The realization path of green innovation in energy legislation

-- Based on Geothermal Energy Listed Companies

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ABSTRACT

In the context of green innovation, enterprises are expected not only to enhance their own capability of technological innovation in the production and operation process, but also to assume the social responsibility of green development. To achieve the "double carbon" goal, China's Energy Law gives priority to the development of renewable energy and lays emphasis on the supply of clean and low carbon energy. Despite this, there remain various flaws in the energy legislation. According to an empirical study of geothermal energy listed companies, the economic incentive offered by the energy legislation can motivate enterprises to improve their capability of green innovation, which is a social effect that can be promoted by both the level of local green financial development and the intensity of environmental legislation. In this sense, China should improve its energy legislation system, paying close attention to its connection with such external laws as environmental protection law and green financial legislation. Moreover, to unify legal and social effects, it is necessary for China to improve the operability of such incentives as government subsidies and green credit, and to implement the legal policies tailored to different energy types and economic incentives.

1 Introduction

In order to promote the prosperity of renewable energy market, China has recently introduced a series of legal policies purposed to encourage the development of renewable energy (Hu et al., 2022a). Usually, there are many factors that can affect how the government chooses to incentivize energy companies, including the overall cost, the transaction costs and overhead involved, and the impact of the cost of subsidies on the output of different companies (Liu et al., 2013; Vandeninden et al., 2022; Li, 2022). As a manufacturing industry with extremely technical attributes, the renewable energy industry is characterized by the high barriers to entry and a long R&D cycle (Barragán-Escandón et al., 2022). Therefore, corporate innovation can be constrained by the limited nature of private capital and the profit-seeking nature of venture capital. The financial bottleneck is considered a major obstacle to the prosperity of green technology, and the lack of green technological innovation will lead to the high cost of green products (Elmawazini et al., 2022). Through financial support, the state government encourages enterprises to invest effort in the prosperity of renewable energy, attracting foreign enterprises to invest in construction. Therefore, the prosperity technology of renewable energy in China can also be improved, which promotes the sustainable development of the renewable energy market (Li et al., 2022a). Among various renewable energy, geothermal energy is the only renewable energy unaffected by weather conditions and seasonal changes of the earths indigenous (Cao et al., 2022). It demonstrates such desirable advantages as large storage capacity, high energy utilization efficiency, low operating cost, energy conservation and emission reduction (Li et al., 2022b). At present, geothermal resources have attracted widespread attention for new energy utilization worldwide. During the period from 2015 to 2020, the

total number of geothermal drilling wells for power projects worldwide was 1159, with the total geothermal investment for power projects amounting to $10.367 billion. By the end of 2019, the total installed capacity of global geothermal direct utilization reached 107,727 MW, an increase of 52.0% from 2015, with a compound annual growth rate of 8.7% (Fazal and Kamran, 2021; Huttrer,2020; Kallin, 2019). China has abundant geothermal resources, huge market potential and broad development prospects. In this sense, the development of geothermal energy is not only essential for upgrading the energy structure and promoting energy conservation, but also crucial to cultivating new industries, facilitating the new urbanization process and increasing employment (Wang et al., 2020). The National Energy Administration, in conjunction with the relevant government departments, has published several documents stating that by 2025, the proportion of areas heated by geothermal energy will improve by 50% compared to 2020, and by 2035, the proportion of areas heated by geothermal energy will double again compared to 2025 (Hu et al., 2022b). However, the utilization of geothermal energy requires plenty of time and capital investment in both the development and application of technology. Therefore, the financial support offered by the government for the geothermal energy industry is effective in reducing the sunk cost of technology research, mitigating the risk carried by technological innovation, attracting more R&D investment, and inducing more innovation of renewable energy technology. This is beneficial to promote technological innovation and the extensive application of geothermal energy, thus reducing carbon emissions (Compernolle et al., 2019; Neves et al., 2021; Chen et al., 2019).

With regard to the existing research on the development of geothermal energy, the focus is placed on its exploitation. As indicated by Cunha and Bourne-Webb (2022), there are many European countries having considered the development of and investment in shallow geothermal energy systems as a source of renewable energy. Through analysis, Pešić (2022) et al. (2022) demonstrated the cost-benefit of utilizing geothermal energy, highlighting its advantages over other energy sources in various aspects. Romanov and Leiss (2022) introduced the latest developments in terms of geothermal technology. Currently, the technologies of geothermal energy development have reached deeper subsurface layers and are applicable to extract heat at higher temperatures. As argued by Zuffi et al. (2022), the pollutant emissions from conventional geothermal power plants are detrimental to the environment. They put forward a life cycle assessment (LCA) approach to evaluate the geothermal systems for its environmental performance. According to the results, the environmental impact of geothermal power plants is consistent with other renewable energy. Regarding the connection between government policy and firm innovation behavior in the energy industry, Xu et al. (2022a) believed that the government subsidy can help improve the exploratory innovative performance output of PV firms in short time. In the view of Chen et al. (2021), tax incentives can enhance innovation performance at the firm level by lowering the costs of R&D for enterprises. Ma et al. (2021) found out that CO2 emissions can be reduced by increased energy investments, technical innovation, renewable energy use, R&D spending, and carbon taxes, which contributes to the carbon reduction strategy adopted by China. In other studies, the focus of attention is on the effects of the government subsidy and tax preference on the innovative performance of enterprises in combination. For example, Yi et al. (2021) pointed out that the combination of government subsidies and tax incentives contributes more to improving innovation performance at the firm level. By exploring the effects of the government subsidy and carbon taxes on green technology development, Yi et al. (2022) found out that government subsidies are advantageous over carbon taxes in generating profits for firms. As indicated by Yu and Zhang (2022), more stringent environmental regulations lead to a sharp decline in labor demand, firm entry, and foreign direct investment. In some literature, the focus is placed on the effect of the government subsidy on the green innovation of firms. According to Peng et al. (2021), the government should focus more on the green innovation guidelines as support for the transformation and upgrading of those major polluting enterprises, not simply pollution emission monitoring. As revealed by Lian et al. (2022), environmental regulations can improve resource utilization and effectively reduce costs, thus improving green innovation. Through an empirical study of energy firms, Zhang et al. (2022a) demonstrated that strict environmental policies can induce power generation

innovation for renewable energy firms, and that the promoting influence on green innovation in geothermal energy can reach a significant extent. Some academics, however, are skeptical about the association between green innovation and corporate success, arguing that the strength of the correlation between the two is uncertain and could even be negative or non-linear. For example, Tang et al. (2021) found that infrastructure development significantly contributes to green technology innovation, and this effect is stronger for low-quality green innovations. According to Stucki (2019), only 19% of businesses can boost their performance through green innovation, and there is no effective guarantee of conversion for the results of corporate green innovation. Despite the useful references provided by the above literature for the analysis of government policies and corporate green innovation, there remains a lack of research for geothermal energy companies. In addition, most of the studies are limited to using data at the local and municipal levels as their samples, with no attention paid to the impact of enterprises as micro entities. However, there is a difference between the concept of corporate innovation and corporate green innovation. Referring more to the technological R&D and technological innovation for environmental protection, it is closely linked to the external environment, such as green finance and environmental legislation.

