Green Finance and Corporate Green Innovation: Mechanisms, Empirical Progress, and Research Prospects

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Abstract. At present, China has steadily promoted the dual carbon goal, and all walks of life are carrying out green transformation. Green finance is an important way to optimize resource allocation and promote sustainable development. Its role in the green innovation of enterprises is a key topic at the academic and policy levels. In the form of a literature review, this paper sorts out the relevant research on green finance and enterprise green innovation at home and abroad. This paper analyzes the current development status of green finance and then analyzes the specific ways in which green finance affects green innovation of enterprises from the perspectives of green credit, financing constraints and ESG. According to the existing literature, green finance can optimize the capital flow, reduce the financing pressure of enterprises, strengthen market supervision, and then promote enterprises to carry out green innovation. However, the promotion effect will vary with the size of the enterprise, the industry and the external institutional environment. In addition, the conclusions of the existing literature are also controversial. Combined with the above, this paper summarizes the development trend and existing problems of green innovation and puts forward relevant suggestions such as improving the green financial system, standardizing information disclosure, and strengthening policy linkage, hoping to provide help for the green transformation of enterprises.

Keywords: Green Innovation, Financing Constraints, ESG.

1 Introduction

In the context of increasingly stringent climate governance and the global acceleration of carbon neutrality, green economic growth is an important way to achieve high-quality economic growth. As the core subject of technological innovation and the leading force in resource allocation, enterprises' green innovation capabilities are of great significance to achieving green development and economic growth. However, due to the characteristics of large upfront investment, long cycle and high uncertainty, green innovation faces the obstacle of difficult and expensive financing, which will hinder enterprises from implementing it. Therefore, many enterprises will have difficulty in financing, which will also affect their implementation of green innovation [1]. At the

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same time, green finance has become an important institutional arrangement to guide capital to support the environmental protection industry. Existing literature has found that green financial instruments such as green credit, green bonds and ESG investment can reduce corporate financing costs and improve resource allocation efficiency, and promote enterprises' environmentally friendly R&D behavior [2, 3]. From the perspective of mechanism, green finance can not only improve corporate financial performance by alleviating financing constraints, but also promote enterprises to increase green R&D investment by strengthening environmental supervision and market constraints [4, 5]. Although existing literature has conducted a relatively rich discussion on the mechanism by which green finance affects corporate green innovation, there is still controversy about its path and effect. Therefore, based on a review of existing research findings, this paper summarizes and compares the pathways through which green finance influences corporate green innovation, and briefly summarizes the current research status and existing problems, hoping to provide some assistance for future research.

2 The Impact of Green Finance on Enterprise Green Innovation

Green finance plays a key role in the process of enterprise green innovation by optimizing resource allocation and strengthening institutional constraints. With the continuous deepening of related research, the academic community has gradually formed a relatively systematic analytical framework, believing that green finance mainly affects enterprise innovation behavior through multiple paths such as credit allocation, financing constraint relief and market mechanisms[5]. However, the degree of influence of different mechanisms varies in specific situations, so it is necessary to conduct a systematic analysis from multiple dimensions.

2.1 Green Credit

Green credit is an important part of the green finance system. It mainly guides funds to tilt towards environmentally friendly enterprises and projects through differentiated credit policies, while increasing the credit costs of heavily polluting enterprises, creating a positive and negative constraint mechanism at the enterprise level. "To reduce credit costs or obtain credit resources, enterprises will spontaneously adjust the direction of production and technological innovation," which further promotes green technological innovation investment. From empirical research, most literature supports that green credit has a significant promoting effect on enterprise green innovation. Yin et al. found that under the promotion of government environmental regulations, green credit significantly increased the number of green invention patent applications of enterprises; that is, changes in credit allocation can effectively incentivize enterprises to carry out innovation activities[4]. From a broader perspective, De Haas & Popov argue that green finance helps promote green economic development, with the optimization of resource allocation playing a leading role [5]. However, the impact of green loans

varies. On the one hand, highly polluting industries face more constraints and are more susceptible to loan policies; on the other hand, due to information asymmetry and severe guarantee constraints, small and micro enterprises have a poor ability to obtain green credit. Therefore, although green loans can promote environmental technology innovation, they will inevitably widen the innovation gap between enterprises to some extent.

