



Green Innovation Drives Coordinated Carbon Reduction in the Industrial Chain

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Abstract: Since the two-carbon strategy was put forward, various carbon reduction policies have been introduced or will soon be introduced, and various enterprises have responded to the call to promote the low-carbon construction of the industrial chain. Green innovation is an important support for low-carbon construction of industrial chain. Green innovation aims to improve the green value of the industrial chain, promote the benign interaction of all links of the industrial chain, and make great contribution to the low-carbon construction of enterprises. Therefore, based on the characteristics of industrial chain innovation, this paper analyzes the main problems and opportunities in innovation driven industrial chain synergy for carbon reduction, and suggests that measures such as cultivating green innovation investment concept, improving green innovation investment support system, and coordinate the planning and direction of Eco-investing should be taken to further promote the low-carbon transformation of enterprises and encourage green innovation investment in the whole industrial chain. To add new impetus to enterprises' green innovation. In short, in the context of the two-carbon strategy, focusing on the development and utilization of low-carbon innovative resources is an important content and direction of the current green development. Green innovation in the industrial chain has injected new impetus into the low-carbon construction of industries and plays an increasingly important role in promoting the carbon reduction construction of enterprises. With the continuous development and application of technology, green innovation will promote the transformation and upgrading of the industrial chain to a high-quality and sustainable direction, and its space and potential will be increasing.

Keywords: Green Innovation, Industrial Chain, Low Carbon, Investment

1. Introduction

In March 2021, at the ninth meeting of the Financial and Economic Commission of the CPC Central Committee, General Secretary Xi Jinping stressed that "carbon peak and carbon neutrality should be included in the overall layout of ecological civilization construction, and the goals of carbon peak by 2030 and carbon neutrality by 2060 should be achieved as scheduled." The 2021 Government Work Report clearly sets out a quantitative target for carbon reduction in the next five years. In the face of various carbon reduction policies that have been or will be introduced soon and the low-carbon consumption demands of consumers, the operating environment of enterprises in the industrial chain is also changing. In view of the main impact of environmental regulation on the industrial chain is to promote green

innovation in the industrial chain, it has become an inevitable choice for enterprises in the whole industrial chain to upgrade the industrial chain with the help of green innovation. The green innovation of the industrial chain is a systematic project. A single enterprise cannot achieve the goal, but only the cooperation among enterprises in the industrial chain can achieve the goal. Therefore, it is of great significance to analyze the green innovation of the whole industrial chain to promote the realization of the goal of "double carbon" in China.

2. The Characteristics of Industrial Chain Innovation

The industrial chain is formed together by the four

dimensions of value chain, supply and demand chain, space chain and enterprise chain in the balanced docking. Among them, the value chain mainly focuses on the research and development and sales of products, the supply chain focuses on material and information flow, the spatial chain includes material transmission in geographical areas, and the enterprise chain focuses on the competition and cooperation between enterprises. In the interweaving and integration of the above dimensions, the company has formed a stable industrial chain system featuring steady improvement of the value value, balanced supply and demand of the supply chain, efficient material transmission in the space chain, and coordinated development of enterprises in each nodes in the enterprise chain. The industrial chain pays more attention to the integration of partners in the chain, and its normal operation is subject to the above docking mechanism, the government, the market and the enterprise internal joint regulation. With the further promotion of the concept of green development, green has become an inevitable choice for the operation and development of the industrial chain [2]. In this context, the green innovation of the industrial chain has become an inevitable trend. The green innovation of the industrial chain is to enhance the green value of the industrial chain, and cooperates with other subjects across organizational boundaries to carry out green innovation, including internal green innovation and external green innovation. Internal green innovation mainly refers to the improvement of the coupling of production factors, the utilization rate of resources, the realization of energy conservation and emission reduction, and the negative impact on the ecological environment through technological innovation. External green innovation is that enterprises jointly carry out research and development of green products through cooperation with stakeholders to improve the overall green level of the industrial chain. This paper believes that the industrial chain innovation has the following characteristics: (1) The unity of modularity and integration. Each node enterprise in the industrial chain, as a collection of certain product suppliers, has formed a relatively stable modular division of labor. The production characteristics of various products determine the formation of the modular division of labor of industrial chain enterprises. Each enterprise needs to clarify the characteristics of its own business products and grasp the ownership of the modular division of labor. Enterprises in the industrial chain nodes carry out integrated innovation [4] under the constraints of innovation rules, and constantly improve the innovative development of enterprises. The formulation of innovation rules not only points out the goal of enterprise innovation and development, but also restricts the direction and method of enterprise innovation development. Under the constraint of innovation rules, the enterprises in the nodes of the industrial chain carry out integrated innovation in a unified direction.(2) Unity of heterogeneity and cooperativity. The micro interleaving of network nodes in the industrial chain makes the innovation subject have heterogeneity, which starts to explain the differentiated development of the subject. Enterprises with differentiated development in the industrial

