# The Impact of Emerging Digital Solutions on the Improvement of ESG Evaluations

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**Abstract.** With the growing emphasis on sustainable and green finance, ESG ratings have become more important for investors and regulators, yet their effectiveness remains a significant concern. This study systematically reviews some critical problems of ESG rating in sustainable investment, such as methodological divergences and consistency challenges among major rating agencies. On this basis, it further synthesizes current progress and practical exploration of digital technologies including blockchain, big data and artificial intelligence in improving transparency and disclosure efficiency for ESG assessments. Specifically, blockchain can enhance the traceability and authenticity of data, AI can improve the scoring consistency through better data processing, and big data can provide more information inputs and dynamic dimensions for evaluation. The conclusion calls for integrating these technologies to foster a more transparent and dynamic ESG rating ecosystem for better reliability, which requires supportive policy frameworks in area such as data governance and cross-sector collaboration to ensure effective implementation.

**Keywords:** ESG Evaluations, Digital Solutions, blockchain, AI, big data.

## 1. Introduction

In recent years, the environmental, social and governance (ESG) rating system has become an important indicator for investment. Deeply entrenched in the financial decision-making of institutional investors and regulators, it helps assess corporate long-term value and mitigate risk [1]. However, rating agencies assign huge divergent results to the same company and thus undermining market confidence. Such inconsistencies stem from different data sources and disclosure practices applied, revealing some shortcomings in current ESG assessments methodology [2]. As a result, improving their rigour and credibility has emerged as a high priority.

Many academic studies examine why ESG ratings vary so much. Based on Christensen et al., rating methodology, data coverage, and weighting differences are the main reasons of disagreement [3]. Moreover, corporate disclosure inconsistencies exacerbate the problem and weaken effectiveness of the rating [4]. However, current research lacks comprehensive approaches to enhance ESG ratings with digital technologies, particularly in improving verifiability and intelligence, and thus practical frameworks and reviews are needed.

To address these challenges and research gaps, this article indicates the potential of three key digital technologies to improve ESG rating systems. In detail, it examines blockchain for enhancing data traceability, artificial intelligence for optimizing assessment processes, and big data for expanding informational dimension. By integrating recent literature and cases, this article aims to provide direction reference for building a more credible and intelligent ESG rating ecosystem.

## 2. ESG ratings focus: Common differences in the current system

With the growing focus on sustainable investment, ESG ratings have become a core reference in evaluating corporate environmental, social, and governance performance. Major agencies like MSCI and Sustainalytics integrate non-financial data to support investment decisions [2]. However, despite the wide application of the ESG rating system, it still faces persistent structural challenges.

First, the significant differences in methodology among rating agencies are a key driver of the high inconsistency in ESG rating results. An analysis by Berg, Kölbel, and Rigobon covering 924 companies and 709 indicators across six major agencies found an average inter-agency correlation of just 0.45, which was significantly lower than the high consistency shown by credit ratings [2]. Further analysis reveals three primary sources of rating divergence: First, measurement methodology differences (56%) account for the largest share, where agencies employ distinct indicators or data sources even when evaluating identical ESG dimensions. Second, assessment scope variations (38%) emerge from significant discrepancies in which specific ESG factors different agencies choose to evaluate. Finally, weighting allocation differences (6%) contribute moderately, reflecting varying priorities agencies assign to the same dimensions in composite scoring [2].

Secondly, fragmented and inconsistent data combined with high reliance on subjective judgment by rating agencies further aggravates rating discrepancies. Christensen, Serafeim, and Sikochi applied fixed effects and difference-in-differences models to examine the relationship between the increase in corporate ESG disclosure and the change in rating differences before and after the implementation of the mandatory disclosure policy, confirming that more detailed disclosure did not alleviate the rating differences [3]. Instead, more detailed disclosure expanded agencies' subjective interpretation space, amplifying inconsistencies. Cheng, Lou, and Yang used the "Tanimoto similarity index" to calculate the similarity between companies and industry peers in terms of disclosure content based on Bloomberg's 122 ESG disclosure data [4]. By converting disclosure content into binary vectors and comparing firms within industries, they found that lower disclosure similarity increased data processing complexity for agencies, deepening rating divergence and weakening ESG ratings' effectiveness in guiding capital allocation and sustainable investment [4].

Additionally, the lack of rating transparency and comparability has tangible negative impacts on investors and markets. Based on the empirical data of China's A-shares from 2009 to 2021, Wang et al. conducted an in-depth study on the impact of ESG rating divergence on stock returns through a multivariate regression model, confirming that rating divergence significantly reduced corporate stock returns [5]. Worse still, rating discrepancies amplify market uncertainty about corporate ESG performance, prompting more conservative investments.