Based on the data related to the economic incentives offered to listed companies in geothermal energy industry and corporate green innovation, etc., this paper adopts a multiple linear regression method to explore the effect of economic incentives on green innovation for geothermal energy companies. Furthermore, the path of achieving green innovation in energy legislation is analyzed. Through the above analysis, the following contributions are made by this study. Firstly, from the research perspective, this paper not only explores how economic incentives relate to corporate green innovation, but also investigates the effect of the level of green finance and the intensity of local environmental legislation on the utility of economic incentives. Ultimately, recommendations are made for the low-carbon development of the geothermal energy industry as well as the renewable energy from both policy and legal perspectives. Secondly, in terms of data and research methods, Chinese geothermal energy listed companies are selected in this paper as the research sample, which solves the localization problem at the local and municipal levels for portraying the green innovation behavior of enterprises. Meanwhile, new ideas are contributed to the empirical analysis of relevant studies.

2 Hypothesis development

2.1 Internal realization path of green innovation in energy legislation

The Renewable Energy Law has an entire chapter dedicated to economic incentives, which come in various forms, including a renewable energy development fund, preferential loans with fiscal subsidies, and tax incentives. The economic incentive system relies mainly on positive incentives to subsidize renewable energy companies, which allows low-carbon companies to achieve profitability through low-carbon activities (Schuman and Lin, 2012). Undoubtedly, the economic incentives for low-carbon products and technologies provide a significant guarantee for green innovation from the financial perspective. Therefore, the focus of research is on economic incentives for the internal implementation path of green innovation in energy legislation as studied in this paper (Liu, 2019; Ko et al., 2022).

2.1.1 Economic incentives and green innovation in geothermal energy companies

It is in the form of financial support for designated projects that enterprises might receive financial benefits from government incentives (Sperling and Arler, 2020). There is a vital role to play for the government's capacity to effectively address market failures and to interfere in the market through this economic instrument (Xu et al., 2021).

As for the restructuring of China's renewable energy sector, financial incentives are regarded as a key strategy. The innovations in green technology, technique, procedure, or product design are conducive to alleviating the load on the energy infrastructure (Wang et al., 2022b). As argued by Guellec and Pottelsberghe (2003), innovation outcomes are public in nature, which means that it is impossible for investors to fully monopolize the benefits brought about by new technological knowledge. Besides, the innovation process is usually time-consuming, investment-intensive, and risky, with minimal short-term gains, which is especially unfavorable to those capital-strapped firms with limited risk tolerance. In addition, it is difficult to ensure the efficacy of green innovation, and the concerns of external investors are heightened by the increased riskiness, uncertainty, and longer payback period of green innovation. These pose challenges in business financing (Wu et al., 2022). By sharing the innovation risks faced by enterprises, economic incentives can effectively reduce their worries to a certain extent. In the absence of policy incentives and institutional constraints, most enterprises would be put off by the high risk and high cost of green innovation (Huang et al., 2019). Therefore, the government can offer subsidy to eligible enterprises for increasing their cash flow and alleviating the pressure of R&D cost incurred by green innovation. Enterprises can be motivated by rewarding innovation results to implement the substantial green innovations that are difficult but can gain competitive advantage, thus improving the pace of green innovation (Fan et al., 2022). With the incentives of government policies, enterprises expect more government subsidies. Also, the incentive to innovate will be enhanced significantly, which will lead to the long-term competitive advantage for enterprises. As the vane of the market, economic incentives can alleviate the financial constraints imposed on enterprises and promote green innovation through financial subsidies, tax exemptions, and targeted innovation investments (Xia et al., 2022a). Therefore, hypothesis 1 is proposed as follows:

H1: Economic incentives can promote green innovation for geothermal energy companies.

2.1.2 The mediating effect of R&D investment

In addition to exerting a direct incentive effect on their innovation performance, the government investment and subsidies offered to enterprises for green innovation will also encourage them to scale up their R&D investment (Xu et al., 2022b). This is because the financial support offered by the government motivates enterprises to seek technical support from the relevant fields in the industry and acquire the latest knowledge, which lowers their own innovation R&D costs and mitigates the R&D risks posed to them (Leung and Sharma, 2021). In turn, the enterprises' willingness to innovate is enhanced, with more funds directed to R&D activities. With the improvement of innovation capability, enterprises tend to re-evaluate their otherwise high-risk and high-cost innovation projects, and then expand their R&D investment by increasing the number and scale of new projects (Chen et al., 2021). Therefore, financial incentives are effective in reducing the opportunity cost and sunk cost pressure of corporate R&D. With the incentives of various subsidies, enterprises will be more motivated to engage in R&D, showing willingness to increase the investment in green innovation (Assefa et al., 2022). This will release the signal of high innovation capacity to the society, receive short-term economic benefits and more economic incentives, and close the loopholes of enterprises in other aspects. Ultimately, the company improves its market competitiveness, increases its market share, builds an invisible green reputation in society and mitigates the risk of government regulation (Adomako et al., 2021). To sum up, economic incentives can provide implicit reputation guarantees for subsidized enterprises, release positive investment signals to social investors, contribute to avoiding the adverse selection problem of investors, attract social investment, motivate enterprises to increase their R&D expenditure, and promote the practice of green innovation. Thus, hypothesis 2 is proposed as follows:

H2: R&D investment keeps a mediating role between economic incentives and corporate green innovation.

