



ESG Disclosure, Rating, Investing, and ESG Reporting: Integrated Review of Global ESG Frameworks, Performance, and Policy Implications

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Article Type	SDG Contribution	Licence Info
Editorial Research Paper ▶ Review Paper Scientific Data Policy Analysis	<ul style="list-style-type: none"> • SDG 9: Industry, Innovation, and Infrastructure • SDG 12: Responsible Consumption & Production • SDG 13: Climate Action 	<p>This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License</p>
Received: 09.10.2025; Revised: 28.04.2026; Accepted: 02.05.2026; Published: 04.05.2026		

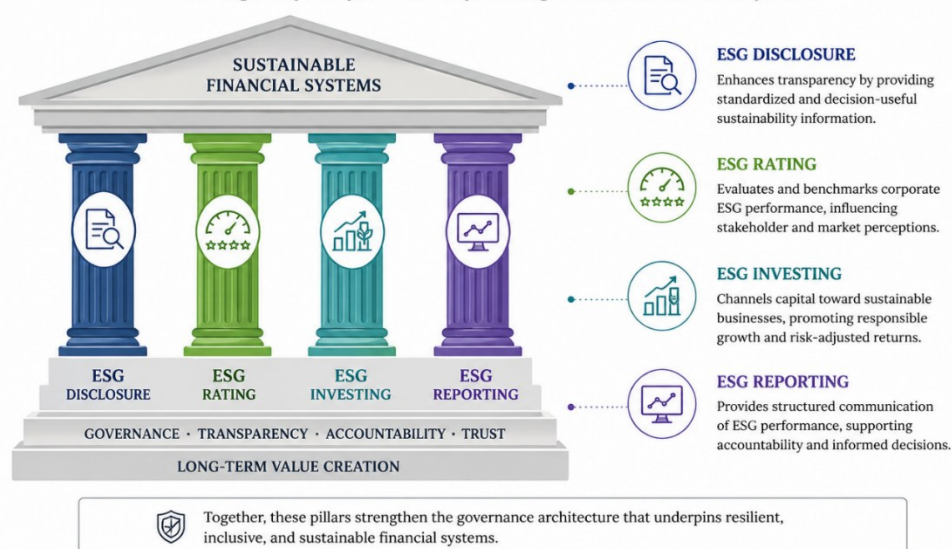
HIGHLIGHTS

- ESG disclosure enhances transparency and improves firm financial performance.
- ESG rating divergence weakens comparability and investor confidence globally.
- High-quality ESG investing drives innovation and systemic financial stability.
- Standardized ESG reporting improves credibility and policy alignment.
- Industry 5.0 technologies strengthen authenticity and traceability in ESG data.

GRAPHICAL ABSTRACT

Foundations of Modern Sustainability Governance

Building transparency, accountability, and long-term value in sustainable finance



ABSTRACT

Environmental, Social, and Governance (ESG) has become a central pillar of sustainable finance, corporate governance, and public policy. This article reviews ESG disclosure, ESG rating, ESG investing, and ESG reporting based on studies from 2021 to 2025. ESG disclosure has evolved from voluntary communication to a strategic governance tool that reduces information asymmetry, enhances transparency, and strengthens corporate legitimacy. High-quality ESG disclosure improves firm performance, investment efficiency, and risk management, while weak ESG disclosure reduces credibility. Mandatory ESG disclosure frameworks deliver greater transparency and comparability than voluntary systems, reinforcing regulatory effectiveness. ESG rating divergence remains a major challenge due to differences in methodology, disclosure scope, and weighting criteria. However, ESG ratings continue to influence investor perception and corporate behavior, driving green innovation, productivity, and governance improvement. Initiatives such as the EU Taxonomy and the ISSB framework are improving ESG data consistency and methodological alignment. ESG investing has become mainstream, linking financial performance with sustainability impact. Evidence shows that ESG investing enhances firm value, fosters innovation, and supports market stability. Transparent ESG disclosure strengthens investor trust and long-term capital flow. Finally, ESG reporting forms the institutional basis of sustainability governance. The adoption of GRI, SASB, and CSRD frameworks has advanced global comparability, though measuring real ESG outcomes remains complex. The integration of Industry 5.0 technologies such as blockchain and AI enhances traceability, credibility, and data integrity. Together, ESG disclosure, ESG rating, ESG investing, and ESG reporting define the foundation of global sustainability and responsible finance.

Keywords: Environmental, Social, and Governance (ESG); ESG disclosure; ESG rating; ESG investing; ESG reporting; ESG performance

Abbreviations

Abbreviation	Full Term
AI	Artificial Intelligence
CDP	Carbon Disclosure Project
CSRD	Corporate Sustainability Reporting Directive
CSR	Corporate Social Responsibility
ESG	Environmental, Social, and Governance
EU	European Union
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
IFRS	International Financial Reporting Standards
IR	Integrated Reporting
ISSB	International Sustainability Standards Board
ROA	Return on Assets
ROE	Return on Equity
SASB	Sustainability Accounting Standards Board
SDGs	Sustainable Development Goals
TCFD	Task Force on Climate-related Financial Disclosures
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNGC	United Nations Global Compact
UNPRI	United Nations Principles for Responsible Investment

1. ESG Disclosure: Theoretical Foundations, Determinants, and Financial Implications

1.1. Overview and Conceptual Foundations

Environmental, Social, and Governance (ESG) disclosure has emerged as a central topic in accounting and finance research, reflecting firms' communication of nonfinancial information to stakeholders [1]. A review by Tsang et al. [2] highlight that ESG disclosure aims to reduce information asymmetry, enhance transparency, and strengthen corporate legitimacy. The study identifies both voluntary and mandatory ESG disclosure regimes, with growing regulatory emphasis worldwide. Figure 1 presents key theoretical perspectives and disclosure approaches that shape ESG reporting, highlighting how firms use voluntary, mandatory, and technology-driven mechanisms to enhance transparency and stakeholder trust.



Figure 1. Theoretical and disclosure frameworks underpinning ESG reporting, integrating classical theories such as stakeholder, legitimacy, and agency theories with emerging concepts like Industry 5.0 integration and digital transformation.

Del Gesso and Lodhi [3] conducted a systematic review revealing that five dominant theories underpin ESG disclosure research: stakeholder theory, legitimacy theory, institutional theory, agency theory, and signaling theory. These frameworks collectively explain why firms disclose ESG information — to maintain legitimacy, meet stakeholder expectations, reduce agency costs, and signal responsible behavior. Additional emerging perspectives such as upper echelons, cognitive cost, and reputation theories further enrich the understanding of managerial motivations behind ESG disclosure.

Asif et al. [4] expanded this theoretical base by integrating Industry 5.0 technologies—including blockchain, AI, and IoT—into ESG disclosure. They argue that digital technologies can enhance authenticity, timeliness, and scope of ESG reporting, transforming it from retrospective to real-time transparency and aligning with future sustainability paradigms. Figure 2 illustrates how Industry 5.0 technologies address key ESG reporting issues by strengthening communication structures, resulting in more valuable and reliable ESG disclosures.

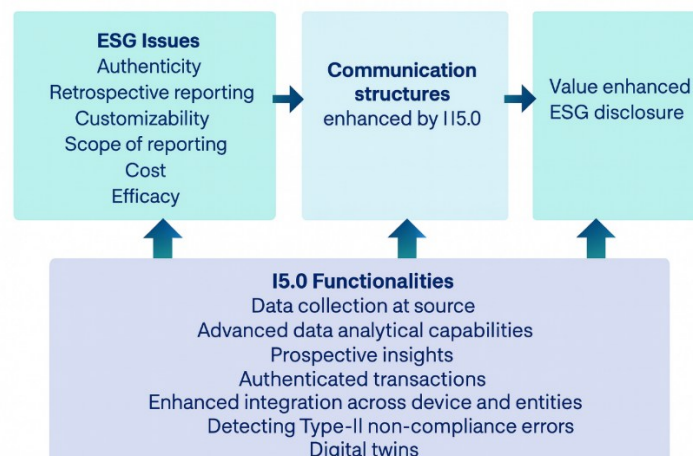


Figure 2. Integration of I5.0 functionalities to enhance ESG communication structures and improve the value of ESG disclosure, reproduced from [4].

1.2. Determinants of ESG Disclosure

The decision and extent of ESG disclosure are influenced by firm-specific and contextual factors. Board characteristics play a significant role: Nuhu and Alam [5] find that gender diversity, board composition, and diligence are positively associated with ESG disclosure levels, especially in the energy sector of emerging economies. Similarly, Helfaya et al. [6] show that a board's CSR orientation and adherence to GRI standards positively affect ESG disclosure quality in Europe, while cultural dimensions such as individualism and femininity correlate with higher ESG disclosure.

Firm size, ownership concentration, and external assurance also matter. Chung et al. [7] find that larger firms and those audited by Big 4 firms disclose more ESG information, and that mandatory disclosure regimes mitigate agency problems by standardizing expectations. Huang and Ge [8] add that industry context (e.g., mining) and country development level shape ESG disclosure quantity and quality, with developed countries producing more detailed and consistent reports. Figure 3 compares ESG performance trends over a decade, highlighting improvements and gaps between developed and developing countries in environmental management, stakeholder relations, and corporate governance practices.

At the macro level, Hassani and Bahini [9] argue that ESG disclosure policies interact with economic growth, suggesting an optimal disclosure threshold that balances information transparency and economic performance. Excessive disclosure may redirect resources away from productive sectors, especially in less developed economies.

1.3. Quality, Standardization, and Rating Divergence of ESG Disclosure

Despite the proliferation of ESG data, rating divergence remains a persistent issue. Liu [10] demonstrates that quantitative ESG disclosure can paradoxically increase rating disagreement among agencies unless standardized formats are adopted. The lack of harmonized standards undermines comparability and credibility, as shown by Eng et al. [11], who found that sustainability disclosures and ESG ratings both provide incremental information to market value, but harmonization would enhance reliability.

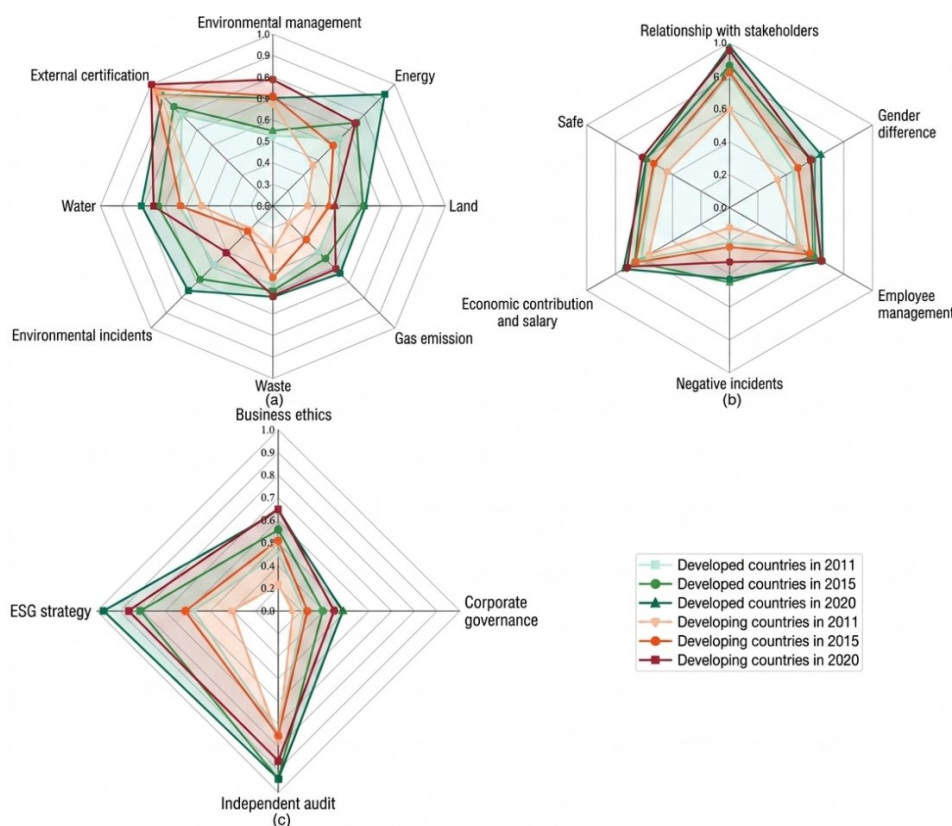


Figure 3. ESG disclosure performance radar charts across developed and developing countries in 2011, 2015, and 2020, reproduced from [8],

This finding aligns with Krueger et al. [12], who provide global evidence on mandatory ESG disclosure improving transparency and aligning firms' practices across countries. Their dataset confirms that well-designed mandates can reduce information asymmetry and foster comparability, similar to financial reporting reforms.

1.4. ESG Disclosure, Financial Performance, and Investment Efficiency

The relationship between ESG disclosure and financial outcomes is a major research focus. Multiple studies (Pulino et al. [13], Chen and Xie [14], Malik and Kashiramka [15]) provide empirical evidence of a positive relationship between ESG disclosure and firm performance. Using data from Europe, China, and India, these studies show that firms with higher ESG disclosure achieve better profitability (EBIT, ROA) and lower cost of debt. The positive effect is stronger when ESG investors are active stakeholders, suggesting that ESG-oriented capital reinforces financial rewards for transparent firms. Figure 4 shows a notable positive shift in percentage change following ESG disclosure, suggesting potential financial performance improvements after transparency initiatives.

Ellili [16] extends this analysis to the UAE, showing that ESG disclosure, combined with high financial reporting quality (FRQ), enhances investment efficiency by mitigating information asymmetry. Xue [17] complements this by modeling ESG disclosure as a mechanism similar to a Pigovian regulatory tool, where precise disclosure motivates firms to internalize environmental externalities through market forces.

