

Opportunities and Practical Challenges of Risk Management for AI-Driven Financial Analysis Under the Background of Sustainable Finance Development

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Abstract: The institutional architecture of sustainable finance is moving from principles to hard limits. The artificial intelligence is entrenched in the financial analysis, and it is changing the reasoning of risk management. This article explains the application of conventional AI to integrating ESG data, quantifying climate transition risk, pricing carbon financing, and evaluating the effectiveness of AI in risk management. We also discuss some of the restrictions including data quality, model transparency, algorithm convergence and institutional latency. The effectiveness of AI-enabled sustainable finance risk management depends on the comprehensiveness of the data infrastructure, the level of model interpretability attained and the flexible adaption of the governance framework. The green development framework of the "15th Five-Year Plan" has been fully launched. The EU "Artificial Intelligence Act" has come into effect in August 2024, and the ISSB standards have been consecutively implemented in several nations. The institutional environment accelerates the reconfiguration. Based on this, this study proposes improvement suggestions from the three aspects of data governance, model regulation and regulatory coordination, and calls for seeking the dynamic balance between technological innovation incentives and systemic risk prevention.

Keywords: Sustainable finance, Artificial intelligence, Financial analysis, Risk management, Institutional governance.

1. Introduction

Sustainable finance has moved from the periphery to the center of the transformation of the global financial system. In 2026, the "15th Five-Year Plan for Beautiful China Construction" and "15th Five-Year Carbon Peak Action Plan" were successively released, making systematic deployments on carbon reduction, pollution reduction, greening and growth, and requiring the enrichment of green credit, green bonds and other product types. Then, the "Opinions on Better Implementing Energy Conservation and Carbon Reduction at a Higher Level and of Higher Quality" and the "Comprehensive Evaluation and Assessment Measures for Carbon Peak and Carbon Neutrality" were promulgated, forming a closed loop system with target assessment and path guidance. The development of the carbon market is getting more and more obvious, and the innovation of carbon financial instruments and derivatives is one of the general patterns. In terms of the policy trend, the green finance has transformed from voluntary advocacy to required system, and the financial institutions are facing compliance duties instead of selected responsibilities.

AI has revolutionised the banking business, using artificial intelligence in loan approval and risk pricing. AI is expected to do a lot in the sustainable finance space. ESG information is scattered, climate hazards are difficult to measure and there is no common scale for the accounting of green assets. AI might be more suited to tackle these issues [1]. The growth of AI is fast enough but there are shortcomings such as insufficient precision and coverage of underlying data, which restrict the release of AI potential, said Yin Guangyue from Standard Chartered Bank. Li Wei, director of the Science and Technology Department of the People's Bank of China, noted that the regulation of technology ethics is still incomplete, model convergence may increase market swings, and there

are problems in the algorithm architecture that are difficult to correct. The dual role of AI in sustainable control of financial risks. It can push the limit of capacity but also has its own limitations.

The paper makes a systematic discussion on this duality. First, the paper presents the application status of the AI financial analysis and discusses the opportunities and real constraints in risk management. And then it discusses the dynamic of institutional governance at home and abroad, and then it discusses the optimisation path.

2. The Application Scenario of AI Financial Analysis in the Field of Sustainable Finance

AI has brought together data collection, analytical modelling and decision support in one line in sustainable finance.

ESG data is seen in yearly reports, social responsibility reports, news articles, even satellite imagery. Going through this material manually is not efficient. Natural language processing and computer vision can convert unstructured text and images into data that can be analysed, enabling access to more information. That's exactly what Ping An Digital Economy Research Center is doing, by applying web crawlers, NLP and satellite remote sensing to cross-check the ESG data disclosed by companies and even discover what companies have not disclosed. The public opinion model monitors environmental violations, while the image detection system evaluates emission traces in satellite images. Some institutions have already started to do experimental research by using these methodologies as part of their due diligence.

