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Optimized application and potential impact of blockchain technology in carbon trading

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Abstract:

The integration of blockchain technology with carbon trading opens up new avenues for carbon market optimization. The use of blockchain technology to address climate change is the main topic of this research. Using case studies as a basis, it examines how blockchain technology might help optimize the carbon trading market. It is discovered that the drawbacks and inefficiencies of the carbon trading market can be technically addressed by the current blockchain technology. Blockchain technology has been instrumental in increasing the market's transparency and streamlining the trading procedure for carbon offsets. Green finance and blockchain technology work together to lessen "greenwashing" behavior, and their cooperation enhances the carbon trading market. This research offers a valuable resource for the enhancement and novelty of carbon trading methods, the growth of environmentally conscious financial enterprises, and the incorporation of the carbon market through the utilization of blockchain technology.

Keywords: blockchain technology; Carbon trading; Green finance.

1. introduction

Reducing carbon emissions has emerged as a key strategic approach for the global community to address climate change and advance the development of an ecological civilization, guided by the principles of green development. Carbon trading is a successful strategy for achieving the goal of reducing carbon emissions and is a crucial governance instrument to ease the tension between the construction of an ecological civilization and social and economic progress. The national economy's transition to a green economy and its development can gain impetus from the systematic and effective establishment of the carbon trading market.

A recent development in the green economy is carbon trading, which presents a new challenge to the market economy. After undergoing pilot research, national market setup, and other practical phases, China's carbon trading program is now facing various institutional issues, which are mostly seen in the market and oversight. First and foremost, the market's primary issues are the imprecise application of price and the ambiguity of trading regulations. The carbon trading market is valuable but not marketable since the existing laws and regulations do not define the legal nature of carbon emission rights or make clear the rights and obligations of the trading subjects in the carbon market. In addition, the market pricing power of carbon trading and carbon tax is constrained by the absence of high-level design and legal backing. On the other hand, data fabrication, fraudulent trading, and inadequate security may result from the centralized trading mechanism of carbon emission rights. Second, from the standpoint of supervision, the information asymmetry between government agencies and businesses results in the arbitrary distribution of the static right structure and accompanying supervision mechanism of carbon trading. This, in turn, causes institutional barriers like ambiguous rights attributes of trading subjects, laborious and ineffective trading procedures, and irregular trading subject behavior, which has become the main factor limiting the market-oriented allocation of carbon resources. It is imperative to incorporate new technology and governance concepts because it is difficult to handle these difficulties just with the current trading mechanism and governance.

Blockchain technology offers fresh perspectives and answers for enhancing the existing carbon trading system and creating a cutting-edge one. With the rise of Ethereum, blockchain gradually evolved into the underlying architecture and distributed computing paradigm, using smart contracts to build business logic. Its application scenarios have been expanded to include social and environmental governance. Initially, blockchain was primarily used in the cryptocurrency industry, which is represented by Bitcoin. A few academics have looked at the feasibility and potential use cases of blockchain in the context of

carbon emissions trading. Certain academics envision the utilization of blockchain technology in the carbon trading industry, to automate carbon trading and guarantee data validity. These concepts offer a theoretical framework for further investigation.

In general, the above-mentioned market and supervisory pain points are the main focus of current research on carbon trading. However, development is constrained by the intrinsic flaws in China's traditional centralized carbon trading paradigm, including asymmetric knowledge, inadequate security, and challenging oversight. Blockchain offers inherent technological benefits in addressing these issues. Nevertheless, applicability analysis, application scenario description, or basic technical application discussion are still the extent of the study being conducted today. At the level of the entire trading system, it was unable to accomplish an inventive breakthrough in carbon trading through the application of blockchain technology. The majority of the research that has already been written has examined how blockchain technology can be used to address the climate change challenge, covering project benefits, technology deployment, and effects.

The analysis that is specifically targeted at the field of carbon trading is still lacking, and the current research does not have an analytical framework that takes into account the drawbacks of carbon accounts and carbon credits. Instead, it focuses on how to achieve carbon neutrality when analyzing the joint mechanism that includes green financial technology. As a result, this study will examine how blockchain technology functions in the carbon trading industry and integrate its benefits to maximize the particulars of carbon trading. The role of green finance and blockchain technology in the carbon trading process is examined in combination.

