

Carbon Cost Accounting Model for the Indonesian Cement Industry

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Abstract

This study develops a carbon cost accounting model tailored to the Indonesian cement industry, a sector that represents one of the nation's largest industrial contributors to CO₂ emissions. While Indonesia introduced a carbon tax in 2022, its effective implementation has been constrained by the lack of clear technical guidelines for integrating carbon costs into corporate accounting systems. Drawing upon environmental management accounting, legitimacy theory, stakeholder theory, and the triple bottom line framework, this research proposes a structured model to identify, measure, and allocate carbon-related costs—namely emission allowances, carbon taxes, and abatement costs—within financial reporting. Using a mixed-methods approach that combines qualitative insights from industry practitioners with quantitative analysis of economic and sustainability data, the model addresses critical gaps in current practices, enhances transparency, and supports regulatory compliance. Beyond compliance, it provides a strategic tool for improving resource efficiency, reducing emissions, and strengthening competitiveness in a carbon-constrained economy. Ultimately, the proposed framework seeks to empower Indonesian cement companies to better manage their environmental impact, align with global sustainability targets, and enhance long-term economic resilience.

Key words: Carbon cost accounting, Cement industry, Carbon tax, Sustainability, Indonesia.

INTRODUCTION

Climate change has become one of the most pressing global issues of the 21st century. In response, many countries have introduced carbon pricing mechanisms such as carbon taxes and emission trading systems, particularly within high-emission sectors like cement

manufacturing. For example, the European Union and China have mandated carbon markets to drive emission reductions and encourage the adoption of greener production technologies. Such initiatives aim to internalize the external costs of carbon emissions, thereby incentivizing industries to invest in sustainable practices and technologies (Chu et al., 2024). In Indonesia, a carbon tax was officially introduced in 2022, signifying a commitment to mitigating climate change and aligning with global efforts (Trijayanto & Hakam, 2025). However, its implementation has been hindered by the absence of clear technical guidelines, particularly in integrating carbon costs into corporate accounting systems. Cement companies, among the country's largest industrial contributors to carbon emissions, often lack systematic approaches to assess and allocate carbon-related costs, resulting in inefficiencies in compliance and strategic planning. The academic literature reveals a research gap: while studies on environmental accounting and carbon cost allocation exist, few have focused on industry-specific models tailored to cement production (Ige et al., 2024). This raises critical questions regarding the development of effective carbon cost accounting models, the identification of relevant carbon cost components, and the facilitation of efficient regulatory compliance within the Indonesian cement industry (Pratama et al., 2025). This study seeks to address these questions by identifying key cost components, developing a practical accounting model, and providing policy recommendations to support the industry's transition toward sustainability. This comprehensive approach is essential for enabling cement manufacturers to accurately quantify their environmental impact and integrate these metrics into financial reporting, ultimately enhancing both environmental and economic performance (Christine et al., 2019; Mondal et al., 2024). Recognizing these challenges, this paper proposes a structured framework for carbon cost accounting specifically designed for the Indonesian cement sector, focusing on granular cost identification and allocation methodologies. This model aims to provide a robust mechanism for companies to manage their carbon footprints, comply with emerging regulations, and ultimately improve their financial performance in the context of a carbon-constrained economy (Tuesta et al., 2020; Kuncoro et al., 2025).

LITERATURE ANALYSIS AND METHODOLOGY

Extending traditional financial reporting to encompass environmental and social performance has become increasingly critical for achieving comprehensive sustainability reporting (Zhen & Rahman, 2024). Green Accounting, in particular, explicitly incorporates environmental costs into financial statements, thereby enabling transparent communication of a company's environmental impact to stakeholders and supporting the evaluation of conservation effectiveness (Anggita et al., 2022; Andi et al., 2020). This approach not only

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identifies, quantifies, and measures environmental contributions within business processes but also provides a long-term strategy for cost efficiency through the reduction of operational burdens (Anggita et al., 2022). Moreover, legitimacy theory emphasizes that aligning corporate values with societal expectations regarding environmental responsibility is essential for maintaining a company's social license to operate and ensuring its long-term sustainability (Anggita et al., 2022).

