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Rethinking ESG Cost Accounting under Carbon Regulation: Toward an Integrated Model of Recognition, Measurement, and Reporting

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Abstract: The accelerating transition toward low-carbon development has intensified the need for enterprises to treat environmental, social, and governance (ESG) costs as material financial items rather than discretionary disclosures. However, existing studies often conceptualize ESG costs qualitatively, lack standardized recognition principles, and offer limited empirical evidence on how carbon policy pressures shape accounting practices. To address these gaps, this paper develops an integrated framework for ESG cost accounting under carbon regulation, linking recognition, measurement, and reporting through a three-layer model encompassing institutional pressures, organizational strategies, and micro-level accounting practices. Methodologically, the study employs a combination of literature review, cross-jurisdictional comparison, and multiple case studies of ArcelorMittal, Shell, and Heidelberg Materials during 2023-2025, drawing on corporate reports, regulatory filings, and assurance statements. Findings indicate that firms are increasingly embedding ESG costs into financial reporting, albeit with divergent recognition approaches, hybrid measurement models that combine historical cost and scenario-based fair value, and evolving assurance practices. These results contribute to academic debates by reconciling conservatism with forward-looking relevance, while offering practical guidance for firms, regulators, and auditors to enhance transparency, comparability, and credibility in ESG cost accounting.

Keywords: ESG cost accounting; carbon regulation; recognition; measurement; reporting; case study

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1. Introduction

The accelerating global transition toward low-carbon development has placed unprecedented emphasis on the role of enterprises in addressing environmental, social, and governance (ESG) responsibilities [1]. Carbon-oriented policies, such as the European Union's Carbon Border Adjustment Mechanism (CBAM), the International Sustainability Standards Board's IFRS S2 on climate-related disclosures, and China's national carbon market expansion since 2021, have heightened the financial consequences of corporate carbon emissions [2]. These regulatory developments have elevated ESG costs from discretionary expenditures to material items affecting firms' profitability, risk exposure, and long-term valuation. Consequently, the accounting treatment of ESG costs has become a critical issue, necessitating rigorous frameworks for recognition, measurement, and reporting that satisfy both compliance requirements and stakeholders' information needs [3].

Despite the rapid growth of ESG research, several gaps persist. First, prior studies often focus narrowly on carbon disclosure or environmental accounting, treating ESG costs primarily as qualitative narratives rather than quantifiable financial items [4]. For instance, sustainability reports frequently emphasize emissions reduction targets or corporate social responsibility initiatives but rarely establish standardized recognition principles akin to conventional financial accounting. Second, existing models of carbon cost accounting typically adopt either a regulatory compliance perspective or a voluntary disclosure approach, with limited integration across environmental, social, and governance dimensions. Third, while international frameworks such as the Global Reporting Initiative (GRI) and the Task Force on Climate-Related Financial Disclosures (TCFD) have improved comparability, they remain largely guidance-oriented, leaving firms substantial discretion that undermines consistency and reliability [5]. These limitations highlight the absence of a unified model capable of translating ESG costs into measurable accounting figures aligned with carbon policy imperatives.

This paper addresses these shortcomings by reconceptualizing ESG cost accounting under carbon regulation and developing an integrated framework for recognition, measurement, and reporting. The study makes three key contributions. First, it frames ESG costs as both compliance-driven obligations (e.g., carbon taxes, emission allowances) and opportunity-driven investments (e.g., green innovation, supply chain adaptation), thereby expanding the scope of recognition. Second, it introduces a hybrid measurement model that combines market-based pricing, scenario simulation, and probabilistic adjustments to manage uncertainty and valuation challenges. Third, it proposes a three-layer reporting model that integrates ESG disclosures with traditional financial statements, enhancing both transparency and decision usefulness. Collectively, these contributions refine theoretical understanding and provide practical mechanisms to operationalize ESG cost accounting in carbon-constrained economies.