2.2 Financing Constraints

Most literature believes that financing constraints are the main channel through which green finance affects corporate green innovation. Due to the large investment, high risk, and long payback period required for green innovation, enterprises under the traditional financial system face severe financing constraints, which inhibit their innovation activities; while green finance can alleviate this problem by reducing borrowing costs and broadening financing channels. Flammer found that issuing green bonds is a long-term and stable source of corporate financing, supporting the sustainable development and R&D innovation activities of enterprises [2]. Some classic studies also show that policy and market incentives can affect corporate technology choices by changing cost structures [6, 7]. Studies in the Chinese context have found that the synergy between the development of digital finance and green finance can promote enterprises' willingness to innovate in the environment through two channels: alleviating financing constraints and improving enterprises' risk management capabilities. In general, reducing financing constraints is an important path to leveraging the effects of green finance. However, this effect varies significantly among different enterprises, and is more prominent in terms of enterprise size, financial status, and regional economic development level.

2.3 ESG

With the development of capital markets, ESG has become an important force influencing corporate behavior. Compared with traditional financial instruments, ESG mainly relies on information disclosure and changes in investor preferences to influence corporate incentive mechanisms and further affect their environmental innovation activities. Existing research shows that the degree of attention companies pay to environmental risks affects their cost of capital. Bolton & Kacperczyk found that high-carbon risk enterprises face a higher cost of capital, which will incentivize companies to improve their environmental performance [3]. Secondly, green bonds are also an important tool for ESG investment and can provide companies with stable project financing [2]. However, Li et al. found that the differences in ESG affect companies' innovation decisions, indicating that the information environment also plays an important role in promoting corporate green innovation. Especially under severe information asymmetry market conditions, its impact will be greater [8]. From the perspective of the path of action, it mainly relies on two elements of ESG: "market constraints" and "reputation incentives". First, investors' preference for green enterprises makes enterprises obtain higher valuations in the market; second, information disclosure enhances the role of external supervision and prompts enterprises to take sustainable development measures. Therefore, the ESG system can make up for the shortcomings of traditional

financial instruments to a certain extent and is an important supplementary tool for promoting green innovation.

2.4 Differences in Literature Conclusions

Although most empirical results have confirmed the promoting effect of green finance on corporate environmental innovation, there are still some differences in the conclusions of existing literature: the differences lie in the direction of influence, the intensity of influence, the transmission mechanism and research methods. Some studies believe that the role of green finance in the economy will not be shown immediately, but there may be a lag phenomenon [9], because the green innovation process behind green finance is long and full of uncertainty, so the effect of policies often takes a longer time to gradually reflect. Moreover, enterprises and institutions in different industries have different response degrees. For example, enterprises in highly polluting industries tend to react more violently to government actions [4]. Some scholars will emphasize the role of reducing financing constraints [2], while others will emphasize the importance of playing market functions and changing investment preferences [3, 10]. It can be seen from these that different impact effects will make the final effect of green finance very diversified. Taking the above contents together, although some consensus has been formed in the existing literature, there are still many differences, so it is necessary to comprehensively investigate different research perspectives.

3 Development Trends and Challenges

3.1 Development Trends

With the continuous advancement of "dual carbon" and sustainable development, the company's environmental innovation has undergone many changes, not limited to technological innovation, but also reflected in the application of financial instruments and market-based means. First, the popularization of ESG investment concepts has strengthened the green and innovative role of the capital market. As investors gradually increase their attention to environmental hazards and corporate sustainable development, they pay more attention to the green attributes of enterprises and their related information disclosure during the financing process [3]. Second, the rapid development of financial products such as green bonds has provided environmental protection projects with a long-term, stable, and sufficient financing channel [2], which has also promoted the growth of environmental innovation from the side. Third, the green finance system is constantly improving, and the green finance policy environment is constantly being optimized. International experience and my country's practice show that green finance has gradually shifted from being mainly policy-driven to a combination of institutional and market-driven, which will help enhance efficiency and incentives [5]. In the future, with the superposition of various policy measures and the establishment of a standard system, green finance will be more conducive to corporate green technology innovation. In summary, green innovation is gradually evolving from relying solely on

technological development to a process promoted under the three-in-one approach of financial support, market demand, and technological innovation.

