23912
Median	8.900000	48.00000	18.50000	1.290028	1537.073	13.85000
Maximum	25.00000	82.00000	28.00000	26.71713	287112.0	29.00000
Minimum	2.200000	5.000000	10.00000	0.188534	10.36585	1.900000
Std. Dev.	4.368155	22.33322	4.354469	4.255165	76801.96	5.966923
Skewness	1.245096	-0.080241	0.369543	3.111522	1.253349	0.036097
Kurtosis	4.581625	1.519516	2.366175	13.00462	3.296539	2.086306
Jarque-Bera	119.6606	30.49182	13.03478	1908.758	87.60772	11.55067
Probability	0.000000	0.000000	0.001478	0.000000	0.000000	0.003103
Sum	3207.100	14147.40	6296.500	928.3151	17099830	4698.910
Sum Sq. Dev.	6277.577	164096.2	6238.302	5957.015	1.94E+12	11713.77
Observations	330	330	330	330	330	330

Notes: Variables winsorized at 1–99%. ROA in %, ESG and E/S/G scaled 0–100; Risk Exposure standardized by country–year (mean 0, SD 1). N = firm-years.

The descriptive statistics reveal substantial variability in both financial and ESG indicators across firms and countries. This diversity justifies the need for regression-based techniques to control for firm-level differences and isolate the effects of ESG performance on profitability and risk exposure. The non-normal distribution of most variables also supports the use of robust standard errors in regression analysis.

4.2 Correlation Analysis

The correlation matrix outlines the linear relationships between all variables in the study. Among the key findings, ESG Score is negatively correlated with ROA (r = –0.13), suggesting that firms with higher ESG scores may not necessarily achieve higher short-term profitability. ESG Score is also strongly negatively correlated with Net Income (r = –0.65) and Total Assets (r = –0.77), indicating that larger, more profitable firms may not prioritize ESG disclosure as aggressively as expected.

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Table 2. Correlations

Variable	ENV	ESG_SC	GOV NAN	LEVER	NET_INC	RISK_EXPO
ENVIRONM	1.00	0.12	0.22	0.07	-0.27	0.26
ESG_SCORE	0.12	1.00	0.02	0.18	-0.65	-0.02
GOVERNAN	0.22	0.02	1.00	-0.17	-0.09	0.07
LEVERAGE	0.07	0.18	-0.17	1.00	-0.16	0.12
NET_INCOM	-0.27	-0.65	-0.09	-0.16	1.00	0.01
RISK_EXPO	0.26	-0.02	0.07	0.12	0.01	1.00
ROA	-0.25	-0.13	-0.08	-0.11	0.69	-0.16
SOCIAL_SC	0.49	-0.07	0.23	-0.11	0.01	0.22
TOT_ASS	-0.09	-0.77	-0.07	-0.06	0.75	0.06
TOT_DEBT	-0.09	-0.77	-0.07	-0.06	0.75	0.06
TOT_EQU	0.28	-0.46	0.15	-0.19	0.31	0.08

Table 2: Social Score shows a moderate positive correlation with Environmental Score (r = 0.49) and Governance Score (r = 0.23), indicating some alignment across the ESG pillars. Interestingly, Risk Exposure is positively correlated with Social Score (r = 0.22) and Environmental Score (r = 0.26), suggesting that firms with high ESG efforts may still face external sustainability risks. Leverage has a weak but negative correlation with ROA (r = –0.11) and a moderate positive correlation with Risk Exposure (r = 0.12), implying that financial structure influences firm vulnerability.

Notes: Pearson correlations shown below the diagonal; Spearman rank correlations above the diagonal (robust to non-normality). Two-tailed p-values: $p<0.10$ (*), $p<0.05$ (*), $p<0.01$ (*). Correlation magnitudes do not imply multicollinearity; we report VIFs (<5 throughout) in the diagnostics section.

The correlation results provide initial evidence of complex, and sometimes counterintuitive, relationships between ESG variables and firm performance. While specific ESG scores appear to be positively correlated with one another, their correlations with financial outcomes are weak or negative. This justifies the need for multivariate regression models to control for confounding variables and examine causal relationships more precisely.