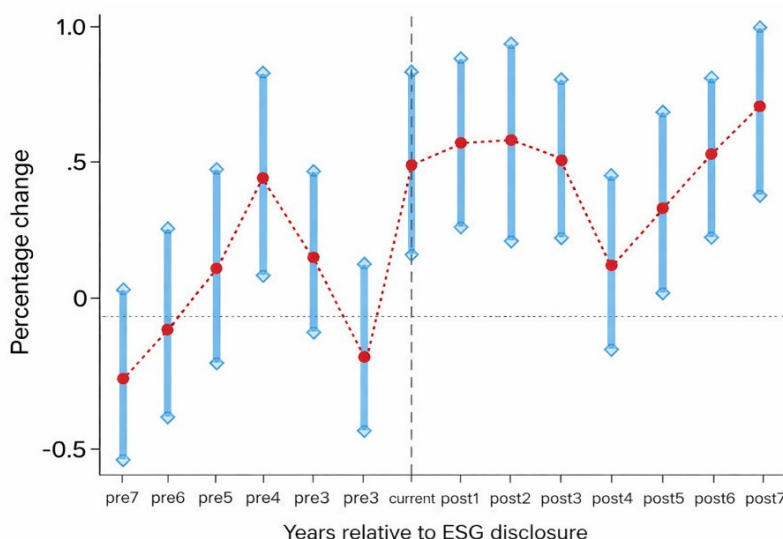


Figure 4. Percentage change of financial performance over time relative to ESG disclosure, reproduced from [14].

Wen et al. [18] further demonstrate that ESG disclosure quality boosts the growth of ESG investing globally, improving firm valuation and lowering downside risks. High-quality disclosure facilitates investor confidence and promotes the spread of ESG-oriented capital markets, especially in countries with mandatory CSR frameworks. Figure 5 shows that longer ESG disclosure experience amplifies the positive impact on ROA and reduces downside risks, especially in countries with mandatory CSR reporting.

1.5. ESG Disclosure, Risk, and Market Behavior

Beyond financial performance, ESG disclosure influences market perceptions and risk. Schiemann and Tietmeyer [19] reveal that ESG disclosure moderates the negative impact of ESG controversies on analyst forecast accuracy. Firms with stronger disclosure experience lower uncertainty and smaller forecast errors, particularly concerning social issues. Yuan et al. [20] similarly find that ESG disclosure reduces corporate financial irregularities in China, acting as a governance tool that strengthens internal control and transparency.

1.6. Cross-Regional Evidence and Policy Implications of ESG Disclosure

Across developed and emerging markets, the literature collectively underscores the dual role of ESG disclosure as a market signal and regulatory instrument. In Europe and Hong Kong, mandatory disclosure regimes drive consistency and comparability (Chung et al. [7]). In emerging markets such as India, China, and the UAE, ESG disclosure serves as a pathway to attract responsible investment and enhance firm governance (Malik and Kashiramka [15]; Ellili [16]; Yuan et al. [20]).

Policy implications include the need for standardized reporting frameworks, regional harmonization of ESG guidelines, and technological integration to enhance authenticity and reduce costs. The convergence between voluntary ESG reporting, regulatory enforcement, and digital transformation defines the next frontier in sustainable finance.

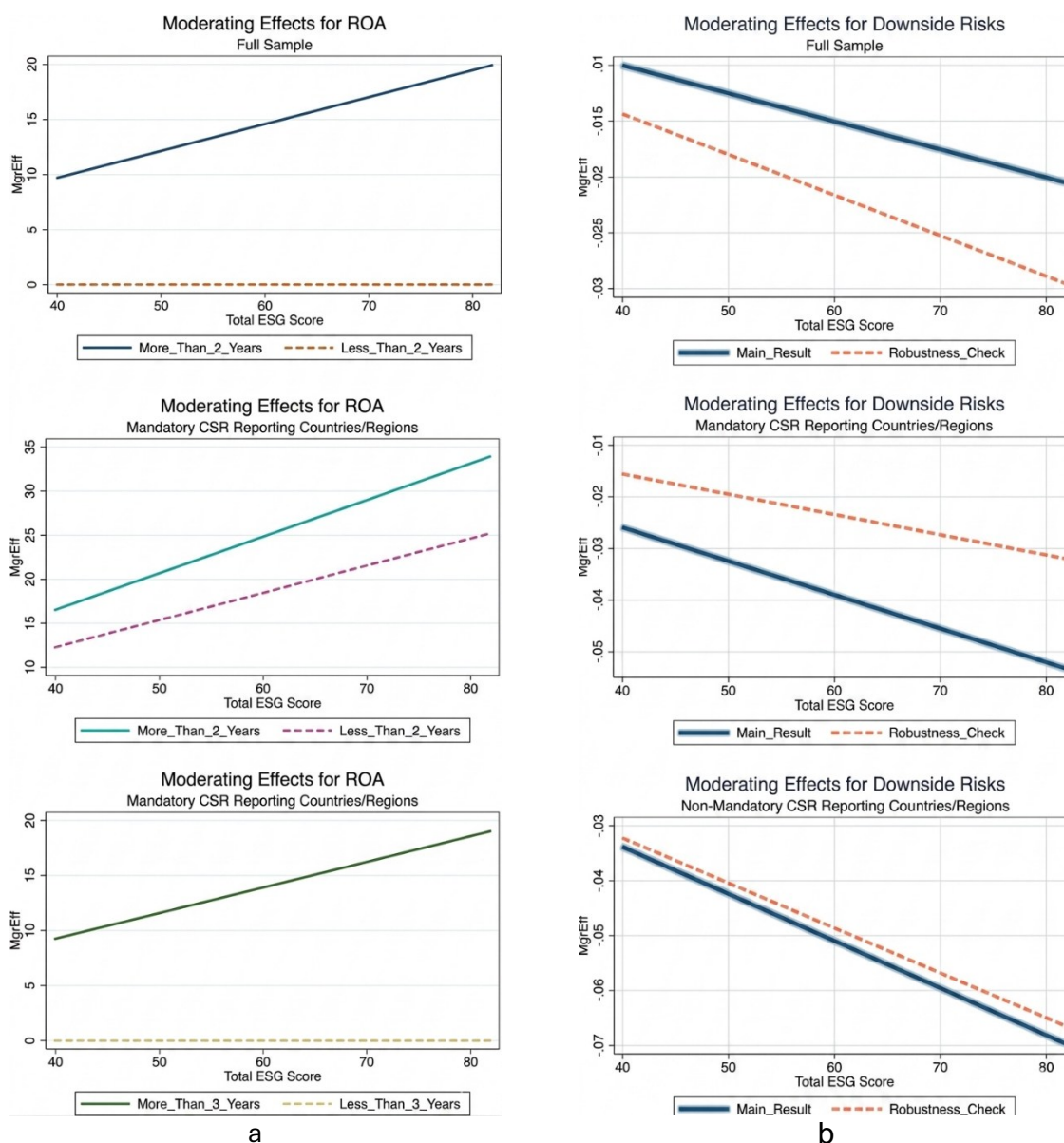


Figure 5. Moderating effects of ESG disclosure quality on firm performance (a) and downside risks (b), reproduced from [18].

1.7. Brief Summary of Key ESG Disclosure Studies

The ESG disclosure literature has evolved from voluntary communication of nonfinancial information to a strategic instrument shaping firm performance, investor behavior, and regulatory policy. The convergence of theoretical diversity, technological advancement, and policy standardization continues to transform ESG disclosure into a cornerstone of sustainable corporate governance and responsible investing. Integrating insights from accounting, finance, and management research will be crucial for advancing ESG disclosure as a global standard for transparency and sustainability. Table 1 shows a comprehensive synthesis table summarizing all the ESG disclosure recent studies. The table integrates authors, year, focus, theory, data/sample, methods, key findings, insights, and implications — allowing comparison across contexts.

Table 1. Comprehensive summary of ESG disclosure literature.

Authors	Geographic Context	Focus / Objective	Theoretical Framework	Methodology	Sample / Data	Main Findings	Key Insights	Policy / Implications
Tsang et al. [2]	Global	Comprehensive review of ESG disclosure literature	Stakeholder, legitimacy, agency, signaling	Literature review	100+ studies	Four dimensions: motivations, consequences, disclosure/user characteristics	Nonfinancial disclosure mitigates info asymmetry but outcomes vary	Need to integrate ESG disclosure with financial systems
Del Gesso & Lodhi [3]	Global (Accounting Studies)	Theories underpinning ESG disclosure	Stakeholder, legitimacy, institutional, agency, signaling	Systematic Review (RStudio, QDA Miner)	142 studies	Five dominant theories + 32 sub-theories	Integrated theoretical approach emerging	Combine traditional theories with cognitive & behavioral approaches
Hassani & Bahini [9]	Global	ESG disclosure and economic growth	Information asymmetry, sustainability theory	Conceptual / Critical Review	Theoretical	ESG disclosure not always optimal; may distort resource allocation	Optimal disclosure threshold depends on national development	Regulators must tailor disclosure intensity to economic maturity
Asif et al. [4]	Conceptual	ESG and Industry 5.0	Stakeholder, legitimacy, transaction cost, signaling	Conceptual analysis	Not empirical	Industry 5.0 tech (AI, blockchain) improves ESG authenticity and scope	Digitalization can reduce ESG cost, expand supply chain visibility	Promote tech-enabled ESG frameworks for real-time reporting
Krueger et al. [12]	Global (multi-country)	Effects of mandatory ESG disclosure	Institutional & regulatory economics	Empirical	Global dataset (OSF.io/syn8t)	Mandatory ESG disclosure improves transparency	Disclosure mandates standardize ESG quality	Policymakers can achieve results comparable to carbon taxes via ESG regulation
Pulino et al. [13]	Italy	ESG disclosure and firm performance	Agency, signaling	Panel regression (10 yrs)	2011–2020, large listed firms	Positive link between ESG disclosure and EBIT	Disclosure enhances firm reputation and profitability	Encourage CSR investment to improve performance
Chen & Xie [14]	China	ESG disclosure and financial performance	Stakeholder & agency	DID + GMM + placebo	2000–2020 listed non-financial firms	ESG disclosure increases financial performance,	ESG investors amplify firm value effects	ESG-oriented capital creates

Authors	Geographic Context	Focus / Objective	Theoretical Framework	Methodology	Sample / Data	Main Findings	Key Insights	Policy / Implications
Liu [10]	China	moderated by ESG investors Quantitative ESG disclosure and rating divergence	Signaling, information economics	Regression + quasi-experiment	Chinese A-shares, Hong Kong guidance	stronger with ESG investors More quantitative disclosure worsens rating divergence unless standardized	Disclosure standardization reduces disagreement	market discipline Harmonize ESG metrics to improve cross-rater consistency
Ellili [16]	UAE	ESG disclosure, financial reporting quality (FRQ), and investment efficiency	Agency, transparency	Econometric models	2010–2019 UAE firms	ESG disclosure & FRQ jointly improve investment efficiency	Strong FRQ enhances ESG's impact on efficiency	Regulators should integrate FRQ and ESG standards
Schiemann & Tietmeyer [19]	Global (51 countries)	ESG controversies, disclosure, and analyst forecast accuracy	Uncertainty & information risk	Regression	8,369 firm-years (2008–2017)	ESG disclosure reduces forecast errors from controversies	Disclosure cushions market uncertainty	Transparency reduces cost of capital during crises
Eng et al. [11]	USA	Comparing sustainability disclosures and ESG ratings	Signaling & valuation	Panel regression	2,600 listed firms (2014–2018)	ESG scores & sustainability disclosures both raise market value	Boilerplate disclosure harms valuation	Tailored narrative disclosure more valuable than generic data
Malik & Kashiramka [15]	India	ESG disclosure and cost of debt	Agency & legitimacy	Panel regression	272 firms (2015–2021)	ESG disclosure improves profitability and creditworthiness	Market rewards ESG transparency	Lenders price ESG disclosure in financing decisions
Helfaya et al. [6]	Europe	Factors determining ESG disclosure	CSR orientation, GRI, Hofstede culture	Regression	7,840 observations	Board CSR strategy & GRI increase ESG disclosure; culture matters	National culture shapes ESG behavior	Policymakers must align ESG policy with cultural context
Yuan et al. [20]	China	ESG disclosure and financial irregularities	Agency, information transparency	Panel regression	Chinese listed firms	ESG disclosure reduces financial irregularities	ESG acts as internal governance mechanism	Use ESG reporting to strengthen audit and control systems

Authors	Geographic Context	Focus / Objective	Theoretical Framework	Methodology	Sample / Data	Main Findings	Key Insights	Policy / Implications
Nuhu & Alam [5]	BRICS	Board characteristics & ESG disclosure in energy industry	Agency, stewardship	Multiple regression	1,260 firm-year obs (2010–2019)	Gender diversity & board diligence increase ESG disclosure	Strong boards foster ESG accountability	Encourage gender-balanced boards for ESG enhancement
Huang & Ge [8]	Global (mining)	ESG disclosure in mining firms	Legitimacy & stakeholder	Grey correlation + regression	2011–2020 mining firms	Developed countries lead in ESG quality; gaps narrowing	E pillar most lagging in developing economies	Global mining firms face pressure to harmonize ESG
Wen et al. [18]	Cross-country	ESG disclosure quality and ESG investing	Stakeholder, capital market	Panel regression	Global firm-level data	High ESG disclosure quality raises Tobin's Q, ROA, and ESG fund growth	Quality disclosure accelerates ESG market expansion	Promote mandatory CSR reporting for investor confidence
Chung et al. [7]	Hong Kong	Voluntary vs mandatory ESG regimes	Agency, institutional	Regression	2019 HKEX ESG guide	Large firms disclose more; Big 4 assurance increases transparency	Voluntary → mandatory shift improves governance	Regulators should move toward mandatory ESG reporting
Xue [17]	Theoretical / Macro	ESG disclosure, market forces, and investment	Market signaling & regulatory economics	Analytical model	Theoretical	Optimal disclosure precision channels investor preferences	Disclosure mandate mimics Pigovian tax	ESG policy can achieve efficiency without direct taxation

1.8. ESG Disclosure Insight

Table 2 shows the meta-level insights, highlighting overarching patterns and gaps after the table.

Table 2. Meta-level insights of ESG disclosure.

