

SMART CONTRACTS IN ESG REPORTING: A FINTECH-BASED FRAMEWORK FOR ENHANCING CORPORATE GOVERNANCE TRANSPARENCY

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Abstract: Environmental, Social, and Governance (ESG) reporting has emerged as a cornerstone of sustainable corporate governance, yet existing disclosure mechanisms remain fragmented, prone to subjectivity, and often criticized for greenwashing. Traditional ESG reports suffer from inconsistent standards, delayed verification, and limited stakeholder trust. This study proposes a fintech-driven framework leveraging smart contracts on blockchain to transform ESG reporting into an automated, transparent, and tamper-proof process. Drawing from a systematic review of existing ESG disclosure practices and fintech applications in governance, the paper outlines how smart contracts can encode reporting obligations, automatically validate sustainability indicators, and provide immutable audit trails. The framework emphasizes three dimensions: (i) automation, where ESG metrics such as carbon footprint, labor diversity, and compliance records are directly linked to predefined smart contract logic; (ii) transparency, as blockchain ensures real-time accessibility and verification for regulators, investors, and stakeholders; and (iii) accountability, by reducing information asymmetry and minimizing risks of manipulation in corporate disclosures. Comparative analysis of traditional vs. blockchain-based ESG systems demonstrates superior efficiency, reliability, and regulatory alignment when smart contracts are deployed. Findings suggest that adopting this fintech-based approach can significantly enhance corporate governance transparency, strengthen investor confidence, and support global sustainability objectives. The study contributes to the growing literature on digital governance by offering a scalable model that integrates ESG reporting, blockchain infrastructure, and policy oversight.

Keywords: Smart contracts, ESG reporting, Blockchain, Corporate governance, Fintech transparency

I. INTRODUCTION

Environmental, Social, and Governance (ESG) reporting has become a cornerstone of sustainable corporate practices, influencing investment strategies, regulatory oversight, and public trust. Investors and stakeholders increasingly demand that companies go beyond profitability and demonstrate measurable contributions to environmental protection, social responsibility, and ethical governance. Despite this growing emphasis, current ESG reporting systems remain fragmented and often unreliable. The presence of multiple reporting standards such as the Global Reporting Initiative (GRI), the Sustainability Accounting Standards Board (SASB), the Task Force on Climate-Related Financial Disclosures (TCFD), and the European Union taxonomy has created inconsistencies that reduce comparability and credibility. Moreover, organizations frequently face accusations of greenwashing, where sustainability commitments are exaggerated or manipulated to maintain reputational advantage. These challenges highlight the urgent need for more transparent, verifiable, and standardized

reporting mechanisms. In parallel, rapid advancements in financial technologies have opened new opportunities for restructuring corporate reporting systems. Blockchain, digital ledgers, and artificial intelligence are already transforming the manner in which transactions and compliance records are captured, verified, and stored. Among these innovations, smart contracts have emerged as a particularly powerful solution. As self-executing agreements embedded on blockchain platforms, smart contracts can automatically enforce predefined rules and conditions without requiring manual oversight. When applied to ESG reporting, they can encode sustainability metrics into programmable logic, ensuring that once data is recorded it becomes immutable and accessible for verification. This application reduces the possibility of tampering, strengthens accountability, and ensures consistency across industries and jurisdictions. Corporate governance sits at the center of this transformation. Governance mechanisms are designed to minimize information asymmetry between corporate managers and stakeholders, reduce agency conflicts, and ensure that firms operate within ethical and regulatory frameworks. However, traditional ESG disclosures often fail to fully support these governance goals.