Methodologically, the study employs a mixed-method approach. A systematic literature review synthesizes existing theories in environmental accounting, sustainability reporting, and institutional regulation. Cross-jurisdictional comparisons highlight how regulatory environments shape accounting practices. Most critically, multiple case studies analyze corporate disclosures from 2023 to 2025, including ArcelorMittal's carbon cost provisions under the EU CBAM, Heidelberg Materials' decarbonization cost accounting, and Shell's treatment of climate-related reserves. These cases empirically test the feasibility and robustness of the proposed framework.

The significance of this research is twofold. Academically, it enriches the literature on ESG and carbon accounting by offering an integrated perspective that bridges regulatory compliance, financial reporting, and sustainability disclosure. Practically, it equips enterprises, auditors, and regulators with actionable guidance to improve the transparency and comparability of ESG cost information, thereby enhancing capital market efficiency and stakeholder trust. In the broader context of global climate governance, the proposed framework may serve as a reference for harmonizing accounting practices across jurisdictions, contributing to a more consistent and accountable ESG reporting landscape.

2. Literature Review

2.1. Carbon and Environmental Accounting for Cost Recognition

Research on carbon and environmental accounting has consistently highlighted the limitations of traditional financial systems in capturing sustainability-related costs. Early studies emphasized that many environmental and carbon-related expenditures are treated as externalities and, as a result, are often excluded from corporate accounting statements [6]. More recent scholarship has sought to develop operational recognition frameworks that integrate carbon costs into corporate accounts, particularly in the context of emerging carbon markets and evolving regulatory instruments [7]. A key point of con-

tention concerns the accounting treatment of such expenditures: should they be recognized as liabilities, recorded as immediate expenses, or capitalized as assets that generate long-term benefits? Another area of divergence lies in measurement approaches: one school of thought favors historical-cost methods that prioritize objectivity and verifiability, while another advocate fair-value or scenario-based models that better capture the forward-looking nature of carbon risk exposure [8]. These debates indicate that, despite notable advances, the field still lacks consensus on recognition principles capable of accommodating both regulatory pressures and corporate strategic responses.

2.2. ESG Disclosure, Assurance, and Reporting Frameworks

A second stream of research focuses on disclosure and assurance mechanisms aimed at making ESG information more accessible and reliable for stakeholders [9]. Much of this literature has examined the trade-offs between voluntary reporting frameworks and mandatory disclosure regimes, highlighting the tension between flexibility and comparability. Studies on assurance practices indicate that external verification can enhance the credibility of ESG information, yet the scope and rigor of such assurance remain highly variable. Another enduring debate contrasts standalone sustainability reports with integrated reporting models. Proponents of standalone reports argue that they provide greater visibility and facilitate stakeholder engagement, whereas advocates of integrated reporting emphasize the advantages of consistency and alignment with financial statements [10]. Despite these advances, a critical gap persists: much of the disclosure and assurance literature treats ESG information as a collection of narrative descriptions or metrics, without sufficiently linking it to the underlying accounting recognition and measurement processes that determine its reliability and comparability.

2.3. Financial Impacts and Valuation of ESG Costs

The third body of literature investigates how ESG practices affect financial performance, particularly regarding capital costs, risk premiums, and firm valuation. Evidence suggests that companies engaging in substantive ESG initiatives often enjoy lower costs of debt or equity, primarily due to reduced risk perceptions among investors and creditors [11]. However, findings across different markets and methodological approaches remain inconsistent, indicating that these effects are highly context-dependent. Importantly, much of this research evaluates ESG performance from the standpoint of external market outcomes, rather than examining the internal accounting mechanisms that generate ESG cost figures [12]. Consequently, the causal link between the accounting recognition of ESG costs and financial valuation outcomes remains underexplored. Without robust accounting foundations, capital market assessments of ESG activities risk being based on inconsistent or non-comparable inputs.