These theoretical foundations collectively underpin the necessity for robust carbon accounting frameworks, particularly given international accords like the Kyoto Protocol, which commit nations to greenhouse gas emission reductions and necessitate effective policies for environmental management in high-polluting sectors (Darlis et al., 2024). The literature has also seen a recent surge in carbon accounting research, examining carbon disclosure, management, performance, and assurance, thereby emerging as a distinct discipline (He et al., 2021). Despite this growth, challenges persist in accurately measuring external costs and benefits of industrial processes within green accounting frameworks, particularly in developing countries such as Indonesia (Andi et al., 2020) (Widyastuti, 2024). This gap is further complicated by the voluntary nature of carbon emission disclosure practices in many regions, including Indonesia, where companies often refer to international protocols for carbon footprint calculation without a standardized national mandate (Anggita et al., 2022). This disparity highlights the urgent need for a standardized approach that specifically addresses the intricacies of carbon cost allocation within industries like cement manufacturing (Hartmann et al., 2013) (Anggraini & Kusuma, 2024) (Anggita et al., 2022). Consequently, integrating robust carbon accounting practices into corporate frameworks is essential for enhancing corporate value and stakeholder confidence (Anggita et al., 2022; Darlis et al., 2024). This is particularly relevant for high-emission sectors, where effective carbon management practices can significantly influence investor perceptions and market valuation by demonstrating a commitment to sustainability and regulatory compliance (Alexander, 2022; Anggita et al., 2022; Darlis et al., 2024). However, current corporate carbon disclosures often lack consistency and technical detail, indicating a need for more streamlined application and approaches to carbon accounting (Ganu & Amo, 2020). Legitimacy theory suggests that companies must align their actions with societal norms and values to gain and maintain societal approval, making transparent carbon accounting critical for stakeholder engagement and corporate sustainability (Darlis et al., 2024). Furthermore, the integration of carbon accounting within an organization is influenced by several factors, including stakeholder collaboration and the company's internal capabilities for environmental management (Kasbun & Ong, 2021). Nevertheless, despite the growing recognition of green accounting's importance, a substantial number of firms, particularly in

Southeast Asia, still lack the requisite knowledge and capabilities to effectively implement these practices (Darlis et al., 2024). This deficiency underscores the need for practical frameworks that bridge the gap between theoretical environmental accounting principles and their concrete application within industrial settings, especially for carbon-intensive sectors (Bazhair et al., 2022). This study proposes to develop such a framework, specifically tailored for the Indonesian cement industry, to facilitate comprehensive carbon cost integration into corporate accounting systems. This framework will address the current fragmentation in carbon accounting standards and methodologies, which often leads to inconsistent reporting and complicates comparative analysis across companies (McDonald et al., 2024).

METHODOLOGY

This study adopts a mixed-methods approach that integrates quantitative analysis of financial and operational data with qualitative insights from industry experts to develop a comprehensive carbon cost accounting model for the Indonesian cement sector. The research specifically examines the influence of environmental management accounting, environmental strategies, and managerial commitment on both environmental and economic performance, particularly within small and medium-sized enterprises. In addition, it emphasizes the importance of integrating carbon cost components into financial reporting to strengthen strategic decision-making, ensure transparency, and support regulatory compliance, drawing on international environmental accounting frameworks.

Research Sites and Sample

Research sites will be selected from Indonesian cement companies with diverse levels of carbon pricing exposure and technological maturity, enabling comparative analysis of accounting practices. The sample will include companies with both nascent and advanced carbon management accounting systems, allowing for a comprehensive assessment of how variations in practice impact environmental and financial performance. This stratified sampling strategy ensures the identification of best practices as well as challenges in carbon cost allocation and disclosure.

Data Sources

Primary data will be collected through semi-structured interviews with accounting managers, sustainability officers, and senior management, supported by internal documents such as carbon emission reports, environmental management records, and financial statements. Secondary data, including annual and sustainability reports from publicly listed

cement companies, will also be analyzed to gather quantitative evidence on environmental costs, carbon disclosures, and financial performance. This triangulation of data sources enhances both the reliability and validity of the findings.

Data Collection

Interviews will explore methodologies for identifying, measuring, and allocating carbon costs, as well as the challenges of integrating such costs into existing accounting systems. Conducted in Bahasa Indonesia, each interview will last approximately one hour, recorded digitally, and transcribed verbatim for rigorous thematic analysis. Confidentiality will be ensured by anonymizing participants. Secondary data will be systematically gathered to assess the reliability and completeness of carbon-related disclosures, with attention to whether firms use precise primary data or rely on industry averages.

