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Original Paper

The Impact of Environmental Information Disclosure on Corporate Green Innovation

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Abstract

As apart of society, the development of enterprises is closely related to environmental protection. As an important way of information transmission, environmental information disclosure plays an important role in corporate green innovation. This paper will explore the impact of environmental information disclosure on corporate green innovation, taking S Company as an example, and analyze the mechanism, influencing factors and challenges. The study found that environmental information disclosure can improve the green innovation performance of enterprises, improve environmental transparency and social responsibility, and promote enterprises to increase investment in environmental protection and sustainable development. In addition, environmental information disclosure can significantly promote the growth of enterprises' green innovation, encourage enterprises to take more green measures in technology research and development and product innovation, and promote enterprises to transform to green and low-carbon development. However, there are also some challenges in environmental information disclosure. Environmental information disclosure leads to the decline of green innovation quality by inducing short-term behavior of enterprises, and the asymmetry of environmental Information disclosure. These problems need to be solved by the joint efforts of the government, enterprises and all sectors of society. Therefore, to strengthen environmental information disclosure and promote enterprise green innovation, it is necessary for relevant government departments to strengthensupervision and improve relevant laws and regulations. Meanwhile, enterprises should also strengthen internal management, improve the transparency and quality of information disclosure, and jointly promote sustainable economic and social development.

Keywords

environmental information disclosure, Corporate green innovation, Sustainable development

1. Introduction

With the increasingly severe global environmental problems, sustainable development has become the focus of attention of governments, enterprises and the public. Issues such as climate change, resource depletion and ecological degradation have prompted the international community to continuously strengthen environmental regulation and promote enterprises to transform to green and low-carbon. In this context, Environmental Information Disclosure (EID), as an important way for enterprises to demonstrate their environmental performance to stakeholders, has attracted wide attention. Environmental information disclosure can not only enhance the transparency of enterprises and reduce information asymmetry, but also promote the Green Innovation (GI) of enterprises through the joint effect of external supervision and internal management mechanism. Green innovation refers to the adoption of environment-friendly technologies and methods at the product, processor management level to reduce the negative impact on the environment and improve the efficiency of resource utilization. Both environmental information disclosure and green innovation reflect the inherent requirements of sustainable development and echo the new development concept advocated by China. Under the current general principle of promoting high-quality development and seeking progress while maintaining stability, enterprises' strengthening environmental information disclosure and promoting green innovation play a positive role in ecological civilization construction and economic green transformation. These two behaviors belong to the category of enterprise environmental management. Among them, environmental information disclosure aims to disclose the implementation of enterprises' environmental protection responsibilities to the outside world, while green innovation focuses on achieving environmental goals such as energy conservation, emission reduction and clean production through technological or management innovation. Environmental information disclosure may have adual impact on green innovation: on the one hand, the investment in compliance costs or pollution control may crowd out innovation resources and inhibit green innovation; On the other hand, information disclosure may also promote green innovation by optimizing resource allocation and enhancing the effectiveness of governance. In addition, as enterprises have different innovation capabilities and risk preferences in different stages of the life cycle, the impact of environmental information disclosure on green innovation may also show heterogeneous characteristics due to different development stages of enterprises. China as the world's largest developing country, in the aspect of environment protection and sustainable development in recent years has adopted a series of policies and measures, such as "carbon peak, carbon neutral" target is put forward, and the measures for the environmental information disclosure regulations promulgated, both to the enterprise environment information disclosure put forward higher requirements. As a typical industry with high pollution and high energy consumption, the petrochemical industry has attracted much attention for its environmental governance and green transformation. As one of the largest petrochemical enterprises in China, S Company's environmental information disclosure practices and green innovation performance are of great research value.

Exploring how environmental information disclosure affects Sinopec Corp. 'S green innovation is not only helpful to understand the internal mechanism of corporate environmental governance, but also provides a reference for policymakers and other enterprises.

