

Empowerment Mechanism and Practical Pathways of Artificial Intelligence in Green Financial Development

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Abstract. Under the dual carbon targets, green finance faces growing demand as a key channel for financing and low-carbon transformation, while Artificial Intelligence (AI) technologies are growing quickly with financial services. This gives AI opportunities to strengthen green finance operations. This paper systematically studies the empowerment mechanism of artificial intelligence in the development of green finance. From the three dimensions of information empowerment, risk empowerment and regulatory empowerment, it reveals the adaptability of AI technology and green finance and its role, and puts forward the practical path of AI to empower green finance in the future. Through the combination of case analysis and quantitative and qualitative methods, this study draws three main findings: AI can integrate dispersed environmental information to provide investors with a clearer decision-making basis; AI model evaluates environmental risks and credit risks more accurately than traditional tools; automated monitoring can find greening faster and at a lower cost. Behavior. At the same time, the study points out the technology, policies and market conditions needed to maintain these results, which provides a practical reference for making green finance more transparent, accurate and reliable with the help of AI.

Keywords: Artificial intelligence, green financial, empowerment mechanism

1. Introduction

Nowadays the global pursuit of carbon neutrality has placed green finance at the core condition in policy. The influence of green finance is more and more important in this era. In fact, green finance has become a key mechanism for low-carbon transformation financing, and it has impacted a number of areas in economy. According to the SME model, green finance has a significant impact of up to 58.777% on policy and strategy, 59.75% on market and products, and 53.37% on international operations [1]. All these data highlight the great role of green financial flows in shaping regulatory frameworks and business behavior. As countries continue to tighten their climate commitments, how to enhance the effectiveness of green finance is becoming increasingly urgent. At the same time, AI has advanced rapidly and reshaping financial services. In fact, AI is applied into many economic areas and plays an important role in helping finance workers. The combination of AI and finance shows a trend that AI can empower green finance. Many artificial capabilities like machine learning, language processing and real-time monitoring can help finance accurately identify the risk or direction on time. Therefore, the increasing development of

technology in AI is recognized by both private and public financial institutions seeking to strengthen their green finance. With this trend, realizing how AI improves green finance effectively is becoming more crucial.

There is some research that has explored this phenomenon. One case indicates that green finance is being actively utilized to drive the development of alternative energy and waste recycling projects in the Russian Federation. Since 2021, Rosatom, Russia's state atomic energy corporation, has been using green bonds as an ESG tool to promote green financing for wind power infrastructure. Meanwhile, in the Sakha Republic in northern Russia, a solar integrated development program supported by green financing is being implemented. Notably, the Yakutsk Solar Power Plant was constructed using a green loan provided by Otkritie Bank to the Enel Group, with the project led by RusHydro Corporation [2]. Moreover, another paper also finds that the growth of total green finance investment in India from 2018 to 2022 indicates an increasing adoption of artificial intelligence by both the private and public financial sectors [3]. In 2022, some data also shows the successful AI application in green finance. The accuracy rate of the new system which combined with AI is 3.31% higher than the existing one. Furthermore, the intelligent AI model applied to review green finance has an accuracy of up to 98.85% [4].

However, existing research tends to examine AI applications in green finance in a fragmented way, either focusing on a single tool or sticking to narrow technical indicators. At present, there is still a lack of a coherent framework to connect the inherent logic of AI and green finance adaptation with specific operating mechanisms and guarantee conditions. This paper aims to fill this gap. Building on this, the research explores this theme by professional methods and gives some evidence. Though case analysis and qualitative and quantitative methods, the empowerment mode and practice path of artificial intelligence in green finance are systematically revealed. With the support of various data and cases, the discussion starts from the inherent logic and basic conditions that artificial intelligence can empower green finance. Then, it gradually extends to the core mechanism and directly hits the deepest pain point of green finance. This part includes three important mechanisms which are information empowerment, risk empowerment and regulatory empowerment. Moreover, it reveals the formation conditions of its practice from technology, policy and market dimension to address the guaranteed conditions. Finally, it reveals the formation conditions of its practice and provides practical recommendations.