chain take innovation as the focus of competition, produce products that are different from competitive enterprises, and reflect their own production advantages. Heterogeneity is an important indicator to distinguish the main enterprises of the industrial chain. At the same time, each link can learn from each other and learn from each other to promote the collaborative innovation of the industrial chain. In short, the green innovation of the industrial chain should take integration, collaboration and innovation as the driving factors, and promote the benign interaction of all links of the industrial chain through the coupling of internal and external elements. At the same time, this also requires the participation of the government, the market and enterprises to form a green innovation ecosystem jointly built and shared benefits, and inject more impetus into green development.

3. The Problem of Innovation-Driven Industrial Chain Collaborative Carbon Reduction

3.1. Figure Unknown Benefits to Inhibit the Green Innovation of the Industrial Chain

Low-carbon technology innovation does not bring direct economic benefits to stakeholders in the short term, so stakeholders do not accurately assess the potential benefits of low-carbon technology innovation. The existence of such unknown benefits affects the investment strategy and scale of stakeholders, and greatly reduces the investment in low-carbon technology innovation. Enterprises' investment in low-carbon technology innovation is mainly a public welfare behavior led by the government. When enterprises fulfill their low-carbon responsibilities, they should obtain more indirect benefits, such as relevant government policy support, low-carbon technology support, or get the favor of consumers with the same consumption concept by creating green brands. In order to achieve the goal of reducing carbon emissions from the industrial chain level, enterprises must invest relevant resources to optimize the production process, management activities, energy structure, etc. By investing resources to optimize the production process, management activities, energy structure can save the development cost of enterprises, so as to promote enterprises to improve the independent innovation ability and improve the production quality and efficiency of enterprises. Under the background of green innovation in the industrial chain, the optimal allocation of innovative resources can increase the adjustment of economic structure, accelerate the transformation of economic development mode, and promote the upgrading of industrial structure. In view of the characteristics of low-carbon technology innovation with high cost, high risk and high income uncertainty, the huge contrast between cost and income has become a realistic dilemma that hinders enterprises to invest in low-carbon technology innovation. In order to avoid the relevant risks, the phenomenon of "free hiking" occurs.

3.2. Regional Differences Should Restrain the Green Innovation of the Industrial Chain in Backward Regions

The Porter hypothesis believes that when the external business environment changes, it will trigger an innovative economic response [3]. That is, when the external environment changes, enterprises need to make innovative changes in the original production in order to adapt to the changes. Improving productivity can stimulate the application of green and innovative technologies by formulating relevant environmental regulation policies. In recent years, domestic scholars have begun to study environmental regulation deeply, and further enrich the relevant content of environmental regulation. In essence, environmental regulation is the sum total of government behaviors and other binding behaviors, including but is not limited to environmental policies, industry standards, emission permits, etc. The importance of environmental regulation policy to the upgrading of industrial structure towards the green and ecological direction is more self-evident. Compared with the traditional structural adjustment perspective based on the evolution and upgrading of different industries, the green and ecological transformation aims to improve the resource utilization efficiency of the non-renewable energy and improve the ecological environment quality within a single industry. The study found that strong environmental regulation will form green barriers to the industry, improve the entry threshold of enterprises in the green transformation, and promote the green transformation of the industry. In current research, it is generally believed that the innovation stimulating effect of environmental regulation depends on the productivity of enterprises, industries and regions, that is, the better the local productivity conditions compared with other economies, the more significant the stimulating effect of environmental regulation innovation will be, and vice versa [6]. In China, the gradient of economic development from east to west is significant, and the innovation effect of environmental regulation also shows an obvious pattern of decline between east and west, that is, environmental regulation will promote the application of green innovation technology in the developed eastern region, restrain the green innovation in the backward western region, and pollution and backward technology will also transfer from the east to the west.