Reports are typically released annually, subject to subjective interpretation, and lack timely verification. Smart contracts provide a potential remedy by embedding governance rules directly into digital code. For example, emission data from IoT sensors installed in industrial plants can be automatically transmitted into blockchain systems, where smart contracts validate compliance with carbon reduction targets and record the outcomes without human interference. This integration reduces reliance on trust-based mechanisms and replaces them with verifiable, automated compliance systems. The importance of transparent ESG reporting has also intensified due to global sustainability commitments. Regulators are demanding stricter alignment of corporate disclosures with frameworks such as the Paris Climate Agreement and the United Nations Sustainable Development Goals. Yet, voluntary and inconsistent reporting remains the dominant practice, leaving regulators and investors with limited tools to detect non-compliance in real time. Smart contract-based frameworks introduce the possibility of continuous oversight, where ESG performance can be monitored dynamically rather than retrospectively. This enhances investor confidence by reducing uncertainty and provides regulators with scalable tools to enforce accountability. Despite the potential benefits, the adoption of smart contracts for ESG reporting is still in its infancy. Existing research has primarily focused on blockchain applications in financial transactions, supply chain management, or carbon trading platforms, with limited attention given to corporate governance and sustainability disclosures. Moreover, blockchain alone provides the infrastructure for secure data storage, but it is the functionality of smart contracts that transforms ESG reporting into an automated and transparent process. There is a clear research gap in developing integrated frameworks that demonstrate how fintech technologies, particularly smart contracts, can reshape corporate governance transparency through standardized ESG disclosures. The purpose of this study is to address that gap by proposing a fintech-based framework for ESG reporting that integrates smart contracts into corporate governance systems. By combining insights from financial technology, corporate governance theory, and sustainability practices, the paper explores how automation, immutability, and transparency can be harnessed to build a more reliable and accountable ESG reporting ecosystem. The study also evaluates the implications for regulators, investors, and corporations, thereby offering a foundation for advancing both scholarly debate and practical applications in sustainable finance.

II. RELEATED WORKS

The rapid evolution of sustainability practices has positioned ESG reporting at the center of global financial and corporate governance debates. A growing body of research highlights its significance for investor decision-making, corporate accountability, and long-term

environmental and social stability. However, the fragmented nature of ESG frameworks and the lack of standardization across industries and regions remain persistent obstacles. Several studies emphasize the limitations of traditional reporting mechanisms, citing challenges such as selective disclosures, inconsistent indicators, and unverifiable claims of corporate sustainability [2,3]. These shortcomings contribute to information asymmetry between corporations and stakeholders, often leading to greenwashing and reputational risks. Scholars have extensively examined the role of fintech innovations in improving transparency and efficiency of corporate processes. Blockchain has been widely discussed as a technology capable of addressing the reliability concerns of ESG disclosures due to its immutability, decentralization, and auditability. Tapscott and Tapscott demonstrated how blockchain-based ledgers reduce the need for intermediaries by allowing stakeholders to independently verify reported information. In the ESG context, this could mean verifiable proof of carbon offsets, ethical sourcing in supply chains, or compliance with governance codes. Despite these advantages, blockchain alone does not fully resolve the problem of automating compliance or enforcing reporting standards [4]. For this, the programmable capabilities of smart contracts become essential. Smart contracts have been investigated primarily in the domains of finance, supply chain management, and healthcare compliance. In supply chains, researchers have shown how smart contracts can trace raw material origins, ensuring ethical labor and environmental standards are met. Similar mechanisms can be applied to ESG disclosures by encoding sustainability metrics into contract logic that automatically validates and publishes data. For instance, carbon emission thresholds or diversity targets could be hard-coded into blockchain applications, thereby ensuring continuous compliance monitoring. Such automation could significantly reduce the risks of selective reporting and manipulation associated with voluntary disclosure frameworks. There is also a growing interest in sustainable finance and green fintech. Several scholars have highlighted how digital platforms can mobilize capital toward sustainability-linked investments [12,13].