2.2 External realization path of green innovation in energy legislation

Under the context of carbon neutral strategy, to establish an effective development mechanism for the energy industry does not rely on the support of green finance, environmental protection policies and relevant laws and regulations. On the one hand, the legislative aim of the Renewable Energy Law is also to emphasize environmental protection, and different ecological and environmental problems will arise from the process of renewable energy development and utilization (Xie et al., 2022). A proper constraint mechanism can be applied to address the problems of environmental externality caused by energy development. For example, geothermal resources are developed at low cost, and the over-exploitation of geothermal resources is damaging to the geological environment. In addition to its high temperature, geothermal water also contains such chemicals as chlorides and sulfides at high concentrations. If not adequately treated, pumped geothermal water can seep into the ground, rivers, or crops, thus posing a severe threat to the aquatic environment (Chen et al., 2020). Therefore, it is essential to resolve the ecological and environmental issues caused by using renewable energy sources. On the other hand, the green finance in China is now on the track of fast development, and China ranks high among the international community in terms of market scale. It is worth paying attention to the role that social capital plays in supporting green innovation through the green financial system under the carbon neutrality target. Renewable energy policy can be adopted to attract investment, promote equipment energy saving transformation, enhance energy efficiency and total factor productivity, and promote carbon emission reduction in such forms as green finance and green certificate trading (Ge et al., 2022). For the external realization path of green innovation in energy legislation as studied in this paper, the focus is placed on the intensity of environmental legislation and the level of green financial to make the corresponding policy recommendations through exploration into the moderating effects of both on the use of economic incentives by firms to promote green innovation.

2.2.1 Moderating effect of the intensity of environmental legislation

Based on the Porter hypothesis, to tighten environmental regulation can prompt firms into improving innovation, which is conducive to creating their own competitive advantage and accelerating industrial upgrading. Wang et al. (2022c) discovered through research of the Chinese manufacturing firms that environmental regulation can lead to the advancement of green technology for firms. As revealed by Zhong and Peng (2022), the environmental policies implemented in Northeast China played a role in significantly promoting green innovation among those heavily polluting enterprises. By using the data sourced from Chinese provinces, Xia et al. (2022b) explored the effect of environmental regulation intensity on industrial risk resistance, concluding that the impact of it on industrial risk resistance showed a significant U-shaped threshold characteristic, rather than a simple linear relationship. For the firms engaged into pollution-intensive industries, Cui et al. (2022a) argued for a significant promoting effect of environmental regulation on the practice of green innovation. The strength of environmental legislation exerts a substantial effect on industrial upgrading in all cases. This is because environmental regulation prompts firms to improve their competitiveness and increase R&D investment, thus achieving green innovation and industrial upgrading. Enterprises are encouraged by the environmental laws and regulations enacted by the legislature and the government to choose cleaner production processes over the more polluting ones. In this process, firms seek to achieve green technology innovation. Thus, hypothesis 3 is proposed as follows:

H3: The intensity of environmental legislation has a positive moderating effect in both the direct and mediated models of economic incentives on green innovation.

2.2.2 Moderating effect of the level of green financial development

As a novel approach to funding, green finance is intended to support eco-friendly businesses and initiatives. It shows the potential of creating a green investment and financing incentive mechanism, internalizing environmental pollution into the financing cost of emission enterprises, facilitating the movement of capital from polluting to fewer polluting sectors, reducing the ROI and access to capital for polluting sectors, increasing the ROI and access to capital for green sectors, and enhancing financial support for environmental protection (Huang et al., 2022a).

The core elements of green finance include green credit, green bonds, green funds, green insurance, and other environmentally friendly financial services and products. In the view of Lian, green credit is effective in promoting the development of green enterprises through the contrast of debt financing costs between green and "two high" enterprises. Differently, Lu et al. (2022) believe that the direct funding represented by green securities is more effective than the indirect financing represented by green credit in driving the development of environmental enterprises. Among other green financial instruments, green funds and green insurance are supported by Jin and Han (2018) as a solution to directing private capital to the effort made on energy conservation and environmental preservation. As for Chinese green SMEs, they usually encounter such problems as the difficulty in financing and the high cost of financing. Through the vigorous development of green finance, more social capital can be guided to green industries, thus reducing the investments in those enterprises with low energy efficiency and severe pollution (Zhang et al., 2021). Meanwhile, enterprises are encouraged to issue green bonds and make green investments, which is beneficial to form a positive and good positive cycle that generates commercial benefits in return. A green and healthy lifestyle is reflected in the increased consciousness of people to reduce their carbon footprint on the planet. For the government, its role is to offer incentives through public funds. Also, the government should reduce the financing cost burdened by enterprises through interest subsidies, guarantees, refinancing, and PPP models to improve their returns, while increasing the utilization rate of public funds (Wang and Zhao, 2021). Therefore, hypothesis 4 is proposed as follows:

H4: The level of green financial development has a positive moderating impact in the direct and mediated models of economic incentives on green innovation.

3 Methods

3.1 Sample selection and data sources

Herein, multiple linear regression is performed to test the impact of government subsidies on firms' green innovation by using the data of listed A-share geothermal energy industry enterprises in China from 2013-2020 as a sample, due to the availability of data. The data before 2013 are missing more seriously, and the latest data in the database is only updated to 2020 at the time of the present study. The data of green innovation are collected from China Research Data Service Platform (CNRDS); the data of environmental legislation intensity and green financial development level are obtained from China Statistical Yearbook; and the data of other variables are gathered from WIND database. Based on the original data collected, the original data are processed in this paper as follows. Firstly, the enterprises that were ST in the sample period are eliminated. Secondly, the samples with missing variable observations are deleted. Lastly, control is imposed on the influence of extreme values and a 1% tailing process (Winsorise) is applied to all continuous variables. A total of 122 samples are obtained in this paper after the above screening.

3.2 Variable Description

3.2.1 Economic incentives

Currently, China has already put in place various economic incentives as support for the development of renewable energy industry, including but not limited to special fund system, technology R&D and industrialization projects, tax incentives, financial investment and subsidy policies. From the annual reports of geothermal energy enterprises, it can be found out that there is no direct data of economic incentives available in the annual reports. Instead, the major government subsidies as mentioned in the notes to the financial statements of geothermal energy enterprises include all forms of project allocations and capital subsidies, incentives, all types of loan subsidies and export subsidies, tax rebates, VAT instant refunds, etc., basically covering all forms of economic incentives (Yang et al., 2019). Therefore, the government subsidies offered to enterprises in the current year are taken in this paper as the indicator of economic incentives. Besides, they are logarized due to the substantial amount of government subsidies.

3.2.2 Green Innovation

The number of green patent applications filed by geothermal energy listed companies is treated as a proxy variable for green innovation, for the following two reasons. On the one hand, although patent application data are more stable, trustworthy, and timely than patent granting data, the approval procedure for a patent is a lengthy one and business performance can be affected by the patented technology. On the other hand, green patents can reflect the extent to which businesses and societies are undergoing a green transition in a more accurate way (Cui et al., 2022b; Liao, 2020; Feng et al., 2022). Green patents have the potential to mitigate the impact of outside variables like innovation subsidies, thus diluting the significance of data based only on patent counts. Meanwhile, it is logarized in this paper by adding 1 to it.