Dimension	Synthesized Insight	Implication
Theoretical Diversity	ESG disclosure studies span multiple frameworks — stakeholder, legitimacy, signaling, agency, and institutional theories dominate. New perspectives (reputation, cognitive cost, Industry 5.0) are emerging.	Indicates maturity of the field with hybrid theory integration; future work may merge socio-technical and behavioral theories.
Disclosure Type	Quantitative vs qualitative ESG disclosure produce different market effects. Quantitative data increase rating divergence; qualitative narratives build trust.	Regulators should balance numeric and narrative disclosure to optimize information value.
Regulatory Context	Mandatory ESG disclosure consistently yields higher comparability and transparency. Voluntary regimes depend heavily on firm incentives.	Global trend shifting toward semi-mandatory hybrid frameworks.
Financial Linkage	Positive correlation between ESG disclosure and firm financial performance (EBIT, ROA, Tobin's Q) across countries.	ESG transparency is now a measurable component of firm value creation.
Investor Behavior	ESG investors moderate and amplify the positive relationship between disclosure and performance.	Investor activism drives ESG disclosure quality.
Technological Integration	Industry 5.0 technologies enable real-time, authentic, and multi-tier ESG reporting.	Future ESG reporting will be digitized and AI-verified.
Cultural & Regional Factors	National culture (individualism, femininity) and firm governance structure shape ESG disclosure extent.	Regional customization of ESG standards necessary.
Governance & Board Effects	Gender diversity and CSR-oriented boards enhance ESG disclosure.	Strengthen corporate governance codes to include ESG accountability.
Information Asymmetry	ESG disclosure reduces uncertainty, improves analyst accuracy, and lowers cost of debt.	ESG reporting now functions as a financial risk-reduction tool.
Emerging Economies	In emerging markets (India, BRICS, UAE), ESG disclosure enhances legitimacy and access to capital but is still uneven.	Urgent need for disclosure harmonization to attract ESG funds.

Key Cross-Cutting Insights

1. **Disclosure Quality > Disclosure Quantity:**
Empirical studies show that simply disclosing ESG data is insufficient; the quality, standardization, and assurance of disclosure matter more for financial and reputational outcomes.
2. **Technology as the Next Frontier:**
Integration of Industry 5.0 and blockchain can reduce greenwashing risks and increase traceability of ESG data.

3. **Rating Divergence Is a Critical Barrier:**
Despite more ESG disclosure, inconsistent metrics across rating agencies reduce investor confidence and comparability.
4. **Regional ESG Policies Shape Global Capital Flows:**
Markets with mandatory disclosure (EU, HK) attract more ESG-focused investors and funds compared to voluntary regimes.
5. **ESG Disclosure as Governance:**
ESG disclosure is evolving beyond communication—it now functions as a governance, investment, and risk-control instrument.

1.9. Research Gaps and Future Directions of ESG Disclosure

The reviewed literature identifies several gaps:

1. Lack of cross-country comparative evidence linking ESG disclosure regimes and macroeconomic performance.
2. Insufficient exploration of digital ESG reporting using Industry 5.0 technologies such as AI and blockchain for real-time transparency.
3. Limited integration of ESG disclosure with firm innovation and productivity outcomes.
4. Need for unified ESG disclosure and rating frameworks to minimize data inconsistency.
5. Policy-level studies to define optimal disclosure intensity relative to economic development stages.

Future studies should employ mixed methodologies, including textual analysis, AI-driven ESG scoring models, and quasi-experimental designs to examine causality and cross-sectoral effects.

2. ESG Rating: Divergence, Market Consequences, and Real-Economy Implications

2.1. ESG Rating: Introduction

Environmental, Social, and Governance (ESG) ratings have become fundamental to sustainable investment decisions, capital allocation, and corporate evaluation. Investors, analysts, and regulators increasingly rely on these scores to quantify corporate sustainability and ethical performance. However, despite their growing prominence, the consistency, transparency, and economic meaning of ESG ratings remain controversial. Recent studies reveal substantial divergence across rating agencies, inconsistent predictive power for financial performance, and heterogeneous real-economy effects. This section synthesizes major contributions across four dimensions: (1) rating divergence and its origins, (2) market consequences of ESG rating changes, (3) corporate behavioral responses and real-economy outcomes, and (4) regulatory and methodological efforts to standardize ESG assessment.

2.2. ESG Rating Divergence and Its Determinants

A recurring theme in the literature is the lack of agreement across ESG rating agencies, which undermines investor confidence and complicates empirical research. Wang et al. [21] show that ESG rating divergence exerts a negative influence on excess stock returns among Chinese A-share firms between 2018 and 2022. The mechanism operates through reduced investor sentiment and weakened information transparency, particularly in companies with active ESG disclosure or high baseline ratings. Figure 6 shows that ESG rating divergence influences excess stock returns directly and indirectly through investor sentiment, ESG improvement potential, and information transparency. Similarly, Zumente and Lāce [22] find only a moderate correlation ($r = 0.58$) among the two leading ESG rating providers for European firms, emphasizing methodological inconsistency in evaluating sustainability performance.

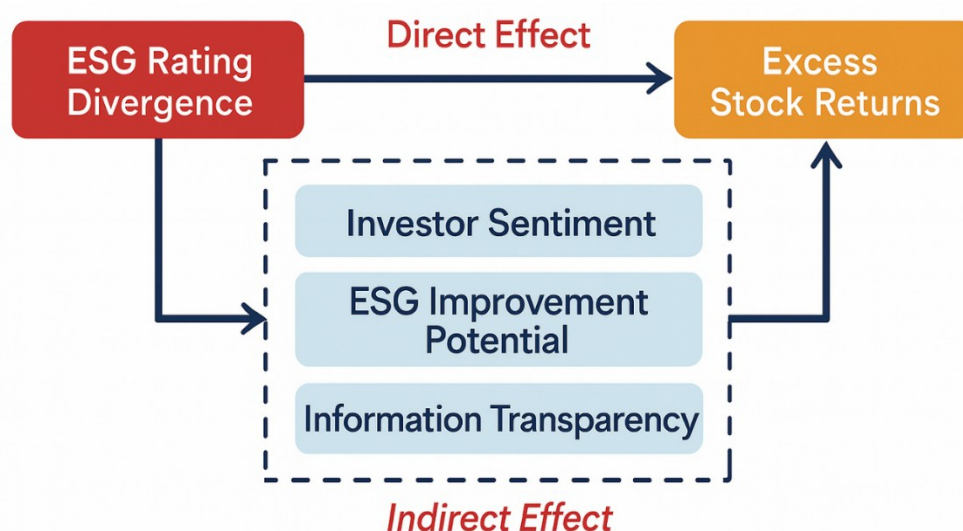


Figure 6. Conceptual framework: The direct and indirect effects of ESG rating divergence on excess stock returns, reproduced from [21].

Liu [10] deepens this understanding by linking quantitative disclosure to ESG rating disagreement. Using a quasi-natural experiment following Hong Kong's disclosure guidance, Liu discovers that numerical ESG reporting initially widens divergence, but once standardized templates are adopted, rating convergence improves. This underscores that inconsistency arises not from the abundance of data but from heterogeneous frameworks and weighting methods across agencies.

From a conceptual angle, Larcker et al. [23] argue that ESG ratings currently function as “a compass without direction”, due to opaque objectives, weak disclosure of weighting schemes, and incentives tied to commercial, rather than scientific, validation. Their work suggests that ESG rating providers differ not only in data inputs but also in ideology—some emphasize risk exposure, others ethical responsibility. Collectively, these studies show that divergence is a structural issue, stemming from uncoordinated methodologies, inconsistent disclosure formats, and varying interpretations of sustainability. Figure 7 illustrates the MSCI ESG ratings key issues framework, categorizing environmental, social, and governance (ESG) factors into three pillars that collectively assess corporate sustainability performance.

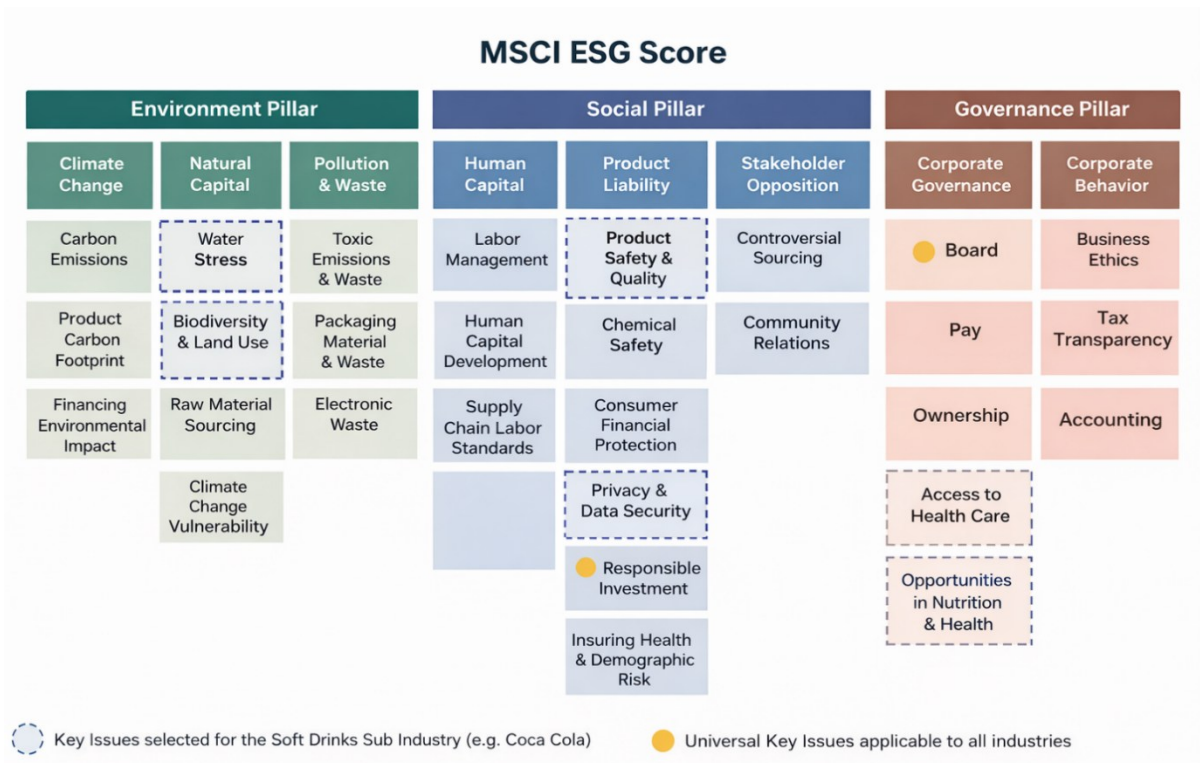


Figure 7. MSCI ESG ratings: Key issues framework highlighting environmental, social, and governance pillars with selected key issues relevant to industry-specific assessments, such as the soft drinks sector, reproduced from [23].

Figure 8 presents four major challenges in ESG rating systems: methodological inconsistency, disclosure heterogeneity, opaque objectives, and commercial incentives, each of which undermines the reliability, comparability, and scientific rigor of sustainability performance assessments.

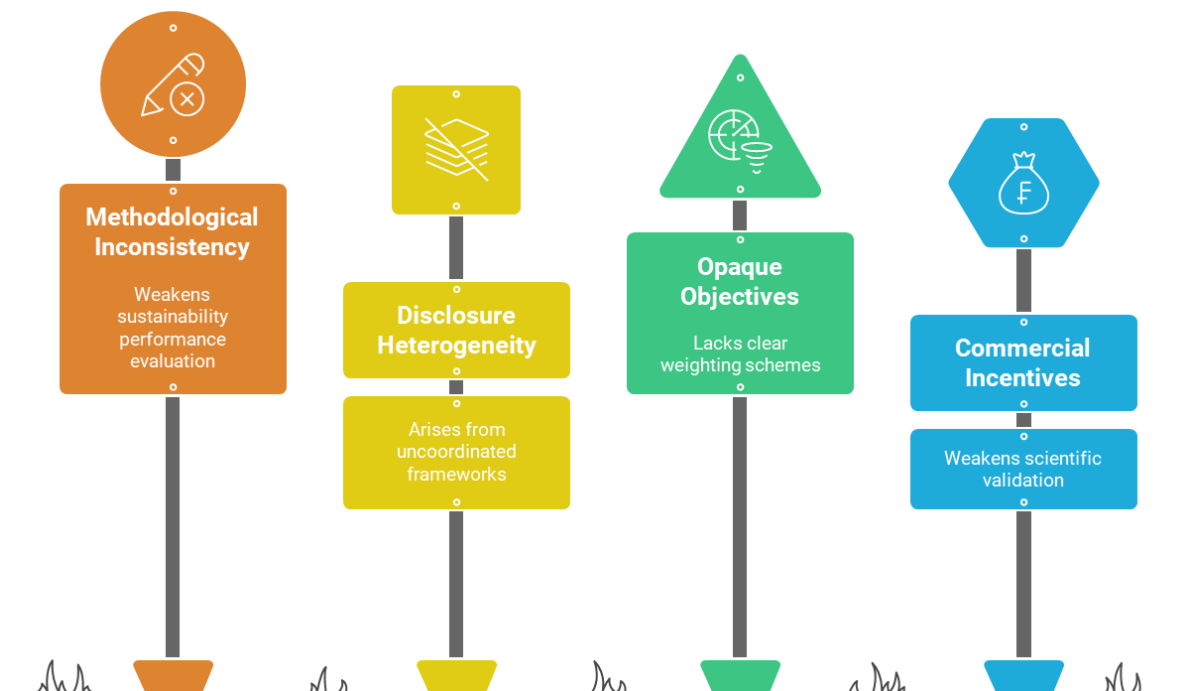


Figure 8. ESG rating divergence hinders investment.

2.3. Market Reactions to ESG Rating Changes

The relationship between ESG ratings and financial markets is multifaceted. Berg et al. [24] examine five major ESG rating systems in the United States and reveal that only MSCI's ESG rating significantly influences ESG-mandated fund holdings. Rating downgrades trigger gradual divestment and negative abnormal returns of approximately -2.37 percent over a one-year horizon, while upgrades lead to smaller positive effects. This lagged adjustment suggests that asset managers use ratings primarily to comply with fund mandates rather than to revise beliefs about corporate fundamentals.

