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Fintech, Green Bonds and High-Quality Green Development in Regions

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Abstract. First of all, this paper explains the role of fintech in enhancing green finance by reducing costs, increasing financial inclusion and improving information. Furthermore, it introduces the incorporation of technology into green finance, including green identification, information disclosure, product innovation, risk evaluation and regulatory reform. Secondly, the paper examines the use of blockchain in data storage and fund traceability, as well as the developments of artificial intelligence in determining prices and assessing credit for green bonds. Thirdly, it reviews the evolution and market expansion of green bonds from the first climate bond issued in 2007 to China's status as the major issuer in the world. The paper investigates how green finance allocates capital, stimulates innovation and supports industrial transformation to promote regional progress. It analyzes the regional differences in green finance and proposes a lifecycle model for fintech-assisted green bonds to promote regional growth. The findings indicate that the combination of fintech and green bonds encounters certain obstacles, such as insufficient environmental information disclosure, uneven development of digital facilities and inconsistent criteria for identifying green assets. Future research should concentrate on the analysis at the micro level, broaden regional and international comparative studies and solve issues like transition finance and biodiversity finance. This summary outlines the main literature and gives suggestions to improve the combination of green and digital finance, which is advantageous to the "dual carbon" objectives.

Keywords: Fintech, Green bonds, High-quality regional green development, Green finance

1. Introduction

With global warming and environmental concerns, countries focus on green and low-carbon development for continued progress. China plans to reach the maximum emission of carbon before 2030 and accomplish the carbon neutrality before 2060. Green development is an important part of its national policy. To reach green development, substantial financial aid is necessary. Green finance allocates capital to environmental protection, resource saving and restoration, promoting green industries, innovation and regional expansion. It links the financial resources with the green enterprises.

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Green bonds have an important position in the green financial industry. They are encouraged because of some regulations concerning the use of funds, regular reports and government assistance. The green bond market in China has grown since 2016. Now more issuers and sectors are involved. By 2024, the total amount issued is over 4 trillion yuan. This guarantees a continuous provision of funds for the expansion of new energy, green transportation and environmental projects. It promotes regional enhancement and green development. Nevertheless, there are still some difficulties, such as the high expense of project evaluation, fund supervision, inadequate reports and various documents. These obstacles affect the efficiency of green bonds.

Financial technology is based on big data, artificial intelligence, blockchain and cloud computing. It alters the financial sector in a fundamental way. Financial technology is a new source of improved green finance. Its advantages comprise powerful data analysis, fast recognition of information, correct pricing of risks and open supervision of funds. These characteristics aid in solving the problems of green bond construction. For example, big data establishes multi-faceted green credit systems, reducing the cost of project identification. Artificial intelligence assists in pricing green bonds precisely and enhances risk management. Blockchain guarantees the trail of green funds and the independent verification of the benefits.

Scholars have investigated the effect of fintech on green finance. They indicate that fintech influences green finance by reducing expenses, enhancing inclusiveness and providing information. Technology aids in green identification, disclosure, new product development, risk control and fulfilling regulations. Huang discovered that fintech increases the issuance of green bonds by decreasing search costs and raising investors' confidence [1]. Dai Xinran also observed the same results in China [2]. Nenavath found that fintech and green bonds are beneficial for renewable energy in India [3].

In the study of the transparency and regulation of green bonds, Alfalah pointed out the significance of financial technology methods [4]. Technologies such as blockchain, artificial intelligence and digital identity systems improve the transparency, trust and availability of the green bond market. From the viewpoint of "dual carbon", Shi and Yang examined the impact of combined digital and green finance on carbon emissions [5]. They found that this kind of combination can lessen the carbon emission intensity. Liu investigated the relationship between green finance and digital technology in China and its effect on pollution and emissions [6]. The joint advancement leads to a reduction. At the enterprise level, Yao discovered that the coordination between green finance and financial technology influences corporate risk-taking [7]. Zhuang analyzed the moderating role of digital technology on the efficiency of green and blue finance by using cross-national data [8]. They discovered that green finance works better in countries with advanced digital equipment. For green innovation, green fintech facilitates corporate carbon neutrality by providing financing and enlarging the scale and quality. This effect is largest in areas with a higher degree of digitalization.