3.2.3 Intermediate variable

The R&D investment of listed companies is adopted as the mediating variable. The term "R&D investment" is applied to describe the funding spent on innovative research and testing, which can include both pure and applied forms of study. Meanwhile, it is logarized in this paper.

3.2.4 Moderating variables

(1) Strength of environmental legislation

The indicators commonly used to measure the intensity of environmental legislation include the volume of emissions, the cost of pollution control, the degree of economic progress, the number of relevant policies and regulations, and the efficiency of pollution prevention. By contrast, there is a relatively weak correlation between the level of economic development and environmental legislation. As for the number of pollution control expenditures and environmental regulations, they can only reflect the investment of relevant parties in protecting the environment, which means they are unable to indicate the effect of treatment accurately. Besides, the suitability of pollutant emissions as an indicator for measurement is controversial. For this reason, the number of environmental laws and regulations in the province where the enterprise is registered in the previous year is used in this paper as the indicator of environmental legislation intensity (Zhang et al., 2022b).

(2) Level of green financial development

"Green finance" is a term that can be used to describe the economic activities contributory to environmental improvement, climate change, and the efficient use of resources. Investment and finance services, project management, and risk analysis and management are all included under this umbrella phrase. Through green financing, funds may be directed away from polluting and energy-hungry businesses to those adopting innovative ideas and technology. In this study, the entropy value approach is taken to evaluate the green financial data of 30 Chinese provinces. The major indicators include green credit, green investment, green insurance, and government backing (Wang and Zhao, 2022).

3.2.5 Control variables

Herein, there are four indicators treated as control variables for their potential influence on the green innovation of firms. The first one is the level of education of the firm's employees (STUD). The second one is the intensity of market competition. The third one is the asset-liability ratio (ALR). The last one is the total asset growth rate (TGR). The specific definitions are shown in Table 1.

Table 1 Variable definition

Type	**Name**	**Symbol**	**Definition**
Independent Variable	Economic incentives	ECO	ECO=ln (government subsidies received by firms in the current year)
Dependent Variable	Green innovation	GPAT	GPAT=ln (the number of green patent applications filed by firms + 1)
Intermediate variable	R&D investment	RD	RD=ln (the number of research and development investment by firms)
Moderating variables	Strength of environmental legislation	LLAW	LLAW= the number of environmental laws and regulations in the province where the enterprise is registered in the previous year
	Level of green financial	GRE	GRE= the entropy value of green credit, green investment, green insurance, and government backing
Control variables	Employee education level	STUD	STUD= Employees with a bachelor's degree/all employees
	Lerner Index	COMP	COMP= (Operating revenues - operating costs - selling expenses - administrative expenses)/operating revenues
	Gearing ratio	ALR	ALR= Total Assets / Total Liabilities
	Total assets growth rate	TGR	TGR=Ratio of annualized asset growth to annualized asset growth at the start of the year
	Company Location	AREA	AREA = 1 (if the firm is registered in Beijing, Tianjin, Hebei, Yangtze River Delta or the Greater Bay Area); AREA = 0 (if the firm is registered in other areas)
	Nature of ownership	STATE	STATE =0 (If the firm is state-owned); STATE=1 (if the firm is non-state-owned)

3.3 Model design

3.3.1 Intermediary effect analysis

The research model adopted in the present study consists of two main parts. On the one hand, the internal realization path of green innovation in energy legislation is tested in this paper, that is, the immediate effect of economic incentives on the green innovation of geothermal energy companies and its mediating effect on corporate R&D investment. As shown in Equation (1), model 1 is the regression model of economic incentives on green innovation. In this model, GPAT represents corporate green innovation, ECO denotes economic incentive, and ε indicates the random error term. As shown in Equation (2), model 2 is the regression model of economic incentives on enterprise R&D investment, where the variable RD refers to corporate R&D investment. Based on model 1, the variable of corporate R&D investment is factor into model 3 for verifying the effect of economic incentives and R&D investment on corporate green innovation, as shown in Equation (3).

$$GPAT = \beta_0 + \beta_1 ECO + \beta_2 STATE + \beta_3 AREA + \beta_4 STUD + \beta_5 ALR + \beta_6 COMP + \beta_7 TGB + \varepsilon \quad (1)$$

$$RD = \beta_0 + \beta_1 ECO + \beta_2 STATE + \beta_3 AREA + \beta_4 STUD + \beta_5 ALR + \beta_6 COMP + \beta_7 TGB + \varepsilon \quad (2)$$

$$GPAT = \beta_0 + \beta_1 ECO + \beta_2 RD + \beta_3 STATE + \beta_4 AREA + \beta_5 STUD + \beta_6 ALR + \beta_7 COMP + \beta_8 TGB + \varepsilon \quad (3)$$

3.3.2 Analysis of the regulation role

In order to test the moderating effect of environmental legislation intensity in the mediation process of "economic incentives - corporate R&D investment - corporate green innovation" and to distinguish the direct moderating effect from the mediating effect, environmental legislation intensity (LLAW) is factored into model (1) (2) (3) and model (4) (5) (6) is set to form ECO*LLAW with economic incentives and R&D investment, respectively. Herein, environmental legislation intensity (LLAW) is introduced into model (1)(2)(3), with model (4)(5)(6) set to form ECO*LLAW and RD*LLAW cross terms with economic incentives and R&D investment, respectively. Meanwhile, the other control variables remain unchanged.

$$GPAT = \beta_0 + \beta_1 ECO + \beta_2 LLAW + \beta_3 ECO * LLAW + \beta_4 STATE + \beta_5 AREA + \beta_6 STUD + \beta_7 ALR + \beta_8 COMP + \beta_9 TGB + \varepsilon \quad (4)$$

$$RD = \beta_0 + \beta_1 ECO + \beta_2 LLAW + \beta_3 ECO * LLAW + \beta_4 STATE + \beta_5 AREA + \beta_6 STUD + \beta_7 ALR + \beta_8 COMP + \beta_9 TGB + \varepsilon \quad (5)$$

$$GPAT = \beta_0 + \beta_1 ECO + \beta_2 LLAW + \beta_3 RD + \beta_4 RD * LLAW + \beta_5 STATE + \beta_6 AREA + \beta_7 STUD + \beta_8 ALR + \beta_9 COMP + \beta_{10} TGB + \varepsilon \quad (6)$$