Analytical Techniques

Qualitative data will undergo thematic analysis using an inductive approach, allowing themes to emerge from the data itself. Quantitative data will be analyzed using descriptive statistics and regression models to examine correlations between carbon emissions, environmental expenditures, and financial outcomes. Additionally, Artificial Intelligence (AI) and Natural Language Processing (NLP) will be applied to extract insights from unstructured data, while machine learning algorithms will predict future carbon costs based on historical trends and regulatory developments.

Final Objective

The methodology aims to produce a robust and practical carbon cost accounting model tailored to the Indonesian cement industry. The findings are expected to provide evidence-based recommendations for policymakers in refining carbon pricing mechanisms, while offering companies a structured framework for integrating carbon costs into financial reporting. Ultimately, this study contributes to advancing green accounting practices, improving corporate transparency, and accelerating the transition toward a low-carbon economy.

RESEARCH AND RESULTS

The study identifies the critical carbon cost components within the Indonesian cement sector and presents a structured accounting model designed to improve regulatory compliance, corporate transparency, and decision-making. By synthesizing qualitative insights from industry interviews and quantitative analyses of financial and sustainability

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reports, the research highlights discrepancies between perceived and actual carbon costs and their strategic implications (Pinckaers et al., 2024; Adelakun et al., 2024).

Advanced analytics, particularly AI-driven reporting tools, are shown to significantly enhance the accuracy and timeliness of disclosures, strengthening governance and improving corporate decision-making (Awad et al., 2025). The integration of large language models (LLMs) further demonstrates potential in automating the analysis of financial and narrative data, uncovering patterns, and generating comprehensive sustainability reports (Toumeh, 2024). This innovation also addresses regulatory lag in AI adoption, ensuring that financial reporting keeps pace with technological change (Simatupang, 2024).

Ultimately, the proposed model provides a structured framework for the identification, measurement, and valuation of carbon costs, ensuring consistency with environmental cost accounting principles. It aligns corporate practices with stakeholder expectations, thereby strengthening legitimacy, accountability, and competitiveness (Adhariani & Sciulli, 2020).

Emission Sources and Measurement Challenges

Cement production is one of the most carbon-intensive industries, with emissions stemming primarily from clinker production, purchased electricity, fuel combustion, and raw material transport (Guidolin et al., 2024; Roston et al., 2023). These direct and indirect emissions contribute between 5–8% of global CO₂ emissions, a figure projected to rise by 4% by 2050, especially in emerging economies (Khaiyum et al., 2023; Kumar et al., 2025). Accurate measurement remains a challenge due to data gaps, incomplete monitoring systems, and reliance on regional averages. These methodological shortcomings can undermine credibility and weaken emission reduction strategies. Advanced sensor technologies, real-time monitoring, and predictive analytics are therefore essential for reliable measurement and reporting (Cement Production in Iran: An Integrated Risk Assessment, n.d.; Khaiyum et al., 2023).

Valuation and Accounting for Carbon Costs

Assigning monetary value to carbon emissions presents further challenges, particularly as many environmental impacts lack explicit market prices. This study emphasizes the adoption of internal carbon pricing, shadow pricing, and other economic valuation methods to translate environmental externalities into measurable financial terms (Ige et al., 2024). Such a valuation not only supports decarbonization investment but also embeds environmental costs into strategic financial planning.

However, inconsistencies across carbon accounting standards such as the Greenhouse Gas Protocol and ISO guidelines make cross-company comparisons difficult, highlighting the need for harmonized frameworks to improve transparency and comparability (McDonald et al., 2024).

Model development

The proposed carbon cost accounting model offers explicit guidance on classifying, measuring, and valuing carbon emissions, incorporating Scope 1, 2, and 3 emissions. It integrates predictive modeling and advanced attribution techniques to isolate cement-related emissions from other industrial or natural sources (Guidolin et al., 2024). The model also accounts for regulatory mechanisms such as emission allowances, carbon taxes, and abatement costs, which together form the total carbon cost impacting profitability and competitiveness.

This structured approach provides a comprehensive and adaptable framework that encourages cement companies to integrate carbon costs into operational and financial systems. By quantifying emissions and associated costs, the model supports the transition toward carbon neutrality while offering strategic insights for competitive positioning.