Past investigations have investigated the support of fintech for green finance, but the literature is divided. The majority of the studies consider the role of fintech from one aspect or conduct general macro analyses. Little research connects fintech with green bonds and strong regional green development. Some important issues still exist. How can fintech facilitate the entire life cycle of green bonds to promote regional growth? In what ways do the technological changes in capital, innovation and industry induced by fintech affect the development of the green economy? Is it possible for fintech to narrow the gaps of green finance among regions? A comprehensive review is required to elucidate the circumstances, summarize the results and indicate the future directions.

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This paper studies fintech, green bonds and regional green development. The objectives are to define the role of fintech in green finance and to establish an empowering system. It also describes the assistance of blockchain and AI in handling green bond information and valuation. Furthermore, this paper introduces the concept and the market of green bonds as a basis. It examines the procedures, methods and regional differences in developing green finance. Additionally, a lifecycle model for green bonds supported by fintech is presented, illustrating the results, pointing out the research limitations and proposing suggestions for future research. This research improves the connection between green and digital financial theories and policies.

2. Research progress on the integration of fintech and green finance

2.1. The theoretical logic of fintech empowering green finance

Fintech, supported by the development of technology and digitization, improves green finance via three aspects: economy, inclusiveness and information. The economy comes from the application of automatic devices and intelligent systems. They transfer the credit examination from offline to online, simplifying the traditional green loan and decreasing the time and labour cost for corporate financing. The inclusiveness makes use of methods such as mobile payments and robot advisors to promote green financial services to small and medium-sized enterprises and 'tail' customers. This avoids the exclusion that usually appeared in conventional finance. The information makes full use of artificial intelligence and big data to gain understanding from vast data sets. It facilitates the precise identification of users for green loans and monitoring of funds flow, thus reducing the moral hazard.

From a technical viewpoint, fintech is based on big data, cloud computing, blockchain and artificial intelligence. It can solve the problems in green finance from different aspects. While assessing green finance, big data and artificial intelligence build an intelligent evaluation system to update the green information in time. At the disclosure stage, the distributed ledger of blockchain stores the entire process of ESG reports and carbon-trading data on the Internet. Cloud computing establishes a database to eliminate the information barrier. For new product development and pricing, artificial intelligence and big data generate green customer profiles and develop intelligent pricing models. They also assist in the production of various green financial products. In risk management and regulation, integrated learning and neural networks construct a green risk control system. Blockchain offers a regulatory sandbox for effective supervision. Regarding operational costs, cloud computing modifies the system to decrease the IT maintenance fees. Artificial intelligence supports precise marketing to decrease unnecessary advertisement expenditures.

2.2. Research on the application of fintech in the field of green bonds

Information asymmetry is the main barrier to the advancement of green finance. At present, the environmental information disclosure system in China is imperfect. The amount of disclosed information by enterprises is not sufficient and the quality of the data is low. Financial institutions need to spend a lot of effort on information search and verification for green identification, which means the process of checking whether the projects or companies truly conform to the environmental criteria. At the same time, the reward and subsidy policies for green projects in various regions motivate enterprises to obtain green labels - formal certificates indicating that a project or enterprise satisfies certain environmental standards - to gain credit advantages. This also raises the identification and risk management costs. Financial technology can greatly solve these

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problems. Big data, which consists of large and complex datasets that can be processed computationally, breaks down "data silos" and allows the real-time and credit-based integration of both standard (structured) and non-standard (unstructured) data. The "authenticity" and "complete recordability" features of blockchain, a decentralized and tamper-proof digital ledger, make it possible to supervise and issue risk warnings for the flow of funds in real time. The system of big technology platforms contains digital footprints such as enterprise operation processes and transaction networks, which document a company's business activities and financial operations. These provide abundant data support for green identification and risk management.