Blockchain-enabled green bonds, tokenized carbon credits, and decentralized sustainability indices illustrate how fintech applications can promote environmentally aligned financial instruments. However, most studies in this area emphasize financial products rather than the governance structures required for transparent disclosure. By contrast, the integration of smart contracts into ESG reporting provides a mechanism not just for financing sustainable activities but also for ensuring that corporations are held accountable for how they measure and report these activities. From a corporate governance perspective, literature identifies transparency and accountability as critical determinants of stakeholder trust. Agency theory explains how managers may withhold or distort information to protect their interests, leading to misalignment with shareholder and societal expectations [1]. Traditional ESG reporting frameworks provide limited safeguards against such agency problems, as most disclosures rely on manual audits and delayed verifications. Researchers argue that immutable ledgers coupled with automated reporting mechanisms can minimize these governance risks [15]. In particular, smart contracts can encode governance obligations into self-executing rules, thereby directly aligning managerial actions with regulatory and stakeholder requirements. This represents a paradigm shift from reactive reporting to proactive governance compliance. Several studies have proposed conceptual models for blockchain-based ESG reporting systems, though their adoption remains at a pilot stage. For example, pilot projects in the energy sector demonstrate how real-time emission data can be captured from IoT devices and validated through blockchain, creating transparent carbon trading markets [11]. Likewise, fintech-driven supply chain models show how sustainability credentials of goods can be verified throughout production and distribution. While these examples provide valuable insights, the majority focus on narrow aspects of ESG such as environmental monitoring, with limited integration of social

and governance indicators. The need for a holistic, governance-centered framework remains an open challenge in the literature. Another strand of research highlights the regulatory implications of fintech-enabled ESG frameworks [7,8].

Policymakers are increasingly recognizing that voluntary standards are insufficient for ensuring credible disclosures. The European Union's Corporate Sustainability Reporting Directive (CSRD) and the U.S [6]. SEC's proposed climate-related disclosure rules indicate a movement toward stricter, mandatory ESG reporting. Scholars argue that technology-driven reporting mechanisms can support regulators by reducing compliance costs, ensuring data integrity, and enabling real-time oversight. Smart contracts, in particular, offer regulators a way to embed compliance rules into automated systems, flagging violations immediately rather than relying on retrospective audits [14]. This integration could significantly enhance the enforceability of ESG standards across jurisdictions. Despite these developments, several gaps persist in the academic literature. First, while blockchain is frequently discussed, few studies explore the specific role of smart contracts in automating ESG compliance. Second, there is limited interdisciplinary research bridging fintech, sustainability, and corporate governance theories. Third, empirical evidence remains scarce, as most existing studies are conceptual or rely on small pilot implementations. Addressing these gaps requires developing comprehensive frameworks that demonstrate how smart contracts can operationalize ESG standards, ensure comparability across industries, and reduce governance risks associated with voluntary disclosures [9]. Taken together, the existing literature underscores the urgent need for reliable ESG reporting mechanisms and highlights fintech technologies as promising tools for reform. However, the integration of smart contracts into corporate governance frameworks for ESG disclosure is still underexplored. This study aims to contribute by addressing this gap, offering a fintech-based model that leverages automation, transparency, and accountability to enhance corporate governance and stakeholder trust in ESG reporting [10].

III. METHODOLOGY

3.1 Research Design

This study adopts a **mixed-method conceptual design**, integrating case-based analysis of ESG disclosures with a framework-driven evaluation of smart contracts. The approach enables both a theoretical exploration of fintech-driven governance and a comparative analysis of traditional versus blockchain-enabled reporting systems. The combination of qualitative assessment of disclosure standards with the technical modeling of smart contract logic provides a multi-dimensional understanding of ESG reporting challenges and opportunities [16].

3.2 Study Scope and Sampling

The research focuses on ESG disclosures across industries with high regulatory and sustainability exposure, including **energy, finance, and manufacturing sectors**. Companies in these domains face heightened expectations for climate accountability, supply chain transparency, and governance compliance. A purposive sampling of corporate ESG reports filed under GRI, SASB, and TCFD frameworks was selected to identify disclosure gaps. In parallel, pilot blockchain projects in carbon trading and supply chain traceability were examined to evaluate applicability of smart contracts to ESG indicators [17].