It is now also used for ESG scoring, climatic stress testing and green bond pricing which were originally based on linear regression or expert scoring [2]. In the multi-variable

nonlinear relationship, the older methods perform less well than ensemble learning and deep learning. Several studies employ random forests or gradient boosting trees to forecast green bond credit spreads and explore the influence of several ESG dimensions on pricing. For climate risk, the neural network is able to simulate the change of the default probability of industries under different temperature rise scenarios. The model is sensitive to input assumptions, although large-scale scenario projections are efficient.

On the decision side, AI output is being used for credit approval, portfolio construction, post-loan monitoring and other processes. MYbank has introduced intellectual property as a kind of "soft assets" to its credit profile by employing an AI big model that has integrated enterprise transaction records, tax information, supply chain and patent data, covering over 640,000 creative small and micro firms. CITIC-Prudential Life Insurance's research risk control integrated platform for ESG investment employs digital technologies in asset identification and risk control. Industrial Bank's dual carbon management platform integrates carbon factor databases, carbon efficiency assessment models and accounting tools, and connects to a huge model for carbon emission prediction. Singapore-based Evercomm and Jingsheng Information's AI financial carbon management platform is focused on climate risk analysis and digital carbon emission management.

To summarise, AI in sustainable finance is still in a stage of co-existence between investigation and implementation. Standards and norms are yet to be finalised. The extent to which this strategy will advance depends not just on algorithmic progress but also on data availability and regulatory attitude [3]. This present position is clarified so that it can be more fully examined in terms of its potential and costs in risk management.

3. The Opportunities of AI Financial Analysis in Enabling Sustainable Financial Risk Management

The contribution of AI to sustainable financial risk management can be seen in three ways.

Traditional ESG ratings are produced based on annual reports and manual judgements that are slow to update and often subjective [4]. The AI captures events such as environmental fines, labour disputes and governance breaches, combines sentiment analysis and event extraction algorithms, and sends alerts on a daily or even hourly basis. Ping An Digital Economy Research Center integrates satellite remote sensing, NLP and web crawlers. It checks public ESG data, but also incorporates data that has not been made public. This monitoring helps financial firms to react to the earliest emergence of unfavourable occurrences rather than passively waiting for their rating to deteriorate. Machine learning can also capture the interaction effects of the ESG sub-items. The combination of environmental penalties and governance failures increases credit risk more than either one alone. The usual scoring cards do not capture this non-linear relationship.

There is also new support to simulate climate risk quantification. These are risks of long cycle, high uncertainty & path dependency. Traditional scenario analysis is quite computer heavy. Deep learning is highly adapted for the task of mapping high-dimensional climate data and economic variables and allows institutions to dynamically evaluate the susceptibility of their asset portfolios under many warming scenarios. The European Central Bank has integrated climate

considerations into the collateral framework, where bonds and credit claims with a higher climate risk will have their maximum collateral value lowered by 5%. The introduction of this system can't be done without AI re-calculation of collateral values. The "15th Five-Year Plan" has charted the route for climate investment and innovation in carbon financing, which has spurred demand in AI modelling.

Pricing carbon finance and searching for green assets are also making progress. The challenge with carbon finance is that it is hard to verify emission data and to price carbon assets rationally. Artificial intelligence is able to build a more granular accounting model than self disclosure by combining firm energy use, production data, supply chain data and satellite surveillance. The AI tracks the flow of money in green bond market, reviews the environmental performance commitment against actual performance, and assists the investors in selecting the green assets [5]. While there is not an appropriate data source, these applications have already shown some promise for improving market transparency and pricing effectiveness.

AI is not merely a replacement of outdated technologies, but expands the frontiers of risk management in terms of information, timeliness and accuracy. This growth also brings with it new vulnerabilities which have to be dealt with.

