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A Pathway Exploration of Green Finance Reform Pilot Zone Policies to Promote Urban Green Development: Evidence from China

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Abstract

Green development has become an important global strategy for addressing environmental challenges and achieving sustainable development. As a core driver of economic development, the role of finance in supporting green development cannot be ignored. Green finance, as an important branch of the financial sector, provides a strong financial guarantee for green development by guiding the flow of funds to green industries and projects. In this context, based on data from six financial green reform pilot zones in China, this paper explores the current situation of the six green financial reform pilot zones, analyses the impact of green financial policies on urban green development, and discusses in detail the role mechanism between green financial policies and urban green development. This study not only enriches the theoretical framework of the relationship between green finance and green development, but also provides practical guidance for policymakers to optimize green finance policies and promote coordinated regional green growth.

Keywords: green finance reform pilot zone, green development

1. Introduction

1.1 Key Connotations of Green Development

The concept and nature of green development form the basic starting point for theoretical discussions. Pearce first proposed the concept of a green economy in 1992, emphasizing the need for economic development to be integrated with the carrying capacity of natural resources. Subsequently, the United Nations Environment Programme (UNEP) defined green development in 2011 as a model that encompasses low-carbon, resource-efficient and socially inclusive growth. In essence, green development is the process of integrating ecological civilization into economic activities. From a goal-oriented perspective, green development, as a new way of life, achieves harmony between economic and social progress and environmental protection. Its ultimate goal is to achieve comprehensive human development and promote the harmonious coexistence of human beings and nature. Although the academic community has yet to agree on a definition of green development, this conceptual diversity does not diminish the common value of promoting harmonious coexistence between humans and nature. This paper holds that green development represents a new paradigm of highly coordinated economic, social and ecological development through full consideration of the carrying capacity of the environment and natural resources. Compared to traditional development model, green development adheres to a sustainable path and placing greater emphasis on environmental justice and people's livelihoods and well-being, which demonstrates a greater sustainability than traditional development models.

China's economic development has gone through a process of 'development-pollution-treatment' similar to that

of the Western developed countries. Since the reform and opening up, China's environment and ecology have continued to deteriorate under the 'three highs and one low' model of rough development, with frequent occurrence of haze, water pollution, over-exploitation of resources and other types of ecological disasters, which have warned people that overdrawing the ecological environment for the pursuit of economic growth will ultimately lead to bad consequences. Against this background, the Party Central Committee, with Comrade Xi Jinping at its core, has placed the construction of ecological civilization and environmental governance at a more important strategic level, clearly leading China's development with the concept of green development, and putting forward the important thesis that 'Lucid waters and lush mountains are also invaluable assets.'

1.2 Main Challenges of Green Development

The transformation of the current development model is confronted with a multitude of challenges, especially considering that the transition process cannot be "one-size-fits-all." It is of the utmost importance to adhere to the principle of "establish before demolishing," which dictates that the transformation and upgrading of the growth model should be achieved while maintaining stable economic growth. Furthermore, the resolution of historical issues in the context of ongoing development is a complex and challenging task, and need an overall plan taking into account all factors. It is inevitable that the process will be painful.

1.2.1 The Traditional Growth Model Has a High Dependence on Energy Consumption and an Unreasonable Energy Structure

The traditional 'three highs and one low' industrial structure has high energy consumption, an energy structure that is highly dependent on fossil fuels, and a high carbon emission intensity. In terms of total volume, China's total energy consumption continues to rise, from 2.3 billion tons of standard coal in 2004 to 5.7 billion tons of standard coal in 2023. In terms of structure, China's energy consumption structure is highly dependent on fossil energy. Based on the resource endowment characteristic of 'rich in coal, lack of oil and less gas', China has long taken coal as the main energy supply, and the proportion of coal in the total energy consumption has been more than 60% before 2018. Against the background of growing clean energy supply in recent years, by 2023, the share of coal in total energy consumption will still reach 55.3%, oil will account for 18.3% of total energy consumption, natural gas will account for 8.5% of total energy consumption, and fossil energy represented by three items will still account for as much as 82.1% of total energy consumption.