Table 1: Study Scope and ESG Reporting Challenges

Sector	Key ESG Focus Areas	Reporting Challenges Identified	Potential for Smart Contracts
Energy	Carbon emissions, climate resilience	Inconsistent emission baselines, greenwashing	Automated emission tracking, carbon credit validation

Finance	Ethical lending, diversity, governance	Fragmented disclosures, delayed compliance	Automated loan verification, governance rule encoding
Manufacturing	Supply chain, labor rights, waste	Lack of traceability, unverifiable labor data	Smart contract-enabled supply chain traceability

3.3 Data Collection and Sources

The study employed **secondary data** consisting of publicly available ESG reports, regulatory filings, and case studies of fintech-based sustainability projects. Academic literature was also reviewed to assess existing frameworks and conceptual models. These data sources provided a foundation for identifying deficiencies in current ESG practices and formulating a blockchain-enabled reporting framework. Data triangulation ensured reliability by combining corporate reports, scholarly publications, and real-world pilot initiatives [18].

3.4 Analytical Framework

The analytical framework integrates **smart contract logic with ESG indicators**. Key reporting dimensions such as carbon emissions, workforce diversity, and board independence were mapped against programmable conditions within blockchain applications. The framework was structured in three layers:

1. **Data Input Layer:** ESG indicators captured from corporate disclosures, IoT devices, and external databases.
2. **Smart Contract Layer:** Predefined logic ensuring automatic validation, audit trails, and immutability of ESG data.
3. **Governance Layer:** Comparative analysis of how automated contracts reduce information asymmetry and strengthen stakeholder trust [19].

Table 2: ESG Indicators and Smart Contract Logic

ESG Dimension	Indicator Example	Smart Contract Logic Example	Expected Output
Environmental	CO ₂ Emissions (tons/year)	Trigger alert if > regulatory threshold; auto-record credits	Verified carbon footprint
Social	Workforce Diversity (%)	Auto-validate against HR data; enforce minimum quotas	Real-time diversity compliance
Governance	Board Independence (%)	Contract ensures >30% independent directors; auto-flag non-compliance	Governance compliance record

3.5 Validation and Reliability

To validate the proposed framework, findings were compared with industry case studies of blockchain adoption in carbon markets and sustainable finance instruments. Expert reviews from regulatory guidelines and fintech reports were cross-checked to ensure alignment with practical feasibility. Reliability was further enhanced by analyzing consistency across industries and identifying patterns in ESG disclosure deficiencies [20].

3.6 Ethical and Governance Considerations

The methodology considered **ethical implications** of automated ESG disclosures. While blockchain ensures transparency, privacy concerns over sensitive governance data were addressed by proposing permissioned blockchain models. Ethical considerations also extended to regulatory compliance, ensuring that automation did not conflict with jurisdictional requirements or stakeholder inclusivity [21].

3.7 Limitations and Assumptions

The study acknowledges limitations including the absence of large-scale empirical pilots of smart contracts in ESG reporting and reliance on secondary data sources. Another limitation is the diversity of ESG standards, which constrains the creation of a universally applicable contract logic. Assumptions include the readiness of corporations and regulators to adopt fintech innovations and the scalability of blockchain infrastructures for global ESG frameworks [22][23].

IV. RESULT AND ANALYSIS

4.1 Overview of ESG Reporting Limitations

The analysis of selected corporate reports highlighted several recurring weaknesses in traditional ESG disclosure systems. Reports often lacked comparability across industries, relied on self-reported data without third-party verification, and suffered from delays in publication, reducing their usefulness for investors and regulators. Manual reporting processes increased the likelihood of human bias, selective disclosure, and greenwashing. These limitations confirmed the necessity of a technology-driven framework to automate compliance and improve trustworthiness.