2. literature review

2.1 The use of blockchain technology for climate change mitigation

The unique advantages and features of blockchain technology itself (Luu et al., 2016; Huang et al., 2023) have played an important role in addressing the climate change crisis, providing new solutions for solving the climate crisis. Chen (2018) introduced blockchain technology analysis into the carbon and energy markets and found that blockchain plays an important role in improving transparency and accountability in the carbon and energy trading markets by studying the application of distributed ledger technology, the core technology of blockchain. Blockchain can build a bridge of technological laws in society by establishing consensus on information and value. This indicates that interdisciplinary cooperation in addressing the climate crisis has led to the emergence of more reliable policies and financial tools, increasing the likelihood of solving the climate crisis. The blockchain technology has had a huge impact on the economy and environment.Catalini (2018) discovered that bitcoin and blockchain technologies can coordinate economic activity while promoting incentive mechanisms. Blockchain technology has the potential to lower network costs, alter the role of middlemen in the relationship between the public sector and the government, and lessen competition for public services. Moreover, operators can increase operational efficiency because of the data integrity that blockchain technology offers. Due to its ability to safeguard sensitive data, blockchain technology further improves data security. Gunay et al. (2023) explained the association between the Solactive Global Sustainability Leadership Performance Index (GSI) and 13 cryptocurrency industries using the quantile VAR model, FIGARCH, and DCC-FIGARCH. The findings indicate a small but steady correlation between global sustainable development, games, entertainment, logistics, and metauniverse NFT. Future application opportunities for blockchain technology are numerous and have a beneficial impact on global sustainable development when implemented in traditional marketplaces. According to Howson's (2019) research, blockchain technology has potential applications in the areas of carbon footprint assessment, smart contract efficiency, and the relationship between tokens and carbon credits. The social impact of these blockchain initiatives is concentrated at the local level, despite their worldwide reach. Certain initiatives don't support the growth of the neighborhood, which will probably make structural inequality worse. As such, we should consider blockchain technology's social and environmental implications in addition to its potential applications in mitigating climate catastrophe.

2.2 The use of carbon trading and blockchain in the financial industry

Theoretically, blockchain may significantly enhance the carbon market, bolstering efforts to combat climate change. There isn't enough real-world experience, though, to say if blockchain technology can create an efficient and transparent carbon market. Sipthorpe et al., An evaluation was conducted on the blockchain solution developed for the carbon market in 2022. They investigated the current blockchain ecosystem and identified 39 organizations dedicated to developing blockchain solutions for the carbon market to understand the benefits of these solutions. The results of this study indicate that some commercially viable solutions have already had an impact on the market.

Although blockchain has been proven to be a powerful tool for improving carbon offset tracking and trading, it is not a panacea. Under the joint mechanism with green finance, blockchain technology will further play a greater role in achieving carbon neutrality goals. Qin et al. (2023) found that although the development of green finance is superior to the blockchain market in terms of sustainability and stability, it lags slightly behind in terms of speed and impact. In addition, green finance can have a positive and lasting impact on the blockchain market. This impact is more stable and significant than the impact of the blockchain market on carbon neutrality. Green finance and blockchain both indirectly affect carbon neutrality goals. Against the backdrop of severe challenges posed by climate change, these findings are crucial for China to vigorously develop its blockchain market and green finance to achieve carbon neutrality.Blockchain technology has significantly impacted the carbon trading business in the financial sector. Certain documents center on the examination of markets and finances, delving into the benefits and blend of carbon trading with blockchain technology, as well as the drawbacks of financial markets. A few papers examine how blockchain technology and green finance work together to mitigate climate change and achieve carbon neutrality.

2.3 Summary

The majority of the literature now in publication examines how blockchain technology can be used to address the climate change challenge, covering project benefits, technology deployment, and impacts. Blockchain technology has a significant influence on the carbon trading market in the financial sector. Additionally, some documents concentrate on the level of financial and market research. These begin with the features of financial markets and blockchain technology and then go on to describe the benefits and advantages of carbon trading and blockchain technology combined. Additionally, other research examines how blockchain technology and green finance work together to mitigate climate change and achieve carbon neutrality. The analysis in the field of carbon trading is still lacking, though, as the current research does not include a framework for analyzing the drawbacks of carbon accounts and credits and instead focuses on the path toward achieving carbon neutrality when analyzing the joint mechanism in conjunction with green financial technology. To examine blockchain technology's function in the carbon trading industry and enhance the particulars of carbon trading, this research will integrate its features and benefits. This research examines the function of green finance and blockchain technology in the carbon trading process.

