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A BLOCKCHAIN-BASED TOKEN INCENTIVE MECHANISM FOR ESG IN THE CONSTRUCTION INDUSTRY

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Abstract

This paper proposes a blockchain-based token incentive mechanism that aims to reward stakeholders in construction industries for their environmental, social, and governance (ESG) performance. The mechanism aims to address the transparency and consistency in existing ESG frameworks , while encouraging the adoption of sustainable practices. By providing an objective and transparent method for recognizing and rewarding stakeholders' ESG performance, this mechanism incentivizes them to enhance their ESG efforts through appealing rewards. Furthermore, it promotes sustainable building practices by encouraging the use of renewable energy sources, recycling of construction waste, and the application of energy-efficient building materials.

Keywords: Blockchain, ESG, Incentive mechanism, Construction industry

Introduction

The third decade of the 21st century is crucial for our planet, as we confront unprecedented challenges, including climate change, natural resource depletion, and significant social inequality (Gillan et al., 2021). In response to these challenges, an increasing number of companies, regulatory bodies, investors, and environmental advocacy organizations are turning to a new form of corporate disclosure known as Environmental, Social, and Governance (ESG). ESG analysis aims to evaluate and enhance companies' and organizations' sustainability and societal impact, including identifying and addressing environmental and social risks, measuring performance and progress in these areas, and promoting overall corporate responsibility (Van Duuren et al., 2016).

ESG has become an increasingly mainstream consideration for companies, investors, and other stakeholders. Governments and regulatory bodies have begun introducing regulations and guidelines requiring companies to disclose their ESG performance and risks (Li et al., 2021). Moreover, ESG can assist investors and other stakeholders in assessing an organization's long-term sustainability and its impact on society, enabling them to make more informed investment decisions and ultimately creating a more sustainable and responsible economy (Giese et al., 2019).

However, current ESG frameworks suffer from a lack of transparency and consistency in reporting (Singhania and Saini, 2021). Companies may employ different metrics or disclose information in varying ways, making it challenging for investors and other stakeholders to compare and evaluate performance (Giese and Lee, 2019). Moreover, the accuracy and reliability of the provided information are often questioned. Blockchain technology has the potential to address this issue of trust by providing a secure and transparent means of recording and tracking ESG data (Liu et al., 2021). The immutable nature of blockchain technology ensures that ESG data cannot be altered or tampered with, thus increasing transparency and trust in the data.

Furthermore, blockchain-based platforms can be used to develop standardized metrics and reporting guidelines, which can help ensure consistency across stakeholders (Sulkowski, 2021). Additionally, the application of smart contracts on a blockchain platform can also be utilized to automate the calculation of ESG metrics, further increasing the accuracy and reliability of the data (Rabbani et al., 2021).

Incentivizing stakeholders to prioritize ESG considerations is a growing area of interest, and blockchain-based token incentive models are increasingly being explored to achieve this goal (Jiang et al., 2022). Blockchain technology can be leveraged to create tokens representing a company's ESG performance. By linking a company's ESG performance to the value of its tokens, stakeholders are motivated to prioritize ESG considerations to increase the value of their tokens and attract more investors (Park and Li, 2021). Additionally, token holders can be incentivized to hold the tokens through distributing rewards, such as dividends, providing access to exclusive products and services, or even granting voting rights on important company decisions. This approach aligns the interests of stakeholders and investors with those of society and the environment (Mugurusi and Ahishakiye, 2022).

The construction industry has recently recognized the significance of ESG factors in operations. Nevertheless, the adoption of ESG token incentive mechanisms to enhance performance and attract investors has been limited (Hadro et al., 2021). The limitation can be attributed to various factors including, but not limited to, a lack of understanding of the concept and potential benefits of ESG tokens, an absence of clear guidelines and regulations for their implementation, and the cost and effort required for integrating ESG tokens into existing systems and processes, which may be perceived as too high, particularly for small and medium-sized enterprises. Furthermore, the competitive nature of the industry and the lack of demand for ESG-compliant construction projects from consumers and investors may not make it economically viable for stakeholders to invest in developing ESG tokens (Daszyńska-Żygadło et al., 2022).