2. The inherent logic and basic conditions of artificial intelligence empowering green finance

2.1. The inherent logic: the adaptability between AI and green finance

As green finance continues to develop, the industry has long faced four core development challenges: information asymmetry, difficulty in accurately assessing risks, high regulatory costs, and low operational efficiency of business activities. The information asymmetry reflects in the achievement statistics which are scattered in different institutions, the difference in report formats and it rarely has unified verification standards. This leads to difficulties for investors to distinguish effective and continuous projects in green finance. In addition, the risk assessment of carbon price fluctuations and adjustments to regulatory policies is lagging, posing a significant challenge to traditional manual regulatory systems. Moreover, the uncertainty of policy, low participation of capital providers in the biomass energy industry, short-term orientation of financial instruments, and lack of professional technical knowledge within enterprises restrict green financing together [3]. This results in the limitation of capital ways in green finance especially in SEMs, which reduces efficiency and increases supervisory expenditures. Therefore, all these challenges require the

regulation in green financing has high transparency, long-period risk pricing and continuous regulation. However, the green financial system built upon traditional manual calculation and offline review models struggles to meet the above three core requirements.

The technical advantages of artificial intelligence can cover these shortages in theory. Its data processing capacity can make ESG report into standardized and compared index, to directly reduce the information opacity. Risk recognition ability empowered by machine learning algorithms can catch policies, technologies on time to make risk assessment more accurately. At the same time, intelligent decision-making models can integrate carbon emission prediction results to help financial institutions build sustainable investment portfolios. Additionally, the real-time monitoring function automates compliance review and identifies potential greening behavior at a low cost. In fact, AI provides strong support for green finance by enhancing environmental risk assessment capabilities, optimizing sustainable investment portfolios, and promoting the development of innovative financial instruments [5]. Therefore, AI adapts to green finance from internal logic.

2.2. Basic conditions: supporting elements for AI-enabled green finance

The basic conditions of AI in green finance depend on three supporting elements, including policy support, technical support and market support. On the policy side, a number of policies like dual carbon policy, financial technology policy and supporting green finance policies bring the certainty of supervision and generate the standardized data under AI system. On the technical support side, a series of emerging AI technologies including big data, algorithm models, computing power infrastructure, and Internet of Things (IoT) technology support AI to continuously provide real-time environmental information. Last but not least, the market element is also important. Furthermore, the green finance market continues to grow, and financial institutions are rapidly going digitally. At the same time, funding needs for green sectors are increasing significantly. All these market changes support the combination of AI and green finance. To take a successful example, top ten Intelligent (AI-Supported) European Countries such as England and Danish, are expected to take a leading position in integrating AI technology into various fields including finance and sustainable development. By examining the interaction between AI and green finance in these leading economies, people can gain insight into the potential interactions and challenges that arise when cutting-edge technological innovation intersects with environmental and financial considerations. One study analyzed the growth of total green finance investment in India from 2018 to 2022, demonstrating that the application of artificial intelligence in public and private financial sectors is becoming increasingly widespread [3]. Data from related industries shows that technological upgrades in leading countries can drive synchronized upgrades in surrounding regions. Economies with mature artificial intelligence applications can lead the digital transformation of regional green finance [5].

3. Core mechanisms of artificial intelligence empowering green finance

3.1. Information empowerment: solving the problem of information asymmetry in green finance

Information asymmetry represents a core barrier to green finance, preventing capital from flowing effectively to sustainable projects. AI can tackle this problem by data integration and intelligent information disclosure. For data integration, AI system can collect information from multi-source data. It can also break down the data barriers, such as corporate ESG, environmental emissions,

green projects, etc. Data integration builds a unified and horizontally comparable information database to help investors accurately identify the green credentials of projects. For intelligent information disclosure, AI can automatically generate ESG reports. Additionally, it can compare disclosure data with external benchmarks to reduce the possibility of selective disclosure or misleading statements. Therefore, the AI system will enhance the quality and transparency of green information disclosure and increase the credibility of green information in the market [6].

As artificial intelligence technology becomes more widespread, the supporting role of intelligent analysis models in environmental development and green finance has gained industry consensus. These models use comprehensive environmental, social and governance (ESG) data to predict the growth and sustainability of enterprises. Thus, it can meet the severe challenges of data scarcity in the development of sustainable energy projects. Moreover, the green financing model can extract valuable information from unstructured data by integrating natural language processing (NLP) algorithms. Thereby, it can enrich the entire analysis process. In the financial decisions of some enterprises, AI models are used to focus on the strategic allocation of resources and investments to achieve initiatives that align with sustainable development during the decision-making phase. Financial institutions can accurately assess a company's sustainable operating level and potential risks and make rational investment judgments based on integrated ESG quantitative indicators [7]. This combination of data integration and intelligent disclosure constitutes AI's core mechanism for resolving the information asymmetry that has long constrained green finance.