4. Realistic Challenges of AI Financial Analysis in Sustainable Financial Risk Management

The problem of data quality and standardisation is the first obstacle on the path of technological development. ESG and carbon emissions data are crucial in sustainable financial risk management, although the data are widely varied in measurement standards, sources and update frequency. When Standard Chartered Bank helped corporations to build internal ESG data management system, it exposed that accuracy and transparency are still the toughest challenges in ESG risk management. The correlation between the scores given by different institutions on China's domestic ESG rating has long been at the level of 0.5, and the degree of structuring and coverage of the underlying data are far from meeting the basic conditions for training AI models [6]. If the AI model is trained with biased data, the output risk assessment will not be beneficial but instead add to the mistakes. AI isn't the answer to the data problem, it's more of a magnifying glass.

The second problem is the black box model. high language models and deep neural networks are sophisticated in their architecture and have a high number of parameters. It is difficult to interpret the internal decision reasoning. If ESG ratings or credit recommendations need to have traceable reasons, if AI is unable to provide them, financial institutions will be in a difficult situation – regulators will ask why they rejected a green loan application from a certain company, investors will question the logic of the allocation of ESG weights in the portfolio, and courts may also step in to determine whether the algorithm has discrimination. The European Union's "Artificial Intelligence Act" has identified credit assessment and credit scoring as high-risk sectors and requires that systems are interpretable. Interpretable AI is improving, but still a long way from being widely utilised in complex financial settings.

A third latent danger is the homogeneity of the algorithms. Many financial institutions are founded on the same underlying big models and common biases can be amplified

easily at the market level. One of the major hazards of AI financial applications is model homogeneity, said Li Wei, director of the Technology Department of the People's Bank of China. Detecting "greenwashing" is caught between technological restrictions and regulatory delay. Artificial intelligence may identify irregularities in disclosed material but the bounds of "green" will be determined by law [7]. Methods for carbon accounting are continuously developing and rules for classification of financial sustainability are not yet standardised. No evident compliance references to the AI's judgement.

These troubles are a judgement: The successful promotion of AI financial analysis cannot be without a systematic response at the institutional level, and local standards should be improved and worldwide experience need to be learned. Below, a further comparison analysis is shown.

5. Institutional Evolution and Comparison of AI Governance in Sustainable Finance at Home and Abroad

Institutional frameworks are being established by regulatory bodies and international organisations to cope with the rapid penetration of AI in the area of sustainable finance. These explorations have traced the outlines of compliance, but have also shown the challenge of fragmented governance.

The EU led the way. The "Artificial Intelligence Act" came into effect in August 2024 and high-risk artificial intelligence systems in the financial industry faced strict regulation. It is vital to accept the competent assessment and implementation of risk management systems, data governance mechanisms, technical documentation and traceability records [8]. If models employed for ESG grading are classified as high-risk, they will be subject to the openness and oversight by humans requirements. Since the Sustainable Finance Disclosure Regulation (SFDR) came into force in March 2021, ESG investments have had to disclose their environmental impact by market actors. The quality of the data utilised for AI analysis is closely linked to the truthfulness of the disclosure.

The Bank for International Settlements, in conjunction with the central banks of Spain, Germany and the European Central Bank, successfully completed the concept verification of Project Gaia in March 2024, which leveraged large language models to extract key indicators like total emissions and green bond issuance from corporate climate disclosure documents. Network for Greening the Financial System (NGFS) has issued a new toolset in 2026, noting that artificial intelligence can boost data quality. No technical specifications have been issued.

But the home path has its own. In 2021, the People's Bank of China released "Evaluation Specifications for Artificial Intelligence Algorithm Financial Applications" whose primary requirements include security and explainability. The People's Bank of China also released "Guidelines on Technological Ethics in the Financial Sector" in 2022, setting out rules on data protection and fairness. In 2025, the National Financial Regulatory Administration released the "Implementation Plan for High-Quality Development of Digital Finance in the Banking and Insurance Industry", calling for institutions to utilise enterprise-level AI platforms and centrally manage model development, deployment, and withdrawal. The China Securities Regulatory Commission has not offered specific recommendations. The "15th Five-

Year Plan" provides a regulatory framework for carbon finance and climate investment, however the specific positioning of AI is unclear [9].