3.3. Table in the Transition Period, the Division of Labor Inhibits the Green Innovation of the Industrial Chain

When the market economic system is relatively perfect, the upgrading of consumer demand can broaden the choice space for the division of labor in the industrial chain. Enterprises can choose the division of labor according to their own advantages to meet the needs of end consumers. In the transition period, the high transaction costs, market segmentation and other factors will restrain the arrangement of the industrial chain division of labor system, and inhibit the industrial upgrading effect brought by consumer demand.

In the transformation economy, the government, as the controller of resource allocation, under the pressure of performance assessment, will use its power to allow local enterprises to operate [7] in a "large and complete" or "small and complete" way to include all links of the industrial chain. If enterprises want to give full play to their own advantages and change the policy division of labor into the market division of labor, the government will hinder them by issuing policy barriers. At the same time, it will also enhance the difficulty of vertical mergers and acquisitions of the industrial chain, which is not conducive to the complementary advantages between enterprises, and then will affect the enthusiasm of enterprises for innovative investment.

Therefore, the low-carbon consumption in the transition period did not bring about the marketization of the industrial chain division of labor. In view of the current market mechanism in China is not perfect, the division of labor in the industrial chain is mainly a policy arrangement led by the government. This passive arrangement is not based on the comparative advantage of the enterprise, so it does not conform to the principle of efficiency maximization. During the transition period, the upgrading of low-carbon consumer demand restricts the division of labor of the industrial chain, affects the overall upgrading of the industrial chain, and suppresses the investment in green innovation in the industrial chain.

4. Innovation-Driven Industrial Chain Collaborative Carbon Reduction Strategy

4.1. Foster a Vision of Green and Innovative Investment

In order to give full play to the dual functions of green innovation in environmental governance and market competition, it is necessary to establish a correct investment concept. First, corporate profits and green innovation investment are not a "zero-sum game". Green innovation investment can not only create profits for enterprises, but also create a good corporate image to the outside world and win business opportunities. The upgrading of consumer demand is an important driver of the development of the industrial chain. As Marshall said, "the ultimate regulator of all needs is the demand of consumers". Consumer demand is the final demand of the industrial chain, and the final demand will affect the demand for intermediate products, while the upgrading of the final demand and intermediate demand will affect the overall division of labor of the industrial chain, and then winning business opportunities for low-carbon enterprises. Secondly, cultivate employees' awareness of low carbon [9]. By cultivating and enhancing the awareness of low carbon environmental protection, employees can practice low-carbon work behavior in practice, and effectively promote the low-carbon transformation of the enterprise. In addition, employees can also be encouraged and guided to

practice low-carbon behaviors in various ways, and a corresponding assessment mechanism can be established to stimulate the enthusiasm of employees to participate in the low-carbon transformation [10]. For example, give rewards or promotion opportunities to employees with outstanding low-carbon work performance, and provide warnings and improvement guidance to employees who fail to meet the standards. Through the mutual transformation of tacit knowledge and explicit knowledge [5], promote the ecological innovation of enterprises, reduce the emission reduction costs of enterprises, and improve the production efficiency and profitability. We will raise the awareness of low carbon in the whole industrial chain, encourage investment in green innovation in the whole industrial chain, and guide enterprises to consciously fulfill their responsibilities for carbon reduction.

4.2. Improve the Investment Support System for Green Innovation

4.2.1. Build an Information Sharing Platform and Promote Collaborative Green Innovation

The spillover of green innovation results suppresses enterprises' investment in innovation. Building an industrial chain information sharing platform to promote enterprise cooperation can effectively improve the level of green investment. Based on the common concept of green development, the operation of the information sharing platform can coordinate the consistent environmental protection investment concept among the members of the industrial chain, integrate their respective advantages, promote green innovation investment, and improve the quality of green products [11]. With the help of the information sharing platform, the members of the industrial chain can jointly deal with similar pollution problems, realize the scale economy of pollution treatment, and reduce the production cost of the emission reduction process of enterprises.