In this study, we aim to design a blockchain-based token incentive mechanism for ESG in the construction industry. We will establish a set of performance indicators for ESG and use them to design a smart contract system. Through this system, the token issuance and incentive mechanism will be developed. This approach is expected to increase standardization, consistency, and transparency in ESG reporting and metrics and to enhance the understanding and awareness of the potential benefits of ESG token incentive mechanisms in the construction industry.

Related work

ESG

As global attention to sustainable development intensifies, the ESG concept has gained increasing prominence in business and investment. The development and promotion of ESG have been supported by a multitude of stakeholders, including investors, regulatory bodies, and environmental organizations. ESG analysis aims to consider economic, social, and environmental objectives when assessing corporate performance, thereby contributing to sustainable development. As depicted in Figure 1, the ESG framework encompasses three key areas: environmental factors, such as a company's impact on climate change and natural resources; social factors, including issues related to human rights, labor practices, and community relations; and governance factors, which pertain to a company's management structure, transparency, and accountability (Friede et al., 2015).

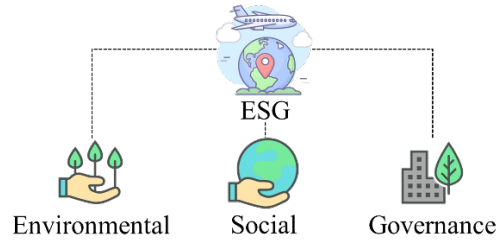

Figure 1: Data structure of a blockchain

In recent years, the financial and investment sectors have shown a growing interest in using ESG analysis to evaluate stakeholders' and organizations' sustainability and societal impact. This is due to the increasing recognition that ESG analysis ensures that businesses and organizations focus not only on short-term financial gains but also consider the long-term impacts on the environment, society, and governance (Giese et al., 2019). Specifically, environmental aspects encompass carbon emissions, ecosystem protection, and pollutant emissions; social aspects involve fairness, diversity, and inclusivity in employee treatment; and governance aspects include the independence of corporate governance, shareholder rights protection, and ethical conduct.

A study conducted by Morgan Stanley Capital International, an investment research firm, found that stakeholders with strong ESG practices had higher returns on equity and lower volatility than those with weaker ESG practices (Giese et al., 2019). Similarly, Hales (2021) discovered that companies with robust ESG practices had lower capital costs, indicating that investors perceive these companies as less risky. Moreover, several studies have explored the relationship between ESG performance and financial performance in the construction industry. Bauer et al. (2011) found that, in the construction and real estate sectors, companies with strong ESG practices had higher returns on assets and equity than those with weaker ESG practices. The study by Mardini (2022) discovered a positive relationship between ESG performance and corporate financial performance, suggesting that companies with strong ESG practices tend to have better financial performance and are more valuable than those with weaker ESG practices.

In the construction sector, ESG evaluation indicators can reflect a building's environmental impact, social impact, and governance structure. Specifically, environmental aspects include energy efficiency, water efficiency, and waste management in buildings; social aspects involve personnel safety, health and welfare, and supply chain management in buildings; and corporate governance aspects encompass board structure, compensation systems, and anti-corruption measures, among others. For instance, some construction projects have significantly reduced carbon emissions by adopting green building technologies and low-carbon materials while improving their social performance by optimizing supply chain management and ensuring employee welfare.

ESG evaluation indicators can help the construction industry measure sustainability goals and provide investors with more information to make informed investment decisions (Daszyńska-Żygadło et al., 2022). However, challenges remain in implementing ESG principles in the construction industry, such as developing appropriate ESG standards, regulatory policies, and technological innovations. Future research could explore ways to overcome these challenges to advance further the adoption of ESG concepts in the construction industry.

In conclusion, the concept of ESG holds significant importance in the construction industry, contributing to achieving sustainability goals. By incorporating ESG principles into building projects' design, construction, and operation stages, the construction industry can enhance its ESG performance, ultimately leading to higher financial returns and social impact.

Blockchain technology in construction

Blockchain technology has emerged as a significant innovation in the construction industry, offering improved transparency, enhanced security, and reduced potential for fraud (Zhao et al., 2022). Since 2017, numerous researchers and consulting firms have identified various use case scenarios for implementing blockchain technology in construction. Hewavitharana et al. (2019) explored how blockchain could address project management challenges in the construction industry, in line with guidelines from the Project Management Body of Knowledge. By utilizing smart construction objects (SCOs) and creating a SCOs-enabled blockchain oracles framework, Lu et al. (2021) provide a novel approach that forms the architecture of a blockchain-enabled construction supply chain management. Based on semi-structured interviews and publicly available information from blockchain and construction supply chain management experts, Qian and Papadonikolaki (2021) investigated the impact of blockchain technology on trust in construction supply chain management using semi-structured interviews and publicly available information from industry experts.