In order to test the moderating effect of green financial development level in the mediation process of "economic incentive - corporate R&D input - corporate green innovation" and to distinguish the direct moderating effect from the mediating effect, the green financial development level (GRE) is introduced into model (1) (2) (3). In the present study, the green financial development level (GRE) is factored into model (1)(2)(3), and model (7)(8)(9) set to form ECO*GRE and RD*GRE cross terms with economic incentives and R&D investment, respectively. In the meantime, the other control variables remain unchanged.

$$GPAT = \beta_0 + \beta_1 ECO + \beta_2 GRE + \beta_3 ECO * GRE + \beta_4 STATE + \beta_5 AREA + \beta_6 STUD + \beta_7 ALR + \beta_8 COMP + \beta_9 TGB + \varepsilon \quad (7)$$

$$RD = \beta_0 + \beta_1 ECO + \beta_2 GRE + \beta_3 ECO * GRE + \beta_4 STATE + \beta_5 AREA + \beta_6 STUD + \beta_7 ALR + \beta_8 COMP + \beta_9 TGB + \varepsilon \quad (8)$$

$$GPAT = \beta_0 + \beta_1 ECO + \beta_2 GRE + \beta_3 RD + \beta_4 ECO * RD + \beta_5 STATE + \beta_6 AREA + \beta_7 STUD + \beta_8 ALR + \beta_9 COMP + \beta_{10} TGB + \varepsilon \quad (9)$$

4 Analysis of results

4.1 Descriptive statistics and correlation

With a total of 122 observations collected in this paper, Table 2 lists the results of descriptive statistics of the variables. According to the above results, the mean value of GAPT is 1.979 for the green innovation of geothermal energy enterprises. Besides, the difference between the maximum value (7.186) and the minimum value (0) reaches a significant extent, which implies the significant differences in green innovation between different geothermal energy enterprises. There are also some environmental enterprises performing poorly in terms of green innovation capability. After the logarithm of government subsidies is taken, ECO ranges from 13.588 to 22.736, suggesting that financial support is offered to most of the listed geothermal energy companies. In addition to illustrating the development orientation of the government and its support for geothermal energy enterprises, these data also show that the government's positive attitude towards encouraging the vigorous development of geothermal energy enterprises. The minimum value of RD of enterprises' R&D investment intensity is 16.785 and the maximum value is 23.787. There is a significant difference in the investment intensity of green innovation among different enterprises. Besides, there are some enterprises paying insufficient attention to green R&D, which may explain why the green innovation result is 0 for some enterprises.

Table 2 Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
GPAT	122	1.979	1.709	0	7.186
ECO	122	17.047	1.891	13.588	22.736
RD	122	18.898	1.656	16.785	23.787
STUD	122	.245	.173	.015	.811
COMP	122	.105	.071	-.001	.276
ALR	122	.451	.152	.093	.794
TGR	122	.104	.165	-.259	.705
LLAW	106	5.557	4.895	0	26
GRE	122	.333	.187	.116	.839

Table 3 shows a preliminary understanding as to the strength of association between these variables. ECO is found to have a significant positive correlation with GPAT and a coefficient of 0.738 is reached at the 1% significance level, which is consistent with hypothesis 1. The coefficient of correlation between RD and GPAT is 0.702, which indicates a significantly positive connection with R&D investment and green innovation in geothermal energy

companies ($p<0.01$). Since the correlation analysis is simply a preliminary indication as to the strength of correlation between the variables, the exact relationship will be explored in the empirical section by means of regression analysis.

Table 3 Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) GPAT	1.000								
(2) ECO	0.738	1.000							
	0.000								
(3) RD	0.702	0.852	1.000						
	0.000	0.000							
(4) STUD	0.147	0.070	0.087	1.000					
	0.107	0.442	0.339						
(5) COMP	0.100	0.099	0.063	0.431	1.000				
	0.275	0.278	0.492	0.000					
(6) ALR	0.156	0.329	0.340	-0.429	-0.491	1.000			
	0.086	0.000	0.000	0.000	0.000				
(7) TGR	-0.274	-0.253	-0.241	0.145	0.257	-0.367	1.000		
	0.002	0.005	0.007	0.111	0.004	0.000			
(8) LLAW	0.213	0.137	0.129	0.133	0.178	-0.045	-0.011	1.000	
	0.028	0.162	0.186	0.175	0.067	0.647	0.911		

(9) GRE	0.502	0.559	0.494	0.274	0.276	-0.073	-0.197	0.320	1.000
	0.000	0.000	0.000	0.002	0.002	0.424	0.030	0.001	

4.2 Internal path test results - mediating effects

In Table 4, models (1) to (3) are used to describe the process of performing stepwise tests of mediating effects. In model (1), the coefficient of ECO is 0.616, passing the test of significance ($p<0.01$). It is indicated that ECO exerts a catalytic effect on green innovation. A higher the economic incentives received by geothermal energy companies leads to their better performance in green innovation. Thus, hypothesis 1 is supported. Model (2) aims mainly to test the effect of ECO on RD. The coefficient of ECO is 0.534, passing the test of significance ($p<0.01$). It is indicated that ECO has a promoting effect on RD. When economic incentives are increased, geothermal energy companies will scale up their R&D investment accordingly. In model (3), the coefficient of ECO is 0.479, which is significant ($p<0.01$). The coefficient of RD is 0.255, which is significant at the 10% significance level. It indicates the significant positive impact of current R&D investment by firms on green innovation.

Accordingly, R&D investment produces a mediating effect, or a partial mediating effect to be exact, in the path of the role of economic incentives on green innovation in geothermal energy firms. To be specific, the magnitude of mediating effect caused by R&D input is the product of coefficient of government subsidy 0.534 in model (2) and the coefficient of R&D input 0.255 in model (4). The result is equal to 0.136, which means that the indirect effect of economic incentives on the green innovation of geothermal energy enterprises through the path of influencing R&D input is 0.136. Thus, hypothesis 2 is supported. R&D investment exerts a mediating effect between economic incentives and the green innovation of geothermal energy firms.