3.2. Risk empowerment: building an intelligent risk prevention and control system for green finance

The AI model can also empower the risk system in green finance. In fact, the risks which green finance faces are difficult to measure by traditional tools. Nowadays, climate policies shift unexpectedly, and technology evolves rapidly in the era of big data. These factors lead to complexity and traditional models which built on historical data have no ability to catch it. However, AI offers a better approach.

In terms of credit assessment, artificial intelligence algorithms can quantify both environmental and credit risks of green projects. Traditional evaluation depends on the subjective judgment of experts. In contrast, AI models can learn from massive data and find the patterns that human analysts may ignore. For example, the machine learning method named gradient elevators have shown better performances than traditional benchmarks in terms of default prediction accuracy [8]. This advantage is particularly valuable for green projects because their risk characteristics are influenced by emerging technologies and uncertain policies. Furthermore, Artificial intelligence can incorporate alternative data such as energy consumption records and supply chains into credit files to comprehensively characterize a company's environmental risk exposure.

In terms of dynamic monitoring, AI is able to continuously monitor green projects in real time. It tracks operational performance, monitors carbon emissions and captures changes in regulatory policies. When a model deviates the expectation in green finance, AI system can issue an early warning than traditional pattern. This changes risk management from regular review during the event to continuous supervision in the middle of the matter. Helping green financial institutions can promptly address hidden dangers before they escalate into major crises. This capability solves the problem which environmental non-compliance or sudden policy changes quickly erode the value of assets. According to the combination of more effective credit assessment and dynamic monitoring, AI can strengthen the entire green financial risk prevention and control system.

3.3. Regulatory empowerment: facilitating intelligence and precise supervision of green finance

AI can strengthen green finance supervision in three methods, including compliance regulation, statistical monitoring and ordained supervision. For compliance regulation, it automates compliance checks. AI system scans transaction records, loan documents and enterprise disclosure information to mark the inconsistency between the green commitment and the actual flow of funds. Thus, it can quickly distinguish between genuine green business practices and false greenwashing behaviors. In contrast with the high consumption of cost and time in manual audit, AI can process massive data at a low cost, making continuous review possible.

For statistical monitoring, AI can help improve statistical monitoring. AI can classify and summarize millions of green financial transactions in near real time. Regulatory agencies thus obtain the latest picture of the scale, flow and composition of green capital, providing a solid data basis for policy formulation. Policy makers do not need to rely on low-frequency sampling surveys to judge industry development trends.

For ordained supervision, AI can realize coordinated supervision. In fact, green financial supervision involves multiple departments, such as environmental data in environmental protection institutions and financial data in financial supervision departments. It is hard to regulate all these data resources at the same time by using traditional supervisory system. However, AI can be used into this part and break down cross-departmental data barriers to enable collaborative supervision of green finance. Compared to traditional models, AI methods can better capture nonlinear relationships and interactions in data. In addition, numerous studies have shown that AI improves prediction accuracy on specific datasets, with Gradient Boosting Machines often outperforming traditional benchmark models in default prediction. Moreover, traditional portfolio theories like Markowitz mean-variance model often struggle with nonlinear constraints. For example, setting carbon footprint caps or addressing sparse data issues in emerging green technology sectors. In contrast, artificial intelligence-optimized models can integrate ESG scores, public sentiment, and supply chain alternative data to nearly real-time predict asset returns and update risk valuations. From a number of research, empirical studies show that AI outperforms classical models in identifying risk exposures and making predictions [9]. Therefore, all these three functions introducing A provide more accurate and in-time data to strengthen the credibility of the whole green finance market.

4. Guaranteeing conditions for AI empowering green finance

4.1. Technical level: deepening AI technology R&D and integrated application

Sustaining AI's role in green finance requires continued technological investment. The primary measure is to increase investment in artificial intelligence research and development, and to build specialized algorithm models tailored for green finance scenarios. It can involve climate scenarios, biodiversity indicators and transformation paths in credit scoring and investment screening tools. By comparison, general models without AI are difficult to fully capture the long-term environmental indicators of green assets. To take an example, RegTech can be used to automate an organization's internal compliance systems and effectively identify various financial crime risks, including money laundering and violations of sanctions regulations.