As the connection center of low-carbon technology information communication and the main body of multi-direction information communication and management, the government can take the lead in building a green information sharing platform, guide the collaborative innovation mode of the industrial chain, and coordinate the contradictions arising from the green innovation of the regional industrial chain. The government can promote the cooperation intention of regional low-carbon technology innovation in terms of time, method and purpose through policy support [1]; in the process of innovation, the government can promote the sharing of information among industrial chains through meetings, visits and investigations, and the government can also provide timely feedback and track the application of low-carbon technology and solve the problems arising in the application process. In 2019, Zhejiang put forward the responsibility system of "chain length system" for the first time [11]. By 2022, 29 provinces in China will have implemented the "chain length system" or relevant policies. The "chain length system" connects the key

links of the industrial chain by means of information transmission and policy assistance, forming a long-term and stable coordinated development mechanism of the industrial chain. "Chain length system" consists of "chain master" and "chain length": "chain master" refers to the core enterprise mastering key technologies or resources, which can directly or indirectly influence the decision of all enterprises in the industrial chain and lead the coordinated development of the industrial chain; "Chain length" is the defender of the industrial chain, as a government department personnel to take advantage of the position to promote the stable development of the industry chain. "Chain long system" is a kind of institutional innovation to strengthen the main responsibility of the industrial chain. The main purpose of "Chain long system" is to promote the collaborative innovation of large, medium and small enterprises in the industrial chain. The advantage of "chain length system" is that it can concentrate internal and external resources to make breakthroughs in the weak links of the industrial chain. Core enterprises should take the "chain length system" as an opportunity to seize the policy opportunities and promote collaborative green innovation in the industrial chain.

4.2.2. Improve the Compensation Effect of Enterprises on Green Innovation

Due to the short survival period of small and medium-sized enterprises, the depreciation cost of energy-saving equipment is high, their capital is limited, so they can only choose cheap energy-saving and emission reduction technologies, resulting in their limited pollution control capacity. There is a big gap between the effective operation scale of energy conservation and emission reduction equipment of small and medium-sized enterprises and its pollution discharge scale, and the pollution control cost of small and medium-sized enterprises will be higher than that of large enterprises. Therefore, only by improving the innovation compensation effect of low-carbon technology can we achieve the win-win development of large and medium-sized enterprises. Encouraging enterprises to increase investment in green innovation and scientific research, and increasing investment in research and development plays an important role in promoting green transformation and upgrading of industries. However, at the enterprise level, the mutual adaptation of supply and demand will lead to the lack of motivation to increase R & D investment in the short term. The advanced frontier innovation activities can be given the corresponding R & D investment subsidies, and promote the full accumulation of advanced production factors, so as to make up for this market failure [12]. At the same time, actively promote the establishment of independent innovation scientific research incubation system, activate the dominant position of enterprises in the market, and cultivate the internal strength of enterprise innovation. Combine external incentives with internal drive to jointly promote China's industry to accept technological innovation in different positions of the global value chain, and finally realize the upgrading of the industrial

value chain through "jumping"

Innovation economics believes that the development of small and medium-sized enterprises is more dependent on innovation, but the innovation activities of small and medium-sized enterprises need more external support due to the constraints of capital, information and talent. In order to realize the innovation compensation effect of emission reduction enterprises, it is necessary to improve the market-based environmental policy, establish a price mechanism in line with the resource recycling economy, and correct the distorted operating cost relationship between emission reduction and non-emission reduction enterprises [13]. By levying resource taxes, increase the cost of resource use, strengthen enterprises' advantages in reducing emissions; through the establishment of waste discharge charge system, increase the cost of waste disposal project, improve the advantages of waste harmless treatment projects; through the establishment of fiscal policy of green innovation technology, make the enterprise enjoy the tax subsidy policy of waste utilization, reduce the cost of waste reuse, and improve the economic performance of the emission reduction enterprises [14]. By improving production efficiency, reducing production costs, reducing the cost of pollution disposal and improving the demand for green products, enterprises can increase the compensation effect of green innovation and enhance the power of green innovation in their enterprises.