Table 4 Regression model for intermediate effect test

	GPAT Model 1	RD Model 2	GPAT Model 3
ECO	0.616***	0.534***	0.479***
	(7.58)	(9.38)	(4.49)
RD			0.255*
			(1.93)
STUD	0.218	-0.080	0.238
	(0.29)	(-0.15)	(0.32)
COMP	1.018	2.787*	0.308
	(0.51)	(1.98)	(0.15)
ALR	-1.652*	0.781	-1.851**
	(-1.77)	(1.19)	(-1.99)
TGR	-1.643**	-0.339	-1.557**
	(-2.35)	(-0.69)	(-2.25)
STATE	-0.476	-1.246***	-0.159

	(-1.35)	(-5.04)	(-0.41)
AREA	-0.117	0.559**	-0.260
	(-0.38)	(2.60)	(-0.83)
Constant	-7.408***	9.538***	-9.838***
	(-5.37)	(9.86)	(-5.30)
Observations	122	122	122
R-squared	0.588	0.784	0.601

t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

To further observe the different effects of various economic incentives on the green innovation and to explore the realization path of green innovation in energy legislation, the economic incentives are classified in this paper. According to Chapter 6 of China's Renewable Energy Law, the economic incentives offered by the government for renewable energy enterprises can be divided into three categories: special funds, tax incentives, and financial subsidies. Accordingly, the amounts of these three types of economic incentives under government subsidies are manually extracted in this paper according to the details of government subsidies as provided in the annual reports of enterprises. Besides, the special funds, tax incentives and fiscal subsidies are denoted as SECO, TECO and BECO, respectively. Then, they are substituted into model 1, model 2 and model 3, respectively, which leads to the results listed in Table 5.

The coefficient of SECO in model (1) is -0.063, passing the test of significance at the 1% significance level. It is indicated that SECO inhibits green innovation. The lower the special fund received by geothermal energy companies, the worse their performance in green innovation. The coefficient of BECO is -0.011, which means it fails the test of significance. The coefficient of TECO is 0.011, failing the test of significance. It indicates the insignificant promoting effect of fiscal subsidies on green innovation. In model (2), the coefficient of SECO is -0.033, which means it passes the test of significance ($p<0.05$). The coefficient of BECO is 0.010, which means it fails the test of significance. It is indicated that fiscal discount exerts an insignificant effect on the promotion of R&D investment. The coefficient of TECO is 0.008, failing the test of significance. It means that the promoting effect of financial subsidies on R&D investment is insignificant. In model (2), the coefficient of RD is 0.584, passing the test of significance ($p<0.01$). It demonstrates that R&D investment plays a positive role in green innovation. However, the coefficients of the three types of economic incentives are either negative or fail the test of significance. Additionally, the mediating effect of R&D investment does not hold under all three types of economic incentives.

This result may be due to the special fund that may increase the output of firms in short order. However, it fails to bring the effect of technological progress in terms of the long-term impact on enterprises. Consequently, it is possible for the overall inhibitory effect of R&D brought about by the special fund to outweigh the promoting effect of output growth under the special fund. This view can be further confirmed by the current state of other renewable energy enterprises. For photovoltaic enterprises, for example, the problem of overcapacity in the photovoltaic industry has arisen from the stimulation of huge subsidies. In respect of core technology, however, they remain in a weak position, which means the reliance on special funds alone is insufficient to sustain the prosperity of renewable energy firms. In addition, the provisions of the "Fund Interim Measures" are clearly vague, with special funds allocated by the central financial from the annual public budget. However, the source of the special fund is not specified, which makes it difficult to guide the specific operation. Moreover, there is a lack of relevant provisions in the existing laws and regulations to conduct supervision on the use and management of the development fund. As a result, the use of

the fund is highly subjective and arbitrary. Due to the prevalence of such phenomena as power-seeking and rent-seeking, the special fund has no promoting effect on the green innovation of enterprises.

Table 5 Tests of mediating effects of different types of economic incentives

	GPAT	RD	GPAT
VARIABLES	Model 1	Model 2	Model 3
SECO	-0.063***	-0.033**	-0.044***
	(-3.49)	(-2.27)	(-2.68)
BECO	-0.011	0.010	-0.017
	(-0.38)	(0.42)	(-0.64)
TECO	0.011	0.008	0.006
	(0.61)	(0.57)	(0.39)
RD			0.584***
			(5.48)
STUD	0.145	-0.185	0.253
	(0.16)	(-0.26)	(0.32)
COMP	6.285***	7.614***	1.835
	(2.89)	(4.44)	(0.87)
ALR	0.813	2.689***	-0.758
	(0.77)	(3.22)	(-0.77)
TGR	-2.686***	-1.137*	-2.022***
	(-3.30)	(-1.77)	(-2.75)
STATE	-2.065***	-2.651***	-0.516
	(-6.41)	(-10.43)	(-1.28)
AREA	0.858***	1.487***	-0.011
	(2.69)	(5.91)	(-0.03)
Constant	2.217***	17.739***	-8.150***
	(3.01)	(30.52)	(-4.07)
Observations	122	122	122
R-squared	0.449	0.634	0.566

4.3 External path test results - moderating effect

4.3.1 Regulating role of environmental legislation intensity

In the previous paper, it has been demonstrated that it is through the mediating path of R&D investment that economic incentives exert a promoting effect on the green innovation of geothermal energy firms. In the correlation analysis, the intensity of environmental legislation is found to have a positive correlation with green innovation, economic incentives, and R&D investment. On this basis, another path is explored in this paper, to establish whether the intensity of environmental legislation maintains a moderating effect on the relationship between economic incentives and corporate green innovation. To test the moderating effect, it is necessary to include interaction terms, and to prevent the excessively large covariance of the explanatory variables. Robinson and Schumacker (2009)

proposed to center the variables, such as subtracting the mean from the fraction of the variables. In this paper, the main variables economic incentives, R&D investment, and strength of environmental legislation are all centered during the moderating tests.

In the test of moderating effect, model 4 is used to test the moderating effect of LLAW between ECO and GPAT. The coefficient of the cross-product term ECO*LLAW is 0.024, which means it fails the test of significance. The moderating effect of environmental legislation intensity is found to be insignificant between ECO and GPAT. Model 5 is applied to test the moderating effect of LLAW between ECO and RD. The coefficient of the cross-product term ECO*LLAW is 0.027, which means it passes the test of significance ($p<0.1$). It is indicated that the positive moderating effect of environmental legislation intensity reaches a significant extent between ECO and RD. According to the positive coefficient of the interaction term, the higher the intensity of environmental legislation, the higher the firm's R&D investment. That is to say, the intensity of environmental legislation can reinforce the positive effect of economic incentives on R&D investment. Model 6 is adopted to test the moderating effect of LLAW between RD and GPAT. The coefficient of the cross-product term RD*LLAW is 0.033, failing the test of significance. It means that the positive moderating effect of environmental legislation intensity does not reach a significant extent between RD and GPAT.