3. Blockchain Technology's Use in Carbon Trading

3.1 Blockchain technology to address the carbon market issue

Blockchain technology is very helpful in achieving carbon neutrality and mitigating climate change. The use of blockchain technology advances the platforms and policies for responding to climate catastrophe. Blockchain technology is a cutting-edge digital innovation with enormous promise across a wide range of industries, including finance, supply chain management, and data storage. Decentralization, or the ability to maintain the database across several network nodes independently of a central control point, is one of its fundamental characteristics. Because every node maintains a copy of the entire blockchain, the system is guaranteed to be transparent and impenetrable. Furthermore, it is nearly impossible to alter data once it has been captured and committed to the blockchain. Consensus algorithms and encryption technologies, which guarantee data confidentiality and integrity, make this non-comparability possible. The very transparent properties of the blockchain are further guaranteed by its decentralized nature and immutability. Everybody has access to the entire history record, as well as completed transactions and activities, on the public blockchain. Smart contracts are a significant use case for blockchain technology that can simultaneously improve processing efficiency and lower human error rates by automatically executing contract terms and triggering preset instructions when specific criteria are satisfied.

Achieving carbon neutrality is integrated with blockchain technology under the "Carbon Neutralization-Blockchain Platform" that China has developed and refined (Figure 1). Through the connection of numerous significant players, such as government agencies, parks, emission companies, financial institutions, third-party verification organizations, and blockchain technology/service providers, the platform unifies the requirements and functions of all parties. Government departments are required to monitor carbon emissions, assess carbon neutrality and peak emissions, monitor energy conservation and emission reduction, monitor carbon vertical integration, and provide guidance for the carbon trading market. They also formulate pertinent policies and environmental protection measures, create laws and regulations, and oversee and evaluate environmental protection indicators. Its primary duty is to put into practice the park's low-carbon park design, low-carbon park management, and carbon emission monitoring regulations. Enterprise carbon information and enterprise carbon emission data are among the services

that emission firms provide. Enterprise emission analysis, management, monitoring, reporting, and verification are among the demands that these businesses have. Financial institutions are required to manage carbon assets, establish a green financial system, finance green projects, and develop new green financial products. They also need to manage green finance (credit, bonds, financing, insurance, etc.), green financial supervision, and carbon asset management. Third-party verification institutions serve the purposes of enterprise certification, product certification, and carbon emission certification. Their demands include carbon emission accounting, carbon emission verification, reporting, and enterprise data sharing. Using the platform as an emission firm to accomplish its green transformation, reach the objective of carbon neutrality, and expand products and services and technical innovation are among the needs of blockchain technology/service providers. Its duties include providing technical development and maintenance, underlying technical architecture, and technical service support. The main goals of the carbon neutrality blockchain platform are to use blockchain technology to handle carbon emission data in a transparent, reliable, and effective manner and to encourage collaboration and advancement among all stakeholders involved in green financing and carbon emission reduction.