Automation further enhances document processing performance, and blockchain-based smart contracts can effectively replace traditional paper-based contracts, ensuring trust between parties. This technology also provides a highly efficient framework for international collaboration. Notably, blockchain's traceability and immutability features ensure data privacy between parties possessing the key (Ding and Hu, 2022). Given the inherent complexity and distributed nature of construction project management, Zhao et al. (2023) proposed ChainPM as a Blockchain 3.0 paradigm. A pilot study of a modular construction project demonstrated that ChainPM reduced information synchronization delays by 99.2% to 99.8% and maintained effective query and analysis functions even without a network connection.

Token Economics

The token economy is a concept that emerged alongside the advent of blockchain technology, which facilitated the creation and trading of digital tokens on decentralized platforms. The origins of the token economy can be traced back to the launch of Bitcoin in 2009, which was the first decentralized digital currency to utilize blockchain technology (Grinberg, 2012). Since then, numerous digital tokens, including utility and security tokens, have been developed. In recent years, the token economy has been a subject of considerable discussion and research, as experts predict that it will play a significant role in shaping the future of finance and the economy (Wu et al., 2022). Many believe that tokenization will give rise to new financial instruments and markets, potentially having a significant impact on traditional financial institutions and intermediaries.

Token economics explores the creation, distribution, and utilization of tokens in decentralized systems. It emphasizes the importance of aligning incentives between token holders and system users, fostering economic growth and decentralization, generating new forms of value, and synchronizing incentives between users and platform operators (Barreiro-Gomez and Tembine, 2019). The Hercules Supply Chain Blockchain Protocol Whitepaper presents the Hercules Protocol and Platform, explaining token economics, introducing the team, and providing a case study involving AnthemGold (Team, 2018). Tan (2019) investigates the principles of token economics within token ecosystems, with the aim of designing robust incentives for participants, producing stable outcomes, minimizing inefficient allocation, and enhancing transaction efficiency within the ecosystem. To boost profits and transparency for stakeholders, ElMessiry et al. (2019) developed a dual token model that accounts for both the financial aspects and the non-fungible characteristics of complex, real-world businesses.

In the construction sector, companies can also leverage token economics to incentivize and reward employees. For instance, employee tokens can be issued based on performance, safety records, and contributions, thereby increasing motivation and productivity (Gutierrez et al., 2020). Moreover, blockchain technology and token economics can streamline cross-border payments and collaborations within the construction industry. Cryptocurrencies can lower the cost and duration of cross-border remittances, facilitating international cooperation and communication (Liao and Shao, 2021). In summary, token economics can be employed to develop decentralized systems that are more efficient, resilient, and reliable than traditional centralized systems by aligning incentives and fostering collaboration among users.

Methodology

First, this study systematically examines ESG criteria and their potential integration within the construction industry, as well as exploring the application of blockchain technology in this sector. The objective is to identify viable avenues for combining ESG principles with blockchain technology to promote sustainable, efficient, and ethical practices throughout the construction industry. This foundational step paves the way for further research into the synergies between ESG standards and blockchain technology in the construction sector, providing the conceptual basis for designing a blockchain-based incentive mechanism.

The second step consists of two parts: literature review and model conceptualization. The literature review aims

to identify key concepts, theories, and frameworks related to ESG performance, stakeholder involvement, and sustainable development in the construction industry. This process involved a comprehensive search of major academic databases, such as Web of Science, Scopus, and Google Scholar, using relevant keywords like "ESG performance," "incentive mechanism," "sustainable construction," and "stakeholder involvement." A snowball method was employed, in which references and cited works from pertinent articles were examined to discover additional sources not identified during the initial database search. To ensure the relevance and quality of the sources, specific inclusion and exclusion criteria were applied, considering factors such as the article's publication date, the journal's impact factor, and the source's relevance to the research topic. Finally, an in-depth analysis and synthesis of the findings from the selected articles were conducted to identify common themes, trends, and gaps in the existing literature.