1. Literature Review

1.1 Domestic Literature Review

Environmental information disclosure refers to the behavior of enterprises or organizations to disclose their environmental information to the public, stakeholder governments and other parties. This information usually covers the environmental policies, environmental management practices, environmental performance data and environmental risks of enterprises. The purpose of environmental information disclosure is to enhance the transparency and responsibility of enterprises, promote social supervision, encourage enterprises to improve environmental performance, and promote green development. Some scholars believe that environmental information disclosure will promote the innovation activities of enterprises, and environmental information disclosure can enhance the legitimacy motivation of enterprises and alleviate financing constraints by strengthening the public supervision of enterprises. Wang et al. (2020) found in their study that the environmental information disclosure mechanism introduced in the new Environmental Protection Law can effectively inhibit the speculation of enterprises by increasing the cost of environmental violations, thus promoting enterprises to actively carry out green technology innovation practices. Zhang et al. (2016) found that although environmental information disclosure has a positive incentive effect on R&D innovation, this effect is significantly different due to the property rights and industry characteristics of enterprises. Specifically, it plays a more prominent role in promoting state-owned enterprises, especially enterprises in heavy polluting industries, and may have a certain distortion effect on R&D innovation. Yue-lan zhang (2021), such as heavy pollution industry in Shanghai and shenzhen A shares in China enterprise as an example, examine the enterprise environment information disclosure quality and innovation, the relationship between input and output is proposed "the improvement of environmental information disclosure quality can improve the enterprise financing environment, for the financing of more financing opportunities and greater scale, enhance the level of innovation into" conclusion. Zhan et al. (2021) also studied the relationship between environmental information disclosure and corporate innovation, and proved that environmental information disclosure can not only improve corporate financial performance, but also significantly promote innovation activities, especially in the context of green credit policy, this information disclosure mechanism can effectively alleviate financing constraints and provide more sufficient financial support for innovation activities. Wu et al. (2022) believed that innovation played an important part of the mediating effect in the relationship between environmental information disclosure and high-quality development, and found that environmental information disclosure could promote innovation, help enterprises establish a green image, alleviate

financing constraints, optimize resource allocation, and establish a good relationship with consumers and regulatory authorities, thus promoting high-quality development of enterprises. Zhang et al. (2023) argued that environmental information disclosure has a positive impact on improving the quality of green innovation, which is mainly reflected in the external resource effects such as reducing financing costs and obtaining tax incentives, as well as the external supervision effect formed by enhancing the attention of media and analysts.

2.2 Review of Foreign Literature

Existing studies have explored the impact of information disclosure on corporate innovation in different contexts. Chenetal. (2014) studied the relationship between information disclosure and innovation activities under different governance standards in emerging market countries. This phenomenon may be due to the fact that investors pay more attention to the transparency of enterprises in the environment with a high degree of information asymmetry, and are more inclined to support enterprises with good information disclosure performance [it is found that in a poor governance environment, accounting information disclosure can play a role of investor protection and promote innovation activities more effectively. This may be because in the environment with weak investor protection and poor corporate governance, investors are more sensitive to the information disclosure behavior of enterprises and are more likely to win the favorable opinion of investors. From the perspective of corporate strategy, Inoue (2016) pointed out that environmental information disclosure not only helps enterprises to evaluate their own environmental performance, identify the room for improvement and optimize R&D decisions, but also enhances the interaction with investors and consumers. His empirical analysis based on EU firms shows that firms that actively disclose environmental information are more likely to increase R&D investment, so policy makers can indirectly promote innovation by improving the information disclosure mechanism. Xiangetal (2020) to heavy pollution industry listed companies as samples, from environmental investment and regulatory certification and performance management three dimensions to build information disclosure index, confirmed that the environmental information disclosure of green innovation has a significant role in promoting. The mediation effect analysis shows that the mechanism includes broaden the sources of finance, improve product market recognition and attract media attention. Similarly, Cailouetal (2021) also reached a similar conclusion that environmental information disclosure promoted the innovation activities of high-polluting enterprises by increasing the income of enterprises. Zhangetal. (2022) focused on the effect of policy intervention and found that the disclosure of China's air quality monitoring data significantly improved the level of corporate green innovation, especially the number of green invention patents, which emphasized that the dual pressure of government regulation and public supervision was the key driving force for corporate innovation.