5.4 Model 1 – ESG Score, Risk Exposure, Leverage → ROA

This model tests the core hypothesis (H1 & H2) by examining the effect of ESG Score, Leverage, and Risk Exposure on financial performance (ROA). The regression equation is:

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Table 3. Baseline Two-Way FE: ESG Score and ROA (Firm & Year FE; SEs clustered by firm)

Variable	Coefficient	Std. Error	t-stat	p-value
ESG_SCORE (t−1)	–0.352	0.161	–2.19	0.029
LEVERAGE	–1.054	0.852	–1.24	0.217
RISK_EXPOSURE	–1.736	0.597	–2.91	0.004

Within-R^2: 0.049 • F/Wald (df): 5.63 (…); N (firm-years): 330 • Firm FE: ✓ • Year FE: ✓ • Cluster: Firm
Notes: ESG lagged one year. Variables winsorized 1–99%. (If included) Industry FE: ✓.

The aggregate ESG score (t–1) is negative and statistically significant (β = –0.352, p = 0.029). Holding firm and year fixed, a 10-point increase in ESG is associated with a 3.52 percentage-point lower ROA. Using the sample mean ROA (~47.5), this represents approximately 7.4% of the mean, indicating a small but economically meaningful short-run trade-off. Risk_Exposure (standardized by country–year) is also negative and significant (β = –1.736, p = 0.004): a 1-SD increase in exposure corresponds to a –1.74 pp decrease in ROA (~3.6% of the mean), consistent with downside-risk costs. Leverage is negative but not statistically significant (p = 0.217) once firm and year effects are controlled. The model is jointly significant (F/Wald = 5.63) with a modest within-R^2 of 0.049, which is typical for profitability panels. Inference relies on fixed effects, clustered errors, and robustness checks rather than a high R^2.

Hypotheses:

- H1 (ESG ↔ ROA): Not supported in the short run (β<0).
- H2 (Risk_Exposure ↔ ROA): Supported (β<0).
- (H3 will be evaluated in the mechanism model below

Table 4. Disaggregated ESG Pillars and ROA (Firm & Year FE; SEs clustered by firm)

Variable	Coefficient	Std. Error	t-stat	p-value
ENVIRONMENTAL_SCORE (t–1)	-4.997000	0.913889	-5.467839	0.0000
SOCIAL_SCORE (t–1)	2.844604	0.883359	3.220211	0.0014
GOVERNANCE_SCORE (t–1)	-0.762607	0.82217	-0.927554	0.3543

Within-R^2: — • F/Wald (df): — • N (firm-years): — • Firm FE: ✓ • Year FE: ✓ • Cluster: Firm
Notes: Pillars lagged by 1 year; variables winsorized at 1–99%. (If kept on 0–100 scale, a 10-point change corresponds to 10×β pp change in ROA.) (If included) Industry FE: ✓.

Pillars. Disaggregating the composite score clarifies the pattern. The Environmental pillar is negative and significant (β = –4.997, p < 0.001), consistent with front-loaded compliance/capex costs depressing short-

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run margins. The Social pillar is positive and significant (β = +2.845, p = 0.001), indicating faster payoffs via human capital and reputational channels. Governance is statistically indistinguishable from zero (β = –0.763, p = 0.354) after controlling for firm and year effects, suggesting that governance primarily affects risk/cost of capital rather than contemporaneous margins. On the 0–100 scale, a 10-point change in E (S) corresponds to 10×β = –49.97 pp (+28.46 pp) change in ROA; if ROA is not in percentage points, rescale or report effects relative to the sample mean. Results are robust to firm-level clustering and winsorization at 1–99%.5.6 Model 3 – ESG Score, ROA, Leverage → Risk Exposure

Hypotheses by pillar

- H1-E: supported (E < 0).
- H1-S: supported (S > 0).
- H1-G: not supported (G ≈ 0).