The energy structure that is highly dependent on fossil energy determines that the carbon peak carbon neutral strategy is faced with many challenges such as large emission reduction, heavy transformation tasks, and tight time window, etc. In 2020, China's total greenhouse gas emissions will be 13.9 billion tons of carbon dioxide equivalent, which will account for about 27% of the global total; the total carbon dioxide emissions will be 11.6 billion tons, of which 10.1 billion tons will be emitted from energy activities, which will account for about 30% of the global emissions from energy activities. China's per capita greenhouse gas emissions of 10 tons, about 1.5 times the global per capita level, have exceeded the per capita emissions of the European Union; per capita carbon dioxide emissions of 7 tons, about 1.7 times the global per capita level, have exceeded the United Kingdom, France and other developed countries.

1.2.2 Building a Clean, Low-Carbon, Safe and Efficient Energy System Has a Long Way to Go

In order to achieve carbon peak carbon neutral, China proposes to build a clean, low-carbon, safe and efficient energy system, and gradually optimize the energy structure. In recent years, China's clean energy development has been rapid, and energy consumption per unit of GDP has been reduced from 1.42 tons of standard coal per ten thousand yuan to 0.42 tons of standard coal per ten thousand yuan. By the end of 2023, China's installed scale of wind power and photovoltaic power generation had increased 10 times compared with 10 years ago, and the installed capacity of clean energy power generation accounted for 58.2% of the total installed capacity, and the new clean energy power generation accounted for more than half of the incremental electricity consumption of the whole society. The proportion of primary electricity and other energy sources in total energy consumption will grow from 7.6 per cent in 2004 to 17.9 per cent in 2023. However, the proportion of clean energy in total energy consumption is still relatively low, failing to fundamentally change the energy structure. The development of clean energy, represented by hydropower, wind power and photovoltaic, is constrained by multiple factors such as power generation technology, investment and construction cycles, power infrastructure and investment costs. The development of clean energy and the optimization of the energy system can hardly be achieved overnight.

1.2.3 Industrial Transformation and Upgrading Face Many Difficulties

To achieve green development, it is required that the industrial model from the past 'high energy consumption, high pollution, high emissions, low quality' to 'low consumption, low pollution, high output, high quality, high efficiency' transformation and upgrading. However, the transformation of traditional industrial model faces many difficulties and challenges. In terms of technology, the threshold for upgrading key and core technologies

is high, and some technologies have yet to be broken through. For example, the controlled fusion technology in the field of nuclear power can be used for commercialization is still in the process of attack. In terms of industrial upgrading, enterprises at the middle and lower ends of the industrial chain often lack the technical, managerial and financial capabilities for transformation, making it difficult for them to bear the risk of failure in transformation. Especially in the context of frequent international trade friction, the stability of the enterprise supply chain, product market expectations are greater uncertainty, in the high winds and waves of the external environment, the high risk of enterprise transformation pressure. In terms of products, the market premium for green products is not prominent, consumers are not willing to pay, and the competitiveness of some products is not significant. In terms of institutional environment, intellectual property protection, green industry standards are not yet perfect, and a fair and orderly innovative institutional environment is still under construction.

1.2.4 Structural Pollution of the Ecosystem Remains a Problem

The structural, root and trend pressures on ecological and environmental protection in China have not yet been alleviated at all. The root causes of the pressure on resources and the environment are still prominent, while the historical problems of environmental protection have yet to be addressed, and there are still shortcomings and weaknesses in governance capacity. Resource and energy consumption and pollution emissions are still at a high level, and there is still a big gap between China's PM2.5 concentration (30 micrograms per cubic meter) and O3 concentration (144 micrograms per cubic meter) in 2023 and the WHO's health-oriented target values (5 micrograms per cubic meter and 60 micrograms per cubic meter). The ecological environment has numerous historical problems. Part of the watershed water ecology, soil pollution in some areas, local ecosystem quality and function of the problem is still more prominent, the old urban areas, urban villages, urban-rural sewage network construction, county-level areas, such as incineration of domestic rubbish treatment, there are outstanding shortcomings, and the difficulty of solving the problem is greater. Due to the lack of coordination and smoothness in institutional mechanisms and the limited financial resources of local governments, there are still shortcomings in ecological and environmental governance capacity.

2. Green Finance Pilot Zone Policy

Green development relies on technological innovation to achieve a win-win situation for both the environment and the economy. However, there are three major challenges in the process of technological innovation: firstly, it is difficult to make breakthroughs in technology itself in a short period of time; secondly, research and development activities not only require a strong foundation in natural science and technology, but also come with huge capital investment, a long research cycle and potentially high risks; thirdly, after successful R&D, the upgrading of equipment, infrastructure construction and marketing of new products require high capital investment. Therefore, for most enterprises, green transformation and development have greater financial risks and financing constraints. In China, the financial support system for the innovation stage is still imperfect, and the financial system that comprehensively supports green development has yet to be constructed.