Figure 9 compares the evolution of ESG ownership coefficients across major rating agencies from 2013 to 2021, showing notable divergence, particularly with MSCI exhibiting a stronger upward trend over time. Furthermore, Figure 10 illustrates how firms respond to ESG rating upgrades and downgrades across four dimensions—investment, environmental, social, and governance practices—showing that upgrades are typically followed by modest improvements, while downgrades often lead to weaker performance or stagnation.

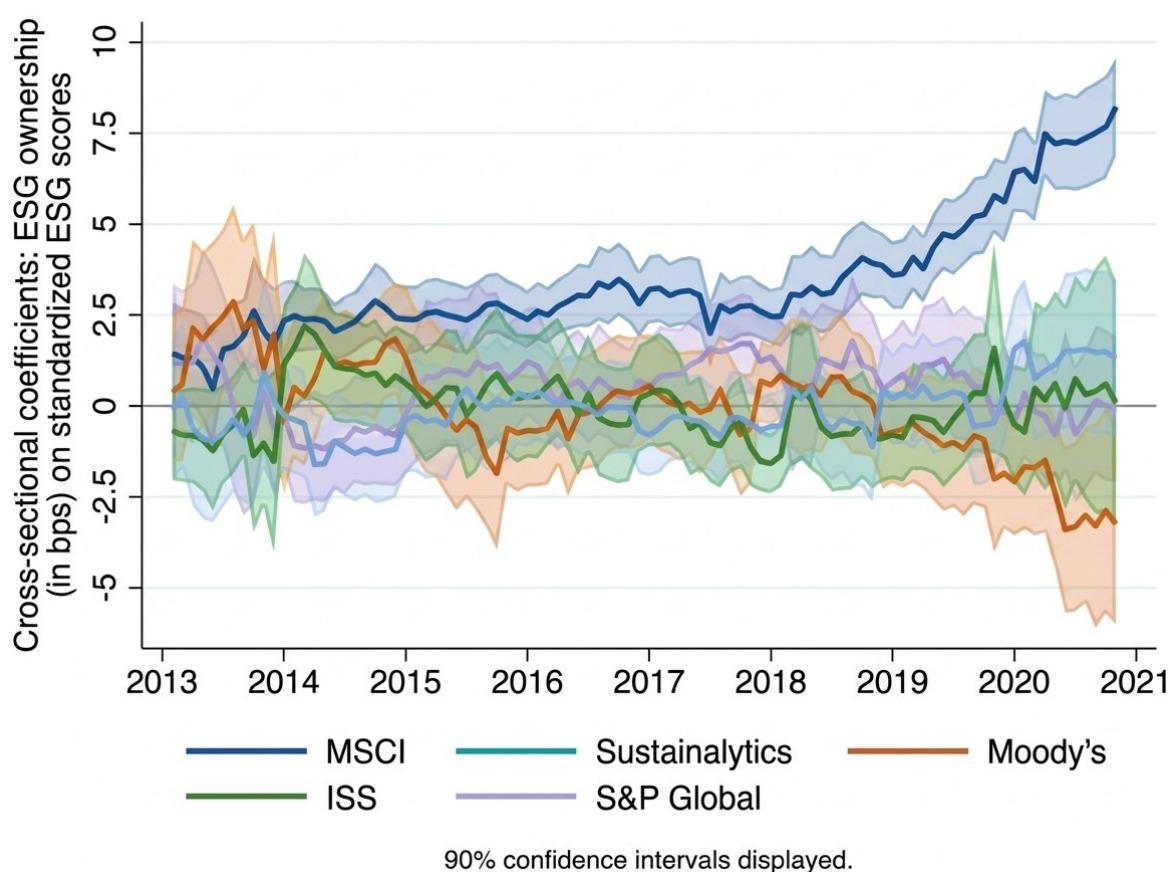


Figure 9. Cross-sectional coefficients of ESG ownership on standardized ESG scores (2013–2021) across five rating agencies, with 90% confidence intervals illustrating variations in methodology and trend consistency, reproduced from [24].

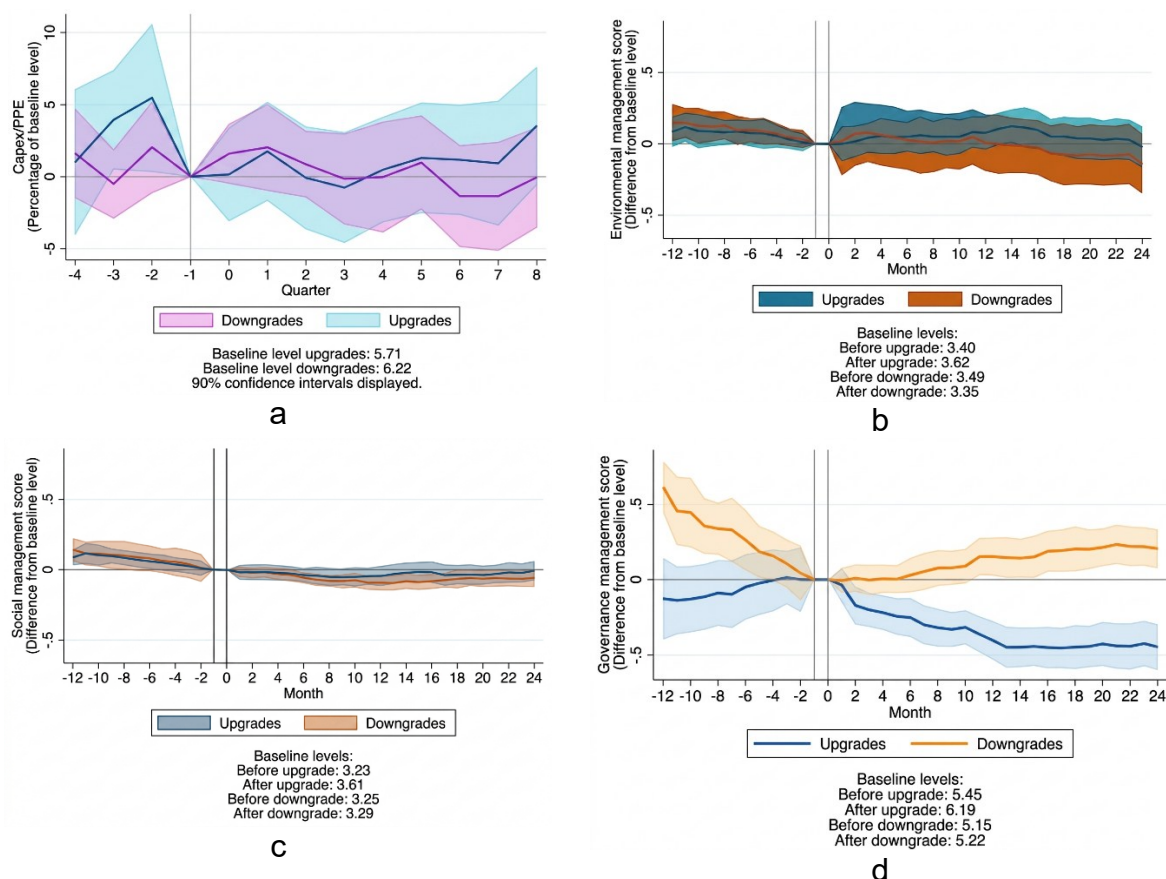


Figure 10. Corporate responses to ESG rating changes: (a) investment behavior, (b) environmental management, (c) social management, and (d) governance practices, each showing baseline levels before and after rating adjustments with 90% confidence intervals, reproduced from [24].

Shanaev and Ghimire [25], employing a calendar-time portfolio approach on 748 ESG rating events for U.S. firms, corroborate this asymmetry. Downgrades yield statistically significant risk-adjusted underperformance (-1.2 percent per month), while upgrades deliver modest and less consistent gains. These effects are stronger for ESG leaders than laggards, indicating greater market sensitivity to reputational loss than to positive recognition.

Wang et al. [26] reach similar conclusions in China: ESG rating disagreement depresses stock returns, particularly in non-state-owned firms and those with high governance-pillar variance. Together, these findings confirm that ESG ratings have measurable yet asymmetric price effects—markets punish deterioration more harshly than they reward improvement.

2.4. ESG Ratings and Corporate Behavior

2.4.1. Green Innovation and Environmental Performance

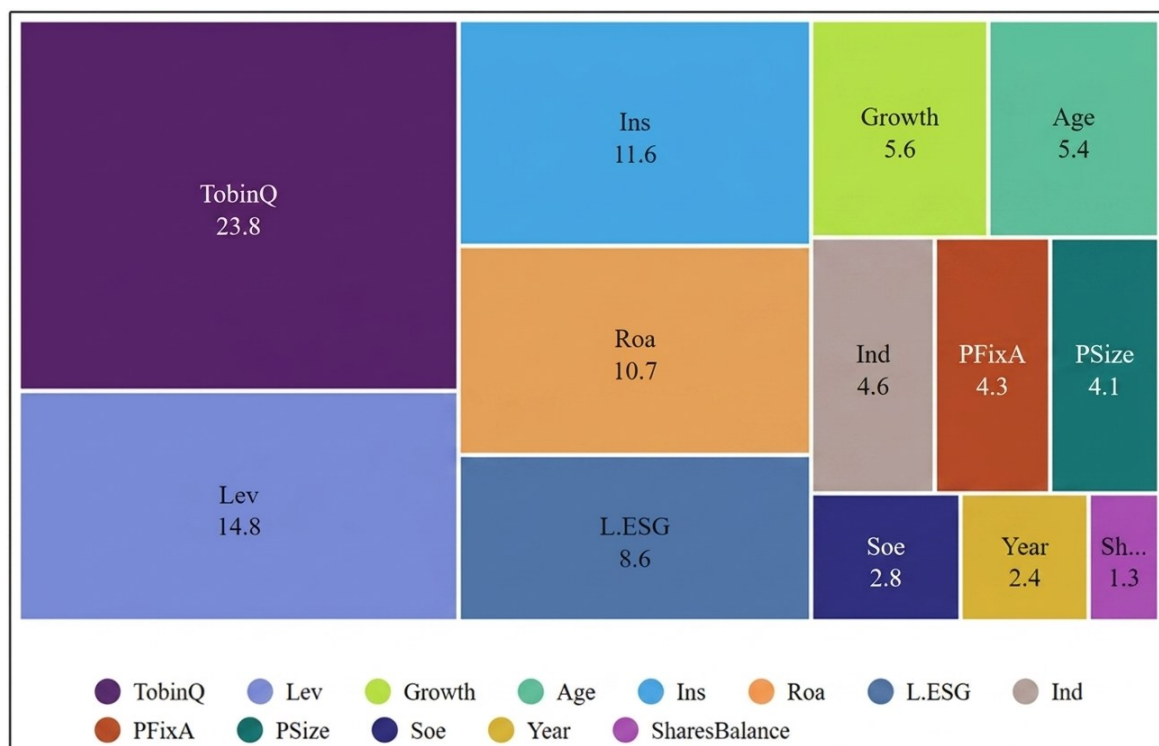
ESG ratings do not merely reflect sustainability—they can shape it. Using SynTao Green Finance's independent ratings, Wang et al. [27] find that ESG coverage increases green innovation output by 3.9 percent, especially in firms with tight financing constraints and less myopic investors. Similarly, Li and Xu [28] document that higher ESG ratings significantly reduce corporate carbon emissions in

China's listed firms between 2010 and 2020. The reduction operates through alleviated financing constraints and mitigated agency problems. Analyst and media attention amplify these benefits, demonstrating complementarity between external visibility and internal discipline.

Mneimneh et al. [29] extend the analysis cross-nationally, showing that ESG ratings have catalyzed green patenting and renewable-energy investments in both developed markets (United States, Singapore) and emerging economies (China). Yet they caution that greenwashing and weak regulation in developing regions dilute the intended benefits, calling for stronger institutional oversight.

2.4.2. Productivity, Digitalization, and Innovation Quality

Beyond environmental outcomes, ESG ratings enhance broader technological and organizational performance. Xue et al. [30] demonstrate that high ESG ratings significantly raise Total Factor Productivity (TFP) by easing financing constraints and increasing government subsidies. Their machine-learning validation reveals that ESG variables improve prediction accuracy for TFP, indicating genuine information content. Figure 11 illustrates the relative importance of model features and the predictive accuracy of the machine learning model, highlighting ESG ratings as a significant contributor and demonstrating reliable alignment between predicted and true values. Hao et al. [31] further show that firms with stronger ESG ratings achieve faster digital-technology innovation, supported by greater R&D spending, improved reputation, and reduced uncertainty. The positive effects are most pronounced in high-tech and heavily polluting sectors, implying that ESG-rated transparency drives technological upgrading in strategically sensitive industries.



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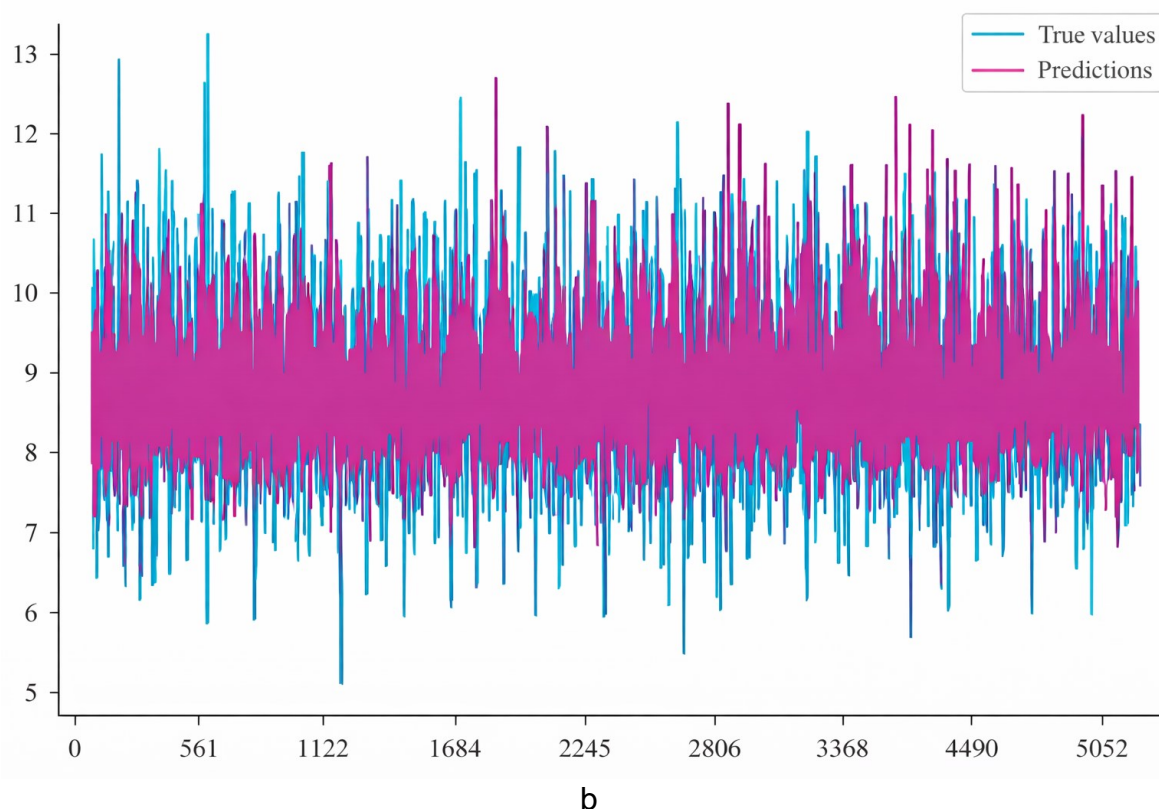


Figure 11. (a) The feature weight distribution where ESG ratings contribute 8.6% to the model's prediction and (b) the comparison between predicted and true values, confirming strong predictive performance and model reliability, reproduced from [30].