The model's conceptualization is based on the literature review and existing frameworks related to ESG performance and stakeholder involvement. First, the key components of ESG performance were be defined, stakeholder involvement, and sustainable development within the construction industry, drawing insights from the literature review. Second, we examine the relationships among these key components, using existing theories and frameworks to establish causal links and interactions. Finally, we integrate the key components and their relationships to create a comprehensive model that captures the complex interplay between ESG performance, stakeholder involvement, and sustainable development in the construction industry.

In the third step, we first define the context by examining the Hong Kong case, where various stakeholders, such as the Construction Industry Council (CIC), Architectural Services Department (ArchSD), and the Housing Department (HD), are embedded in the local appellation. Next, the boundary conditions to ensure the thought experiment's relevance and applicability was established. These conditions encompass the regulatory framework, market dynamics, technological advances, and different levels of stakeholder engagement, all of which could affect the model's outcomes. Furthermore, the strategies and directions set by Hong Kong in ESG and Web 3.0 are also taken into consideration. Finally, to focus on the analysis and maintain the thought experiment's feasibility, we explicitly state the evaluation metrics for ESG and the assumptions of the token economy model. Based on these assumptions, we design reward and incentive mechanisms that align with the model's objectives. This comprehensive thought experiment enables a deeper understanding of the conceptual model's implications in the Hong Kong construction industry.

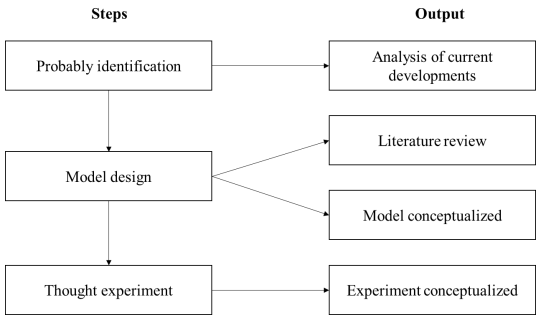

Figure 2 Research methodology in this study

Model design

As shown in Figure 3, implementing an incentive mechanism for ESG stakeholders involves a multi-step process. Initially, stakeholders participate in the mechanism and evaluate their ESG behavior using established performance indicators. A federated chain of stakeholders also ensures that smart contracts can be deployed in a distributed manner. Based on the evaluation results, stakeholders receive tokens as recognition for their efforts in promoting ESG practices. Furthermore, to encourage continued adherence to high ESG standards, additional tokens are distributed to stakeholders exhibiting exceptional performance.

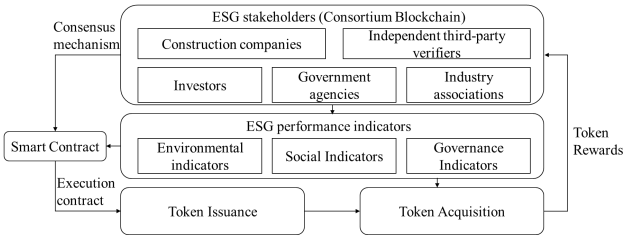

Figure 3: Overall model architecture

ESG stakeholders

Construction companies can serve as the primary participants, as they can be responsible for submitting their sustainability data for verification and demonstrating compliance with established criteria to earn ESG tokens. Adopting the necessary blockchain platform, smart contract, and user interface would also require companies to participate in the mechanism.

Investors in the construction industry, such as venture capitalists and private equity firms, also have a vested interest in the mechanism, as it can allow them to invest in companies that prioritize sustainability. By purchasing ESG tokens from compliant companies, investors can have a tangible metric for assessing a company's sustainability efforts.

Government agencies, such as the HD and ArchSD, can play a key role in the mechanism by verifying that companies are meeting sustainability standards and awarding ESG tokens. They monitor the implementation

and impact of the mechanism, too, to ensure it achieves its goals.

Independent third-party verifiers can be responsible for ensuring the accuracy of the construction companies' sustainability data. Using industry-standard methods, they can evaluate the data and certify that companies meet the established criteria for ESG tokens.

Furthermore, industry associations such as the CIC can promote the mechanism among their members, encourage participation, and provide guidance on best practices and standards for sustainability in the construction industry.