To sum up, it is only in model 5 that the positive moderating effect of the intensity of environmental legislation holds significantly, which is possibly attributed to the intensity of environmental legislation published by the government placing higher requirements on the level of pollution control of enterprises to increase their treatment costs. To comply with the requirements of various environmental regulations, enterprises tend to scale up their R&D investment in green technology innovation. However, a certain lag period may exist for the output of this part of the results, and it is difficult to show the green innovation achieved by the increased R&D investment in the same year. This explains why the moderating effect of environmental legislation intensity on green innovation fails to reach a significant extent, despite the positive coefficient.

Table 6 Tests of the moderating effect of the intensity of environmental legislation

	GPAT	RD	GPAT
VARIABLES	Model 4	Model 5	Model 6
ECO	0.611***	0.465***	0.512***
	(6.60)	(7.01)	(4.65)
RD			0.186
			(1.25)
LLAW	0.056**	0.028	0.051**
	(2.13)	(1.51)	(2.09)
RD*LLAW			0.033
			(1.44)
STUD	0.149	0.002	0.168
	(0.19)	(0.00)	(0.22)
COMP	1.374	2.799*	0.891
	(0.61)	(1.72)	(0.39)
ALR	-0.939	1.360*	-1.118
	(-0.85)	(1.71)	(-1.03)

TGR	-1.541**	-0.269	-1.438*
	(-2.09)	(-0.51)	(-1.98)
STATE	-0.356	-1.224***	-0.133
	(-0.94)	(-4.52)	(-0.32)
AREA	-0.298	0.488**	-0.397
	(-0.90)	(2.06)	(-1.20)
ECO*LLAW	0.024	0.027*	
	(1.15)	(1.83)	
Constant	-7.849***	10.269***	-9.615***
	(-5.29)	(9.64)	(-4.49)
Observations	106	106	106
R-squared	0.620	0.774	0.637

4.3.2 The moderating role of the level of green financial development

Model 7 is used to test the moderating effect of GRE between ECO and GPAT. The cross-product term ECO*GRE coefficient is 0.796, which means it passes the test of significance ($p<0.05$). It is demonstrated that the moderating effect of green finance holds between ECO and GPAT. As implied by a positive coefficient of the interaction term, the higher the level of green finance, the more significant the promoting effect of economic incentives on green innovation. Model 8 is applied to test the moderating effect of GRE between ECO and RD. The coefficient of the cross-product term ECO*GRE is 0.800, passing the test of significance ($p<0.01$). That is to say, the positive moderating effect of green finance reaches a significant extent between ECO and RD. The higher the level of green finance, the more significant the promoting effect of economic incentives on R&D investment. Model 9 is used to test the moderating effect of GRE between RD and GPAT. The cross-product term RD*GRE coefficient is 0.478, which means it fails the test of significance. The positive moderating effect of GRE is insignificant between RD and GPAT.

To sum up, it is only in models 7 and 8 that the positive moderating effect of green finance holds significantly. The improvement of green finance leads to stronger behavioral incentives for the green production behavior of enterprises, and it is more likely that the financial support offered within the green financial system is received by those technological innovation projects with strong willingness to innovate but insufficient economic benefits. As a result, the crowding out of funds can be alleviated through environmental legislations for technological innovation, which enables enterprises to achieve low-carbon development through technological innovation. Under the context of green development, the improvement of green finance is made continuously in various regions, and there are various financial institutions increasing their financial support for green enterprises and green projects. Therefore, the capability of green innovation is improved by the attention of both the government and financial institutions. By relaxing the financing constraints of enterprises, green finance promotes the flow of funds, which is not only conducive to the healthy and sustainable operation of enterprises but also effective in improving the practice of green innovation. The improved level of green finance development allows enterprises to receive economic incentives. For those general enterprises whose pollution level is between green enterprises and polluting enterprises, the government and various financial institutions provide the guidance on the transition into green enterprises, rather than offering them green funds.

Table 7 Tests of the moderating effect of green finance

VARIABLES	GPAT Model 7	RD Model 8	GPAT Model 9
ECO	0.337***	0.314***	0.399***
	(3.03)	(4.08)	(3.63)
RD			0.046
			(0.25)
GRE	1.639*	0.403	1.874**
	(1.77)	(0.63)	(2.03)
RD*GRE			0.478
			(1.30)
STUD	0.114	0.153	-0.098
	(0.15)	(0.29)	(-0.13)
COMP	1.925	3.481**	1.354
	(1.00)	(2.60)	(0.66)
ALR	0.055	2.295***	-0.676
	(0.05)	(3.17)	(-0.60)
TGR	-1.473**	-0.293	-1.472**
	(-2.18)	(-0.63)	(-2.14)
STATE	-0.287	-1.057***	-0.322
	(-0.83)	(-4.44)	(-0.83)
AREA	-0.546	0.384	-0.580
	(-1.58)	(1.61)	(-1.62)
ECO*GRE	0.796**	0.800***	
	(2.56)	(3.71)	
Constant	-4.034**	12.200***	-5.480*
	(-2.47)	(10.82)	(-1.89)
Observations	122	122	122
R-squared	0.630	0.812	0.624

4.4 Robustness tests

Robustness tests are performed to establish the dependability and non-randomness of the empirical data as shown above. In this paper, according to the model and data, the robustness test is conducted through both variable replacement and model replacement. Firstly, the indicator of green innovation is replaced with the number of green patents granted by enterprises, which leads to the results showing the positive correlation between economic incentives, green innovation, and R&D investment. This is coherent with the results of the previous tests. In the above empirical process, there may be some lag effect that economic incentives have on green innovation. Therefore, all the data of economic incentives are lagged by one year in the robustness test, and then the above results are tested. According to the test results, economic incentives are positively correlated with green innovation, and R&D investment exerts a mediating effect on it. In addition, there is a positive moderating role played by both the level of green finance and the intensity of environmental legislation. It indicates the robustness of the findings.