2.4.3. Governance and Risk Management

ESG ratings also influence managerial behavior. Tsang et al. [32] provide evidence that firms newly covered by ESG rating agencies reduce regulatory violations, confirming the monitoring role of third-party assessors. Zhang et al. [33] find that high ESG ratings help curb managerial myopia, as they improve accounting transparency, attract analyst scrutiny, and lower financing costs—thereby encouraging long-term decision-making. Ji et al. [34] highlight an important contingency: board faultlines, defined as divisions within board demographics or values, weaken the positive link between ESG performance and firm value. Fu et al. [35] focus on the mining industry and find that better ESG ratings lower financial risk by improving governance, mitigating agency problems, and easing access to resources.

Conversely, Mao et al. [36] warn that ESG rating divergence can incentivize opportunism. Firms with large discrepancies among raters engage more in earnings management, especially when CEO power is strong and agency costs are high. Liu et al. [37] similarly reveal that analyst forecast errors increase with ESG rating disagreement, though the effect is mitigated when forecasts come from experienced or “star” analysts. Collectively, these findings show that ESG ratings function as both a monitoring and signaling device, but their effectiveness depends on corporate governance quality and the consistency of external assessments.

2.5. Regulation, Standardization, and the EU Taxonomy of ESG Rating

Efforts to reduce inconsistency and enhance credibility have led to emerging regulatory frameworks. Dumrose et al. [38] evaluate the EU Taxonomy's potential to harmonize environmental ESG ratings across European providers. Their Tobit regression results reveal that while environmental ratings correlate positively with Taxonomy alignment for three out of four major raters, measurement divergence persists, implying that the taxonomy's promise remains under-realized. Nonetheless, this alignment marks a crucial step toward a unified ESG reporting language. The findings by Liu [10] and Dumrose et al. [38] converge: standardized disclosure templates, shared taxonomies, and mandatory reporting reduce rating noise and increase comparability. These conclusions support policy initiatives from the EU, the ISSB (International Sustainability Standards Board), and regional regulators seeking to integrate ESG data into mainstream financial reporting.

2.6. Summary of ESG Rating

The expanding body of literature on ESG ratings reveals a paradox: while these ratings have become indispensable to modern finance, their inconsistency threatens their legitimacy. Empirical evidence consistently shows that divergence among raters distorts market signals, yet rating coverage and high scores drive real improvements in innovation, productivity, and risk management. As the global economy transitions toward sustainability, the challenge lies in transforming ESG ratings from fragmented commercial products into standardized, credible, and decision-useful measures of corporate responsibility. Achieving this will require collaboration among regulators, data providers, and scholars to design transparent methodologies, promote taxonomy convergence, and integrate ESG metrics into mainstream financial governance.

Table 3 shows comprehensive synthesis table summarizing all the ESG Rating key studies. It combines study focus, data, theory, methods, findings, insights, and implications, arranged to show cross-comparative patterns. The following is the analytical summary:

1. Empirical Consensus. ESG rating divergence is structural, measurable, and impactful. Disagreement undermines market efficiency, but rating coverage drives tangible sustainability improvements.
2. Practical Implication. ESG ratings are dual-purpose instruments: they act as both a *market signal* and a *governance mechanism*. However, they only function effectively when backed by standardized disclosure and independent assurance.
3. Future Challenge. To evolve beyond fragmented credibility, ESG ratings require interoperable taxonomies (EU, ISSB), transparency mandates, and technology integration (AI, blockchain) to verify data accuracy and reduce subjective bias.

Table 3. Summary of key studies on ESG ratings: Divergence, market impact, and real-economy implications.

Authors	Country / Region	Research Focus	Data & Sample	Theoretical Lens	Methodology	Key Variables / Indicators	Main Findings	Mechanism / Moderators	Key Insights	Policy / Implications
Wang et al. [21]	China (A-shares)	ESG rating divergence and excess stock returns	2018–2022, Shanghai & Shenzhen listed firms	Information asymmetry; investor sentiment	Panel regression	ESG divergence index, excess returns, ESG report disclosure	Rating divergence negatively affects excess stock returns; strongest in firms with ESG reports, QFII investors, and high divergence	Investor sentiment, transparency, ESG potential moderate the link	Divergent ratings confuse investors and reduce returns	Regulators must standardize ESG methodologies to stabilize markets
Zumente & Lāce [22]	Europe (CEE)	Correlation and necessity of ESG ratings	European stock-listed firms	Information relevance theory	Correlation & t-test	ESG ratings (2 agencies), trading volume, returns	Correlation only 0.58 between leading ratings; rated firms trade more	ESG rating presence increases liquidity and visibility	Ratings matter for both firms and investors	Firms must engage with raters; agencies must align scoring criteria
Berg et al. [24]	USA	Economic impact of ESG ratings on fund holdings & returns	US-listed firms, 5 major rating agencies	Institutional theory; signaling	Event study & panel regression	MSCI ESG ratings, fund holdings, stock returns	Only MSCI ratings explain ESG fund holdings; downgrades → -2.37% abnormal return;	Gradual adjustment; fund mandate compliance	Ratings shape ownership but less firm fundamentals	ESG fund managers rely on ratings for compliance, not alpha

Authors	Country / Region	Research Focus	Data & Sample	Theoretical Lens	Methodology	Key Variables / Indicators	Main Findings	Mechanism / Moderators	Key Insights	Policy / Implications
Liu [10]	China / HK	Quantitative ESG disclosure & rating divergence	Chinese A-shares; HK quasi-experiment	Signaling & information economics	Difference-in-differences	ESG disclosure intensity, rating divergence	More quantitative disclosure increases divergence, but standardized disclosure reduces it	Disclosure standardization moderates divergence	Quality, not quantity, drives rating convergence	Regulators should require consistent templates and metrics
Larcker et al. [23]	USA / Global	Critique of ESG rating system design	Conceptual / industry analysis	Institutional theory	Qualitative review	Rating agency methodology, incentives	Ratings act as “a compass without direction”; divergent aims and weak incentives	Methodological opacity drives inconsistency	Ratings reflect business models, not shared standards	Need global auditing, methodological disclosure, and regulation
Wang et al. [27]	China	ESG ratings and corporate green innovation	SynTao Green Finance ESG data, 2009–2020	Innovation diffusion; stakeholder theory	Quasi-natural experiment	ESG coverage, green patents	ESG coverage ↑ green patents by 3.9%, mainly non-SOEs	Investor horizon, financing constraints moderate	Rating coverage stimulates innovation	Third-party ESG coverage incentivizes green transformation
Li & Xu [28]	China	ESG rating and corporate	2010–2020 A-	Agency & financing constraint	Difference-in-differences	Carbon emissions,	Higher ratings → lower	Financing & agency channels; media	ESG ratings drive	Promote rating-based policies for carbon

Authors	Country / Region	Research Focus	Data & Sample	Theoretical Lens	Methodology	Key Variables / Indicators	Main Findings	Mechanism / Moderators	Key Insights	Policy / Implications
		carbon emissions	share firms			financing, ESG rating	carbon emissions	attention strengthens effect	emission reduction	neutrality goals
Xue et al. [30]	China	ESG rating and total factor productivity (TFP)	Listed firms; panel data	Resource-based view	Regression + ML validation	ESG ratings, TFP, financing constraints	Higher ratings ↑ TFP via financing, subsidies	Reputation and government subsidy mediation	ESG rating improves operational efficiency	Policymakers can use ESG as productivity signal
Hao et al. [31]	China	ESG ratings and digital innovation	18,741 A-share firms, 2009–2021	Innovation & legitimacy	DID panel model	ESG rating, R&D, patents	High ratings ↑ digital innovation, esp. in high-tech/polluting sectors	Financing access, R&D spending, reputation	ESG promotes digital transformation	ESG score reforms can guide innovation policy
Mneimneh et al. [29]	USA, Singapore, China	Green innovation and environmental dimension of ESG ratings	Multicountry comparison	Sustainability & institutional theory	Comparative analysis	Green patents, ESG index, energy use	ESG ratings correlate with green innovation and financial stability	Greenwashing, weak regulation reduce impact	ESG ratings catalyze green investment but face trust deficits	Strengthen verification & anti-greenwashing regulation
Fu et al. [35]	China (Mining)	ESG rating and financial risk	2009–2021 mining firms	Risk management & governance	Panel regression	ESG score, Z-score, agency cost proxies	Higher ESG ratings ↓ financial risk	Governance, risk control, financing constraint	ESG ratings enhance resilience in high-risk sectors	Encourage ESG adoption in high-polluting industries

Authors	Country / Region	Research Focus	Data & Sample	Theoretical Lens	Methodology	Key Variables / Indicators	Main Findings	Mechanism / Moderators	Key Insights	Policy / Implications
Tsang et al. [32]	USA	ESG rating coverage and corporate violations	2000–2018 US firms, 4 agencies	Monitoring & legitimacy	Difference-in-differences	ESG coverage, violation frequency	ESG coverage ↓ regulatory violations	Strongest with low analyst/media attention	Ratings substitute weak external monitoring	ESG coverage complements public oversight
Zhang et al. [33]	China	ESG ratings and managerial myopia	2009–2021 listed firms	Behavioral & agency theory	Text analysis + regression	ESG score, myopia index	Higher ratings suppress managerial myopia	Financing constraints, analyst attention mediate	ESG induces long-termism	Use ESG metrics to reward long-term strategic focus
Ji et al. [34]	China	ESG rating, board faultlines & firm performance	2009–2021 firms	Upper echelons & governance theory	Regression	ESG rating, board diversity, performance	ESG rating ↑ performance; board faultlines weaken effect	Deep demographic faultlines strongest moderator	ESG gains need cohesive boards	Board integration enhances ESG impact
Mao et al. [36]	China	ESG rating divergence & earnings management	2009–2021 firms	Agency theory	Heckman 2-stage regression	ESG performance, rating divergence, EM	High divergence → more earnings manipulation	CEO power, agency cost intensify effect	Divergent ratings enable opportunism	Enforce rating regulation & disclosure transparency
Liu et al. [37]	China	Rating disagreement & analyst forecast quality	2015–2021 A-share, 6 agencies	Information asymmetry	Regression	Forecast error, dispersion, ESG divergence	Greater divergence ↑ forecast errors & dispersion	Analyst experience mitigates	Divergent ESG data hinder analyst accuracy	Training analysts & improving data comparability essential

Authors	Country / Region	Research Focus	Data & Sample	Theoretical Lens	Methodology	Key Variables / Indicators	Main Findings	Mechanism / Moderators	Key Insights	Policy / Implications
Shanaev & Ghimire [25]	USA	ESG rating changes & stock returns	2016–2021 US firms, 748 events	Signaling & investor attention	Calendar-time portfolio	ESG upgrades/downgrades	Downgrades → -1.2% monthly return; upgrades weak	Market punishes downgrades more	Negative ESG shocks dominate valuation impact	Manage ESG reputation proactively
Dumrose et al. [38]	EU	EU Taxonomy & ESG rating convergence	EU firms, 4 rating providers	Institutional & regulatory theory	Tobit regression	ESG environmental scores, taxonomy link	Taxonomy alignment partially reduces divergence	Incomplete harmonization	EU Taxonomy helps convergence but uneven	Policymakers must extend taxonomy to S & G pillars
Berg et al. [24]	USA	ESG fund holdings, stock performance, governance	US listed companies	Institutional investors & mandate theory	Panel regression	MSCI ratings, fund holdings	Downgrades → fund divestment; upgrades slower	Ownership change lags rating event	Ratings guide compliance not price discovery	ESG fund criteria need real-time updates
Li et al. [28]	China	ESG rating events, finance, & innovation	2010–2020 non-financial A-share firms	Resource-based & financial behavior theory	Regression + mediation	ESG events, innovation output, investment	ESG + financial behavior ↑ innovation	Property rights, capital reserves moderate	Financially motivated ESG enhances innovation	Link ESG incentives to capital allocation efficiency

2.7. Integrative Insights and Emerging Themes in ESG Rating

Synthesizing across studies, three cross-cutting insights emerge (Table 4).

First, ESG rating divergence is structural and economically consequential. Across markets, inconsistent methodologies among rating agencies generate uncertainty that influences asset pricing, analyst accuracy, and managerial incentives. This implies that the credibility of ESG finance depends as much on methodological convergence as on data availability.

Second, ESG ratings act as indirect levers of change in the real economy. Through reputational and financing channels, they encourage greener technologies, greater productivity, and improved governance. High ratings serve as quasi-regulatory mechanisms that internalize externalities without direct state intervention, aligning with the findings of Li and Xu [28] and Xue et al. [30].