ESG performance indicators

Non-financial key performance indicators (KPIs) are crucial for organizations to comprehensively assess their progress towards sustainability goals. As investors become increasingly cautious about supporting stakeholders that disregard environmental and social performance, they recognize such enterprises as higher risk (Kocmanova et al., 2012). A thorough examination of the selection and utilization of performance indicators is essential to address the economic, environmental, social, and corporate governance aspects of business performance.

Various agencies are dedicated to systematically developing indicators related to environmental, social, and economic performance. The Global Reporting Initiative (GRI) has established a reporting framework and comprehensive indicators encompassing economic, environmental, and social domains (GRI, 2022). The United Nations Conference on Trade and Development (UNCTAD) released guidance on incorporating corporate responsibility indicators in annual reports, which includes a review of measurement methodologies (UNCTAD, 2018). The CFA Institute crafted a handbook for investors outlining ESG metrics to consider when investing in companies (CFA Institute, 2015).

The European Federation of Financial Analyst Societies (EFFAS), commissioned by the European Commission, has integrated ESG factors into investment decision-making processes (EFFAS, 2021). Furthermore, the International Federation of Accountants (IFAC) developed an overview of performance characteristics and key indicators for each of the three sustainability pillars (IFAC, 2021). The creation of supplementary corporate performance indicators is influenced by the efforts of international organizations that have devised macro indicators for environmental, social, and economic aspects. These organizations include the United Nations, the Organization for Economic Co-operation and Development, the European Environment Agency, and Eurostat.

To assess the ESG performance of stakeholders in the construction industry, a range of ESG indicators have been developed and validated through a combination of empirical research and industry standards (Kocmanova et al., 2012, Veenstra and Ellemers, 2020, Kocmanová et al., 2012). These indicators can be divided into three aspects: ESG:

- Green Building: Standards such as Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), and Global Real Estate Sustainability Benchmark (GRESB) ratings are used to evaluate the environmental performance of buildings.
- Carbon emissions: Metrics, such as the measurement of CO2 emissions generated by the company's operations and construction activities (including energy consumption and transportation), can be used to evaluate a company's carbon footprint.
- Energy efficiency: Indicators such as energy use intensity and the Energy Star rating can be used to evaluate the energy efficiency of buildings constructed by a company.
- Water consumption: Measurement of the amount of water consumed by the company's operations and construction activities, including irrigation and cooling systems.
- Material use: The quantity of materials used in construction and the percentage of those recycled or sourced from sustainable sources can be used to evaluate a company's material usage.

Social Indicators:

- Employee safety: Analysis of workplace injuries and accidents and the company's compliance with safety regulations.
- Employee diversity: Evaluation of the company's workforce diversity in gender, race, and ethnicity.
- Community engagement: Measure the company's engagement with local communities through community outreach programs and philanthropic initiatives.
- Labor rights: Examining the company's compliance with labor laws and regulations and adherence to fair labor practices.

Governance Indicators:

- Transparency: Metrics, such as the company's level of transparency in financial and operational reporting and governance practices like board composition and executive compensation, can be used to evaluate a company's governance practices.
- Stakeholder engagement: Indicators, such as the company's engagement with stakeholders, including investors, customers, and employees, can be used to evaluate a company's commitment to stakeholder engagement.
- Compliance: Measurement of the company's compliance with relevant laws and regulations, such as environmental and labor laws.

Issue tokens

The construction industry plays a significant role in shaping the built environment and has a substantial impact on the environment. To mitigate these effects and incentivize the adoption of sustainable building practices, a blockchain-based ESG token, the "EcoBuild Token" (EBT), could be implemented.

In our conceptual model, we envision an EcoBuild token market that facilitates transactions and incentivizes sustainable practices within the construction industry. Establishing a decentralized exchange (DEX) or collaborating with existing DEX platforms can enable trading of EcoBuild tokens, creating a market for stakeholders to buy, sell, or exchange them for other cryptocurrencies or fiat currencies. Integration with DeFi can provide additional financial services, such as staking, lending, and liquidity farming, creating opportunities for stakeholders to maximize the value of their token holdings and further incentivize sustainable practices. By constructing the EcoBuild token market at the smart contract level, transparency, security, and automation can be ensured throughout the process, fostering a resilient ecosystem that rewards and promotes sustainable development in the construction industry.