Artificial intelligence plays an important role in the pricing and credit evaluation of green bonds. The pricing of green bonds should consider various aspects, like the market interest rate (the cost of borrowing in financial markets), the credit risk (the possibility that the bond issuer will not pay back the loan) and the environmental externalities (the environmental advantages or disadvantages of the project financed by the bond). But the precision of the traditional linear models is usually insufficient. The application of deep learning technology offers a new way to solve this problem. The hybrid models, for example, combining convolutional neural networks (which are good at recognizing patterns) and bidirectional long short-term memory networks (which handle sequential data from both directions), can improve the accuracy of yield prediction greatly compared with the traditional methods.

Alfalah pointed out that blockchain (a secure and decentralized digital record of transactions) and artificial intelligence (the application of computer systems to carry out tasks which usually need human intelligence) are important in increasing the transparency of the green bond market and the investor's confidence. Huang's empirical study showed that financial technology (the application of new technologies to finance) can greatly facilitate the issuance of green bonds [9]. Its working principle mainly includes decreasing the cost of information search (the time and resources spent to obtain relevant information) and improving the investor's confidence. Similarly, this conclusion was also obtained from the data of Chinese provincial governments.

In conclusion, fintech enhances the green finance system via the combined action of several methods. These methods involve restructuring the information system, decreasing transaction costs, improving risk management and promoting the innovation of regulatory technology. This gives a theoretical foundation for studying the coupling and coordination among fintech and green bonds, as well as their impacts on green development.

3. The concept and evolution of green bonds

Green bonds are kinds of debt investments. Compared with normal bonds, green bonds must be used for green industries, projects or activities which conform to certain environmental standards.They are issued according to legal procedures by governments, financial organizations or business enterprises. The issuers commit to paying interest at a predetermined rate and repaying the principal under given conditions. According to the 'Green Bond Supported Project Catalog (2021 Edition)' by the People's Bank of China and other two departments, green bonds mainly consist of green financial bonds (issued by financial institutions to finance green projects), green corporate bonds (issued by companies for green programmes), green company bonds (same type of bonds issued by non-financial companies), green debt financing instruments (short-term borrowings for green purposes) and green asset-backed securities (bonds supported by groups of green-associated assets). The 'Green Bond Principles' released by the International Capital Market Association (ICMA) in 2015 specify four basic elements: use of funds (how the money is applied), project evaluation and selection (selection of green projects), management of proceeds (tracking and controlling funds) and

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information disclosure (communicating information to the stakeholders). The main difference between green bonds and normal bonds lies in the application of green funds. This characteristic draws socially conscious investors and forms a mechanism to make issuers responsible for their green commitments, promoting the low-carbon transformation.

From an international viewpoint, the global green bond market was initiated by the European Investment Bank's first "climate-conscious bond" in 2007. This marked the beginning of the market's primary development stage. Since 2013, the green bond market has experienced a period of rapid growth. The total issuance was US 11.042billionin2013andUS 36.593 billion in 2014, which together account for 80% of the cumulative issuance from 2007. According to the Climate Bonds Initiative, there was further growth: from 2012 to 2017, the global issuance of green labelled bonds increased from US$3 billion to US$155.5 billion. This indicated a compound annual growth rate of 120%. The issuers, bond types and investor structures became more diversified. Their influence extended from Europe to other parts of the world.

Although the green bond market in China began relatively late, it has developed a fast pace. In May 2014, CGN Wind Power Co., Ltd. issued the first domestic "carbon bond". A carbon bond is a kind of green bond whose interest rate is related to the revenue from the certified voluntary emission reductions (carbon credits). This indicates the beginning of China's green bond market. In 2015, Xinjiang Goldwind Science and Technology issued the first green corporate bond abroad. In 2016, both Industrial Bank and Shanghai Pudong Development Bank were authorized to issue 50 billion yuan in green financial bonds, respectively. Green financial bonds are securities issued by financial institutions to invest in green projects. This marks the official start of China's domestic green bond market. In the same year, China became the largest issuer in the world with a total amount of US$36.2 billion, which accounts for 39% of the global total. By the end of 2024, the cumulative green bond issuance in China exceeded 4 trillion yuan. The annual growth rate was approximately 16.5%. In the first half of 2025, 219 green bonds with a total value of 473.68 billion yuan were issued in China, representing a year-on-year increase of 93.79%. This shows an accelerating development trend. Geographically, Beijing ranks first with a total value of 197.879 billion yuan, followed by Fujian, Shanghai and Guangdong. These four regions account for more than 73% of the total, suggesting a high degree of regional concentration. In summary, the green bond market in China is mainly driven by policies and is developing rapidly. At present, it has become an important financing method to achieve the 'dual carbon' strategy, which includes reaching the peak of carbon emissions and achieving carbon neutrality.