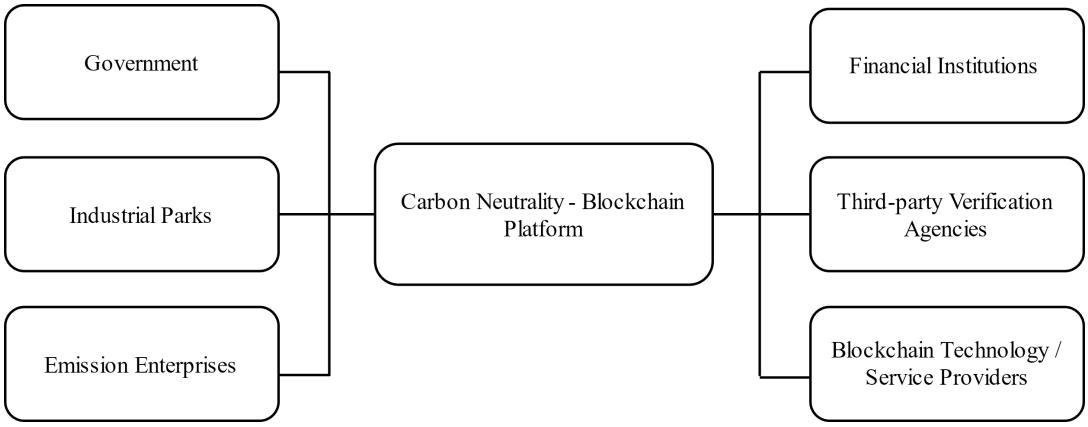

Figure 1. Platform Framework of Blockchain and Carbon Neutralization

The carbon market offers financial incentives for cutting greenhouse gas emissions by allowing the selling of carbon emission rights against the backdrop of global climate change. Nevertheless, inefficiency and a lack of transparency are issues that carbon trading must deal with given the market's growth and complexity. The current carbon market faces multiple challenges, which to some extent limit the efficiency and potential of the market. Firstly, there is the issue of transaction efficiency. Due to the global and complex nature of the carbon market, the carbon trading process often involves tedious recording and verification steps, resulting in low trading efficiency. In addition, the carbon market also faces the problem of insufficient transparency. In the existing carbon trading system, the quantification, reporting, and verification (MRV) process of carbon emissions lacks sufficient transparency, which may lead to market participants questioning the effectiveness of trading. In addition, regulation and compliance are also important challenges facing the carbon market. Different countries and regions have inconsistent regulatory standards for carbon emissions, making cross-border carbon trading complex. Meanwhile, ensuring that all market participants comply with relevant regulations and standards is crucial for maintaining market fairness and effectiveness. The introduction of blockchain technology may provide new solutions to these challenges.

The characteristics of blockchain technology, such as decentralization, transparency, and security, are expected to solve the transparency and efficiency issues in the carbon market (Figure 2). The digital currency products generated by the application of blockchain technology in the currency system may simplify the process of cross-border carbon trading through their fast and convenient payment characteristics. Blockchain can be used to track carbon emissions and manage carbon footprints. Enterprises can store their carbon emission data on the blockchain, ensuring transparency and immutability of the data, which helps to better understand and manage their carbon footprint. In addition, blockchain can support carbon markets and carbon emissions trading. A carbon trading platform can be built on a blockchain to facilitate the buying, selling, and trading of carbon emission rights. This encourages companies to take carbon reduction actions and earn rewards by selling excess emission rights.

Overall, although the carbon market provides economic incentives in reducing greenhouse gas emissions, its inefficiency, lack of transparency, and regulatory and com-

pliance issues limit the market's efficiency and potential. The introduction of blockchain technology may provide new ways to solve these problems, thereby promoting the development and improvement of the carbon market. In the future, we can foresee that through the application of blockchain technology, the carbon market will become more efficient and transparent. Regulatory agencies and market participants will be able to better coordinate and cooperate to jointly address the challenges of climate change. The development of carbon markets not only contributes to the achievement of global climate goals, but also promotes technological innovation and economic development.

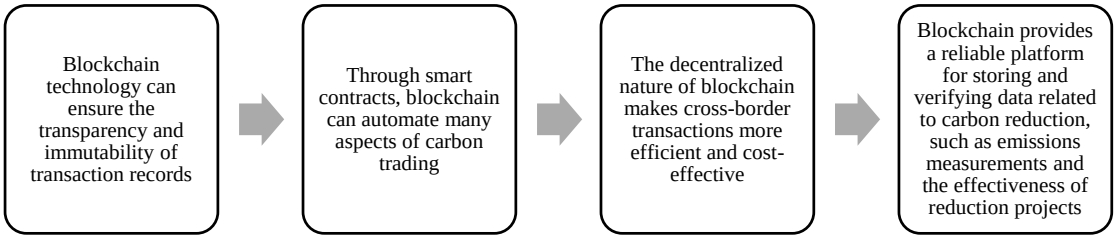

Figure 2. Specific application mode of blockchain technology in carbon trading

3.2 Veridium with IBM: A Blockchain Technology Use Case

IBM and Veridium Labs are collaborating to revolutionize the carbon credit market. Veridium plans to leverage blockchain technology from IBM to streamline the process of mitigating its environmental impact.