2.4. Comparative Perspectives and Theoretical Gaps

Across these three streams, two theoretical divides are particularly salient. The first concerns the tension between discretion and obligation: some frameworks portray ESG accounting as largely voluntary and motivated by corporate reputation, whereas others emphasize that increasingly stringent carbon regulations require mandatory recognition and disclosure [13]. The second divide relates to the choice of measurement base: traditional approaches favor conservative, historical-cost accounting for its verifiability, while reformist perspectives advocate forward-looking fair-value models that better capture anticipated risks and opportunities [14]. Despite substantial scholarly contributions, the literature remains fragmented. No widely accepted model currently integrates the recognition, measurement, and reporting of ESG costs into a coherent system aligned with carbon policy imperatives. Moreover, empirical, case-based evidence linking recognition practices, disclosure behaviors, and financial outcomes is limited-particularly in light of post-2023 policy developments, including cross-border carbon adjustment mechanisms and ex-

panding carbon trading systems [15]. This paper seeks to address these gaps by developing an integrated framework that unites recognition principles, measurement techniques, and reporting structures, and empirically tests it against contemporary corporate practices across diverse regulatory environments [16].

3. Theoretical Framework and Methodology

3.1. Theoretical Framework

This paper is grounded in a hybrid theoretical foundation that integrates institutional theory, stakeholder theory, and the risk-cost mapping model, which links carbon risk exposure to accounting cost recognition [17]. Institutional theory explains how carbon policy regimes—such as emissions trading systems and carbon border adjustment mechanisms—create formal regulatory pressures that push firms toward standardized accounting treatment of ESG costs [18]. Stakeholder theory highlights the informational demands of investors, regulators, and civil society, emphasizing the need for transparency and accountability. The risk-cost mapping approach provides a microfoundation, connecting specific carbon risks—compliance costs, regulatory uncertainty, and technology-related risks—to decisions regarding cost recognition, measurement, and reporting.

Building on this foundation, we propose a three-layer analytical model:

1. **Macro / Institutional Layer:** Captures external regulatory pressures, including carbon markets, carbon border taxes, and mandatory disclosure mandates.
2. **Mesoscale / Organizational Layer:** Examines how firm governance, internal carbon pricing, and strategic choices mediate these external pressures into concrete accounting practices.
3. **Micro / Accounting Layer:** Focuses on the recognition, measurement, and reporting of ESG costs in financial statements and sustainability reports.

The model posits that under strong regulatory pressure, ESG costs shift from voluntary disclosures to quasi-mandatory accounting entries. Firms must then navigate trade-offs between relevance and reliability, discretion and conservatism, and comparability and flexibility. By integrating these three layers, the framework seeks to ensure consistency: recognized costs should accurately reflect the firm's carbon risk exposures and strategic responses, while disclosures should align with and inform stakeholder expectations.

3.2. Research Methods

To operationalize the proposed theoretical framework, this study employs a combination of multiple case study methodology, textual and content analysis, and comparative cross-jurisdictional analysis. This mixed-methods approach captures both the depth of firm-level practices and the breadth of regulatory contexts, ensuring that the resulting model is both empirically grounded and theoretically robust.

The multiple case study approach focuses on firms from carbon-intensive sectors whose disclosures between 2023 and 2025 demonstrate proactive responses to carbon regulation. Three focal cases are selected: ArcelorMittal in the steel industry, Shell plc in the energy sector, and Heidelberg Materials in the cement industry. Each company operates across multiple jurisdictions, faces substantial regulatory pressures, and has implemented extensive sustainability strategies. ArcelorMittal provides evidence through decarbonization investments, delays in hydrogen-based steel projects, and product-level greenhouse gas (GHG) pilot disclosures. Shell contributes insights via its governance of climate assurance, impairment charges under scenario analysis, and responses to climate litigation. Heidelberg Materials illustrates the accounting implications of large-scale low-carbon investments, including carbon capture and storage (CCS) projects and fuel substitution, which pose complex challenges for the recognition and valuation of long-term green expenditures. Collectively, these cases offer complementary perspectives for evaluating ESG cost accounting under carbon policy.