The EU has high entry requirements, strong institutional rigidity, and tough regulations, but this could impede innovation; China mostly provides principle-based guidance, providing room for institutions to explore, but the laws are not clear enough. Institutional Gaps: Both systems need certain characteristics for sustainable finance scenarios such as transparency of ESG grading methodologies, AI accounting verification of carbon data and conflict of interest protection. Cross-market AI financial analysis is subject to compliance uncertainty in cross-market operations because of fragmented governance. The institutional framework needs to be improved.

6. Building a Risk Governance Path Tailored to AI-Sustainable Finance Integration

Governance framework for integrating AI in sustainable finance needs to be created at the data, model and regulatory levels simultaneously.

Data governance is mostly about harmonising the laws on disclosure of ESG information and accounting of carbon emissions. The quality of today's data is not good enough to guarantee the efficacy of the AI's operations and also reduces the credibility of risk management. China is also developing sustainable disclosure standards utilising the ISSB framework. The Ministry of Finance has produced "Enterprise Sustainable Disclosure Guideline No. 1—Climate (Trial)" (Finance and Accounting [2025] 34). Gradually establish a differentiated reporting mechanism by industry and scale, introduce independent third-party verification, and explore the establishment of a public data platform for sustainable finance to integrate government data such as industry registration, environmental protection, taxation, and energy. At now, the accounting techniques and disclosure criteria for carbon emissions are relatively variable among different industries and different sizes of organisations, and the process of standard unification is similarly gradual [10].

Develop guidelines for model specifications for interpretability. Develop file systems that segregate categories of risk. AI models for crucial scenarios such as credit approval, green bond certification and ESG rating should have interpretability of AI models or separate explanation modules. In 2026, the National Financial Regulatory Administration issued the "Guidelines on the Safe Development and Application of Artificial Intelligence in Banking and Insurance" (Jinfa [2026] 8), which set out 32 requirements in the fields of governance structure, development and application, and data governance. Financial institutions should conduct periodic retrospective testing and deviation audits. Technical regulations for the deployment of AI in sustainable finance should be set forth with precise definitions on transparency standards, monitoring frequencies and exit conditions for high risk circumstances.

The core of regulatory collaboration consists in establishing a hierarchical categorisation and incentive compatible structure [11]. It can borrow the risk classification thoughts of the European Union and develop the "regulatory sandbox" system to provide the testing area for innovation for small and medium-sized institutions. The China Securities Regulatory Commission has made clear that it will enrich the

regulatory sandbox scenarios and pilot programs have been rolled out in Beijing and Chengdu. Coordination among departments is also critical. The "Overall Statistical System for the Five Major Financial Articles (Trial)" jointly released by 4 departments in 2025 has preliminarily developed a data exchange and division of work partnership mechanism. The Ministry of Finance's development of climate guidance has also built up experience in terms of inter-departmental cooperation. The governance path building is not a one-off event but a continuous calibration between institutional design and technical innovation.

7. Conclusion

Can artificial intelligence meet the challenge posed by the perils of sustainable finance? It is not a simple question to answer. If any link in the chain fails, from data collecting, to model output, to building of linked systems, AI will be of no use. If one of the three conditions is lacking, weak data, fuzzy models, or regulation trailing behind, the research of AI may have no reference value, but may even aggravate the original hazards. This is not an issue of the quality of the technology itself but of whether the circumstances of use and institutional framework can keep pace.

What we appear to have here is a simple judgement: Automatic realisation of the function of AI in monitoring ESG, quantifying climate risk, and pricing carbon financing. Its effectiveness is grounded in the combination of the data basis, model transparency and institutional supply. Any single innovation in one of these three points is not sufficient to boost global capacities. At present, institutional research at home and abroad is mainly scattered and passive, lacking systematic thinking on specific scenarios of sustainable finance, and even causing uncertain areas of compliance concerns in cross-market activities.