The entire carbon footprint accounting and offset procedure will be covered by Veridium's carbon credit service. Veridium wants to transform carbon credits into marketable digital assets that can be traded on the Stellar network and lessen friction by utilizing IBM's blockchain technology and experience. Customers and developers will be able to engage in token-related networks through the project, which will operate on IBM's public and private blockchain networks.

Veridium, like many others, believes that to address the issues of climate change and other social and environmental concerns including deforestation, biodiversity loss, and reaching the UN sustainable development goals, there is an urgent need for workable and market-oriented solutions.

The biggest corporation in the world is currently dealing with enormous environmental liabilities, which could force a significant write-down of stranded assets and a significant loss of shareholder value.

Veridium aims to offer a market-based subversive solution for the point of consumption, even if the primary focus of scholarly and political attention has historically been on finding solutions to these issues at the production point. The original members of Veridium have directly incorporated environmental effect mitigation into EcoSmart offset tokens through a series of EcoSmart agreements.

Many businesses purchase third-party carbon credits, but determining emissions throughout an intricate supply chain may be difficult and expensive, and purchasing financial instruments linked to carbon credits can be just as challenging.

Tokens or digital assets based on blockchain technology may offer a fresh approach to buying and using possible carbon offsets. Tokens on the network may be moved and settled, which is what makes them appealing.

Tokenization, according to Veridium, improves information flows and confidence between network users and trading partners. Furthermore, a more accurate measurement of the environmental impact can be achieved by incorporating the entire carbon accounting procedure and offset into the digital token on the public licensing blockchain network. Additionally, it facilitates the ownership transfer and increases the efficiency of base carbon offset redemption.

3.3 Possible drawbacks of blockchain usage in Carbon trading

Using blockchain technology in carbon trading could provide several difficulties. Any new technology will unavoidably have some risks and issues along with the possibility of advancement and benefits for certain applications. In the application phase, blockchain will encounter numerous obstacles due to its revolutionary and fundamental nature, including market and technological issues. Consequently, rather than overly idealizing its application, it is imperative to approach it rationally and objectively and to establish a solid foundation and route for the advancement of blockchain technology. The implementation of blockchain technology in carbon trading may encounter subsequent obstacles.

3.3.1 Escalation of current issues with the carbon market

First off, benefit transfers and money laundering might be

simpler thanks to the blockchain's smart contract technology. Blockchain promotes the autonomy of participating nodes and minimizes the intrusion of external parties, in contrast to the old centralized administration style. This demonstrates how transactions between market participants in the carbon market are automatically received and carried out by intelligent contract software. The efficiency and standardization of carbon emission trading have increased as a result of this shift from "system-driven" to "machine-driven" organization and management, but it may also result in the automation of issue trading. Second, even while blockchain technology prevents tampering and guarantees data integrity and security, incorrect data supplied to the chain could have a greater detrimental effect. While blockchain's tamper-proof and traceability features help to guarantee data authenticity, data security and quality problems are still there and need to be addressed.

3.3.2 Technical Issues Resulting from Blockchain

The first technological difficulty is the possibility of errors when incorporating carbon trading regulations into smart contracts, which could cause the real operation results to differ from the predicted outcomes. Blockchain is a decentralized consensus method that relies on algorithms to provide traceability, non-tampering, and node participant recognition. Asymmetric encryption, hash algorithms, and other algorithms make up blockchain technology's consensus architecture. The second issue is the absence of technological standards for data about carbon trading, which could have an impact on data application and sharing as well as prevent blockchain functions from operating to their full potential. Integrating and sharing all facets of carbon trading—complete control, quota distribution, registration, transaction processing, performance verification, market oversight, and credit oversight—is a key objective of blockchain applications. It seeks to achieve the coordinated operation of carbon trading management and supervision by closing the gap between the regulatory agencies of the ecological environment, industry and commerce, finance and registration, trading, and other regulatory agencies.

3.3.3 Complexity of responsibility attribution

The first accountability issue is that it's currently unclear who is responsible for blockchain research and development. Blockchain is an abstract network mapping of entity existence, and for this mapping process to be realized, a specific material carrier is required. Blockchain is a digital transmission path of information and value. This indicates that the technical implementation of "blockchain+carbon trading" must be founded on the technical design and system development of computer experts and that the operational performance of blockchain carbon trading will be significantly impacted by the advancements made in pertinent R&D fields. The second issue is that it's still unclear who is responsible for what in terms of blockchain operation and maintenance. Apart from research and development, operation and maintenance constitute a crucial component for the secure and reliable functioning of blockchain technology. The technical proficiency and value-based approach of these subjects are the primary determinants of the safety of blockchain operations. As a result, one of the key organizations that influence how well blockchain carbon trading performs is the core organization responsible for blockchain operation and maintenance.