Third, institutional context mediates outcomes. In developed markets, ratings influence fund flows and investor screening; in emerging economies, they primarily affect innovation and compliance. Thus, ESG ratings are both global and local instruments, reflecting differences in governance systems, information infrastructure, and market maturity.

Table 4. Cross-cutting insights from the literature.

Thematic Category	Synthesized Insight	Evidence Source	Implication
Rating Divergence	ESG ratings show low inter-provider consistency ($r \approx 0.5-0.6$), reducing reliability for investors.	Zumente & Lāce [22]; Liu [10]; Wang et al. [27]	Standardization and disclosure harmonization crucial to enhance comparability.
Market Response	Downgrades trigger stronger negative reactions than upgrades (-1.2% to -2.4%), showing asymmetric investor behavior.	Berg et al. [24]; Shanaev & Ghimire [25]; Wang et al. [27]	Market penalizes poor ESG performance more severely than it rewards improvement.
Investor Behavior	ESG ratings mainly guide mandate compliance, not alpha generation; ownership changes are slow.	Berg et al. [24]	ESG funds need dynamic, forward-looking rating integration.
Corporate Behavior	ESG ratings stimulate green innovation, emission reduction, and digital transformation.	Wang et al. [27]; Li & Xu [28]; Hao et al. [31]; Xue et al. [30]	ESG acts as an innovation policy lever via financing and reputation.
Governance Effect	Rating coverage reduces violations, myopia, and risk, but high divergence encourages opportunism.	Tsang et al. [32]; Zhang et al. [33]; Mao et al. [36]	External ESG monitoring complements internal governance systems.
Sectoral Sensitivity	ESG has strongest impact in polluting, capital-intensive industries (e.g., mining, heavy industry).	Fu et al. [35]; Hao et al. [31]	ESG rating systems should integrate sector-adjusted benchmarks.
Regional Context	Developed markets emphasize investment signaling; emerging	Mneimneh et al. [29]; Li & Xu [28]	ESG ratings must account for institutional

Thematic Category	Synthesized Insight	Evidence Source	Implication
	markets emphasize innovation and compliance.		maturity and data infrastructure.
Analyst and Information Environment	Greater rating disagreement increases forecast dispersion; experienced analysts mitigate errors.	Liu et al. [37]	Training and AI-assisted ESG data validation improve analyst accuracy.
Taxonomy and Regulation	EU Taxonomy and standardized frameworks partially reduce divergence but remain incomplete.	Dumrose et al. [38]; Liu [10]	Extend taxonomy to S & G pillars and adopt machine-readable ESG templates.
Overall Trend	ESG ratings are evolving from voluntary symbolic measures to quasi-regulatory mechanisms driving real corporate outcomes.	Multi-study synthesis	Regulatory alignment and data interoperability define next ESG era.

2.8. Future Research Directions in ESG Rating

The reviewed literature identifies several opportunities for scholarly advancement. First, future studies should employ causal identification strategies—such as instrumental variables or event studies—to isolate the impact of rating divergence from endogeneity biases.

Second, researchers should examine cross-provider calibration, quantifying how methodological transparency affects investor trust and cost of capital. Third, integrating machine-learning and textual-analysis tools could enhance understanding of how unstructured ESG data translate into rating variance. Fourth, more research is needed on spillover effects—how ESG rating reforms in one jurisdiction (e.g., EU Taxonomy) propagate through global supply chains and investment networks.

Finally, interdisciplinary approaches linking behavioral finance, data science, and policy design could yield a more coherent theory of ESG rating reliability and effectiveness.

3. ESG Investing: Performance, Ethics, Disclosure, and Heterogeneous Preferences in Global Contexts

3.1. ESG Investing: Introduction

Environmental, Social, and Governance (ESG) investing has rapidly evolved from a niche approach to a mainstream financial philosophy shaping how investors, corporations, and regulators define value. Its promise lies in aligning profit with purpose, yet persistent questions remain about its financial performance, ethical credibility, and contribution to sustainability goals. This review synthesizes findings from leading studies between 2010 and 2025 to clarify how ESG investing functions across different markets, data systems, and behavioral contexts.

3.2. Theoretical and Behavioral Foundations of ESG Investing

ESG investing reflects a blend of moral motivation and economic reasoning. Through equilibrium models of agents with differing sustainability preferences, Kräussl et al. [39] show that while ESG assets may yield lower long-term returns because investors accept smaller risk premiums, short-term outperformance can arise through market sentiment and policy interventions. They emphasize that investor demand for ESG can reduce firms' capital costs, thus driving corporate sustainability transitions.

The role of heterogeneous investor preferences in shaping market information is further examined by Goldstein et al. [40], who find that when green and traditional investors trade based on different value systems, prices become less informative about firms' actual payoffs. They argue that a higher share of green investors or improved ESG data can paradoxically reduce price informativeness while increasing capital costs—highlighting the complex trade-off between sustainability and market efficiency.

3.3. ESG and Firm Financial Performance

The financial effects of ESG integration remain widely studied yet inconsistently measured. Using a systematic literature review of 198 papers published from 2010–2022, Narula et al. [41] confirm a generally positive relationship between ESG ratings and firm performance but note strong methodological variation across databases such as Bloomberg and Thomson Reuters. They propose a conceptual framework explaining how ESG ratings translate into shareholder value and call for standardized metrics. Figure 12 presents a chronological timeline highlighting major milestones in the evolution of sustainable and responsible investment, tracing key policy, institutional, and market developments from the 1970s to 2011.

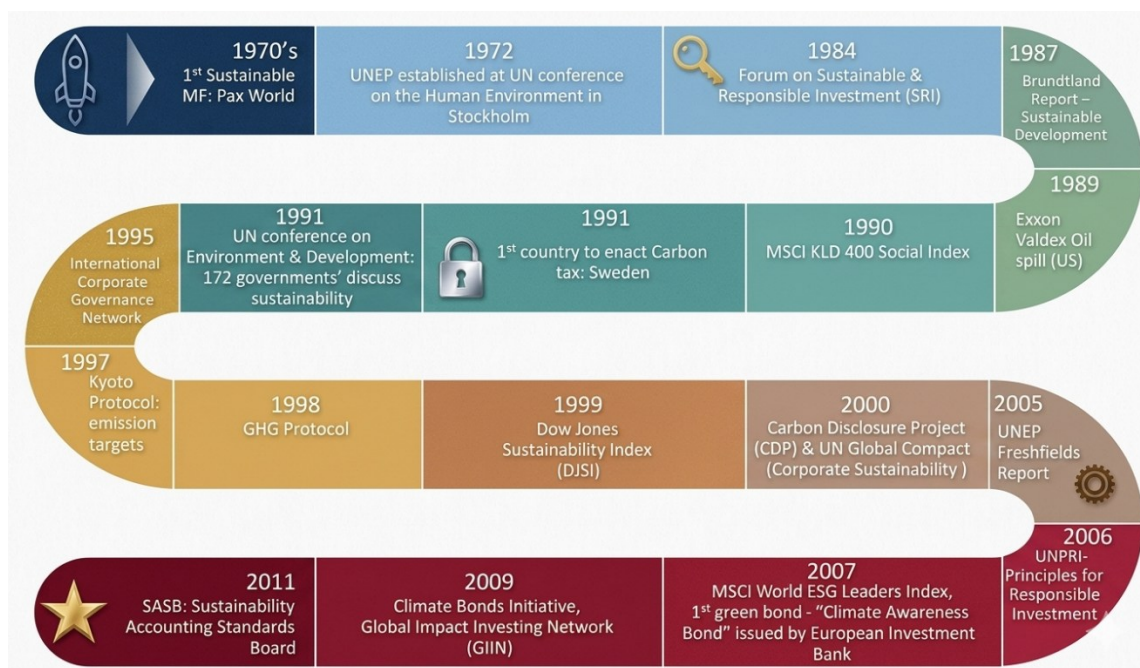


Figure 12. Evolution of sustainable and responsible investment milestones, showcasing major global initiatives, protocols, and organizations that shaped ESG and sustainability practices over four decades, reproduced from [41].

Empirical work in emerging markets offers further nuance. Zhang et al. [42] reveal that following China's 2016 "Green Financial System Guidelines," high-ESG portfolios outperformed low-ESG ones due to reduced cost of equity rather than profitability gains. Extending this analysis, Zhang et al. [43] find a nonlinear link between ESG and portfolio returns—where both very high and very low ESG portfolios can outperform depending on sectoral context.

At the institutional level, Cao et al. [44] demonstrate that ESG investment enhances bank efficiency, especially through environmental and governance components, while financial technology further strengthens this link. Complementing this, Zhu et al. [45] show that firms with independent boards, sustainability committees, and gender diversity exhibit stronger ESG performance, whereas CEO duality and oversized boards reduce commitment to sustainability. Figure 13 summarizes four possible outcomes of ESG portfolio performance, illustrating how variations in sector dependence, integration, and equity costs influence whether ESG portfolios outperform or underperform in financial returns.

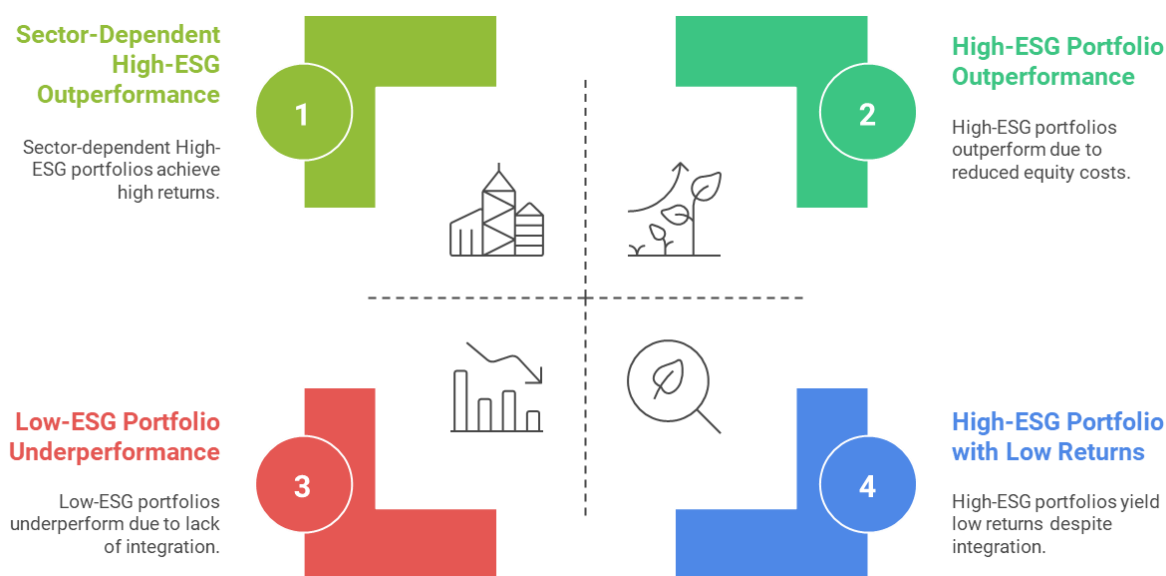


Figure 13. ESG integration and financial performance.

3.4. ESG Disclosure Quality and Market Trust

Transparent disclosure remains a cornerstone of credible ESG investing. Using a multi-country panel dataset, Wen et al. [18] find that high-quality ESG disclosure improves firm valuation (Tobin's Q and ROA) and lowers downside risks. This effect is especially pronounced in countries with mandatory CSR reporting, where disclosure drives the expansion and equal distribution of ESG investment.

Ethical credibility, however, is increasingly under scrutiny. Foley et al. [46] argue that the core issue lies not in ESG frameworks but in the absence of ethical consistency in corporate decision-making. They propose embedding "just transition ethics" across sectors to rebuild stakeholder trust and realign ESG investment with the broader goals of the 2030 UN Agenda and the Paris Agreement.

3.5. Investor Preferences, Heterogeneity, and Behavior

Not all investors interpret ESG information in the same way. A survey of French retail investors by Assaf et al. [47] finds that ESG attitudes cluster into five distinct categories, revealing that a single ESG score fails to capture personal sustainability preferences. This heterogeneity complicates the implementation of the European MIFID II directive, which requires financial products to align with investor sustainability goals. Behavioral experiments by Seifert et al. [48] further indicate that providing either ESG or financial performance information increases the likelihood of sustainable investment, though combining both has no additional effect. Interestingly, investors evaluate financial and ESG data through separate cognitive frames. Fund-level analyses also suggest that stronger ESG profiles enhance portfolio stability. Wang [49] reports that high-ESG funds show lower vulnerability, greater liquidity, and reduced sensitivity to investor outflows—attributes that support long-term resilience.

3.6. ESG, Sustainability, and Systemic Stability

Evidence increasingly links ESG participation to financial stability and environmental outcomes. Using time-varying spillover models, Liu et al. [50] find that ESG investment reduces volatility transmission across China's stock, bond, and interbank markets, promoting systemic stability by encouraging long-term investment over short-term speculation. From an environmental standpoint, Wang et al. [51] show that a 1% increase in ESG investment leads to a 1.39% short-term and 0.0046% long-term reduction in greenhouse gas emissions, suggesting a measurable link between ESG finance and COP-26 targets. In the United States, Bagh et al. [52] find that ESG engagement mitigates the negative impact of climate risk on firm value, positioning ESG as a resilience mechanism rather than merely a reputational tool.

3.7. ESG and Contractual Mechanisms

The integration of ESG metrics into performance contracts is reshaping corporate governance. Zhang and Yang [53] propose a continuous-time incentive model showing that ESG-oriented contracts improve managerial efficiency by reducing information asymmetry and aligning executive behavior with emission-reduction targets. The inclusion of carbon credits and emission pricing enhances contract performance and capital allocation efficiency, demonstrating that ESG investing can reinforce both ethical and economic alignment.

3.8. The “S” Dimension and Supply Chain Responsibility

While environmental and governance factors dominate ESG research, the social component remains underexplored. Baid and Jayaraman [54] advocate for amplifying the social dimension of ESG within supply chain finance. Their framework translates qualitative social outcomes—such as labor welfare, community engagement, and human rights—into quantifiable indicators. Integrating such metrics into financing decisions supports regulatory compliance and advances social equity within global supply networks.