Textual and content analysis is applied to annual reports, ESG and sustainability reports, investor disclosures, regulatory filings, and judicial or policy documents. These texts are systematically coded to identify how firms recognize ESG cost elements, specify recognition criteria, and present measurement assumptions such as discount rates, fair-value adjustments, and scenario sensitivities. Special attention is given to assurance and third-party validation, which enhance credibility with stakeholders. By analyzing both quantitative disclosures and qualitative narratives, this method uncovers the embedded logic linking accounting treatment to reporting practices.

Comparative cross-jurisdictional analysis highlights how diverse regulatory environments shape accounting practices. The firms operate under heterogeneous regimes, ranging from the European Union's carbon border adjustment mechanism (CBAM) to national emissions trading systems in China, and litigation-driven requirements in the United States. Comparing these contexts reveals how disclosure and recognition practices vary under different pressures, providing insights into the adaptability and generalizability of the proposed framework, and illustrating the influence of regulatory environments on accounting behavior.

The methodological flow and case selection are summarized in Table 1, which outlines the main features of each firm, their carbon policy pressures, disclosed ESG cost items, and the observed challenges in recognition and measurement.

Table 1. Case Comparison Overview.

Case / Firm	Industry	Key Carbon Policy Pressure	Key ESG Cost Items / Disclosures	Observed Accounting / Recognition Challenges
ArcelorMittal	Steel	EU decarbonization, CBAM, national ETS	Investments in hydrogen-DRI, product-level GHG pilot, delays in projects	Ambiguity in product-capitalization vs expense; uncertainty in project success
Shell plc	Energy	Climate litigation, mandatory disclosure regimes	Impairments related to unused facilities, scenario stress tests	Discretion in fair-value impairment; sensitivity to scenario assumptions
Heidelberg Materials	Cement	EU ETS, CBAM, low-carbon building material rules	CCS investments, fuel substitution projects	Recognition of long-term green investments; measurement of uncertain payoffs

Through this comparative overview, the study evaluates how firms navigate recognition boundaries among liabilities, expenses, and assets, how they disclose measurement assumptions with differing levels of transparency, and how they employ assurance or external validation to bolster credibility. By triangulating evidence from case studies, textual analysis, and cross-jurisdictional comparison, the research establishes a robust empirical foundation for refining and empirically testing the proposed integrated framework of ESG cost accounting under carbon regulation.

3.3. Case Selection Rationale and Process

The selection of ArcelorMittal, Shell plc, and Heidelberg Materials is guided by their relevance to carbon policy and the material significance of their ESG costs. These firms operate in highly carbon-intensive sectors—steel, energy, and cement—that are directly targeted by global decarbonization initiatives. Their exposure to regulatory mechanisms such as the EU Emissions Trading System (EU ETS), the Carbon Border Adjustment Mechanism (CBAM), and climate-related litigation ensures that ESG costs are central, rather than peripheral, to both corporate strategy and financial reporting.

Another rationale for their selection is the quality of disclosure. All three companies publish detailed annual and sustainability reports documenting climate strategies, carbon-related investments, and financial provisions. The presence of assurance statements further enhances the credibility and reliability of these materials. Moreover, their global

operations provide regulatory diversity: ArcelorMittal and Heidelberg Materials are embedded primarily in EU policy regimes, whereas Shell operates across both EU and U.S. contexts. This mix allows for meaningful comparison of recognition and reporting practices under heterogeneous regulatory pressures.

The research process followed three steps. First, firms were screened for comprehensive disclosures covering the 2023-2025 period. Second, relevant documents-including annual reports, ESG and sustainability statements, investor presentations, and regulatory filings-were collected and systematically coded using a recognition-measurement-reporting framework. Third, within-case analyses traced how regulatory pressures translated into accounting choices, followed by cross-case comparison to identify patterns, commonalities, and divergences. This structured approach ensures both empirical richness and analytical rigor.

3.4. Validity, Reliability, and Limitations

Validity was strengthened through the triangulation of multiple sources, including corporate disclosures, regulatory documents, and assurance reports. Coding categories were piloted and refined to ensure consistent interpretation of recognition boundaries and measurement assumptions. Reliability was further supported by clear documentation of coding rules and audit trails, allowing replication by other researchers.