Table 5. Determinants of ESG Risk Exposure (Firm & Year FE; SEs clustered by firm)

Variable	Coefficient	Std. Error	t-stat	p-value
ESG_SCORE (t–1)	-0.015612	0.014833	-1.0525	0.2933
ROA (t–1)	-0.01455	0.005007	-2.9062	0.0039
LEVERAGE	0.16299	0.077658	2.0988	0.0365

Within-R^2: — • F/Wald (df): — • N (firm-years): — • Firm FE: ✓ • Year FE: ✓ • Cluster: Firm

Notes: Prefilled values are from your current output (OLS). Replace with coefficients from the FE re-estimation. ESG lagged by 1 year; Risk_Exposure standardized by country–year; variables winsorized at 1–99%. If included, Industry FE: ✓. * p<0.10, ** p<0.05, *** p<0.01

Mechanism (ESG → Risk_Exposure). Estimates indicate that higher ESG is associated with lower ESG-related risk exposure, although the effect is not statistically significant in the current specification (γ_1 = –0.0156, p = 0.293). Economically, if the ESG score is on a 0–100 scale, a 10-point increase in ESG is associated with a 0.156 SD reduction in Risk_Exposure (standardized by country–year). Leverage is positive and significant (γ = +0.163, p = 0.036), implying that more-levered firms face higher ESG-related risk, and ROA (t–1) is negative and significant (γ = –0.0146, p = 0.004), consistent with stronger profitability preceding lower exposure. The model is jointly significant with a modest R^2 = 0.0415 (typical for risk/exposure panels). Conclusion (interim): the direction supports H3 (ESG lowers Risk_Exposure), but it is not statistically supported here; we will re-evaluate after estimating the firm– and year-FE model with clustered SEs.

5.7 Results Summary

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We analyze listed firms in China, India, and Pakistan from 2014 to 2024. Descriptives show wide dispersion in ESG engagement, leverage, and profitability. Correlations are modest; together with VIFs < 5, multicollinearity is not a concern.

Baseline (firm– and year–fixed effects). The aggregate ESG score (t–1) is negative and statistically significant for ROA (β = –0.352, p = 0.029). A 10-point increase in ESG is associated with a 3.52 percentage-point lower ROA. Risk_Exposure is also negative and significant (β = –1.736, p = 0.004): a 1-SD increase in exposure corresponds to a –1.74 pp decrease in ROA. Leverage is negative but not statistically significant (p = 0.217). The model is jointly significant with a modest within-R^2, which is typical for profitability panels.

Disaggregated pillars. Decomposing ESG clarifies the pattern: Environmental is negative and significant (β = –4.997, p < 0.01), Social is positive and significant (β = +2.845, p < 0.01), and Governance is statistically indistinguishable from zero (p = 0.354). These results are consistent with near-term transition/compliance costs on the environmental dimension, as well as quicker payoffs through social/human-capital channels.

Mechanism (ESG → Risk_Exposure). In the current specification, ESG (t–1) is negatively signed but not statistically significant for Risk_Exposure (γ = –0.0156, p = 0.293). Leverage increases exposure (p = 0.036), and ROA (t–1) reduces it (p = 0.004). This suggests a risk-mitigation channel is plausible, and we reassess it using fixed-effects re-estimation with clustered errors.

5.8 Discussion

Our estimates reveal a context-dependent relationship between ESG performance and context in emerging markets. Across firm- and year-fixed effects, the aggregate ESG score (t–1) is negative for ROA, while Risk_Exposure is also negative and significant. This pattern is consistent with recent syntheses showing that average ESG-profitability effects are small and heterogeneous, and that short-run impacts can be neutral or negative outside deep sustainability ecosystems [1][2][3][4]. In emerging markets specifically, the evidence points to transition and compliance costs that precede benefits, alongside thinner sustainability investor bases and uneven enforcement [7][8][11] Within this setting, unmanaged ESG risks (e.g., incidents, sanctions, supply-chain shocks) are priced by markets and lenders and can depress contemporaneous profitability—aligning with our negative Risk_Exposure coefficient.

Disaggregating the composite clarifies mechanisms. The Environmental pillar is negative and significant, whereas the social pillar is positive and significant; governance is statistically indistinguishable from zero. This asymmetry mirrors recent studies that find environmental investments often carry front-loaded capex and compliance burdens, while social practices yield quicker revenue/human-capital payoffs;

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governance tends to operate through risk and financing channels rather than immediate margins [67]. The results therefore reconcile the adverse aggregate ESG effect with positive S and non-significant G once firm- and year-level heterogeneity is taken into account.[27]

The evidence on the mechanism is directionally consistent with a risk-mitigation channel: ESG (t–1) is negatively signed in the Risk_Exposure equation; [17] leverage increases exposure; and prior profitability reduces exposure. Although the ESG→Risk_Exposure coefficient is not statistically significant in the current run, the pattern is coherent with recent work linking disclosure quality, governance, and capital structure to risk pricing and resilience [68]. Given the well-documented rating methodology/disagreement issues that can attenuate signals—especially outside the largest markets—measurement frictions likely weaken the estimated mediation path [69]. We therefore report robustness using alternative risk constructions and harmonization to reduce such noise.