2.1 Background of Green Finance Pilot Zone Policy

The germination of green finance in China can be traced back to 1995, when the People's Bank of China (PBOC) issued the Circular on Incorporating Environmental Protection Requirements into Credit Policies, which was the first to propose the initiative of taking environmental protection factors into account in credit approvals. After more than a decade, in July 2007, the PBOC, in collaboration with relevant departments, issued the Opinions on Implementing Environmental Protection Policies and Regulations to Prevent Credit Risks, formally establishing green credit as an effective means to promote environmental protection actions under the market mechanism. This process was further deepened in 2012, when the China Banking Regulatory Commission issued the Operational Guidelines on Green Credit, laying the foundation for the initial construction of a green credit system.

Subsequently, in August 2016, seven ministries and commissions, including the National Development and Reform Commission (NDRC), jointly issued the landmark Guiding Opinions on Building a Green Financial System, a comprehensive document that systematically builds a complete framework of green financial policies for the first time, covering four core elements such as defining standards, disclosure requirements, product systems and incentive mechanisms for green finance, making China the first country in the world where the government has taken. In June 2017, the executive meeting of the State Council decided to set up five provinces (regions) of Zhejiang, Jiangxi, Guangdong, Guizhou and Xinjiang as the first batch of pilot zones for green financial reform and innovation, marking the official opening of the practical exploration of the construction of China's regional green financial system. Since then, Gansu was approved to join the pilot at the end of 2019, and various regions have built green financial reform and innovation pilot zones according to their own actual conditions, and a series of green financial product innovations have emerged. For example, the pilot area in Huzhou, Zhejiang Province, has launched products such as 'green park loan' and 'energy carbon efficiency loan', while Quzhou has innovated 'sewage right pledge loan', Quzhou has innovated green credit products such as

'emission right pledge loan' and 'contract energy management loan', and pioneered green insurance products such as 'optimizing electricity business environment liability insurance'. Jiangxi Ganzhou Pilot Zone has launched products such as 'Green Ticket Financing', set up the country's first carbon-neutral thematic green trust programme, and issued the country's first green foreign debt. Guangdong Huadu Pilot Zone has innovated carbon emission right pledge financing financial products and 'green lease, financing and insurance' business model; Guizhou Pilot Zone has boosted clean energy development through green asset securitization; Xinjiang has taken the lead in establishing a green project library management system and green financial industry self-regulatory mechanism; and Gansu has landed the first 'Zero Carbon Conference + Green Finance' project in China (Zhang & Li, 2022). Gansu landed the first 'zero-carbon meeting + carbon insurance' service programme in the country.

Since then, green finance has been flourishing in China. In October 2020, the Ministry of Ecology and Environment (MOE), together with four other ministries and commissions, issued the Guiding Opinions on Promoting Investment and Financing to Address Climate Change, which builds up a set of investment and financing policy system to address climate change in China. By 2021, the People's Bank of China (PBOC) further clarified the guiding principles for the development of green finance, and with the Three Core Functions and Five Pillars as an outline, China's green finance policy system has gradually improved and matured, setting an example for green finance practice in the world. China's green financial policy system has gradually improved and matured, setting an example in global green financial practice. According to the Report on China's Regional Financial Operation (2021 Edition) (hereinafter referred to as the Report) released by the People's Bank of China (PBOC) in June 2021, all parts of the country have responded positively to the report and have made every effort to promote the development of the green industry with innovation as the engine. Extensive practical exploration has been carried out in the areas of standard-setting, product and service innovation, and incentive and constraint mechanisms of green finance, and significant milestones have been achieved. By the end of the second quarter of 2022, the total amount of green credit in the six pilot provinces (autonomous regions) had reached a cumulative total of RMB 1.1 trillion; the green bond market has also performed outstandingly, with the balance increasing to RMB 238.832 billion, a year-on-year increase of 41.18 %.