3.9. Synthesis and Future Research Directions

A synthesis of the reviewed literature identifies four overarching insights shaping the ESG landscape:

Table 5. Theme and key insights: ESG investing.

Theme	Key Insights
Performance Paradox	ESG tends to enhance firm value and risk resilience, yet investor demand may compress returns.
Disclosure and Trust	Transparent reporting and ethical practice are central to rebuilding investor confidence.
Investor Heterogeneity	Diverse investor values challenge universal ESG metrics and call for tailored strategies.
Systemic Stability	ESG contributes to financial resilience and environmental gains, aligning markets with global climate goals.

Table 6 consolidates empirical and theoretical research on Environmental, Social, and Governance (ESG) investing. The synthesis reveals four cross-cutting insights. First, the performance paradox—ESG tends to improve long-term resilience while occasionally compressing returns through demand premiums. Second, disclosure quality and ethical credibility drive investor confidence and lower capital costs. Third, investor heterogeneity demands tailored ESG metrics beyond a single score. Fourth, systemic stability improves when ESG integration aligns financial markets with sustainability and climate-policy objectives. Future work should focus on harmonizing ESG data methodologies, incorporating ethical governance into corporate policy, quantifying the causal link between ESG investment and emissions reduction, and leveraging AI-based analytics to detect ESG performance anomalies.

3.10. ESG Investing Brief Summary

ESG investing has evolved from a moral aspiration into a sophisticated mechanism that links finance, governance, and sustainability. Yet despite its global expansion, inconsistencies in scoring methods, shallow ethical commitment, and uneven regulatory enforcement threaten its credibility. Sustaining trust in ESG markets requires a multidimensional approach—anchored in transparency, ethics, and innovation—that allows markets to balance financial performance with planetary well-being.

Table 6. Comprehensive summary of major ESG investing studies.

Authors	Setting or Region	Sample and Period	Method	Main Question	Key Findings	Limitations
Kräussl et al. [39]	Global multi market	Literature review recent decades	Equilibrium theory review synthesis	Do preferences and beliefs support ESG outperformance and impact	Long run lower returns from taste premium short run outperformance possible investor demand lowers financing cost and drives impact	Publication bias and scope spread
Narula et al. [41]	Global cross sector	One hundred ninety eight studies 2010 to 2022	SLR TCCM SPAR framework meta insights	Does ESG improve firm performance across data providers	Overall positive link but strength depends on provider and approach	Publication selection and data divergence
Foley et al. [46]	Global with focus on large corporates	Narrative with sector cases energy and food	Conceptual ethics policy analysis	Why trust in ESG eroded and how to fix	Frameworks fine practice ethics weak just transition ethics can rebuild credibility	Conceptual no causal estimates
Wen et al. [18]	Cross country firm level	Multi region panel firm years not stated here	Panel regression with interaction on CSR mandate	Does disclosure quality raise value and expand ESG investing	Higher Tobin Q higher ROA lower downside risk stronger where CSR is mandatory	Disclosure scoring and comparability limits
Assaf et al. [47]	France retail investors	Survey of retail investors sample reported in paper	Factor analysis and regression	Does a single ESG score match retail preferences	Five attitude clusters one score often uninformative willingness to pay differs across clusters	External validity beyond France
Cao et al. [44]	China banking sector	Chinese banks multi year	Stochastic frontier analysis with fintech moderator	Does ESG improve bank profit efficiency and does fintech help	ESG increases efficiency E and G drive gains S reduces efficiency fintech strengthens relation	Prioritize E and G in bank ESG plans pair with fintech to harvest efficiency
Zhang et al. [42]	China equity market	Pre and post 2016 policy event	Portfolio sorts and stock level tests	Do policy guidelines lift ESG performance	Post 2016 high ESG earns higher abnormal returns pre 2016 not evident gains tied to equity cost advantage	Short window and data limits
Zhang et al. [43]	China equity market	Cross section sector split	Portfolio and stock regressions	Shape of ESG return link across sectors	Nonlinear relation both high and low ESG can outperform governance and social predict returns	Use sector aware ESG tilts and watch pillar tradeoffs

Authors	Setting or Region	Sample and Period	Method	Main Question	Key Findings	Limitations
Wang et al. [51]	China macro	Annual data 1990 to 2021	ARDL bounds testing	Do ESG investments cut GHG emissions	in opposite ways sector dependent One percent ESG rise reduces GHG by one point three nine percent short term and zero point zero zero four six percent long term	Link ESG finance with climate policy tracking and digital infra
Zhang and Yang [53]	Theoretical with empirical implications	Model based no fixed sample	Continuous time contract theory with carbon credits	Can ESG incentives improve contract efficiency	ESG investing enhances contract efficiency stronger when emission cuts larger or cost lower raises optimal investment to capital ratios	Tie pay to auditable ESG outcomes and credible carbon markets
Zhu et al. [45]	China manufacturing firms	Two thousand ten to two thousand twenty two	System GMM and fixed effects	Which board traits raise ESG investment and how financing moderates	Board independence sustainability committee gender diversity managerial ownership and meeting frequency positive CEO duality board size foreign nationals and high pay negative financing decisions moderate effects	
Liu et al. [50]	China multi market	Long sample with focus years two thousand thirteen and two thousand twenty events	TVP VAR and DY spillover indices	Does ESG reduce cross market spillovers	Using ESG index lowers total directional and pairwise spillovers overall index near thirteen percent but volatile around stress dates	Use ESG indices to anchor long horizon allocation reduce contagion risk
Goldstein et al. [40]	Theoretical with market implications	Model based	Rational expectations equilibrium	How do mixed preferences affect price informativeness	More green investors and better ESG information can reduce price informativeness and raise capital cost due to opposing trades on same news	Balance transparency with mechanisms that preserve price discovery

Authors	Setting or Region	Sample and Period	Method	Main Question	Key Findings	Limitations
Bagh et al. [52]	United States listed firms	One thousand seven hundred seventy one firms two thousand six to two thousand twenty one	System GMM	Can ESG engagement offset climate risk on value	Climate risk lowers value ESG engagement raises value and moderates the negative effect results robust	
Baid and Jayaraman [54]	Global supply chains	Conceptual with practice cases	Framework development and review	How to quantify and finance social outcomes in supply chains	Social metrics can be translated to quantitative indicators to guide financing decisions and compliance	Build measurable S indicators into supplier finance covenants
Wang [49]	Fund level market	Micro data on fund holdings and ESG	Panel models flow performance sensitivity liquidity timing	Does ESG reduce vulnerability of funds	Better ESG lowers vulnerability raises liquidity weakens flow performance sensitivity effects stronger with lower network centrality and strong liquidity timing dual carbon policy strengthens effect	Use ESG strength to buffer flow shocks and sustain strategy
Seifert et al. [48]	Austria with retail investors and public sample	Two thousand two hundred fifty four participants	Randomized information experiment	Which information moves ESG investing and does elicitation mode matter	Either financial return info or ESG impact info increases ESG investment both together no extra lift elicitation mode has no effect on decisions or satisfaction	

4. ESG Reporting: From Transparency Narratives to Measurable Sustainability Performance

4.1. ESG Reporting: Introduction

Environmental, Social, and Governance (ESG) reporting has evolved from voluntary goodwill disclosure into a central element of corporate governance and sustainable investment. Over time, it has been shaped by multiple frameworks, regulations, and societal expectations, creating a complex landscape where transparency, accountability, and impact often compete. Despite the growing adoption of ESG reporting worldwide, questions remain about its credibility, standardization, and ability to translate disclosure into measurable sustainability outcomes. Recent reviews of the field reveal persistent misalignments between the quantity and the quality of ESG information and the actual performance improvements it claims to support (Pande and Mishra [55])

4.2. Evolution and Standardization of ESG Reporting

The history of ESG disclosure mirrors the increasing demand from investors for non-financial information. As sustainability became a financial priority, multiple frameworks such as GRI, SASB, and TCFD emerged to harmonize environmental and social reporting. These frameworks improved comparability across firms but also created a trade-off between standardized simplicity and meaningful depth of data. Bose [56] pointed out that standardized, easily collected data is often less valuable for investment insights than nuanced, complex information obtained through deeper analysis and expertise.

In recent years, regulatory bodies have moved to unify and strengthen disclosure regimes. The EU's Corporate Sustainability Reporting Directive (CSRD) and the IFRS Foundation's integration of the VRF and CDSB under a single global standard (Foltin and Holtzblatt [57]) mark a shift from voluntary initiatives toward mandatory, harmonized ESG reporting. Frade and Froumouh [58] observed that such policy moves aim not only to improve disclosure quality but also to build investor confidence through cross-border comparability and verification. Figure 14 shows key drivers shaping the evolution of ESG disclosure, highlighting investor demand, framework development, data standardization challenges, regulatory integration, and improvements in disclosure quality and investor confidence.

4.3. Quantity, Quality, and the ESG–Performance Gap

While disclosure levels have risen globally, improvements in ESG performance are less evident. A study of Swedish multinational firms revealed that although the quality of ESG reporting steadily increased, actual corporate performance plateaued after 2015 (Arvidsson and Dumay [59]). This finding highlights the persistent disconnect between reporting sophistication and real environmental or social progress. The authors argue that policymakers and firms must shift their attention from reporting for compliance toward generating measurable sustainability outcomes.



Figure 14. Evolution of ESG reporting.

Similar concerns arise in accounting and finance contexts, where ESG reporting is both a transparency instrument and a signaling mechanism. As noted by Raghavan [60], companies use ESG reports to meet stakeholder demands and demonstrate commitment to ethical and responsible management. However, when ESG reports become tools of public relations rather than instruments of accountability, their strategic value weakens.

4.4. Frameworks, Measurement, and Theoretical Insights

Several researchers have proposed new systems to address inconsistencies in ESG metrics. Kaplan and Ramanna [61] argued that existing frameworks often double-count emissions across supply chains, leading to unreliable performance data. They introduced a comprehensive accounting-based model for greenhouse gas reporting that transfers emissions accurately across production and distribution chains. Such precision, they argue, is essential for restoring the reliability of ESG information.

From a theoretical standpoint, Friedman et al. [62] developed a model explaining how investors interpret ESG disclosures when pricing firms. They found that ESG reports emphasizing outcomes rather than inputs tend to trigger stronger investor reactions and generate higher firm value. Reports that integrate both financial and non-financial dimensions produce more credible signals, encouraging genuine ESG improvements over symbolic gestures.

4.5. Governance, Verification, and Policy Influence

Verification mechanisms remain central to the credibility of ESG disclosures. In Japan, firms given the choice between process- and content-focused verification disclosed substantially more information when adopting content-based assurance (Darnall et al. [63]). The study revealed that global reporting guidelines emphasizing process verification might inadvertently discourage deeper and more meaningful disclosure.

Regulatory developments in Europe further demonstrate the power of policy in shaping corporate behavior. Following the European Union's Directive 2014/95, firms exhibited reduced "ESG decoupling" — a gap between symbolic disclosure and actual practice. Aboud et al. [64] found that mandatory reporting requirements promote alignment between what firms disclose and what they implement, although the strength of national enforcement did not significantly alter the results.

4.6. ESG Reporting and Market Impact

Beyond regulation, ESG disclosure affects how investors, auditors, and rating agencies interpret corporate sustainability. Evidence from Kimbrough et al. [65] suggests that voluntary ESG reports can reduce disagreement among rating agencies, particularly when supported by third-party attestations or advanced adherence to GRI standards. Conversely, overly positive or vague disclosures tend to amplify disagreement and uncertainty in capital markets. Another layer of motivation comes from risk management. Murphy and McGrath [66] observed that companies may use ESG reporting as a deterrent strategy against class-action lawsuits, seeking legal and reputational protection. This pragmatic view extends ESG reporting beyond ethics and legitimacy theory toward deterrence and avoidance theory, suggesting that firms disclose not only to build trust but also to reduce exposure to litigation.

4.7. Reporting, Carbon Mitigation, and Environmental Outcomes

Despite the growing prevalence of ESG reports, their tangible environmental benefits remain inconsistent. Luo and Tang [67] found that generic ESG reporting alone does not directly lead to carbon mitigation. However, firms adopting Global Reporting Initiative (GRI) standards show stronger emission reductions, particularly in countries with weak institutional frameworks. This suggests that standardized ESG frameworks can partially substitute for regulatory enforcement in advancing environmental performance.

4.8. Expanding ESG to Public Governance

While ESG reporting is often framed within corporate settings, governments are beginning to adopt similar practices. Research by Gu et al. [68] proposed integrating ESG reporting into smart city governance. By using real-time mobility data from New York City, they demonstrated how municipal ESG metrics can enhance transparency and policy design. This broadens the ESG discourse from private-sector responsibility to public-sector accountability and inter-governmental collaboration. Figure 15 illustrates the interaction between government ESG reporting, smart city data, and physical world implementation layers that collectively strengthen social, economic, and environmental resilience.

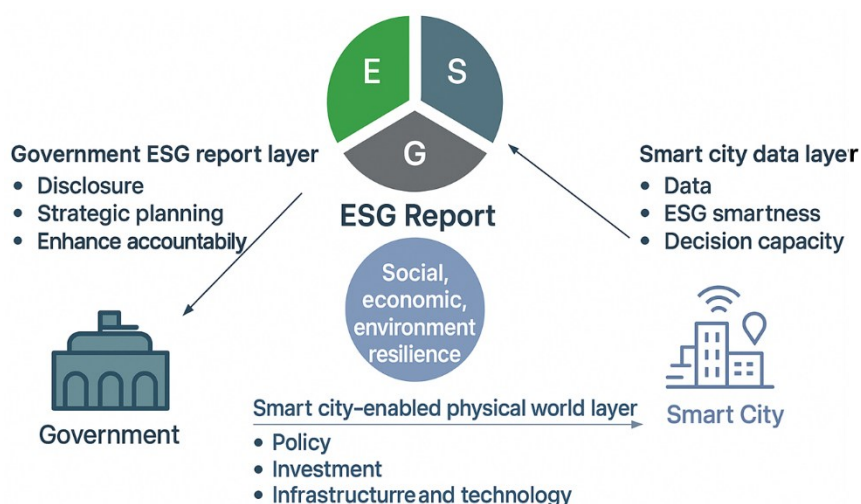


Figure 15. Conceptual framework linking government ESG reports and smart city data systems, reproduced from [68].