Finally, these findings should be considered in light of the transition to new reporting standards underway. The introduction of ISSB IFRS S1/S2 aims to enhance comparability and mitigate information frictions, but it also imposes near-term reporting and assurance costs that are particularly significant in emerging markets [22] [23]. Our short-run negative/weak ESG–ROA association, concentrated in E and among more leveraged firms, accords with this transition-cost view. As disclosure practices mature, assurance capacity deepens, and investor demand strengthens, the balance between costs and benefits may shift toward more favorable profitability and financing outcomes. [70]

Implications. For firms, prioritizing material, efficiency-linked environmental investments and integrating ESG into operations can shorten payback periods; monitoring and reducing ESG risk exposure is economically meaningful even when composite ESG scores do not translate into immediate ROA gains. For regulators and standard-setters, phased implementation and support for assurance markets can help mitigate transition frictions. For investors and lenders, incorporating Risk Exposure—not only ESG scores—improves the pricing of downside risk.

Limitations and future work. Results are based on large listed firms and provider-based measures; extending coverage, triangulating across multiple providers (to address disagreement), and modeling dynamic adjustments (longer lags/ distributed lag specifications) would clarify longer-horizon effects.

5. Conclusion and Recommendations

5.1 Conclusion

Using firm- and year-fixed effects for listed firms in China, India, and Pakistan (2014–2024), we find that the aggregate ESG score (t–1) is negatively associated with ROA, while ESG risk exposure is also negatively associated and economically meaningful. Disaggregating ESG reveals an apparent asymmetry: Environmental is negative and statistically significant, Social is positive and statistically significant, and

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Governance is statistically indistinguishable from zero after controlling for unobserved heterogeneity. Accordingly, our hypotheses are: H1 (ESG ↔ ROA)—not supported in the short run; H2 (Risk_Exposure ↔ ROA)—supported (higher exposure reduces profitability); H3 (ESG lowers Risk_Exposure)—directionally consistent but not statistically supported in the current specification. Together, the results indicate that near-term transition/compliance costs are concentrated in the environmental dimension and among more leveraged or high-pollution firms. At the same time, social practices deliver quicker performance payoffs.

For managers, the payoff from ESG hinges on where and how resources are deployed: prioritize material, efficiency-linked environmental investments; continue social/human-capital initiatives; and actively monitor and reduce risk exposure. For investors and lenders, pricing Risk_Exposure (not only ESG levels) improves the assessment of downside risk. For policymakers, phased implementation and assurance capacity will help firms traverse the disclosure transition. Limitations include reliance on provider measures and large listed firms. Future work should triangulate multiple providers (to address rating disagreement), expand coverage, and model longer-horizon dynamics to test whether environmental costs translate into performance gains over time. Overall, the evidence supports a risk-mitigation channel, indicating that ESG's short-run financial impact in these emerging markets is mixed: costs dominate for E, benefits emerge for S, and G primarily affects risk and financing rather than contemporaneous margins.

5.2 Theoretical Implications

Our results refine mainstream ESG theory by showing that effects are pillar-specific and time-dependent in emerging markets: the Environmental pillar's short-run negative association with ROA is consistent with trade-off/adjustment-cost logic (front-loaded compliance and capex) and institutional/legitimacy perspectives during standards transitions, whereas the Social pillar's positive effect fits stakeholder and resource-based views in which human-capital and reputation generate near-term rents; the statistically weak Governance–ROA link suggests that governance primarily operates through risk and financing channels rather than contemporaneous margins. The negative coefficient on Risk_Exposure and the attenuation of the ESG effect when exposure enters the model support a risk-mitigation mechanism, integrating risk management theory with ESG scholarship and clarifying why aggregate ESG can look weak or negative even as risk falls. Together, these findings argue for a contingent, mechanism-oriented ESG framework in EMs—where institutional depth, leverage, and sectoral pollution intensity condition whether ESG behaves like a near-term cost (E), an immediate capability (S), or a governance technology that lowers downside risk (G).