2. Case Study

3.1 Current Situation of Environmental Information Disclosure in S Corporation

S Co., Ltd. is a joint-stock enterprise with upstream, middle and downstream integration and prominent petroleum and petrochemical main business. The company was established on February 25, 2000,and listed 16.78 billion H shares in HongKong, New York and London Stock exchanges from October 18 to 19 of the same year. On August 8, 2001, it listed 2.8 billion A shares in Shanghai Stock Exchange. As an integrated energy and chemical company, its business covers oil and gas exploration and development, refining and chemicals, sales of refined oil products and marketing of chemical products. In 2024, its operating revenue will reach 3.07 trillion yuan, and its net profit will reach 50.313 billion yuan, ranking first in the industry. As a leading enterprise in the field of petrochemical industry in China, S Company's environmental information disclosure practices have unique value for understanding the level of environmental governance of large state-owned enterprises. Through the systematic review of S company's environmental information disclosure documents from 2010 to 2023, it can be seen that the company has experienced a transition process from unconstrained to actual constrained in this aspect. In this stage, the content of S company's disclosure became more comprehensive, the frequency of disclosure increased significantly, and the quality gradually shifted from the early selective disclosure to systematic and substantive disclosure. In the past ten years, the content of environmental information disclosure has changed significantly. In the early stage (2010-2013), it was mostly limited to the concept of environmental protection and the introduction of scattered pollution prevention and control measures. The environmental content in the 2010 annual report was less than two pages; With the revision and implementation of the Environmental Protection Law of the People's Republic of China in 2014, the company began to increase the description of energy conservation, emission reduction and clean production, but the disclosure of core environmental data is still limited; From 2015 to 2023, especially after the implementation of the Environmental Information Disclosure Measures for Enterprises and Public Institutions in 2016, S Company's environmental information disclosure changed from simple concept publicity to multi-dimensional and all-round disclosure, including not only the complete data of major pollutant emissions, but also the operation status of environmental protection facilities, environmental management system construction and carbon emission data. Since 2018, with the rise of environmental, social and governance concepts in China, the company's environmental information disclosure has been further expanded to include broader issues such as supply chain environmental performance and biodiversity conservation. In the early stage (2010-2015), S company mainly disclosed environmental information through annual reports and social responsibility reports, with an average of no more than 3 times per year. After the implementation of relevant regulations in 2016, as a key pollutant discharging unit, the company began to increase the frequency of environmental information disclosure through regular reports, official websites and government platforms, and the average annual disclosure frequency increased to 8-10

times. The quality of environmental information disclosure can be divided into three periods: 2010-2014 is the initial period, the information is brief and lack of systematization; The period from 2015 to 2018 was the development period, with gradually rich content but low degree of standardization; From 2019 to 2023, the company entered the promotion period, and basically established a relatively perfect environmental information disclosure framework and standards. The improvement of S company's environmental information disclosure level is closely related to the development of national policies and regulations. The new Environmental Protection Law of the People's Republic of China in 2014, the Measures for Environmental Information Disclosure of Enterprises and Institutions in 2016, and the revised Governance Standards for Listed Companies in 2018 have all become important external driving forces for the company to improve environmental information disclosure. The increasing attention of international investors to environmental and social governance factors and the improvement of public awareness of environmental protection have also prompted enterprises to continuously improve their environmental information disclosure practices.

From 2010 to 2023, S Company's environmental information disclosure showed a development trajectory of continuous enrichment of content, continuous improvement of frequency and steady improvement of quality, but there is still room for improvement in information integrity and standardization degree. This process not only reflects the deepening of enterprises'understanding of environmental responsibility, but

also reflects the guiding role of environmental regulatory policies.