4.2.3. Green Innovation and Information Disclosure Mechanism

There is information asymmetry between enterprises and stakeholders, and stakeholders cannot obtain comprehensive environmental protection information of enterprises through enterprise announcements. A sound low-carbon investment information disclosure mechanism can reduce the cost of information search for stakeholders, and facilitate the effective communication between enterprises and stakeholders [15]. At present, the information disclosure of Chinese enterprises is still mainly voluntary, and many enterprises are not willing to participate in or even refuse to disclose any information based on their own interests. At present, there is no policy document to clarify the detailed rules for the disclosure of green innovation information, so that relevant enterprises usually publicize their performance too much and disclose less or even do not disclose relevant negative information. Information disclosure is a key link in developing green innovation and an important basis for solving market information asymmetry. In order to give full play to the role of green innovation information disclosure mechanism and reconstruct the green development path in China, it is necessary to learn from the useful experience at home and abroad, give play to the leading role of government departments, improve laws and regulations and provide financial support, strengthen the construction of information sharing mechanism and basic database, and improve the incentive and restraint mechanism. At the same time, the specific structure and level of corporate social responsibility and corporate governance information disclosure should be

clarified, the standardization of compilation should be clarified, ambiguous qualitative expression should be avoided, and the quality of social responsibility and corporate governance information should be improved. Enterprises rated as "excellent" in information disclosure will be given priority to green innovation support and investment "favor", so as to win more market development opportunities for enterprises.

With the gradual deepening of the concept of green development, more and more investors participate in environmental protection. They pay more attention to the green innovation potential of enterprises, and determine their investment strategies by building non-financial indicators such as environmental protection and society. High-quality carbon disclosure means high-quality carbon performance of enterprises. Enterprises will take the initiative to disclose low-carbon technology information and fulfill their carbon reduction obligations, which will convey the information of good operation to investors and reduce the financing cost of enterprises. Improving the quality of carbon investment information disclosure can demonstrate the efficient risk management ability of enterprises, improve the trust of investors, reduce the cost of enterprise contract making, and enhance the value of enterprises. A sound low-carbon investment information disclosure mechanism includes: First, according to the demands and expectations of stakeholders, continuous disclosure of low-carbon investment related information such as amount, research and development progress, risks, environmental governance capacity, etc. Current environment-sensitive customers can only understand the product information through the static instructions. By continuously disclosing the green innovation process of products and related technologies, customers can have a deeper understanding of the core competitiveness of green products, so as to attract more environmentally sensitive customers and lead the development of the environment-friendly product market. Secondly, fully consider the disclosure method and the disclosure time limit, and provide the information of pure text or text and image according to the actual needs of stakeholders. Finally, we should adhere to the collaborative disclosure among enterprises in the industrial chain, maintain the unity and coherence of low-carbon investment information disclosure in the industrial chain, and avoid problems such as free-rider behavior and contradictory information.

4.3. Coordinate with Green Investment Planning and Direction

The green innovation of the industrial chain includes both the interactive innovation between the macro modules and the interactive innovation between each node in the micro level (such as the interactive innovation between enterprises and schools). Green innovation is an important force in promoting the transformation of the whole industrial chain to a green and low-carbon direction. First of all, enterprises need to choose the internal green innovation mode according to their own actual situation, and promote diversified green investment

practices. Develop a clearer technology upgrade plan for the high-carbon industrial chain to further induce investment in green innovation. Paying attention to the ability of enterprises to transform resources in green innovation is also the key to improving the competitiveness of enterprises. By optimizing the green innovation strategy, capacity and resource combination, enterprises can balance the proportion of investment in green production technology and terminal governance technology. Enterprises should make full use of digital technologies such as artificial intelligence, robots and the Internet to promote their green and intelligent transformation. Secondly, cooperate with suppliers, customers and other subjects to carry out external green innovation. Enterprises need to coordinate multiple resources to promote internal and external stakeholders to jointly achieve green development. Enterprises need to build green alliances and adjust the investment structure and direction of green innovation according to consumers' green needs.