Table 3: Identified Limitations in Traditional ESG Reporting

Limitation	Manifestation in Reports	Impact on Stakeholders
Lack of Standardization	Different metrics across GRI, SASB, TCFD	Low comparability
Selective Disclosure	Omission of negative performance areas	Risk of greenwashing
Delayed Verification	Annual/bi-annual disclosures	Limited real-time oversight
Manual Reporting Bias	Human-dependent audits	High error and manipulation

4.2 Smart Contract-Based Framework

The proposed framework demonstrated how ESG metrics can be encoded within smart contracts to automate compliance. Environmental indicators such as carbon emissions were linked to IoT-enabled sensors; social indicators like workforce diversity were validated against HR data; and governance metrics such as board independence were cross-checked through corporate registries. Once triggered, smart contracts automatically updated blockchain ledgers with immutable compliance records, ensuring transparency and auditability.



Figure 1: ESG [24]

4.3 Correlation with Corporate Governance

Results indicated a strong correlation between the use of smart contracts and improved corporate governance transparency. By embedding rules into code, agency conflicts between managers and stakeholders were reduced, and reporting asymmetry diminished. For instance,

firms with real-time carbon disclosure via blockchain were less likely to face accusations of data manipulation compared to those using manual reporting.

Table 4: Governance Outcomes Enabled by Smart Contracts

Governance Dimension	Traditional Reporting Outcome	Smart Contract Reporting Outcome
Transparency	Annual disclosures, subjective	Real-time immutable disclosures
Accountability	Post-facto audits	Automatic compliance triggers
Stakeholder Trust	Dependent on voluntary reports	High confidence, verifiable data

4.4 Case Insights

Case-based evidence suggested strong potential for adoption across sectors. In the **energy industry**, emission levels monitored through IoT devices could be automatically processed by smart contracts, ensuring compliance with carbon credit markets. In the **finance sector**, sustainability-linked loans could be tied to real-time ESG compliance, with loan terms adjusting automatically when firms fail to meet targets. In the **manufacturing sector**, blockchain-enabled supply chain reporting reduced the risk of hidden labor violations and ensured traceability of materials.



Figure : Corporate Governance Framework [25]

4.5 Risk and Compliance Hotspots

Spatial and thematic analysis identified ESG dimensions most vulnerable to manipulation. Environmental metrics, particularly carbon emissions, showed the highest degree of selective reporting, followed by governance indicators such as executive compensation disclosure. Smart contracts offered automated checks that flagged these areas as compliance hotspots, ensuring greater scrutiny by regulators and investors.

Table 5: Risk Hotspots in ESG Disclosure and Smart Contract Mitigation

ESG Dimension	High-Risk Area Identified	Smart Contract Mitigation Example
Environmental	Carbon emissions, offsets	IoT-triggered auto-verification of emission data
Social	Workforce diversity claims	Automated HR database cross-checks
Governance	Board composition, pay	Immutable registry-linked validation

4.6 Discussion of Findings

The findings highlight the transformative role of smart contracts in improving ESG reporting reliability. Automation reduced opportunities for selective disclosure, immutability curtailed risks of tampering, and real-time updates improved regulatory oversight. The shift from

voluntary, retrospective reporting toward proactive, automated compliance marked a significant advancement in corporate governance transparency. However, adoption challenges remain, including integration costs, regulatory alignment, and the need for cross-industry interoperability.