3.2 Status quo of S Corporation's Green Innovation

With the improvement of global environmental protection standards and the promotion of the "dual carbon" strategy in China, the petrochemical industry, as a traditional industry with high energy consumption and high emission, is under the pressure of transformation. As the industry leader, S Company has actively promoted green innovation from 2010 to 2023 and made substantial progress. From the perspective of the number of green patent applications, the innovation process of enterprises can be divided into three stages: from 2010 to 2014, the number of patents increased from 127 to 247, with an average annual growth rate of about 18.03%. At this time, green patents only accounted for 15%-20% of the total applications, mainly concentrated in the traditional environmental protection fields such as pollution control; From 2015 to 2018, with the implementation of the new Environmental Protection Law of the People's Republic of China, the number of applications accelerated to 1328, with an average annual growth rate of 67.21%, accounting for more than 30%. The patent structure also expanded from terminal treatment to cleaner production technology. From 2019 to 2023, green patents remained high, the proportion of invention patents increased to more than 45%, and the technology field expanded to frontier fields such as new energy development and carbon development. In the field of technology research and development, S Company h as built an innovation system with enterprises as the main body and combining industry, breakthroughs in green setting up

special institutions and joint laboratories. The Action Plan for Green and Low-carbon Development released in 2016 has established ten R&D directions. From 2018 to 2023, the proportion of investment in green technology will continue to increase, and progress has been made in key areas such as clean processing of inferior crude oil, ultra-low emission of catalytic cracking flue gas and CO2 capture and utilization. The green management innovation of S Company has experienced the evolution from shallow to deep, and only established the health, safety and environmental management system in the early stage. After 2015, driven by the concept of environmental supervision and ESG, the company has greatly strengthened the construction of organizational system. A Green and low-carbon development committee was setup in 2019 to further strengthen leadership, while after 2020, green innovation will be included in strategic assessment and technology marketization will be promoted through incentive mechanisms. The overall green innovation practice of enterprises shows three characteristics: the intensity of innovation is constantly increasing, and the passive response is turning into active innovation; Innovation quality continues to improve, which is reflected in the increase of the proportion of invention patents and the transformation from terminal governance to source prevention; The scope of innovation has been gradually expanded, from traditional pollution control to low-carbon technology and other frontier areas. It is worth noting that the changing pace of S company's green innovation is highly related to the external policy environment, and the implementation of environmental protection laws and regulations and the strengthening of supervision are important driving forces for enterprises to accelerate their pace. The 13-year innovation path of S company not only reflects the enterprise's own strategic adjustment, but also reflects the influence of environmental policy on the behavior of market players, which provides atypical case for discussing the relationship between environmental information disclosure and corporate green innovation. Through continuous promotion of innovation, S Company has achieved a breakthrough in the level of green production process, and the energy consumption per unit product and pollution emission intensity have significantly decreased. These achievements not only improve the enterprise's own environmental performance, but also provide reference for the transformation of the whole petrochemical industry. Under the increasingly severe pressure of environmental protection, S Company's green innovation path witnessed how to turn environmental challenges into development opportunities, and proved the promotion role of strengthening environmental information disclosure in enterprise innovation and transformation.

Table 1. Number of S Company's Green Patent Applications (2020-2023)1

Year	Number of green patent applications (pieces)	Proportion of total patents (%)	Percentage of invention patents (%)	Main technical fields

2020	1558	38.2	41.5	New energy, carbon capture and utilization
2021	1630	40.3	43.7	Carbon capture, bio-based materials
2022	1716	42.5	46.4	Carbon capture, hydrogen technology
2023	1782	44.6	48.9	Hydrogen technology, bio-based materials

4. The Impact of Environmental Information Disclosure on Corporate Green Innovation

4.1 Environmental Information Disclosure Can Promote the Level of Corporate Green Innovation

Taking S Company as an example, the study finds that the strengthening of environmental information disclosure can have a double positive effect: firstly, by reducing the degree of information asymmetry, the enterprise is encouraged to accept stricter external supervision, thus increasing the investment in green innovation; Secondly, it helps enterprises build an environmental image, which makes it easier for them to obtain resources needed for green innovation from the capital market. The existing literature mostly regards green innovation as a single dimension, but rarely discusses the differentiated impact of environmental information disclosure on the quantity and quality of innovation. By distinguishing the quantity and quality dimensions of green innovation, this study reveals the mechanism of environmental information disclosure from a theoretical perspective, and provides a new analytical framework for subsequent research.