3.2 Development Challenges

Although the prospects for green innovation are broad, it still faces many limitations in actual operation.

First, the lack of unified standards not only increases the compliance costs of enterprises but may also lead to the misallocation of financial resources, thereby weakening the actual role of green finance. Second, the problems of information asymmetry and "greenwashing" (i.e., exaggerating environmental performance) still exist. In the context of the rapid development of ESG investment, some enterprises will exaggerate their own environmental performance to obtain financing support. This behavior weakens the effectiveness of the market mechanism and also affects investors' trust in green financial instruments [3]. At the same time, there are obvious differences in the green innovation capabilities among enterprises. Large enterprises are more likely to obtain green financial support and carry out innovation activities due to their advantages in capital, technology and information; while small and medium-sized enterprises are relatively limited in their green innovation capabilities due to their strong financing constraints. This structural difference exacerbates the problem of innovation differentiation to a certain extent [2].

Finally, from a dynamic perspective, green innovation has the characteristics of a relatively long cycle and high uncertainty, so the effect of policies often lags to a certain extent. This is closely related to the dependence on the technology path and the cost of innovation adjustment[10]. Therefore, green finance policies need to maintain the characteristics of long-term stability in order to avoid the negative impact of short-term fluctuations on corporate innovation decisions. Looking at the overall situation, although green innovation shows a good development trend, in order to make it continue to advance, it still cannot be separated from the improvement of the system, the standardization of the market and the further strengthening of policy efforts.

4 Conclusion

From the empirical results, the green innovation of enterprises as a whole is maintaining a steady growth state. Under the joint action of policy regulation and market forces, the number of green patent applications and R&D investment of enterprises are constantly increasing. However, there are structural imbalances in the process of development. The gap in the level of green innovation between enterprises in different industries and regions is still obvious. In regions with high environmental protection requirements and large policy support, the efficiency of green innovation will be improved faster, which also shows that a good institutional environment can effectively help green development.

With the continuous implementation and role of green finance, its supporting role for green innovation of enterprises is gradually emerging. First, it relies on tools such as green credit to guide the flow of funds, so that more capital can flow into green-

related industries. Secondly, it can help enterprises to alleviate the financing problems and reduce the costs and risks involved in the innovation process. Finally, the relevant requirements of ESG will form a kind of market constraint, which forces enterprises to pay attention to the responsibility of environmental protection. On the whole, green finance can positively promote enterprises to carry out green innovation, but the actual effect will be restricted by enterprise scale, industry type and external institutional environment.

If take a long-term view, the green financial system and market mechanism will continue to be improved, and its contribution to green innovation will become stronger and stronger. At present, the development of the industry is slowly changing from simply relying on the government to the direction of synergy between the government and the market. Although the process of this transformation is slow, the relevant trends have begun to appear.

Based on the above analysis, this paper believes that the following aspects should be improved. First, the green standard system should be further standardized and unified, especially the rules for the identification and disclosure of green projects, which can effectively reduce the occurrence of resource mismatches and improve the overall efficiency. Second, individuals should appropriately strengthen the supervision of the company's environmental protection information disclosure, and standardize the company's information disclosure behavior, to avoid the negative effects caused by the "green floating" phenomenon, which will be very beneficial to the establishment of market trust. Third, give more substantive help to small and micro enterprises. Residents can ease the financial burden they face by enriching the forms of financial products and innovating the financing methods, to give them more opportunities to implement green innovation. Fourth, accelerate the integration process between green finance and digital technology, use digital technology to improve the efficiency of financial services and strengthen the ability of risk identification, to transmit the corresponding support policies to the entity enterprises more effectively.

The above research still has limitations: there are many research results focusing on single countries, especially China, but fewer results comparing different countries. This necessitates further verification of the universality of certain conclusions under different institutional environments. A large amount of literature uses short-term data, and the understanding of the long-term role of green finance in promoting corporate green innovation is not yet clear enough. The influence relationships between different pathways lack in-depth discussion; future research can analyze the mutual influence relationships between pathways from a holistic perspective.

In conclusion, as green transformation continues to advance, the demand for green finance for enterprises to carry out green innovation will gradually emerge, and further research in this area is needed.

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