Another important factor is to promote the integration of AI with big data, IoT, and blockchain to strengthen the technical foundation. Additionally, synchronously build a green finance data sharing

platform and unify data statistics and disclosure standards across the entire industry. To address cross-border issues and create a level playing field for green finance and fintech startups, regulatory authorities across countries also need to establish efficient cooperative relationships. On the other hand, the harmonization of international standards and information sharing can foster a favorable environment that promotes innovation while preventing "regulatory arbitrage" [10]. It is clear that technology, green finance, supportive macroeconomics and a digital environment play interconnected roles in driving the transition of developing countries toward sustainability. Therefore, technological advancements have not only improved the transparency and traceability of green investments, thereby reduced the risk of "greenwashing", but also promoted real-time ESG analysis [11]. These technological advancements have built investor confidence and accelerated the mainstreaming of sustainable finance.

4.2. Policy level: improving institutional guarantees and incentive-restriction mechanisms

Policy measures are important for leading the AI innovation in green finance as well as controlling its risk. The first step can be encouraging targeted policies. Regulatory sandboxes, innovation subsidies and pilot projects provide space for financial institutions to test AI tools. All these policies can lower the threshold for early adoption. Then, establish AI green financial ethics standards to prevent algorithmic bias and data security risks. Strengthen regulatory coordination and severely crack down on 'greenwashing' behaviors caused by the abuse of AI technology. At present, Various international organizations have introduced supporting regulatory policies, and their implementation has yielded significant results. The International Organization of Securities Commissions (IOSCO) and the Financial Stability Board (FSB) have issued regulatory guidelines on fintech and sustainable finance, while the Paris Agreement, aligned with global climate goals, has established a macro-level framework for this area [10].

4.3. Market Level: cultivating an AI green financial ecosystem

From the market level, it is necessary to guide various types of social capital to participate in the digital innovation of green finance and activate market vitality. Venture capital, institutional investors and public welfare funds can all contribute. Their participation brings new ideas and also stimulates competition. More competition will reduce the costs and accelerate application promotion. Furthermore, strengthen international exchanges and cooperation, and draw on mature integrated practice experiences from overseas. Different countries have different ways to introduce AI in green finance market. Some take the lead in using AI for green bond verification, some use AI for climate risk stress testing. Sharing experience to make cooperation among countries can avoid repeating mistakes. Thus, cross-border knowledge exchange will spread best practices faster. Lastly, enhancing green finance awareness among market entities is also significant. The main reason is that many financial practitioners still know little about AI while many enterprise managers lack knowledge of green finance. Training programs and publicity are essential to improve two aspects of literacy. Follow this strategy, a full- information market can distinguish between real green products and "greening" behavior. Then, it can reward real innovation. Thus, it can be guaranteed conditions for AI empowering green finance.

5. Conclusion

This study examines how artificial intelligence empowers green finance and gives practical suggestions. Based on the literature analysis method and data analysis method, the research expounds the inherent logic and basic conditions of artificial intelligence empowering green finance. It analyzes the abilities of AI in data processing, risk assessment, intelligent decision-making and real-time monitoring to respond to the difficulties in this area under the traditional system, including information asymmetry, difficulty in accurately assessing risks, high regulatory costs, and low operational efficiency. Building on this, the study then examines core mechanisms of artificial intelligence empowering green finance from three parts. This is manifested on information dimension, risk dimension and regulatory dimension. Information empowerment breaks down data barriers and improves the quality of disclosure. Risk empowerment achieves more accurate credit assessment and dynamic project monitoring. Regulatory empowerment promotes the automation of compliance inspection, the accuracy of statistical tracking and promotes cross-departmental coordination. Then, the study shows the guaranteeing conditions from technology, policy and market level. The integrated applications of AI technology, use of institutional guarantees and incentive-restriction mechanisms, and healthy green finance ecosystem are all essential to make sure the empowering of AI in green finance.

The research findings indicate that AI is not only the auxiliary tool, but also the new power of reshaping the way of information collection, risk pricing and compliance guarantee methods. Under the premise of proper governance, AI can significantly empower green finance from different parts by using the combination of new technology. To unleash this potential requires actions concerned by all parts like information, management and regulation. In the future, policy makers should construct clear rules. In addition, financial institutions should invest in dedicated models and data sharing. Furthermore, the wider market in the future needs the cooperation of countries. Therefore, the international communication in AI empowering green finance is significant.

In conclusion, the development of AI in green finance will depend on the close combination of technological progress and governance. As green finance continues to expand in service of global sustainability goals, the intelligent empowerment discussed in this paper will become more and more critical.

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