External validity was addressed by selecting firms across different industries and jurisdictions, ensuring that insights extend beyond a single case. While the qualitative design does not aim for statistical generalization, the cross-case logic supports analytical generalization, rendering the findings relevant for firms operating under diverse carbon regimes.

Nonetheless, certain limitations remain. Public disclosures may understate internal accounting practices, and large multinationals may not fully represent smaller firms with limited resources. Additionally, evolving standards-such as new ISSB guidelines or national regulations introduced after 2025-may alter recognition and reporting requirements.

Despite these constraints, the methodology provides a robust foundation for theory development. By combining carefully selected cases, systematic textual analysis, and cross-jurisdictional comparison, the study generates findings that are empirically credible, conceptually grounded, and practically relevant.

4. Findings and Discussion

4.1. Recognition of ESG Costs under Carbon Regulation

The analysis of the three case studies demonstrates that carbon policy pressures have fundamentally reshaped the boundaries of ESG cost recognition. **ArcelorMittal** illustrates how firms in heavy industry must navigate the ambiguity between capitalized investments and expensed items. Its hydrogen-based direct reduced iron (DRI) projects, for example, involve substantial upfront costs with uncertain long-term returns. The company's selective disclosure of pilot project expenditures-without full capitalization-highlights the balance it must strike between signaling decarbonization commitments strategically and exercising prudence in managing uncertain project outcomes.

Shell, in contrast, addresses the recognition challenge primarily through asset impairments. Its disclosures of write-downs linked to climate scenario stress tests indicate that litigation and mandatory disclosure regimes compel firms to recognize ESG-related risks as impairments, thereby embedding them into financial statements.

Heidelberg Materials presents yet another perspective: its carbon capture and storage (CCS) and alternative fuel investments are framed as long-term green assets, but their accounting treatment remains contested. Whether such expenditures should be classified as tangible fixed assets or as research and development outlays continues to be unresolved.

Table 2 summarizes the recognition approaches observed across the three cases, highlighting both commonalities and divergences in ESG cost accounting under carbon policy pressures.

Table 2. Recognition Approaches across Case Firms.

Firm	Recognition Practices	Observed Challenges
ArcelorMittal	Selective capitalization of decarbonization investments alongside expensing of pilot projects	Balancing strategic signaling of green commitments with prudence in uncertain project outcomes
Shell plc	Impairment charges linked to climate scenarios	Subjectivity in scenario choice; litigation pressure
Heidelberg Materials	Capitalization of CCS and alternative fuels as long-term assets	Ambiguity in asset classification; uncertain payoffs

The findings confirm that ESG costs are no longer treated as voluntary or peripheral expenditures but are increasingly recognized as central accounting items. Nevertheless, divergences across firms indicate that standard-setting remains fragmented, posing challenges to comparability.

4.2. Measurement Models and Valuation Assumptions

A second key finding concerns the measurement of ESG costs. The cases reveal that firms employ hybrid approaches combining historical cost and forward-looking valuation. ArcelorMittal reports project expenditures based on incurred costs while supplementing these with scenario-based forecasts of hydrogen technology viability. Shell applies probability-weighted scenarios, disclosing sensitivities to assumptions such as oil prices, discount rates, and policy pathways. Heidelberg Materials incorporates projected abatement costs into its valuation of CCS investments, although uncertainty regarding technological success complicates fair-value measurement.

These practices partially align with the forward-looking school of accounting, which advocates fair-value methods and scenario analysis, yet firms continue to rely heavily on historical costs for verifiability. This dual approach exemplifies what may be termed a "hybrid measurement model," wherein conservative recognition principles are complemented by supplementary disclosures of scenario-based risks. Figure 1 illustrates the hybrid measurement continuum observed in the cases.



Figure 1. Hybrid Measurement Continuum.

This continuum underscores both innovation and inconsistency: although firms tailor measurement practices to carbon policy contexts, the lack of standardized guidance preserves discretionary judgment, which may undermine comparability.