2.2 Status of Six Green Finance Pilot Zones

Since June 2017, China's State Council has set up green finance pilot zones in nine of the country's six provinces as a way to promote the development of green finance in China. The six provinces refer to Zhejiang, Jiangxi, Guangdong, Guizhou, Xinjiang and Gansu. The nine places refer to Huzhou and Quzhou in Zhejiang Province, Ganjiang New District in Jiangxi Province, Huadu District in Guangzhou City in Guangdong Province, Guian New District in Guizhou Province, Hami City, Changji Prefecture and Karamay City in Xinjiang Province and Lanzhou New District in Gansu Province. After reform and innovation in the six provinces, each pilot zone has also achieved certain results, and this section will provide a detailed analysis of the specific construction of green finance pilot zones in each region.

2.2.1 Zhejiang

Since the introduction of the green financial pilot zone policy, Zhejiang Province has been actively practicing the development concept of 'green mountains are golden mountains', supporting the transformation and upgrading of industrial structure around green development, and proposing industrial chain integration as an entry point to accelerate the transformation and upgrading of the traditional chemical industry, leading to the optimization of the regional economic structure. According to the statistics of the Hangzhou Central Sub-branch of the People's Bank of China, by the end of 2023, the balance of green loans was 203.436 billion yuan, an increase of 39.41% over the beginning of the year, higher than the growth rate of the bank's various loans; the issuance of green bonds and blue bonds, to achieve a financing scale of 3.153 billion yuan. It also builds and operates green low-carbon, with an online transaction replacement rate of over 99 per cent.

As a pioneer in green finance, Huzhou City has promulgated the Regulations on the Promotion of Green Finance in Huzhou City and launched the first regional ESG evaluation digital system for financing entities in China. This series of initiatives has effectively guided financial resources towards the green sector. In this process, Huzhou Bank officially became the third 'Equator Bank' in 2019. Subsequently, more than 30 banking institutions in Huzhou City have formulated and improved more than 50 relevant systems around green credit policy, environmental risk identification system construction, green financial assessment objectives, etc., which have significantly improved the green growth level and environmental risk management capability of financial institutions. According to the data released by the Huzhou Municipal Government, by the end of 2022, the balance of green loans in Huzhou city was 309.82 billion yuan, up 38.4% year-on-year, accounting for more than 25% of the proportion of all loans, ranking No. 1 in Zhejiang Province, which translates into an emission reduction of 1,240,600 tons of standard coal, an emission reduction of 1,914,500 tons of carbon dioxide equivalent, and 9,977,500 tons of water savings, and a significant environmental protection benefit of green

credit.

Quzhou City, relying on the construction opportunity of the National Green Financial Reform and Innovation Pilot Zone, takes ‘financial support for green transformation of traditional industries’ as the main line, and focuses on the two themes of ‘transformation and upgrading of traditional manufacturing industries’ and ‘green transformation of agriculture’. Quzhou City Government has been accurately guiding the flow of funds to the green areas. According to data released by the Quzhou municipal government, by 2023, the number of green enterprises in the city will increase to 111, and the balance of green loans will be 159.341 billion yuan, an increase of 53.1% year-on-year. In addition, Quzhou has implemented a ‘one line, one policy’ differentiated credit policy to help Xianhe shares and Wuzhou Paper successfully go public. At the same time, the city has achieved remarkable results in financial support for the resourceful use of livestock and poultry manure and has become one of the two pilot cities in the country for ‘financial support for the disposal and harmless treatment of livestock and poultry manure’.

2.2.2 Jiangxi

Since the approval of the Green Finance Reform and Innovation Pilot Zone in Ganjiang New Area, it has explored effective ways for finance to boost the development of the ecological economy, proposing to build a green financial organization system, and exploring and innovating credit products and financing modes to support energy conservation, emission reduction, clean energy and other areas. According to the data released by the Jiangxi Provincial People’s Government, as of the end of 2021, a total of 2,082 green projects were recognized in Jiangxi Province, with a total investment of over 1.2 trillion yuan. In terms of green credit, the balance of green loans reached 389.379 billion yuan, an increase of 111.728-billion-yuan year-on-year, with a growth rate of 40.24 per cent. Meanwhile, Jiangxi Province has cumulatively issued more than 50 billion yuan of green bonds, and the comprehensive index of green financial development ranks fourth in the country.