5 Conclusions and policy implications

5.1 Conclusion

Herein, the data sourced from Chinese geothermal energy listed firms from 2013 to 2020 are used and an empirical analysis is conducted by using the mediating and moderating effect models. Firstly, the realization path of green innovation within energy legislation is explored by analyzing the impact of economic incentives on the green innovation of geothermal energy enterprises. According to the findings, economic incentives exert a promoting effect on the green innovation of geothermal energy enterprises, and the R&D investment of enterprises has a mediating effect. Among various economic incentives, special funds exert a significant inhibitory effect on the green innovation of geothermal energy enterprises. It shows that the role of special funds is not played to the full in China at present. Tax incentives and financial subsidies fail to maintain a vital role in accelerating the green innovation of geothermal energy enterprises. Therefore, it is necessary to formulate more subdivided legal policies in the future for different types of government subsidies. Secondly, for the realization path of green innovation external to energy legislation, examination is conducted this paper to analyze the moderating effect of environmental legislation intensity and the developmental level of green finance. According to the findings, the intensity of environmental legislation exerts a positive moderating effect between economic incentives and R&D investment. A high intensity of environmental legislation can prompt geothermal energy companies into the conversion of more economic incentives into R&D investments. The level of green finance maintains a positive moderating role, whether in the direct model of economic incentives and green innovation or the mediating model of R&D investment. It is suggested that the level of green financial development among regions plays a significant role in the capability and motivation of enterprises to achieve green innovation.

5.2 Policy Recommendations

Firstly, economic incentives are beneficial to promote green innovation in the geothermal energy industry through the internal path of energy legislation. On the one hand, economic incentives can be used to reduce production costs for geothermal energy enterprises. On the other hand, economic incentives play a role in guiding market players to engage in the investment in the development of renewable energy as represented by the geothermal energy industry, diversifying the funding source of renewable energy industry, and promoting the realization of low-carbon development goals. Therefore, economic incentives are essential in the primary stage of renewable energy development. Besides, it is necessary to continue implementing the incentive policies for renewable energy enterprises, which motivates them to seek technological innovation for the reduction in production costs (Xu et al., 2022c).

As for the type of economic incentive breakdown, the special fund exerts a significant inhibitory effect on the green innovation of geothermal energy companies currently. Although the special fund was originally purposed to support the development and utilization of the renewable energy industry through the central fiscal budget, there are various reasons for the fact that the effect of the special fund is not exerted to the full. Therefore, it is necessary to further refine the purpose of the special fund, and to avoid rent-seeking phenomenon as much as possible by clarifying the scope of the special fund. To address the inadequate supervision of special funds, the government should develop and put in place some specific procedures for their use and further promote information disclosure. To ensure the fairness of fund allocation, the transparency of fund management must be improved. Meanwhile, the Ministry of Finance is responsible for the management of development funds at this stage. In this case, an independent supervisory and management body should be established to ensure the professionalism of fund management and better balance the interests of all parties, for example, this idea has been followed by the special fund management committee and fund council proposed by scholars. In addition, tax incentives and financial subsidies are still not

significant enough to promote green innovation in geothermal energy industry. Therefore, it is worthwhile to consider lowering the preferential application threshold as appropriate and simplify the application procedures. In general, geothermal energy projects require heavy investment, subsidies are not implemented, sustainable profit models need to be improved, and economic benefits are not obvious. To some extent, the development of geothermal industry has been restricted by the difficulty of approval by some local government geothermal management departments and the significant differences in management approaches in different regions. Therefore, the government is supposed to accelerate the research and introduction of geothermal power generation support policies, refer to the support policies of wind power, photoelectricity and other new energy industries at the initial stage of development, and offer electricity price subsidies to the geothermal power generation industry at the initial stage of development, to attract capital investment from domestic enterprises (Çetin et al., 2022). In addition, the government should enforce geothermal resource tax exemptions, and offer subsidies to the geothermal energy projects that achieve "heat extraction without water consumption" as required. For hydrothermal geothermal energy projects, tax breaks should be implemented to support the large-scale development of renewable energy.

As for the external realization path of green innovation in energy legislation, energy legislation is closely associated with the Environmental Protection Law. Therefore, the quasi-regulatory approach can be invoked to link the goal of "protecting the ecological environment" in the Environmental Protection Law to energy legislation. Moreover, according to the previous study, a high intensity of environmental legislation can, to a certain extent, prompt geothermal energy enterprises into increasing their R&D investment. By increasing the intensity of environmental legislation as appropriate, the green innovation of enterprises can be improved. In terms of specific measures, it is worth considering a transformation of the current excessive emission fees applied to renewable energy enterprises into an environmental pollution tax. In this way, the behavioral constraints on emission units or individuals can be strengthened by increasing the economic costs of taxpayers and using taxes (Zhao et al., 2022). Besides, the utilization of fossil energy by enterprises and individuals is restricted. In addition to drawing attention from the whole society to environmental protection, this also gives full play to taxation in promoting resource conservation and environmental protection. Secondly, green finance is an initiative that is essential for the development of renewable energy. Green financial loans, green bonds, green insurance, and other financial tools can be applied to effectively provide financial support for renewable energy enterprises and guide them through the process of low carbon transformation. In comparison to the eastern coastal areas, the central and western regions of China still lag in terms of green finance development (Li et al., 2022b). Consequently, there are fewer financing options available to the businesses in these areas. Therefore, the investment in green finance prosperity in the central and western areas can be increased as appropriate and green finance policies can be formulated according to local conditions. Finally, environmental legislation and green finance legislation are not completely independent of each other. For those more polluting enterprises, they will further scale down their R&D investment in the absence of support from green financial policies, which is averse to their green innovation. At this time, the intensity of high environmental legislation places more stringent requirements on enterprise development, which will make it more difficult for enterprises to survive. Therefore, legislative departments should pay attention to the mechanism of action between the two for the formulation of environmental policies and green financial policies. Also, it is better to enhance the link between the two in policies and improve their complementary and synergistic development for promoting the green innovation of enterprises (Huang et al., 2022b).

5.3 Limitations

One of the limitations of this paper lies in the small sample size. The time of listing of geothermal energy enterprises in China varies significantly and the overall number is small. Besides, only 122 research samples are finally obtained

after the removal of those enterprises with missing data. As a result, there may be incomplete information and insufficient data. Besides, there may be flaws in the classification and data of different ways of economic incentives. Herein, manual classification is performed according to the details of government subsidies and the data of different ways of subsidy are calculated through aggregation. Since some enterprises do not disclose the details of government subsidies and incomplete disclosure also leads to the difficulty of subsidy data calculation, the calculation results may show some deviation. In the future research, multiple channels and methods can be involved to obtain more comprehensive information on the different ways of government subsidies. Therefore, a more detailed and in-depth investigation can be conducted into geothermal energy enterprises, which improves the accuracy of research results. Finally, this paper focuses only on the geothermal energy industry for exploring the realization path of green innovation in energy legislation, and the policy recommendations made in this paper are mostly directed at the development of geothermal energy. In the future, different types of renewable energy enterprises will be included for better comparison and a further study will be carried out.

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