4. A review of research on green finance and high-quality green development in regions

4.1. The connotation of high-quality green development in the region

High-quality green development is guided by ecological principles to promote economic growth, conserve resources, protect the environment, and improve well-being. Rather than quick GDP growth at the environment's expense, it seeks balance among the economy, society, and nature by raising productivity, changing energy use and industrial practices, and strengthening land support. It values quality and focuses on green technology, carbon reduction, environmental management, and green jobs. Regional development depends on local resources, industries, and the use of funds.

4.2. Research on the path of green finance to drive regional development

Green finance guides high-quality regional green development through three main paths:

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First, the capital allocation effect, through differentiated credit policies, green bond issuance, green fund establishment, and other measures, promotes the transfer of social capital from high-pollution and high-energy-consumption industries to energy conservation, environmental protection, clean energy, green transportation, and other directions. The capital allocation logic of "supporting green and limiting pollution" improves the regional investment structure and enhances environmental output efficiency per unit of GDP. Xu and Yang further demonstrated that optimizing bond financing can significantly improve regional ecological resilience [10].

Second, the innovation-driven effect emerges as green finance provides long-term, low-cost funding for green technology research (the development of environmentally friendly technologies), achievement transformation (the process of turning research results into practical applications), and industrialization (scaling up technologies for widespread use in industry). Research shows that green credit (loans provided by banks for environmentally friendly projects) and green bonds (debt securities issued to raise funds for green initiatives) significantly increase patent applications and authorizations for enterprises in pollution control technology, clean production processes, and renewable energy equipment. Fintech (financial technology, such as digital platforms and tools) reduces information asymmetry (when one party has more or better information than another, causing inequality) and financing costs for green innovation projects.

The influence of industrial transformation is obvious. Green finance prevents the financing of high-carbon industries and offers encouragement to develop green industrial chains. This change promotes the regional industry towards a low-carbon, service-oriented and high-end development. Major projects like rail transit and smart grids, financed by green bonds, establish powerful industrial connections. Such effects promote the expansion of green jobs and green services in both the primary and secondary industries.

4.3. A differentiated study on the development of green finance in different regions

China's green finance shows an obvious regional inequality. The eastern coastal areas, which have advanced financial markets and started green policy trials early, possess much larger amounts of green loans and green bonds compared with other regions. On the contrary, the central and western parts, abundant in renewable energy resources like wind and solar, are lagging in the supply of green finance because of the poor financial facilities and lack of ability to recognize green projects. Some research indicates that financial technology can partly solve this problem by allowing small and medium-sized green projects in the central and western regions to obtain low-cost funding, thus reducing the regional difference in green finance. Nevertheless, the efficiency of financial technology support is still related to the degree of local information infrastructure and human resources.

5. Interdisciplinary research on fintech, green bonds, and high-quality green development in regions

5.1. Fintech-enabled green bonds drive regional development

Fintech-supported green bonds not only enhance the fund supply but also, by optimizing life cycle management, promote in an indirect way high-quality green development at the regional level. The main routes are as follows:

Pre-issuance precise identification: Through the use of big data and AI, dynamic profiles of the potential issuers' environmental performance, carbon emission amounts and compliance records are

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established, which can decrease the cost of due diligence and avoid "greenwashing" before the issuance of green bonds.

Smart pricing at issue: Yield forecasting models based on deep learning take into account environmental externalities in bond pricing, increasing the attraction of green bonds for investors and thus improving the financial access of green projects in local areas.