4.3. Reporting and Assurance Practices

Reporting practices across the cases reveal a growing integration of ESG cost information into mainstream financial disclosures. ArcelorMittal publishes standalone sustainability reports while supplementing them with product-level greenhouse gas disclosures in its annual filings, signaling a gradual move toward integration. Shell embeds climate scenario disclosures directly into its financial statements, particularly within impairment notes, illustrating a deeper incorporation of ESG considerations into core accounting. Hei-

delberg Materials relies primarily on integrated reporting, combining financial and sustainability information in a single document, thereby offering a comprehensive view of cost recognition and long-term investment implications.

A notable feature across all three firms is the role of assurance. Each company employs third-party validation to enhance credibility, although the scope varies: Shell emphasizes verification of scenario methodologies, while Heidelberg focuses on the accuracy of emissions data. These practices suggest that assurance functions as a bridge between qualitative narratives and quantitative accounting figures, addressing stakeholder demands for reliability. Table 3 provides a comparative overview of reporting and assurance practices.

Table 3. Reporting and Assurance Practices.

Firm	Reporting Mode	Assurance Scope	Firm
ArcelorMittal	Standalone ESG + selective integration	Verification of GHG metrics, pilot projects	ArcelorMittal
Shell plc	Integrated financial + ESG disclosures	Scenario methodology and impairment validation	Shell plc
Heidelberg Materials	Fully integrated reporting	Emissions verification, CCS disclosure assurance	Heidelberg Materials

These findings indicate that, despite variations in reporting practices, a common trend toward integration is emerging, driven by stakeholder demand for decision-useful information.

4.4. Comparative Insights and Theoretical Implications

Comparative analysis of the cases reveals two key insights. First, the choice of recognition and measurement practices is strongly path-dependent on regulatory context. EU-based firms (ArcelorMittal and Heidelberg Materials) emphasize capitalizing green investments to align with EU sustainability taxonomies, whereas Shell, operating under both U.S. and European litigation pressures, prioritizes impairment recognition as a risk management strategy. This divergence reflects the distinct institutional environments in which the firms operate: EU taxonomy frameworks incentivize the capitalization of green assets, while U.S. litigation encourages more conservative recognition through impairments.

Second, assurance practices evolve in tandem with disclosure integration: the greater the embedding of ESG costs into financial statements, the more firms rely on third-party assurance to enhance credibility.

From a theoretical standpoint, these findings support the validity of the three-layer framework proposed in this study. At the macro level, institutional pressures—such as CBAM and litigation—trigger recognition decisions. At the organizational level, firms adapt strategies in response to industry characteristics and governance priorities. At the micro level, accounting entries exhibit hybrid approaches that balance conservative recognition with forward-looking relevance. Figure 2 maps these findings onto the proposed theoretical framework, illustrating the alignment between regulatory pressures, organizational adaptation, and accounting practices.

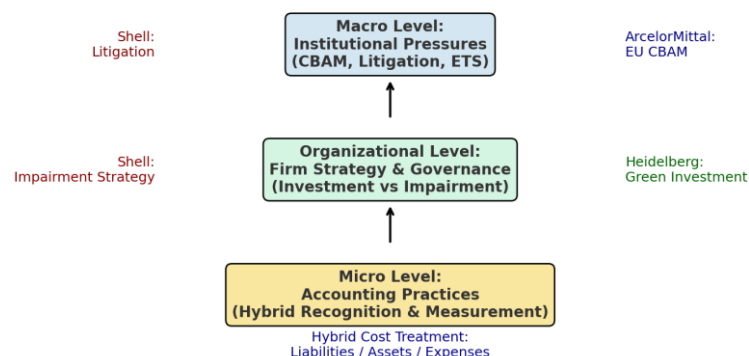


Figure 2. Empirical Mapping of the Three-Layer Framework.

This mapping illustrates how the theoretical framework accounts for real-world variations in ESG cost accounting, thereby reinforcing its explanatory power.