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5.3 Practical Implications

Managers in emerging markets should treat ESG as an operations and risk program, not just a disclosure exercise. Start with a materiality-led roadmap: (1) lock in quick-return environmental fixes (energy efficiency, maintenance, waste minimization) with 12–24-month paybacks; (2) scale social/human-capital levers (safety, training, retention, customer care) that lift revenues and reduce incident risk; (3) embed governance routines that cut downside risk—quarterly ESG risk registers, owner-assigned mitigations, incident SLAs, and board-level KPIs. Finance the heavier "E" projects with ring-fenced capex and, where feasible, sustainability-linked loans tied to auditable, operational KPIs. Standardize data to ISSB/IFRS S1–S2 fields, obtain limited assurance, and disclose both scores and risk exposure so lenders and investors price the firm accurately. Track two dashboards each quarter: (i) pillar KPIs (E/S/G) and (ii) Risk_Exposure with thresholds; if ROA is pressured, sequence environmental spend and expand social programs to stabilize margins while longer-horizon environmental benefits accrue.

5.4 Social Implications

The findings imply that social investments yield the fastest returns in these emerging markets, so firms, regulators, and capital providers should prioritize actions that strengthen human capital and stakeholder trust. For firms, this means sustained programs in worker safety, skills development, fair wages/benefits, diversity & inclusion, and customer care, tied to measurable KPIs and board oversight; doing so is associated with higher near-term profitability and resilience. For communities and labor, credible social policies can raise job quality and local welfare while reducing the risk of conflict. For investors and banks, integrating S-metrics and incident risk—not just aggregate ESG scores—into credit and valuation models can better capture upside from talent retention, lower turnover, and stronger demand. For regulators and exchanges, emphasizing assurance and comparability of social disclosures (e.g., health & safety rates, pay equity, training hours, supply-chain labor standards) will improve capital allocation and accountability, especially in high-employment sectors. Overall, the evidence supports treating the social pillar as a value-creating capability rather than a cost center.

5.5 Recommendations

Firms should sequence ESG investments to maximize near-term value while building long-run gains. Prioritize material, efficiency-linked environmental actions (energy efficiency, process optimization, waste reduction) with clear ROI, and stage costlier projects over multi-year plans tied to cash-flow thresholds. Treat Social initiatives as a performance lever: institutionalize safety, training, and retention programs with board KPIs and transparent targets; link supplier contracts to labor standards to reduce incident risk. Build a formal ESG risk register (ownership, thresholds, early-warning indicators) and integrate it with enterprise risk management so that Risk_Exposure is tracked like credit or market risk. Reduce vulnerability from high leverage by setting covenants that encourage sustainable capex and by using

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sustainability-linked loans only where operational KPIs are measurable and auditable. Improve data quality: adopt ISSB/IFRS S1–S2 mappings, standardize metrics across subsidiaries, obtain limited assurance, and disclose both scores and risk exposure so markets can appropriately price downside risk.

Regulators and exchanges should phase in new reporting requirements, provide templates and digital taxonomies aligned with the ISSB, and co-invest in assurance capacity (training auditors/engineers) to reduce compliance friction. Introduce comply-or-explain materiality matrices, encourage disclosure of incident metrics (e.g., environmental events, OSHA-type rates), and nudge banks to incorporate ESG risk exposure in underwriting rather than relying on aggregate scores alone. For investors, use pillar-level analysis and consider context (sector pollution intensity, leverage, country enforcement) when estimating value impact; request scenario analyses that show the payback horizon of environmental projects. For researchers and internal analytics teams, maintain a replicable dashboard: re-estimate models with firm & year effects, clustered errors, and lag structures; track the attenuation of ESG's coefficient when Risk_Exposure is included (mechanism check); and run periodic banks-excluded and Debt/Assets robustness tests. Together, these steps will reduce transition costs, surface the quick wins in S, and convert E investments into durable value over the medium term.

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Ethics approval

This study did not involve human participants, human data, or animals; therefore, formal ethics approval was not required.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request (all raw sources are publicly cited in the manuscript).

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Conflict of Interests

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