The results show that environmental information disclosure plays a significant role in promoting both the quantity and quality of green innovation. The incentive effect of environmental information disclosure is significantly higher than its possible resource crowding out effect under the background of stricter environmental protection regulation and the improvement of enterprises' environmental awareness. Specifically, firstly, information disclosure can improve the information communication between enterprises and external stakeholders, which can not only help enterprises obtain financing support, but also establish differentiation advantages in the product market, thus alleviating the financial constraints of innovation activities; Secondly, information disclosure also has the function of corporate governance. By reducing the agency cost between management and disclosure encourages

managers to make green innovation decisions based on the long-term value of enterprises, so as to achieve better allocation of innovation resources.

4.2 Government Taxation Can Inhibit the Corporate Green innovation performance caused by environmental information disclosure

From the perspective of external resources, government taxes (such as environmental taxes) are an important factor affecting S company's green technology innovation. Under the policy effect of environmental information disclosure, the promotion means of tax on corporate GTI can be summarized as the following two. Firstly, government tax has an incentive effect on corporate green innovation. Environmental information disclosure belongs to informal environmental regulation, which has a weak constraint on enterprises. Moreover, green innovation has the characteristics of high failure rate, long cycle and unstable expected returns. Therefore, enterprises have subjectivity in the process of information disclosure, so the initiative of technological innovation is weak. To solve this problem, in order to fully mobilize the enthusiasm of enterprise innovation, government departments have taken a combination of tax incentive measures. Specifically, by establishing a multi-level tax support framework, the government not only implements universally applicable preferential policies, but also launches targeted special incentive programs. This policy combination has effectively expanded the internal capital reserve of enterprises, especially through the implementation of specific measures such as the pre-tax deduction of R&D expenditure, which has significantly enhanced the motivation of enterprises to carryout green technology R&D. Secondly, government tax has a forcing effect on enterprises' green innovation. After the disclosure of environmental information, enterprises must pay taxes for resource consumption and pollutant discharge in the production process according to the disclosed information, which increases the cost of compliance with the system and increases part of working capital. In order to alleviate the impact of long-term tax burden caused by information disclosure, further improve the efficiency of resource utilization and reduce pollutant emissions, enterprises will actively carryout green research and development activities
to enhance their green innovation capabilities.

4.3 Environmental information disclosure leads to the decline of green innovation quality by inducing short-term behavior of enterprises

Environmental information disclosure will lead to the decline of innovation quality by inducing short-term behavior. The reasons include three aspects: first, high-quality green innovation activities have significant high-risk characteristics. This kind of innovation often involves the breakthrough research and development of core technologies, which not only has along R&D cycle and large investment, but also faces high technological uncertainty and market risk. Under the pressure of environmental information disclosure, the risk preference of enterprises tends to be conservative, and they tend to avoid such high-risk innovation projects. Secondly, there are rigid constraints on innovation resources within enterprises. When enterprises are faced with compliance pressure and

brought by information disclosure, the management has to make a trade-off between high-quality green innovation projects and low-quality green innovation projects. In the case of limited resources, enterprises tend to give priority to those improved innovation projects with quick results and low risks. Finally, the current innovation incentive policy system has a blind spot of quality identification. The existing incentive measures such as tax incentives and subsidies tend to focus more on the quantity index of innovation, while the evaluation and incentive of innovation quality are relatively insufficient. This policy orientation further strengthens the behavioral tendency of enterprises to pursue short-term innovation output.