To summarise, the key issues currently existing in ESG rating systems are methodological inconsistency and disclosure diversity, which increase subjective judgement. These issues undermine the informational function of ESG ratings in capital allocation and reveal fundamental problems in data processing and standardization. Exploring digital technologies to address current issues has become increasingly important.

## 3. Digital technology empowerment: The key path to solving difficulties

Digital technologies offer a viable solution to current ESG rating challenges, particularly methodological inconsistencies and transparency deficits. Unlike traditional manual processes reliant on static disclosures, blockchain, big data, and AI demonstrate superior capacity for processing heterogeneous data streams [6]. These technologies enhance transparency, ensure traceability, and reduce subjectivity, while their inherent scalability and automation enable standardized, dynamic rating mechanisms that mitigate cross-agency discrepancies arising from methodological variations[7]

### 3.1. Blockchain: Ensuring the traceability and authenticity of information

Blockchain technology has emerged as a key solution for enhancing ESG data reliability through its decentralized, immutable, and verifiably traceable nature. In their systematic review, Rejeb et al. systematically analysed 94 articles and conducted content analysis on how companies use blockchain to record carbon footprints, labor standards compliance and other behaviors, and clearly pointed out that blockchain can build a "trust infrastructure" for ESG data disclosure for companies, especially for quantitative data certification in the environmental and governance metrics [6]. Wang et al. proposed an ESG assessment framework leveraging blockchain technology to record third-party

verified data. This data-driven approach ensures end-to-end consistency in information sources and processing procedures, with empirical results confirming its effectiveness in mitigating data bias and manipulation risks [8]. Zhou and Liu further corroborated these findings using Chinese corporate data, showing a positive correlation between blockchain adoption and sustainable performance [9]. While existing research confirms blockchain's dual role in authenticating ESG data and enabling cross-institutional data standardization, current implementations remain limited to pilot projects rather than widespread integration.

### 3.2. Artificial intelligence: Improving data processing efficiency and scoring consistency

Artificial intelligence demonstrates strong potential to address key ESG rating challenges, including data heterogeneity, subjective bias, and inconsistent interpretation. Natural language processing (NLP), as a core AI application, effectively analyzes unstructured textual data such as corporate sustainability reports, media reports, and regulatory statements to identify environmental and social related signals [7]. This method solves traditional rating problems. It does not rely only on standard reports and metrics but also uses hidden information. On this basis, Chen et al. further demonstrated through machine learning models that AI methods achieve superior accuracy-consistency balance, particularly for traditionally hard-to-quantify dimensions, while enhancing sensitivity to subtle signals and ambiguous disclosures [10]. These advances significantly boost ESG rating adaptability in complex information environments and facilitate scalable automation, particularly for markets struggling with unstructured data and disclosure inconsistencies.

### 3.3. Big data: Enhancing information integration and dynamic response capabilities

Within ESG rating systems, corporate data processing and integration capabilities have become pivotal determinants of evaluation efficacy. Liu et al. empirically establish that enhanced data capabilities significantly improve capital markets' recognition accuracy of ESG performance, confirming data infrastructure's foundational role [11]. Responding to this imperative, Liu and Zhang designed a big data-driven sustainability information framework that systematically manages data collection, structuring, cleansing, and multi-stakeholder sharing [12]. Such framework connects corporate internal systems with external data from rating agencies, which also brings compatibility of AI and blockchain. Specifically, the platform can link with AI models to automatically classify unstructured data and then outputs standardized data streams for blockchain verification and tracing [12]. This strengthens the information integration, which enables the rating process to become more dynamic and accurate.

## 4. Navigating challenges and opportunities: Pathways for future development

Although digital technology has demonstrated potential for improvement in ESG ratings, why it has not been widely applied still involves many institutional challenges. On one hand, different levels of technology access and system compatibility lead to institutional differences in data access and processing capacity. As Rejeb et al. observe, although blockchain has been tested by multinationals, there are high technical entry barriers for smaller institutions without scalable technology implementation pathways [6]. At the corporate level, Liu et al. show that differences in data infrastructure development across institutions lead to significant differences in ESG information completeness and comparability, making it harder for digital technologies to systematically improve overall rating quality [11]. On the other hand, data privacy protection and compliance risks also pose practical limitations to the application of technology. For example, Wang et al. observe that despite blockchain's capacity to strengthen data traceability, missing standardized regulations and authorization protocols risk exposing sensitive information through on-chain records, which may generate ethical and compliance dilemmas [8].