The EBT can be designed with the following properties:

- Token name: EcoBuild Token (EBT)
- Token standard: EBT tokens can be built on the Ethereum blockchain using the ERC-20 standard.
- Token purpose: To incentivize and reward stakeholders in the construction industry for implementing sustainable building practices and reducing their environmental impact.
- Token use: EBT tokens would serve as a reward for construction stakeholders that meet certain sustainability standards. Stakeholders that earn EBT tokens could use them as recognition for their sustainability efforts and potentially trade them with investors interested in funding sustainable construction projects. EBT tokens could also help raise capital for sustainable construction projects and provide access to sustainable construction supply chains.
- Criteria for earning tokens: Stakeholders would need to meet specific criteria in order to earn EBT tokens. These criteria could include:
    - Using renewable energy sources for at least 50% of the building's energy needs
    - Recycling at least 75% of construction waste
    - Using energy-efficient building materials, such as insulated walls and windows
    - Implementing a green roof or green wall
    - Obtaining a LEED or BREEAM certification
- Token issuance: EBT tokens would be issued through smart contracts on the Ethereum blockchain, transparently and automatically, ensuring that qualifying stakeholders are rewarded accordingly. The formulation of smart contracts will be jointly participated by stakeholders participating in the token economic model to ensure that consensus is reached.
- Token transfer: EBT tokens would be transferable on the Ethereum blockchain, allowing for trading among investors and construction stakeholders who own them, enabling stakeholders to use the tokens as collateral or to raise capital for sustainable construction projects.
- Token tracking: A blockchain-based system would be implemented to track the issuance, transfer, and ownership of EBT tokens, ensuring transparency and immutability of data. This would enable government agencies and industry associations to monitor the performance of the incentive mechanism.

The implementation of EBT would not only incentivize the adoption of sustainable building practices in the construction industry but also provide a transparent and accountable mechanism for tracking and reporting on the sustainable performance of stakeholders. This would help promote sustainable practices in the construction industry and ultimately lead to a more sustainable built environment.

Rewards and incentives

The proposed incentive mechanism utilizes a points-based system to evaluate stakeholders' ESG performance. These points are then used to determine the rewards earned by the companies, which may include financial incentives or recognition of their overall ESG score. The formula for calculating the rewards in the form of Environmental Building Token (EBT) is as follows:

EBT Rewards = (ESG Points / Total Possible Points) * Total EBT Available * Tier Factor

Where:

- ESG Points is the company's overall score based on its ESG performance.
- Total Possible Points represents the maximum number of points that can be earned based on the ESG performance criteria.
- The total EBT Available is the total amount of EBT that can be earned.
- The tier Factor is a multiplier that represents the rewards available for a specific tier, and it's based on the predefined ESG performance thresholds.

The Tier Factor incentive mechanism, which rewards companies based on their ESG performance, can be optimized through various strategies. One approach involves regularly updating the Tier Factor thresholds to align with current industry standards and best practices, ensuring that the rewards accurately represent companies' actual ESG performance. Moreover, enlisting a third-party auditor to conduct impartial and transparent evaluations of companies' ESG performance is crucial for

maintaining fairness and equity within the system. Additionally, taking into account a company's size and resources can enhance the fairness and equity of the rewards distributed.

Promoting collaboration and inclusivity is essential; therefore, engaging stakeholders such as suppliers, customers, and communities in the design and implementation of the Tier Factor is critical. This involvement ensures that the incentive mechanism effectively encourages companies to improve their ESG performance. Lastly, routinely reviewing and updating the rewards in accordance with current industry standards helps maintain the incentives' appeal and efficacy, thus continuously motivating companies to enhance their ESG performance over time.

Conclusions

In this paper, we introduced a blockchain-based token incentive mechanism specifically designed for the construction industry, aimed at rewarding stakeholders who engage in ESG practices. The proposed token, EBT, functions as a reputation token representing corporate sustainability performance disclosure. This mechanism offers several advantages to the construction sector, such as: 1) providing a transparent and objective method for companies to be acknowledged and rewarded for their ESG performance, 2) encouraging companies to improve their ESG performance through appealing rewards, and 3) fostering sustainable building practices by incentivizing the use of renewable energy sources, recycling construction waste, and adopting energy-efficient building materials. In future research, we intend to refine the proposed incentive mechanism and develop user-friendly interfaces for conducting large-scale feasibility testing.

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