4. The development of carbon trading through the blockchain's and green finance's complementary mechanisms

Based on earlier trial programs, China began building a carbon trading market in December 2017 that will eventually overtake the European Union to become the biggest carbon trading market globally. Initially, the market for carbon trading was limited to the power sector and included emissions of 3.5 billion tons of carbon dioxide, which is more than double the emissions of the European Union. Regarding goods, the carbon emission market in China primarily deals in carbon forwards, some of which resemble futures. For instance, Hubei's 2016 launch of carbon forward goods featured a centralized matching transaction system and demonstrated a wide range of market prospects with a trading volume of more than 150 million yuan and 6,802,200 tons on the first day of listing. Furthermore, Shanghai's early 2017 carbon quota forward products have a clear "futures-like" quality in that they can be delivered in kind or cash in February, May, August, and November. By December 31, 2021, the national carbon market had been incorporated into 2162 important emission units in the power generation sector since its official launch on July 16, 2021. Over 114 trading days, 179 million tons of carbon emission quotas were traded, with a total turnover of 7.661 billion yuan. While the carbon trading market employs market processes to disperse carbon quota resources and encourage businesses to reduce their carbon emissions through financial incentives, green financing can fill the capital gap for low-carbon enterprise transformation. Simultaneously, the carbon market can assist businesses in implementing low-carbon technological changes, enhancing energy efficiency, and reaching emission reduction objectives at a reduced cost.

However, issues including the high cost of green identification and asymmetric information persist in China's carbon trading market and green finance system. These issues raise credit risk and severely impede the growth

of the carbon trading and green financing sectors. For instance, there are often "greenwashing" issues with certain businesses and financial institutions. If the financial market is allowed to run wild, good money will be driven out by bad, increasing the amount of money invested in the "greenwashing" venture and making it more difficult for genuine green businesses to secure funding. The information imbalance between the capital supplier and the capital demander is the primary cause of the "greenwashing" problem. According to Dorfleitner and Braun (2019), blockchain technology can lessen the possibility of "greenwashing" and increase accountability and transparency through efficient monitoring, reporting, and verification. Blockchain's immutability can address the traceability issue in the sharing of environmentally friendly information. Blockchain technology offers benefits in lowering transaction costs, addressing information asymmetry, and expanding financial services. The carbon trading scheme is more reliable because of its well-coordinated development with green money.

5. conclusion

This article discusses the current challenges that limit the efficiency and potential of carbon markets. A major issue is the trading process, which involves cumbersome documents and verification steps due to the global and complex nature of the carbon market, resulting in low efficiency. In addition, higher transparency is needed in quantifying, reporting, and verifying carbon emissions, as existing systems may question the effectiveness of trading. Regulatory emission standards vary by country and region, complicating cross-border carbon trading. Ensuring compliance with regulations is crucial for maintaining market fairness and effectiveness.

Blockchain technology has the characteristics of decentralization, transparency, and security, which is expected to improve the transparency and efficiency of the carbon market. The digital currency products generated by applying blockchain technology to the currency system can simplify cross-border carbon trading through fast and convenient payment functions. In addition, blockchain can track carbon emissions and manage carbon footprints, ensuring transparency and immutability of data. It can also support carbon markets and trading platforms, promote the buying, selling, and trading of carbon emission rights, thereby encouraging companies to take action to reduce carbon emissions and receive rewards by selling excess emission rights.

Blockchain technology is anticipated to be applied in the future to improve the efficiency and transparency of the carbon market. To address the challenge of climate change, regulators and market actors will be able to collaborate and coordinate more effectively. This development will support economic growth and technical innovation in addition to aiding in the achievement of global climate goals. This study does still have certain limitations, though, and the decision to use IBM and Veridium as the case was unavoidably subjective. Thus, by merging data and machine learning, it is proposed that future research can further model and analyze the benefits and pathways of the coupling of blockchain technology and carbon trading.

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