In the traditional linear innovation mode, the industrial chain collaborative innovation depends on the authority of the industrial chain leader. The industrial chain innovation mode has been upgraded from linear innovation to network innovation. In the network industrial chain, industrial chain leaders should help small and medium-sized enterprises overcome the "autophagy effect" brought by technological innovation, and adopt open innovation and the means of free or low charge of intellectual property rights to promote innovation investment [8]. In view of the important role of multi-agent participation in the green integration of the industrial chain, enterprises should have a forward-looking and long-term vision, increase the proportion of their own green investment, and promote the sustainable development of the industrial chain. Industrial chain leaders can build a green investment information exchange platform, and realize the overall green transition of the industrial chain through coordinated multi-party green investment planning.

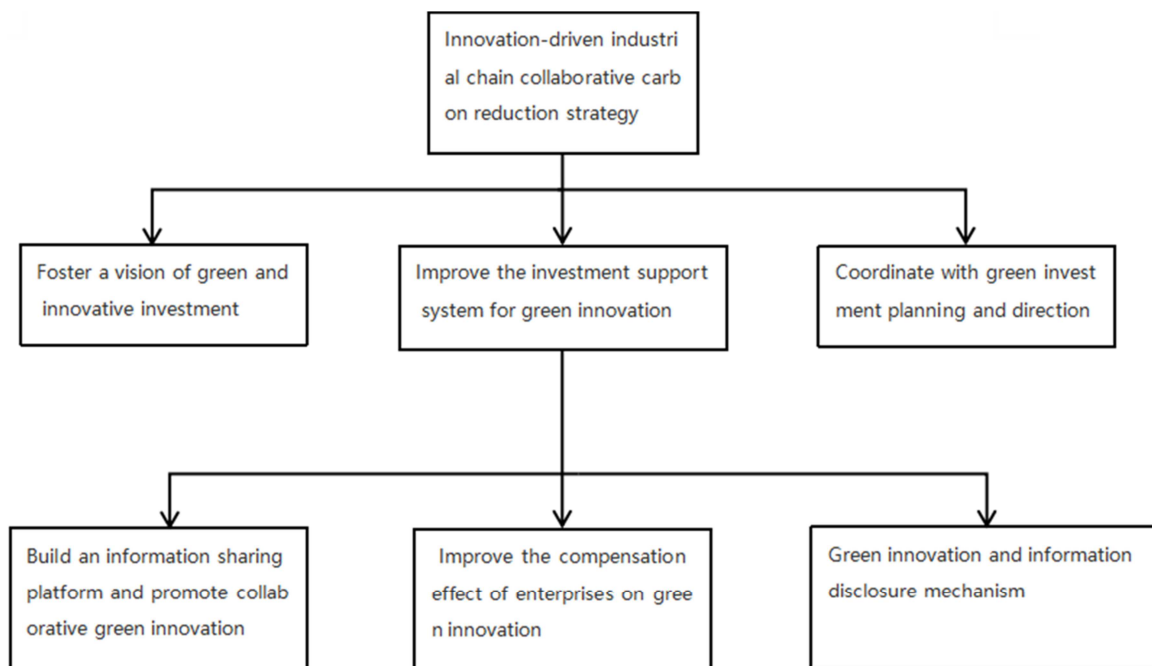


Figure 1. Collaborative carbon reduction strategy.

5. Conclusion

Green innovation is an important part of the low-carbon construction of the industrial chain, and it plays an increasingly important role in promoting the carbon reduction construction of enterprises. Jointly building green innovation has injected new impetus into the low-carbon industrial construction. With the increasing severity of global climate change, countries are actively taking actions to deal with climate change. China has also set double-carbon targets, taking carbon peak and carbon neutrality as long-term strategic goals, and it is imperative to promote the carbon reduction construction of enterprises. With the acceleration of industrial carbon reduction construction, green and

innovative development has gradually become an important way for the low-carbon construction of the industrial chain. Under the background of the dual-carbon strategy, focusing on the development and utilization of low-carbon innovation resources is the objective need to realize the low-carbon and high-quality development of the industrial chain. In short, green innovation in the industrial chain is an important content and direction of the current green development, and it plays a role in promoting the transformation and upgrading of the industrial chain to a high-quality and sustainable direction. With the continuous development and application of technology, the space and potential of green innovation in the industrial chain will become larger and larger, which also makes the green become an inevitable choice for the future development of the industrial chain. This paper focuses on

green innovation to explore the problem of low-carbon innovation of the industrial chain, in order to promote the carbon reduction of China's industrial chain.

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