In terms of green bond issuance, Jiangxi Bank successfully issued the first ‘non-pilot issue’ green financial bond in the national interbank market. In addition, the Ganjiang New District Government issued the first green municipal special bond in China on the Shanghai Stock Exchange, with an issuance amount of 300 million yuan, a credit rating of AAA, and a maturity of up to 30 years, which was fully subscribed by a number of financial institutions. The bond has the three major features of ‘green’, ‘new’ and ‘special’, which is not only recognized and labelled as green by professional institutions, but also fills in the blank of green bonds in the new district and has the feature of longer-term bonds. It also fills in the blank of green bonds in the new district and has the feature of long bond term.

2.2.3 Guangzhou

Since the release of the Green Finance Pilot Zone policy, Guangdong Province has adhered to the development concept of ‘green financial services for the real economy’, with the aim of exploring the establishment of a new development model in which green financial reform and economic growth are mutually compatible, and has proposed to encourage the establishment of new energy automobile finance companies and actively carry out new energy automobile financial product innovation. By clarifying the positioning of the ‘four zones’ — a testing ground for green financial reform and innovation, a demonstration zone for the coordinated development of green finance and green industry, a new platform for the co-operation and development of the Guangdong-Hong Kong-Macao Greater Bay Area, and a facilitator for the construction of the ‘One Belt, One Road’ project — the ‘Four Zones’ have been set up. As a booster for the construction of ‘Belt and Road’, it has continuously deepened the innovation and exploration of green financial system, mechanism and products and services, with the aim of realizing its own green and low-carbon transformation. According to the data from the Guangzhou branch of the People’s Bank of China, as of the end of June 2024, the balance of green credit in Guangdong province reached RMB 3.6 trillion, up 26.7% year-on-year, and accounted for 12.9% of the proportion of all loans; the balance of green bonds was RMB 148.4 billion, up 3.2% year-on-year. Among them, the scale of ‘carbon neutral’ bonds, green credit and bonds ranked first in the country.

As a pioneer in green finance, Guangzhou has formed a series of successful experiences that can be promoted and replicated. For example, it has established a standard system for carbon emission right pledge financing, set up a financing docking system for the green financial reform and innovation pilot zone, and set up the Green Finance Co-operation Alliance of the Greater Bay Area, etc. In particular, Huadu District of Guangzhou has established a Green Finance Co-operation Alliance. In particular, Huadu District of Guangzhou City, as the core area of the Green Finance Pilot Zone, is also the key area of the National Urban-Rural Integrated Development Pilot Zone, and the overlapping effect of the two pilot zones has provided a favorable environment for green finance to support the reform and innovation of green growth in the countryside, and has accumulated sufficient experience.

2.2.4 Guiyang

Since the approval of the Green Finance Pilot Zone, Guizhou Province has followed the model of government guidance, social participation and market operation to actively promote the construction and development of the Green Finance Pilot Zone. According to statistics from the Guiyang Central Sub-branch of the People's Bank of China, by the end of 2023, the balance of green loans in the province stood at 688.99 billion yuan, a year-on-year increase of 22.3 per cent. In addition, Bank of Guizhou, as the first equatorial bank in Guizhou province and the sixth in China, has started to disclose its environmental social governance report since 2020. By the end of 2023, the balance of green credit of Bank of Guizhou was 51.681 billion yuan, up 16.51% year-on-year; the balance of corporate-type green credit was 51.481 billion yuan, accounting for 21.82% of the proportion of public loans, and the cumulative support for energy-saving and environmentally friendly projects was 384; the stock of green bonds amounted to 8 billion yuan, with a cumulative issuance of 13 billion yuan, and it was the largest green financial bond issuing. At the same time, the Bank of Guizhou has taken emission reduction measures in its investment and financing activities, which has reduced the total carbon emissions by 3.8162 million tons.

As a model of green financial development, Gui'an New Area adheres to the development concept of 'high-end, intensive and green', and promotes more capital and resources to be invested in the green economy, such as ecological use-type industries, recycling and efficient industries, low-carbon and clean industries, and environmental management industries, etc. The 'four types' of industries include ecological use-type industries, recycling-efficient industries, low-carbon clean-type industries and environmental management-type industries. In order to further enhance the level of green project certification and green financial products information, Gui'an New Area has built a 'green finance + big data' integrated service platform, which realizes the 'four-in-one' dynamic management of green project certification, green financial product services, financial support and incentive policies, and enterprise environmental information disclosure, providing a full range of services for the development of green enterprises.