Post-issuance open supervision: The whole fund utilization procedure can be traced and cannot be falsified due to the application of blockchain technology. This enhances the control on green investment projects and avoids misappropriation or false reporting.

Improvement of secondary market liquidity: Financial technology platforms facilitate the standardization of green bond information disclosure and automatic interest payment by using smart contracts, which can decrease transaction friction costs and enhance the liquidity of the secondary market for green bonds, thus reducing the long-term financing costs for regional green projects. Naifar's study indicates that financial technology is significant in transferring returns between green bonds and the renewable energy industry, as well as in inter-industry correlation, providing empirical evidence for the promoting influence of financial technology during the whole lifecycle of green bonds [11].

These routes result in reduced financing charges, increased capital utilization efficiency and greater environmental compliance. Consequently, green investment, innovation and industrial concentration in the region are all encouraged.

5.2. Core findings of existing interdisciplinary research

There isn't much existing literature that studies fintech, green bonds, and regional green development together, but these perspectives are gradually emerging:

Independent positive effect: Each unit increase in financial technology (fintech) development significantly increases regional green total factor productivity or the green development index. The scale of green bond issuance (debt earmarked for climate and environmental projects) is also positively correlated with emission-reduction efficiency and green innovation capability.

Interactive enhancement effect: Fintech (the use of technology for financial services) strengthens the green effect of green bonds (bonds for environmental or climate projects). In regions with more fintech, green bonds better promote regional green development. This happens mainly by reducing information asymmetry (uneven information), cutting transaction costs (buying or selling expenses), and improving fund supervision (oversight of funds). At the micro level, research shows fintech boosts green bond issuance by highly polluting enterprises, increasing corporate environmental investment [12].

Coupling and coordination: Fintech and green bonds are closely related. Provinces showing better coordination between these two tend to make greater progress in green fields. It is suggested to recommend them together as a whole rather than as separate policy measures.

Furthermore, there exists regional diversity. In the east, a better financial technology basis results in more significant regulatory and coupling influences. While in the central and western areas, financial technology greatly enhances access to green bonds.

6. Conclusion

This paper studies the relationship between the provincial panel data of China (from 2016 to 2022) regarding the influence of fintech and green bonds on high-quality green development. It is observed that, firstly, both the rise in green bond issuance and the promotion of fintech can promote regional

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green development. Green bonds provide continuous finance for the green industry. Fintech enhances the green financial system. Secondly, fintech significantly improves the environmental benefits of green bonds by decreasing information asymmetry, reinforcing supervision and reducing transaction costs. This advantage is more evident in regions with advanced fintech. Thirdly, fintech and green bonds are closely connected and work together. They function as an integrated system instead of separate methods. The provinces having better cooperation achieve a higher degree of green development. The complementary effects result in a growth rate greater than the sum of the individual influences of the two factors. These findings indicate how fintech and green bonds support green development through their own characteristics, interactions and synergies.

Based on the aforementioned findings, the present paper suggests the following measures: First, accelerate the integration between the green bond market and financial technological means. Improve the process of issuing approval, continuous management, information release and fund supervision through digitization to increase transparency and efficiency. Second, give technical support and implement pilot policies for the central and western financial technological areas. Utilize digital inclusive finance to lower the cost of identifying green projects and reduce the obstacles in financing, thus narrowing the gap in green finance. Lastly, set up an evaluation index for the coordinated development of 'financial technology-green bond' and include it in the assessment of the excellent development of different places. Promote these activities from basic 'physical superposition' to deeper 'chemical integration', really achieving policy synergy. There are some shortcomings in this study. The provincial area data may not reflect the differences among cities and enterprises. The causal relationship between the coupling and coordination needs to be further verified by using methods such as natural experiments or instrumental variables. In the future, the investigation of prefecture-level cities or enterprises should be conducted to trace the flow of funds and environmental performance, in order to uncover the micro-mechanisms of their joint effects on promoting green development.

Author contribution

All the authors contributed equally and their names were listed in alphabetical order.

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