In the future, deeper integration of digital technology into ESG rating systems will require both multi-technology convergence and collaborative governance. Liu and Zhang suggest that a big data-

centric architecture can bridge AI-driven analysis and blockchain-based verification, creating a closed-loop system for "recognition-integration-validation" and enabling dynamic evaluation for real-time record [12]. Furthermore, regulatory coordination is critical. Governments, rating agencies, and tech firms must collaborate on a unified platform to standardize disclosure, verification, and assessment processes [9]. Therefore, scaling digital solutions for ESG ratings hinges not only on technological innovation but also on synchronized progress in governance, standards, and multi-stakeholder cooperation -- the foundation for a credible, transparent, and scalable system.

## 5. Conclusion

ESG rating method has important significance in sustainable investment, but ESG rating has obvious defects in methodological transparency and data disclosure, as well as subjectivity in data processing also affects the rating result. These defects not only reduce the ability of ESG rating in allocating capital but also reflect the inadequacy of ESG rating in processing dynamic and structured data. This article discusses how to reform ESG rating method by applying blockchain, AI and big data in enhancing transparency, reducing subjectivity and dynamically adjusting ESG rating.

ESG rating development needs coordinated development of technology integration and institution. In terms of technology, further convergence of big data platform, AI analysis and blockchain certification should form a scalable architecture based on dynamic scoring mechanism. Institutionally, standardized data protocol, open interface and clear regulation should be implemented.

Currently, these findings are limited to a few empirical cases, and the feasibility of technology implementation should be tested in more field cases. It is vital to verify region-specific implementations, especially their technical interoperability across different regulatory environments. When combined with the advancement of technical infrastructure and institution, ESG rating may toward more dynamically integrated and intelligent evaluation system.

## References

[1] R. Gibson Brandon, P. Krueger, P. S. Schmidt, ESG rating disagreement and stock returns. *Financ. Anal. J.* **77**, 104–127 (2021)

[2] F. Berg, J. F. Kölbel, R. Rigobon, Aggregate confusion: The divergence of ESG rating. *Rev. Finance* 26, 1315–1344 (2022) https://doi.org/10.1093/rof/rfac033

[3] D. M. Christensen, G. Serafeim, A. Sikochi, Why is corporate virtue in the eye of the beholder? The case of ESG ratings. *Account. Rev.* 97, 147–175 (2022) https://doi.org/10.2308/tar-2019-0506

[4] Q. Cheng, Y. Lou, M. Yang, ESG reporting divergence. *HKU Bus. Sch. Pap. Ser.* (2023)

[5] J. Wang, S. Wang, M. Dong, H. Wang, ESG rating disagreement and stock returns: Evidence from China. Int. *Rev. Financ. Anal.* 91, 103043 (2024)

[6] A. Rejeb, K. Rejeb, S. Simske, H. Treiblmaier, S. Zailani, Blockchain for sustainable development: A systematic review. *J. Clean. Prod.* 379, 134712 (2023) https://doi.org/10.1016/j.jclepro.2022.134712

[7] G. Gianfrate, M. Kievid, ESG and artificial intelligence in finance: State-of-the-art and research takeaways. *Finance Res. Lett.* 48, 102949 (2022) https://doi.org/10.1016/j.frl.2022.102949

[8] Y. Wang, J. Han, X. Zhao, Data-driven ESG assessment for blockchain services. *J. Clean. Prod.* 367, 132984 (2022) https://doi.org/10.1016/j.jclepro.2022.132984

[9] Q. Zhou, Q. Liu, Blockchain adoption and corporate sustainability performance. *J. Bus. Res.* 143, 456–468 (2022) https://doi.org/10.1016/j.jbusres.2022.01.015

[10] Y. Chen, Z. Hu, L. Fang, Artificial intelligence technology and corporate ESG performance. Technovation 122, 102619 (2023) https://doi.org/10.1016/j.technovation.2023.102619

[11] H. Liu, Y. Wang, Z. Yu, Big data capabilities, ESG performance and corporate value. *Technol.* Forecast. *Soc.* Change 180, 121705 (2022) https://doi.org/10.1016/j.techfore.2022.121705

[12] X. Liu, Y. Zhang, The role of digital technologies in corporate sustainability: A review and research agenda. *J.* Bus. *Res.* 160, 113763 (2023) https://doi.org/10.1016/j.jbusres.2023.113763