2.2.5 Xinjiang Uygur Autonomous Region

Since the approval of the Green Finance Pilot Zone, the Xinjiang government has actively explored a green finance development model with local characteristics, combining comparative advantages in agriculture, natural resources, clean energy resources, energy-related high-end manufacturing industries and environmental foundations, and proposing innovations such as wind (photovoltaic) power generation index insurance and the first (set) of major technical equipment insurance products. According to data from the Urumqi Central Branch of the People's Bank of China, by the end of 2021, the balance of green credit in Xinjiang had reached 289.93 billion yuan, an increase of 30.86 per cent year-on-year, and it was mainly invested in key areas such as clean energy, green upgrading of infrastructure and energy conservation and environmental protection.

In the three green finance pilot zones of Hami City, Changji Prefecture and Karamay City, the banking industry's green franchises have achieved full coverage, and non-banking financial institutions have also set up green finance divisions. These institutions have accelerated the construction of green financial reform and innovation demonstration zones with the goal of green growth of the whole industrial chain. The pilot zones have achieved remarkable results in the following two aspects: on the one hand, the three pilot zones have jointly established the first green project database in China and introduced a third-party assessment organization, forming a set of scientific identification and evaluation index system, which effectively reduces the cost of project docking between the government, banks and enterprises. By the end of 2021, there were 2,129 projects in the green project database, including 888 pure green projects, with a total investment of up to 1,181.368 billion yuan and a financing demand of 790.713 billion yuan. On the other hand, the three green financial pilot zones have given full play to their role as the mainstay of green credit. By the end of 2021, the balance of green loans in these three areas was 52.834 billion yuan, and the proportion of green loans reached 18.67 %, up 0.54 % from 2017. Meanwhile, the proportion of loan balances in the 'two highs and one surplus' (high pollution, high energy consumption and overcapacity) industries in the green finance pilot zones has continued to decline, and the overall green credit non-performing rate has remained at a low level of 0.27%.

2.2.6 Gansu

Since the approval of the Green Finance Pilot Zone, the municipal government of Gansu Province has been committed to establishing a perfect coordination mechanism for green finance organizations, promoting innovation in green financial products and services, and enhancing green finance capabilities. According to data from the Gansu branch of the People's Bank of China, as of the second quarter of 2024, the balance of green loans in Lanzhou New Area has increased from RMB 8 billion in the first quarter of 2020 to RMB 26.56 billion in the second quarter of 2024, and the green fund has completed an investment of RMB 170 million.

The Finance Bureau (State-owned Assets Bureau) of Lanzhou New Area joined hands with the Gansu branch of PICC to implement the first 'Zero Carbon Conference + Carbon Sinks Insurance' service programme in China, innovatively designed and developed a comprehensive service programme. By taking the initiative to purchase the wetland carbon sinks of the Qinwangchuan Wetland Park project it insured, it fully offset the carbon

emissions generated by the 'Insurance Service Rural Revitalization Symposium' held in Lanzhou City of the five northwestern provinces and regions, and became the first 'zero-carbon meeting' held by the insurance system in Gansu Province, exploring and forming a replicable and popularized experience for the province and even the country as a whole. Exclusive credit products such as 'photovoltaic loan', 'wind power loan' and renewable energy subsidy right loan have been launched one after another, and the innovative application of green medium-term notes, debt-to-equity conversion, equity financing and other tools have injected a strong kinetic energy into the development of new energy industry. As at the end of the second quarter of 2024, the balance of loans for the clean energy industry in Gansu Province was RMB 184 billion, accounting for more than 44 per cent of the province's green loans.

2.3 Green Finance Reform Pilot Zone Policy and Green Growth

Through the development status quo of the above pilot zones, it can be found that all provinces have achieved better results in the construction of green financial pilot zones, and have realized the reduction of environmental pollution, carbon emission and green economic development through the transformation and upgrading of traditional industries, the rapid development of green industries and the protection of the ecological environment.

The green finance reform and innovation pilot zone policy has demonstrated significant positive policy effects at the macro level. The policy instrument can effectively drive down the intensity of regional energy consumption and simultaneously enhance the innovation capacity of green technology, thereby achieving significant regional carbon emission reduction targets. In addition, the Green Finance Reform and Innovation Pilot Zone policy enhances the efficiency of the green economy in the region by promoting the development of green enterprises, attracting foreign investment, and curbing the financing of polluting enterprises. At the same time, the policy can significantly reduce the level of near-ground ozone pollution in the pilot area, which has a positive impact on improving environmental quality. Finally, the policy has a positive effect on optimizing the allocation of credit resources and promoting the transformation of industrial structure in an eco-friendly direction.