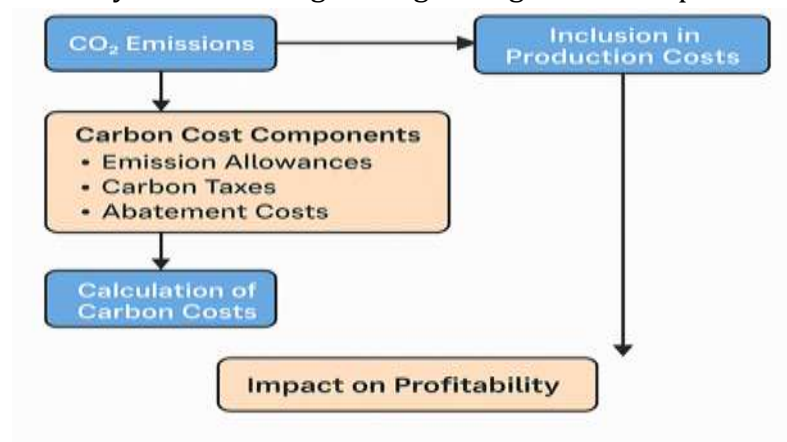


Figure 1. Carbon Cost Model For the Cement Industry

Impacts of Implementation

The implementation of this model extends beyond compliance to deliver tangible operational and financial benefits. Companies adopting robust carbon cost accounting can improve resource efficiency, reduce energy consumption, foster low-carbon innovations, and strengthen stakeholder trust (Ibishova et al., 2024). Enhanced transparency not only

meets regulatory and societal demands but also attracts sustainability-focused investors and unlocks market opportunities for eco-labeled products (Mondal et al., 2024).

By embedding carbon costs into strategic planning, cement producers can better anticipate sustainability risks, manage financial liabilities, and improve corporate resilience. Moreover, systemic adoption of this model can catalyze industry-wide transformation, promoting decarbonization while enhancing corporate reputation and access to green financing (Schaltegger & Csutora, 2012).

DISCUSSION

The research situates its findings within the Triple Bottom Line (TBL) framework, which broadens corporate success beyond financial performance to include environmental and social dimensions. For high-emission industries like cement manufacturing, this framework is particularly relevant, as it aligns sustainability practices with long-term viability and community acceptance (Pan et al., 2023; Tseng et al., 2020).

While TBL has faced criticism for its vagueness and lack of standardized metrics (Nunhes et al., 2020), its evolution into a more integrated model underscores its utility in guiding corporate decision-making. By considering the interconnectedness of profit, people, and planet, companies can identify opportunities for innovation such as low-carbon cement alternatives and circular economy practices thereby enhancing resilience and competitive positioning (Nogueira et al., 2025).

In essence, the findings reaffirm the importance of adopting integrated sustainability frameworks, such as TBL, to balance corporate objectives with societal and environmental responsibilities. This holistic perspective not only improves reporting quality but also drives long-term strategic transformation in carbon-intensive industries.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates that a **comprehensive carbon cost accounting model** is both feasible and necessary for the Indonesian cement industry. By integrating advanced analytics, robust measurement systems, and valuation methodologies, the model addresses current gaps in carbon reporting, ensures regulatory compliance, and enhances corporate decision-making. Its alignment with stakeholder theory and TBL principles provides a strong foundation for improving transparency, accountability, and competitiveness in a carbon-constrained global economy.

The recommendations of this study emphasize the need for multi-level action to strengthen carbon cost accounting in the Indonesian cement industry. For cement companies, the adoption of a structured carbon cost accounting model is essential to systematically

identify, measure, and value emissions, supported by advanced monitoring technologies and data analytics to ensure accurate and timely reporting. Strengthening corporate governance and implementing internal carbon pricing strategies will further enhance accountability and incentivize low-carbon innovation. For policymakers and regulators, the priority lies in developing standardized guidelines harmonized with global frameworks, providing fiscal and financial incentives for carbon reduction investments, and establishing robust verification mechanisms to improve the credibility of disclosures. Industry associations and stakeholders are encouraged to facilitate knowledge-sharing platforms, promote best practices, and foster collaborative initiatives to address Scope 3 emissions and supply chain sustainability. Finally, future research should explore real-time monitoring technologies, conduct cross-industry comparisons, and assess the long-term impacts of carbon accounting practices on firm value, investor perceptions, and competitiveness. Collectively, these recommendations provide a roadmap for advancing transparency, accountability, and sustainability in the cement sector while aligning with broader low-carbon economy goals.

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