4.9. Challenges, Benefits, and Future Research Directions

The benefits of ESG reporting — transparency, accountability, stakeholder engagement, and ethical conduct — are well recognized, yet implementation challenges persist. Data inconsistency, lack of standardization, and limited verification frameworks undermine trust. Aziz and Alshdaifat [69] highlighted that integrating emerging technologies such as artificial intelligence and blockchain could enhance data accuracy and traceability.

Looking ahead, Chopra et al. [70] emphasized the need for interdisciplinary expertise under the Social and Environmental Accounting (SEA) framework to make ESG reporting more holistic and reflective of actual sustainability outcomes. Meanwhile, Pande and Mishra's large-scale review identified emerging research themes such as ownership structure, tax avoidance, and investor behavior as new frontiers in ESG research. Figure 16 depicts the dynamic relationship between firms and investors in ESG reporting, showing how financial accounting and ESG assessment drive informed decisions, effective capital allocation, and improved eco-social outcomes.

4.10. ESG Reporting: Brief Summary

ESG reporting has matured from fragmented disclosure practices into a structured global system integrating financial, environmental, and social dimensions. Yet, the field remains in transition — balancing standardization and flexibility, compliance and performance, transparency and impact. The literature reveals that while regulatory interventions and standardized frameworks have improved disclosure comparability, the translation of ESG narratives into real sustainability progress is far from complete. Future research must focus on the interplay between institutional design, data verification, and investor behavior. The challenge is to ensure that ESG reporting evolves not merely as a reflection of compliance but as a catalyst for genuine environmental and social transformation.

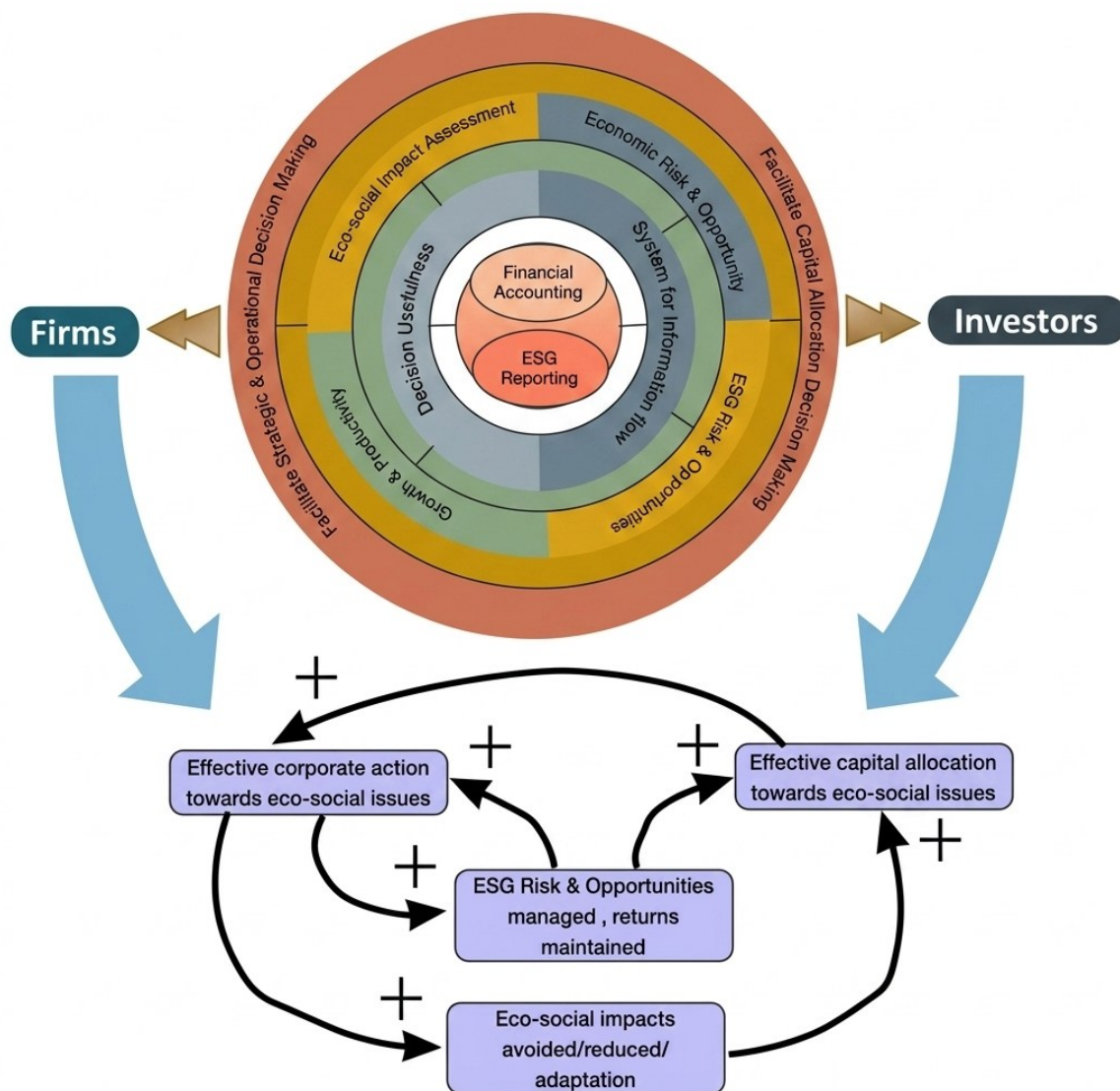


Figure 16. Integrated ESG reporting framework, reproduced from [70].

Table 7 shows the comprehensive table summarizing ESG Reporting studies. The table summarizes major ESG reporting studies spanning 2021–2025. The works collectively map the evolution of ESG disclosure from voluntary narratives toward regulated, standardized, and performance-oriented systems. They demonstrate four key academic trends:

1. Shift from quantity to quality — better disclosure standards do not always lead to improved ESG outcomes.
2. Regulation and standardization — mandatory directives and IFRS unification drive global convergence.
3. Verification and credibility — content-based assurance, third-party attestation, and digital transparency improve trust.
4. Broadening scope — ESG now extends beyond corporate boards to governments and smart cities, reinforcing the need for interdisciplinary policy frameworks.

Table 7. Summary of key studies on ESG reporting: Evolution, quality, regulation, and impact.

Author(s)	Focus/Scope	Dataset or Method	Theoretical/ Analytical Lens	Key Findings	Policy or Practical Implications	Identified Limitations
Arvidsson & Dumay [59]	Examines ESG report quantity, quality, and performance among Swedish MNCs	Sustainalytics, corporateregister.com, Alliance for Corporate Transparency	Comparative performance analysis	ESG report quality improved but performance stagnated since 2015	Policy focus should shift from reporting enhancement to performance improvement	Study limited to Swedish context
Raghavan [60]	Reviews ESG reporting as an accounting and finance transparency tool	Conceptual review, industry examples	Stakeholder and legitimacy theory	ESG reporting enhances transparency, improves stakeholder value	Encourages inclusion of accountants in ESG frameworks	Lacks empirical validation
Kaplan & Ramanna [61]	Develops accounting-based model for GHG emission reporting	Conceptual framework	Measurement and accountability theory	Proposes eliminating double-counting in GHG data	Improves credibility and auditability of ESG data	Focused mainly on environmental metrics
Bose [56]	Traces the development of ESG reporting frameworks	Literature review	Institutional evolution theory	Standardization improves comparability but reduces strategic differentiation	Need for balance between framework simplicity and data richness	Conceptual without empirical data
Chopra et al. [70]	Explores ESG reporting challenges and link to SDGs	Conceptual discussion, SEA framework	Social and Environmental Accounting (SEA)	ESG reporting should integrate interdisciplinary expertise	Proposes SEA to bridge sustainability gaps	No quantitative validation
Darnall et al. [63]	Compares process vs. content verification in ESG reporting (Japan)	Empirical, firm-level reports	Institutional theory, verification typology	Content-focused verification yields 23% more disclosure than process-based	Supports content verification as global best practice	Japan-only context
Friedman et al. [62]	Builds theoretical model on ESG reporting's market effects	Formal modeling	Agency theory and signaling	ESG reports aligned with investor preferences boost firm value and ESG outcomes	Integrate ESG with financial reporting for better alignment	Model assumptions idealized
Aziz & Alshdaifat [69]	Discusses benefits, challenges, and future of ESG reporting	Review of practices across industries	Stakeholder and sustainability performance theory	ESG improves transparency and accountability; AI and blockchain can enhance reliability	Recommends tech integration in reporting	Conceptual, lacks quantitative testing

Author(s)	Focus/Scope	Dataset or Method	Theoretical/ Analytical Lens	Key Findings	Policy or Practical Implications	Identified Limitations
Kimbrough et al. [65]	Examines link between voluntary ESG reports and rating agency disagreement	Empirical, US firms, textual analysis	Information asymmetry theory	Voluntary ESG reports reduce rating disagreement; third-party assurance increases credibility	Encourages independent attestation in ESG reporting	US-only sample
Murphy & McGrath [66]	Investigates motivations behind ESG reporting	Conceptual	Deterrence and avoidance theory	ESG disclosure used to mitigate legal and reputational risks	Recognizes ESG as legal deterrence mechanism	No empirical validation
Pande & Mishra [55]	Synthesizes 2,864 ESG research papers (1975–2025)	Structural Topic Modeling (STM)	Stimulus–Organism–Response (SOR)	Identifies 20 major ESG research themes and emerging topics	Informs future ESG research and policy alignment	Limited to Scopus database
Luo & Tang [67]	Tests if ESG reporting affects carbon mitigation	Regression, global sample	Institutional and environmental economics	General ESG reporting has no effect, but GRI adherence improves carbon reduction	GRI standards act as substitute for weak climate regulation	Limited causality analysis
Gu et al. [68]	Expands ESG reporting to government level	Smart city case analysis (New York)	Public governance and data transparency	Smart cities can use ESG reporting to improve accountability	Encourages data-driven municipal ESG disclosure	Lacks multi-country validation
Aboud et al. [64]	Studies EU Directive impact on ESG decoupling	Diff-in-Diff, 3020 firm-year data	Compliance and enforcement theory	Mandated ESG disclosure reduces decoupling; enforcement strength non-significant	Demonstrates positive impact of regulation	Limited to EU-US comparison
Foltin and Holtzblatt [57]	Explains IFRS Foundation's unified ESG standards	Policy commentary	Accounting standards development	Global unification of ESG frameworks under IFRS improves investor trust	Accelerates global alignment for sustainability reporting	Commentary rather than empirical
Frade & Froumouh [58]	Reviews regulatory developments and mandatory ESG disclosure	Regulatory review	Institutional and compliance theory	Transition from voluntary to mandatory ESG reporting enhances comparability and trust	Regulatory clarity needed beyond climate focus	Limited cross-regional data

5. Conclusion and Future Research Directions

5.1. Conclusion

This review consolidates four major dimensions of Environmental, Social, and Governance (ESG) research—ESG disclosure, ESG rating, ESG investing, and ESG reporting—into a unified analytical framework. The literature consistently shows that ESG disclosure enhances transparency, reduces information asymmetry, and strengthens firm legitimacy. Empirical studies demonstrate that firms with high-quality ESG disclosure achieve superior profitability, lower cost of capital, and greater investment efficiency. However, quantity alone is insufficient; the credibility and standardization of ESG information determine its value. Mandatory ESG disclosure frameworks, particularly in Europe, Hong Kong, and the UAE, have proven effective in improving comparability and governance outcomes.

The evidence on ESG rating reveals a structural challenge: divergence among rating agencies undermines consistency, investor trust, and market efficiency. Despite this, ESG ratings function as powerful governance and signaling tools, driving real corporate change in innovation, risk management, and productivity. Regulatory efforts such as the EU Taxonomy and the International Sustainability Standards Board (ISSB) initiatives are vital steps toward convergence and reliability in ESG assessment.

ESG investing continues to expand globally, integrating financial performance with social and environmental outcomes. High-quality ESG data increase investor confidence, promote long-termism, and support systemic financial stability. However, heterogeneity in investor preferences and the persistence of greenwashing practices highlight the need for stronger ethical standards and regulatory oversight.

ESG reporting represents the institutional backbone of sustainability governance. The transition from voluntary to standardized frameworks—such as GRI, SASB, and the CSRD—has improved transparency and comparability but has yet to guarantee tangible performance outcomes. Integrating Industry 5.0 technologies such as blockchain, AI, and IoT offers promising solutions for enhancing data traceability, verification, and real-time disclosure authenticity.

5.2. Future Research Directions

The reviewed literature identifies several critical gaps and emerging opportunities:

1. Cross-country comparative analysis linking ESG disclosure regimes, economic growth, and firm-level innovation remains limited, especially in emerging economies.
2. Digital ESG reporting and Industry 5.0 integration require deeper empirical study to assess how AI, blockchain, and IoT improve ESG data accuracy and reduce greenwashing.
3. Unified ESG disclosure and rating frameworks must be developed to address persistent rating divergence and data inconsistency across providers.

4. Behavioral and institutional analysis is needed to explore how cultural context, governance structures, and investor behavior shape ESG effectiveness.
5. Policy-level studies should define optimal disclosure intensity, balancing transparency benefits with resource allocation efficiency, especially in developing nations.
6. Causal identification methods such as quasi-experiments and textual or machine-learning models should be applied to measure ESG's real economic and environmental impact.

Overall, future ESG research should focus on bridging the gap between reporting and performance by integrating regulatory design, data science, and behavioral insights. The convergence of ESG disclosure, ESG rating, ESG investing, and ESG reporting will determine the credibility and effectiveness of global sustainable finance in the coming decade.

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.

Acknowledgements/Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

CRedit Authorship Contribution Statement

I.V.: Conceptualization, Methodology, Supervision, Writing – original draft.

A.T.: Data curation, Investigation, Formal analysis, Writing – original draft.

A.H.: Validation, Visualization, Formal analysis.

S.G.H.: Methodology, Resources, Writing – review & editing.

E.O.: Investigation, Project administration.

M.S.: Supervision, Writing – review & editing.

All authors have read and agreed to the published version of the manuscript.

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