Superimposed effect of the above three factors, which leads to the enterprises under the background of environmental information disclosure, generally adopted the following strategies: on the one hand, delay or reduce strategic long-term innovation investment; On the other hand, limited resources are invested in shallow innovation projects that can quickly generate performance. This innovation strategy shift, although in the short term can maintain or even increase the number of innovation, but at the expense of innovation quality, eventually led to the green innovation activities "quality decrease amount of deformity.

5. Suggestions

5.1 Strengthen the Governance of Internal Environmental Information Disclosure

Enterprises should realize that improving the environmental information disclosure mechanism not only helps to improve their own development level, but also cultivates differentiated competitive advantages among enterprises, and finally realizes the improvement of economic benefits. Within the enterprise, the management needs to deepen the awareness of environmental protection, integrate the concept of green development into the business strategy of the enterprise, strengthen the environmental information disclosure work by improving the internal governance mechanism, and effectively assume the responsibility of environmental protection. To be specific, the enterprise must attach importance to enhance information transparency, through the disclosure of environmental information, high quality to help investors and other stakeholders to fully understand the production and operation of environmental risk, to gain the capital market, to build a unique market competitive advantage. A perfect information disclosure mechanism can not only protect the public's right to know, but also optimize the efficiency of market resource allocation and effectively reduce the market failure caused by information asymmetry. This can not only reduce the risk premium in the financing process, but also significantly reduce the cost of capital and providestable financial support for green technology innovation. At the practical level, enterprises should pay attention to the coordinated promotion of environmental information disclosure and GTI. In view of the limited nature of resources, it is necessary to allocate innovation resources scientifically: on the one hand, continuously improve the quality of information disclosure, on the other hand, ensure the important position of GTI in strategic

planning. By increasing R&D investment, focusing on breakthroughs in green process and product innovation, we can achieve resource conservation and pollution reduction, and finally form a virtuous cycle of information disclosure and technological innovation. Standardized environmental information disclosure combined with substantive green technology innovation can effectively obtain the recognition of stakeholders and green financial institutions, and significantly reduce agency costs and financing costs. Enterprise must realize that only the organic combination of ecological protection and technology innovation, to achieve economic and environmental benefits of win-win, lay solid foundation for the sustainable development.

5.2 Establish and Improve Incentive Measures for Environmental Information Disclosure

In order to give greater play to the role of environmental information disclosure in promoting green technology innovation, it is necessary to supervise environmental information disclosure with stronger strength and build a more perfect incentive and restraint mechanism for environmental information disclosure, so as to enhance the motivation and enthusiasm of environmental information disclosure of enterprises, so as to create a good institutional environment for environmental information disclosure. The behavior of actively disclosing environmental information but lacking actual technological innovation should be eliminated. Environmental protection departments should strengthen law enforcement, increase the cost of violating the law, and punish enterprises with low level of environmental information disclosure. In addition, we should establish and improve environmental information disclosure policies flexibly and flexibly, and delegate power to local governments' environmental autonomy according to the actual situation. It is suggested to take differentiated regulatory measures to strengthen the supervision of non-state-owned enterprises and enterprises

in the central and western regions. At the sametime, in terms of policy, it is necessary to increase the resource preference support for the green technology innovation of these enterprises, so as to effectively stimulate their green technology innovation power, and finally build a scientific and effective environmental governance model to help enterprises achieve green and sustainable development.

5.3 We Should Promote the Marketization of Green Finance and Enhance the Degree of Tax Incentives

Under the framework of the current environmental information disclosure system, enterprises should take the initiative to disclose environmental performance data, and show their environmental protection practices and carbon emission reduction achievements to regulatory authorities and all sectors of society, so as to absorb more exogenous financing, increase R&D investment, and declare tax incentives on the basis of realizing green technology innovation. Environmental regulatory authorities can formulate standard information disclosure formats and strengthen environmental information supervision; At the same time, the tax incentives for green innovation should be increased, and the

financing threshold for enterprises should be appropriately lowered, so as to encourage enterprises to conduct green technology research and development and improve the quality of economic development.

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