4.5. Contribution, Innovation, and Comparison with Prior Research

These findings contribute to the literature in several important ways. First, they provide empirical evidence that ESG costs are shifting from voluntary disclosures to formally recognized accounting items—a transition long anticipated but rarely documented in prior studies. Second, the identification of hybrid measurement models represents a methodological innovation, reconciling traditional historical-cost approaches with the forward-looking valuation advocated by reformist scholars. Third, the analysis demonstrates that assurance is not merely symbolic but serves as a crucial mechanism for enhancing credibility when ESG costs are integrated into financial reporting.

In contrast to previous research, which often treated ESG disclosure as narrative or symbolic, these cases illustrate a substantive incorporation of ESG costs into accounting systems. Unlike earlier studies that examined environmental reporting in isolation, this study integrates recognition, measurement, and reporting dimensions, offering a holistic perspective. Moreover, the cross-jurisdictional comparison underscores regulatory diversity as a key determinant of accounting practices—a factor frequently underemphasized in prior work.

4.6. Practical and Policy Implications

The findings have several implications for practice and policy. For firms, adopting hybrid measurement models and ensuring comprehensive assurance coverage are critical for enhancing both credibility and comparability. For regulators, the observed divergence across cases highlights the need for harmonized guidance on ESG cost recognition and measurement, aimed at reducing discretionary judgment. For investors, awareness of the hybrid nature of ESG cost reporting can improve the assessment of firm risk exposures and long-term value creation. At a systemic level, these findings lend support to ongoing initiatives by standard-setting bodies to integrate ESG disclosures into financial reporting frameworks, thereby promoting the global convergence of sustainability and financial accounting.

5. Conclusion

This study examined how enterprises in carbon-intensive industries recognize, measure, and report ESG costs under the evolving pressures of carbon policies. By integrating institutional, stakeholder, and risk-cost perspectives, it developed a three-layer framework linking macro-level policy triggers, organizational strategies, and micro-level accounting practices. Through multiple case studies of ArcelorMittal, Shell, and Heidelberg

Materials, the research demonstrated that ESG costs are no longer peripheral but are increasingly embedded in financial reporting, albeit with divergent recognition approaches, hybrid measurement models, and varying degrees of disclosure integration.

The primary contribution lies in empirically showing how ESG cost accounting is shaped by regulatory contexts and organizational strategies, thereby addressing a gap in the literature that has often treated recognition, measurement, and reporting as isolated dimensions. The identification of hybrid measurement models and the expanding role of assurance practices further advance theoretical debates on balancing conservatism with forward-looking relevance in sustainability accounting.

From a practical perspective, the findings underscore the importance of harmonizing recognition rules, standardizing measurement guidance, and strengthening assurance mechanisms to enhance comparability and reliability. Regulators can leverage these insights to refine disclosure frameworks, while firms can apply the proposed model to improve internal consistency and stakeholder credibility.

Future research should broaden the empirical base by including smaller firms, emerging markets, and additional industries. Longitudinal studies could also trace how accounting practices evolve as new standards, such as those issued by the ISSB, become mandatory. Such work will enable scholars and practitioners to better understand how ESG cost accounting contributes not only to corporate decision-making but also to global climate governance.