The "15th Five-Year Plan" green development framework has been formed, and the creation of the carbon market and innovation of carbon finance have been carried out. Here is a real demand scenario for AI application. The attitude of the regulating agencies is to be "proactive and prudent, safe and orderly". The trick is how one translates this guiding principle into institutional designs on the ground. The future focus should be on three aspects: how to establish standards for AI data in sustainable finance, how to implement interpretable AI in risk control, and how to maintain the always changing updates of differential regulatory norms. Ultimately, the question of whether conventional artificial intelligence can be the primary underpinning for sustainable financial risk management is not about the algorithm itself, but if we can design a sufficiently practical and adaptive governing structure for it. It is a technical problem but also a test of the capacity of institutional design.

References

- [1] Mustafa, F., Smolarski, J., & Elamer, A. A. (2025). The convergence of artificial intelligence and sustainability reporting: A systematic review of applications, challenges and future directions. *Business Strategy and the Environment*, 34(8), 9761–9784. <https://doi.org/10.1002/bse.4414>
- [2] Agosto, A., Cerchiello, P., & Giudici, P. (2025). Bayesian learning models to measure the relative impact of ESG factors on credit ratings. *International Journal of Data Science and Analytics*, 20(2), 357–368. <https://doi.org/10.1007/s41060-024-00382-1>
- [3] Fuster, A., Goldsmith-Pinkham, P., Ramadorai, T., & Walther, A. (2022). Predictably unequal? The effects of machine learning on credit markets. *The Journal of Finance*, 77(1), 5–47. <https://doi.org/10.1111/jofi.13090>
- [4] Lim, T. (2024). Environmental, social, and governance (ESG) and artificial intelligence in finance: State-of-the-art and research takeaways. *Artificial Intelligence Review*, 57(4), 76. <https://doi.org/10.1007/s10462-024-10742-0>
- [5] Soltani, H., Taleb, J., Ben Hamadou, F., & Boujelbene-Abbes, M. (2026). Using machine learning to forecast clean energy, commodities, green bonds and ESG index prices: How important is financial stress?. *EuroMed Journal of Business*, 21(1), 318–344. <https://doi.org/10.1108/EMJB-02-2025-0041>
- [6] Berg, F., Kölbel, J. F., & Rigobon, R. (2022). Aggregate confusion: The divergence of ESG ratings. *Review of Finance*, 26(6), 1315–1344. <https://doi.org/10.1093/rof/rfac045>
- [7] Zeng, F., Wang, J., & Zeng, C. (2025). An optimized machine learning framework for predicting and interpreting corporate ESG greenwashing behavior. *PLoS One*, 20(3), e0316287. <https://doi.org/10.1371/journal.pone.0316287>
- [8] Mazzini, G., & Bagni, F. (2023). Considerations on the regulation of AI systems in the financial sector by the AI Act. *Frontiers in Artificial Intelligence*, 6, 1277544. <https://doi.org/10.3389/frai.2023.1277544>
- [9] Du, Z., & Chen, C. (2025). AI vs. ESG? Uncovering a bidirectional struggle in China's sustainable finance. *Sustainability*, 17(9), 4238. <https://doi.org/10.3390/su17094238>
- [10] Naveed, K., Farooq, M. B., Zahir-UI-Hassan, M. K., & Rauf, F. (2025). AI adoption, ESG disclosure quality and sustainability committee heterogeneity: Evidence from Chinese companies. *Meditari Accountancy Research*, 33(2), 708–732. <https://doi.org/10.1108/MEDAR-05-2024-0214>
- [11] Cordeiro, C. M., Adomaitis, L., & Huang, L. (2025). The AI-policy-governance nexus: How regulation and AI shift corporate governance toward stakeholders. *Technology in Society*, 103117. <https://doi.org/10.1016/j.techsoc.2025.103117>