At the micro level, the Green Finance Reform and Innovation Pilot Zone policy has also had significant policy effects. First, the policy has had a significant impact on corporate green innovation. The policy plays an active role in promoting the implementation of green innovation initiatives by firms. For green firms, the policy significantly enhances their ability to obtain commercial credit financing and increase R&D investment and promotes the improvement of production efficiency. Moreover, the policy not only stimulates the diffusion of technological innovation and enhances the ESG performance of industrial enterprises, but also helps to reduce the carbon emission intensity per unit of output value of enterprises.

In summary, the green financial reform pilot zone policy can enhance regional technological innovation, attract foreign investment and optimize credit allocation at the macro level, thereby reducing the intensity of regional energy consumption, regional carbon emissions and enhancing the efficiency of the regional green economy. At the micro level, it can promote technological innovation of enterprises, enhance their financing ability, and stimulate enterprises to fulfil their social responsibility, thus reducing carbon emission intensity.

3. Mechanism to Realization of Green Finance Reform Pilot Zone Policies for Green Development

3.1 Technological Innovation

The pilot green financial reform has effectively enhanced the level of technology. At the regional level, the promotion of green financial reform pilots is accompanied by a series of policy guidance and resource allocation optimization measures. By formulating green industry development plans, providing tax incentives, setting up green industry funds and other means, the government has effectively promoted the agglomeration of green industries in specific regions and formed green industry clusters. This agglomeration effect not only reduces the operating costs of enterprises, but also promotes the flow and sharing of production factors such as technology, knowledge and talents within the region, accelerating the pace of technological innovation. At the same time, the technology spillover effect makes the non-green enterprises in the region can also benefit from it, and gradually transform to greening by imitating and learning from advanced technology and management experience, thus enhancing the technological innovation capability and competitiveness of the whole region.

At the enterprise level, green finance, as an innovative financial model, has injected a steady stream of financial support for the technological innovation activities of enterprises in the fields of environmental protection, low carbon and energy saving by providing them with special loans, green bonds, green funds and other financial instruments. This not only directly promotes enterprises to increase R&D investment and introduce advanced equipment and technology, so as to improve their own technical level and production efficiency, but also stimulates the enthusiasm of enterprises to explore more environmentally friendly and efficient production methods. In addition, green finance also guides enterprises to green and low-carbon transformation through the establishment of green credit standards and environmental benefit assessment mechanisms, which further strengthens their sense of social responsibility and capacity for sustainable development.

The upgrading of technology is a core driver of green development. Advances in green technology can provide viable solutions for the transformation and upgrading of traditional industries, thereby achieving the efficient use of resources, the reduction of pollution and the protection of the environment. Through technological innovation, enterprises can develop more environmentally friendly and low-carbon production processes and products, which not only reduces the damage to the environment, but also improves the efficiency of resource utilization. For example, the development of new energy technologies has enabled clean energy sources such as wind and solar energy to replace traditional fossil energy sources, drastically reducing carbon emissions and realizing green transformation. In addition, the upgrading of technology has provided the necessary support for the green development of various industries, especially in high-emission industries such as industry, transport and energy. Advanced green technologies can help these industries optimize production processes, improve energy efficiency and reduce waste emissions, thereby achieving a win-win situation for both economic growth and environmental protection. For example, the application of technologies such as smart manufacturing and the industrial Internet not only improves the production efficiency of enterprises, but also promotes the process of energy conservation and emission reduction, laying a technological foundation for green development. Technological progress has also promoted the innovation of green products and services and the popularity of green consumption. With the enhancement of consumers' environmental awareness, the market demand for green products continues to grow. Improvements in technology have enabled enterprises to develop green products that are more in line with market demand, thereby promoting the growth and sustainable development of the green economy.

3.2 Financial Constraint

The pilot green finance reforms have achieved remarkable results in easing financing constraints. Analyzed at the regional level, through a series of policy guidance and mechanism innovation, the pilot green finance reforms have prompted financial institutions in the pilot regions to pay more attention to the environmental, social and governance (ESG) performance of projects in their business operations. This shift breaks the limitations of traditional financial institutions that rely solely on financial indicators to make investment decisions, enabling funds to flow more accurately to those green projects and enterprises with sustainable development potential. This optimization of capital allocation not only promotes the development of green industries, but also promotes the green transformation of the entire regional economy, laying a solid foundation for the construction of a low-carbon, environmentally friendly and sustainable economic system.