References

1. J. Liu, S. Lau, S. S. Liu, and Y. Hu, "How firm's commitment to ESG drives green and low-carbon transition: A longitudinal case study from hang lung properties," *Sustainability*, vol. 16, no. 2, p. 711, 2024. doi: 10.3390/su16020711
2. F. Clora, W. Yu, and E. Corong, "Alternative carbon border adjustment mechanisms in the European Union and international responses: aggregate and within-coalition results," *Energy Policy*, vol. 174, p. 113454, 2023. doi: 10.1016/j.enpol.2023.113454
3. M. B. Dasinapa, "The integration of sustainability and ESG accounting into corporate reporting practices," *Advances in Applied Accounting Research*, vol. 2, no. 1, pp. 13-25, 2024. doi: 10.60079/aaar.v2i1.167
4. C. Del Gesso, and R. N. Lodhi, "Theories underlying environmental, social and governance (ESG) disclosure: a systematic review of accounting studies," *Journal of Accounting Literature*, vol. 47, no. 2, pp. 433-461, 2025. doi: 10.1108/jal-08-2023-0143
5. Y. K. Tumewang, C. G. Ntim, and F. Haque, "Task Force on ClimateRelated Financial Disclosures: A Systematic Literature Review and Future Research Agenda," *Business Strategy and the Environment*, 2025. doi: 10.1002/bse.70112
6. J. Wang and P. Wang, "Research on the path of enterprise strategic transformation under the background of enterprise reform," in *Mod. Econ. Manag. Forum*, vol. 6, no. 3, pp. 462-464, 2025, doi: 10.32629/memf.v6i3.4035.
7. M. A. Syam, S. Djaddang, A. Adam, E. E. Merawati, and M. Roziq, "Carbon accounting: Its implications on accounting practices and corporate sustainability reports," *International Journal of Economics and Financial Issues*, vol. 14, no. 4, p. 178, 2024.
8. N. C. Onat, J. Mandouri, M. Kucukvar, A. A. Kutty, and A. A. Al - Muftah, "Driving Sustainable Business Practices With Carbon Accounting and Reporting: A Holistic Framework and Empirical Analysis," *Corporate Social Responsibility and Environmental Management*, vol. 32, no. 2, pp. 2795-2814, 2025. doi: 10.1002/csr.3096
9. D. West, and D. Euler, "Back to the Future: The Impact Valuation of Net Zero Transition Plans," *Available at SSRN 4684976*, 2024. doi: 10.2139/ssrn.4684976
10. L. Yun, "Analyzing credit risk management in the digital age: Challenges and solutions," *Economics and Management Innovation*, vol. 2, no. 2, pp. 81-92, 2025, doi: 10.71222/ps8sw070.
11. O. Boiral, M. C. Brotherton, and D. Talbot, "What you see is what you get? Building confidence in ESG disclosures for sustainable finance through external assurance," *Business Ethics, the Environment & Responsibility*, vol. 33, no. 4, pp. 617-632, 2024.
12. A. Caglio, and P. Quattrone, "Sustainability Reporting and the Digital Stakeholder: The drive for greater sustainability disclosure brings with it major challenges as businesses face increasing demand from stakeholders," *Strategic Finance*, vol. 105, no. 5, pp. 37-46, 2023.
13. X. Luo, "Reshaping coordination efficiency in the textile supply chain through intelligent scheduling technologies," *Economics and Management Innovation*, vol. 2, no. 4, pp. 1-9, 2025, doi: 10.71222/ww35bp29.
14. Y. Zhao, Y. Gao, and D. Hong, "Sustainable innovation and economic resilience: Deciphering ESG ratings' role in lowering debt financing costs," *Journal of the Knowledge Economy*, vol. 16, no. 1, pp. 4309-4343, 2025. doi: 10.1007/s13132-024-02129-y
15. W. K. Wong, B. H. Teh, and T. S. Hooi, "The influence of external stakeholders on environmental, social, and governance (ESG) reporting: Toward a conceptual framework for ESG disclosure," *Foresight and STI Governance*, vol. 17, 2023.

16. W. Cai, M. Bai, and H. Davey, "Mandatory environmental disclosure policy in the largest carbon emission country," *Pacific Accounting Review*, vol. 36, no. 5, pp. 527-560, 2024. doi: 10.1108/par-04-2023-0055
17. A. R. Ayeni-Agbaje, O. D. Adesina, and A. I. Adebayo, "Assessment of fair value measurement for financial reporting in industrial manufacturing firms in Nigeria," *The Journal of Accounting and Management*, vol. 14, no. 3, pp. 26-41, 2024.
18. P. E. Stek, R. Lima - de - Oliveira, and T. Vasudhevan, "The Development of Carbon Markets in UpperMiddleIncome Countries," *Regulation & Governance*, vol. 19, no. 2, pp. 482-495, 2025. doi: 10.1111/rego.70010

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