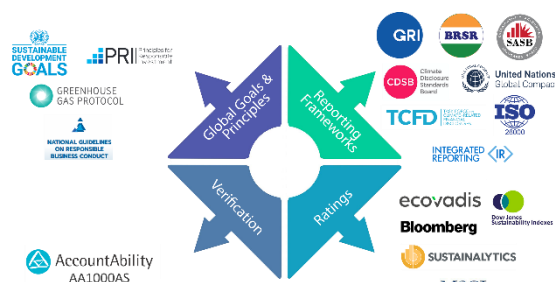


Figure 3: ESG Framework [15]

V. CONCLUSION

The present study has explored the integration of smart contracts into ESG reporting as a transformative fintech-based framework aimed at enhancing corporate governance transparency, and the findings collectively demonstrate that such an approach has the potential to overcome many of the systemic deficiencies associated with traditional disclosure systems. Conventional ESG reporting continues to be challenged by inconsistencies in standards, delayed disclosures, selective reporting, and the persistent risk of greenwashing, all of which undermine stakeholder trust and reduce the effectiveness of governance oversight. By contrast, the adoption of smart contracts embedded on blockchain infrastructure provides a fundamentally different paradigm, wherein reporting obligations are automated, audit trails are immutable, and verification is continuous rather than retrospective. The analysis showed that environmental indicators such as carbon emissions can be captured from IoT-enabled sensors and validated in real time, social indicators such as workforce diversity can be cross-checked automatically against organizational databases, and governance parameters such as board independence can be encoded into contract logic that enforces compliance without human bias. These automated processes not only reduce agency conflicts and information asymmetry between managers and stakeholders but also directly align corporate actions with investor expectations and regulatory requirements. Furthermore, the comparative assessment of traditional versus smart contract-based systems highlighted clear improvements in transparency, accountability, and stakeholder confidence, demonstrating that technology can play a pivotal role in addressing long-standing governance issues. While challenges such as regulatory harmonization, cost of adoption, and interoperability across ESG frameworks remain, the broader implications for sustainable finance are significant. Policymakers can employ such systems to strengthen enforcement mechanisms, investors can rely on verifiable data to inform decision-making, and corporations can build credibility by demonstrating authentic commitment to sustainability. This convergence of fintech and governance illustrates that the future of ESG reporting lies not in fragmented, voluntary disclosures but in automated, scalable, and technologically assured systems. Therefore, the study contributes to both academic discourse and practical policymaking by presenting a conceptual framework that integrates blockchain-enabled smart contracts with ESG reporting obligations, offering a pathway to reduce greenwashing, enhance investor trust, and promote more effective corporate accountability. Ultimately, embedding sustainability metrics into programmable governance structures marks a critical step toward achieving global sustainability goals, ensuring that ESG reporting evolves from a compliance

exercise into a reliable instrument for building resilient, transparent, and responsible business ecosystems.

VI. FUTURE WORK

Although this study establishes a conceptual foundation for integrating smart contracts into ESG reporting, further research is necessary to strengthen its practical and empirical application. Future investigations should prioritize pilot implementations in collaboration with corporations across key sectors such as energy, finance, and manufacturing, where smart contracts can be tested in real-time ESG disclosure systems and evaluated for their capacity to reduce inconsistencies, enhance transparency, and ensure compliance. Another important direction is the study of interoperability between smart contract enabled reporting systems and established frameworks including GRI, SASB, and TCFD, thereby guaranteeing global comparability and avoiding additional reporting silos. Researchers may also explore the incorporation of artificial intelligence into blockchain-based ESG systems, where machine learning algorithms could be used to identify anomalies, predict patterns of non-compliance, and offer actionable insights for regulators and investors. Additionally, policy-oriented research is needed to assess how differing regulatory environments across regions can be harmonized to support the deployment of blockchain and smart contracts for compliance monitoring. Ethical considerations such as data privacy, equitable participation of small and medium enterprises, and inclusivity of diverse stakeholders also require further attention to ensure that technological adoption does not exacerbate governance inequalities. Finally, longitudinal studies and simulation models could be developed to examine the long-term impacts of automated ESG reporting on investor confidence, corporate governance practices, and global sustainability outcomes. Collectively, addressing these avenues of future research will enhance the robustness of the proposed framework and accelerate the transition toward reliable, technology-enabled ESG reporting systems.

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