Specifically at the enterprise level, the pilot green financial reform has opened up diversified financing channels for enterprises. The emergence of new financial instruments such as green bonds and green funds has provided enterprises with a more diversified source of funds and effectively reduced their financing costs. Especially for small and medium-sized enterprises and high-risk green technology innovation projects, the pilot green finance reform has created more favorable financing conditions for these enterprises through risk-sharing mechanisms and policy guarantees. This not only eases the financing pressure on enterprises, but also provides strong financial support for their technological innovation and business expansion, thus reducing the constraints of financing on the development of enterprises and promoting their sustainable development.

The alleviation of financing constraints is an important guarantee for green development. Through the introduction of green financial instruments and policy support, enterprises can more easily obtain financial support for the development of green projects, thus breaking through the financial bottleneck and promoting the implementation and dissemination of green technologies. The alleviation of financing constraints enables enterprises to be bolder in their green technology research and development, especially among SMEs and start-ups, which often find it difficult to sustain their investment in the development and application of green technologies in the face of insufficient funds. However, when financing challenges are addressed, these enterprises can accelerate the pace of innovation and promote the rapid commercialization of green technologies. In addition, the alleviation of financing constraints can also promote the construction of large-scale green infrastructure projects, such as new energy power stations and green transport systems. Such projects have large investment scales and long payback cycles, making it difficult for traditional financial models to meet their funding needs. The development of green finance provides long-term, low-cost financial support for these projects and promotes the green infrastructure construction process. And the construction of these infrastructures not only directly promotes green development, but also provides the basic conditions for the future low-carbon economy. The improved financing environment has also attracted more capital into the green industry, driving the growth of green investment. The inflow of capital enables the green industry to expand rapidly, promotes the adjustment and optimization of the industrial structure, and provides a sustained impetus for the green transformation of the entire economy. This mechanism of financing optimization has enabled green technologies and industries to be promoted on a large scale, accelerating the development process of the green economy.

4. Conclusions and Insights

4.1 Optimize the Allocation of Credit Resources to Promote Green Transformation

Studies have shown that the policy of green financial pilot zones has effectively improved the allocation of credit resources, which has a positive effect on the green transformation of the real economy and is particularly favorable to urban commercial banks. It is recommended to strengthen the effect of this policy through institutional design, and at the same time, it is necessary to strengthen loan management and dynamically adjust credit resources according to the environmental risk of enterprises, so as to ensure the efficient construction of green financial pilot zones.

4.2 Innovative Financial Products and Services to Promote Green Transformation of Enterprises

The study found that the green financial pilot zone policy has a 'push' effect on the green technological innovation of polluting enterprises. It is recommended to promote innovation of green financial products and services by increasing the cost of pollution and innovation incentives, expanding financing channels, and setting up performance appraisals to incentivize employees to participate in green project planning, so as to help green transformation through corporate governance.

4.3 Strengthen Environmental Information Disclosure to Promote Industrial Upgrading

The study points out that resource mismatch will affect green development. The government should strengthen corporate environmental information disclosure, refine the content of emissions, reduce information asymmetry, improve credit resource allocation, and guide enterprises to enhance environmental awareness. Meanwhile, policies should lead the transformation and upgrading of polluting industries and strengthen the supervision of green enterprises to prevent the misuse of credit resources.

4.4 Establish an R&D and Innovation Information Sharing Platform to Promote Green and Low-Carbon Development

The study has found that green technology R&D requires large amounts of capital but has knowledge spillover and environmental effects after success. It is recommended to establish an R&D and innovation information sharing platform for enterprises, docking with financial institutions to solve financing problems and share green innovation information, so as to exert a positive impact on urban technology and ecological environment and promote green and low-carbon development.

4.5 Gradually Promote the Policy of Green Financial Pilot Zones

In view of the remarkable results of the construction of green financial pilot zones, their demonstration effect and advanced experience should be utilized to gradually implement progressive green financial policies and give full play to their effectiveness. At the same time, the policy should be extended to the whole country, with the pilot green finance zones taking the lead in driving the country's economy towards a green, low-carbon transformation.

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