*Financial Statistical Journal (2023) Volume 6 Issue 2*
doi: 10.24294/fsj.v6i2.6048

ORIGINAL RESEARCH ARTICLE

# The influence mechanism of ESG performance on corporate green innovation: Evidence based on Chinese A-share listed companies

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## ABSTRACT

Green innovation helps companies achieve high-quality sustainable development, and environmental, social responsibility and corporate governance (ESG) performance impacts enterprises' green innovation capability. Taking the data from 2011 to 2021 of Chinese A-share listed companies as the research sample, this paper empirically tests the impact of corporate ESG performance on green innovation and explores the impact mechanism. Measuring firms' ESG performance through ESG score given by a third-party rating agency, this paper finds that better ESG performance enhances firms' green innovation capability. Based on the double externality of green innovation, we find that better ESG performance of enterprises can enhance their green innovation capability by incentivizing firms in the same industry to innovate, strengthening external supervision, and alleviating financing constraints. As an important informal system in China, Confucianism has a certain inhibitory effect on firms' green innovation capability. This paper provides a decision-making reference for the effectiveness of ESG in the Chinese market and corporate green sustainable development by investigating the impact mechanism of ESG performance on corporate green innovation capability.

***Keywords:*** green innovation; ESG performance; double externalities; financing constraint; Confucianism

**ARTICLE INFO**

Received: 26 July 2023
Accepted: 10 September 2023
Available online: 17 September 2023



## 1. Introduction

Enterprises are the most important main body in the market economy and are also the main producer of environmental pollution; their green innovation is an important initiative to break through the economic and environmental synergistic development dilemma[1]. Under the new development stage, Chinese enterprises seek high-quality sustainable development, and enhancing their green innovation capability is a strategic and forward-looking decision to solve ecological and environmental problems. Green innovation has three features: double externality, obvious push and pull effect by regulation, and strong correlation with society and system[2]. At the same time, green innovation is characterized by high investment, high risk, and a long return cycle compared with ordinary innovation, which indicates that enterprises need more financial support to carry out green innovation.

ESG stands for Environmental, Social, and Corporate Governance and is a value concept, investment strategy, and assessment tool that focuses on the environment, social responsibility, and corporate governance. As society continues to evolve and corporate values continue to improve, responsible investment points to the protection of the ecological environment, the fulfillment of

social responsibility, and the improvement of corporate governance, resulting in the formation of a systematic and comprehensive measure—ESG performance. Measuring a company is no longer limited to financial performance. The protection of conservation, fulfillment of social responsibility, and improvement of corporate governance in the development of enterprises is a code of conduct and a criterion for investors to evaluate enterprises' sustainability and green operation status[3]. ESG has always been highly valued and widely paid attention to by society, which influences enterprises' decision-making and helps them cultivate a good reputation[4]. Meanwhile, it is important to study the impact of ESG on the economic consequences of emerging markets[5]. China's ESG practice started late, and studying the impact of ESG on Chinese listed companies can better utilize the role of ESG.

The concepts of ESG and green innovation have common characteristics. Evaluating an enterprise's ESG performance requires a combination of environmental, social, and corporate governance. In terms of the environment, companies should enhance their ability to protect the ecology, save energy, and reduce emissions by improving technologies for the production and treatment of pollutants, using renewable raw materials, and increasing the utilization rate of resources so as to implement environmental friendliness in the entire production and operation process. In terms of social responsibility, enterprises not only actively undertake responsibilities to stakeholders such as customers and investors but also implement green management and development. In terms of corporate governance, enterprises need to improve internal management to achieve efficient allocation of resources, effectively reduce agency costs, and realize long-term value enhancement. Green innovation is also known as eco-innovation, environmental innovation, environment-driven innovation, and sustainable innovation. Due to its environmentally friendly characteristics, it is considered an important means of resolving the conflict between economic development and environmental protection[6]. Enterprises will create and use more advanced and efficient processes and technologies with the aim of reducing or avoiding pollution damage to the environment[7]. At the same time, green innovation not only involves the development and introduction of new products and technologies but also emphasizes ecological protection in the business strategy[8].

Based on the quasi-natural experiment of ESG ratings published by SynTao Green Finance in 2015, ESG ratings can significantly promote the green innovation capacity of enterprises[9,10]. However, there are fewer studies on the mechanism of ESG's influence on corporate green innovation capability. This paper selects the data of A-share listed companies from 2011 to 2021. It measures the green innovation capability by the total number of green innovation patent applications and the number of green invention patent applications to explore the impact of ESG performance on the green innovation capability of enterprises as well as the impact mechanism. Starting from the characteristics of double externality, this paper selects the level of green innovation in the same industry and the intensity of firms subject to external supervision, respectively, to explore whether ESG can mitigate the positive externality of innovation knowledge spillover and the negative externality generated by pollutant emissions and have a positive effect on the enhancement of firms' green innovation capability. Meanwhile, as a new type of information disclosure, this paper explores whether ESG can alleviate the financing constraints faced by firms by reducing information asymmetry and promoting green innovation. In addition, this paper will innovatively explore whether green innovation behavior is influenced by the informal system, Confucianism, which enriches the characteristics of ESG as a new type of market practice in China and fills a gap in the literature in related fields. This paper provides theoretical evidence that ESG promotes the high-quality development of China's economy and enhances the green innovation ability of enterprises.

Compared to the existing literature, the main contributions and innovations of this paper focus on the following points: first, ESG performance mainly affects the substantive green innovation activities of enterprises and enhances their green innovation capability; second, in the exploration of the mechanism, ESG

performance can mitigate the double externality and enhance the green innovation capability of enterprises by promoting enterprises in this industry to carry out green innovation, increasing the intensity of external supervision and the attention of stakeholders, and alleviating the double externality; third, in ESG practice, this paper focuses on the impact of informal systems.

## 2. Theory and hypotheses

ESG includes three aspects of performance: environment, social responsibility, and corporate governance. Better ESG performance will win more development space for enterprises. In terms of corporate participation in environmental governance, enterprises that actively undertake environmental responsibility will further increase their investment in environmental management and environmental technology innovation to form a competitive advantage. According to stakeholder theory and information transfer theory, by actively undertaking social responsibility, enterprises will obtain the recognition of stakeholders and form reputational advantages[11], which improves the innovation ability of enterprises; CSR performance has a significant role in promoting green innovation[12]. At the same time, corporate governance capacity also has a certain impact on the level of technological innovation of enterprises[13]. We propose the following hypothesis:

- H1: ESG can significantly enhance a company's green innovation capability.

The double externality of green innovation is characterized by the negative externality of pollution mitigation and the positive externality of green innovation knowledge spillover[14,15]. Environmental protection and knowledge spillovers can lead to market failures, reduce the incentives for firms to engage in innovation, limit the development of green technologies, and prevent firms from reaching the optimal level of green innovation[16,17]. Based on the double externality, literature has examined the impact of various policy instruments on green innovation, such as green credit policy[18] and cross-instrumental policy mix on green innovation[19]. The positive externality is that firms do not receive the full benefits of the innovation, and there are opportunities for other firms to "free ride". Specifically, firms in the same industry can acquire new technologies by copying and imitating them at a much lower cost than the investment in innovation. The fact that firms do not receive the full benefits of R&D can seriously dampen their incentives to engage in green innovation. To a certain extent, it will harm the enhancement of enterprises' green innovation capability. Negative externality is manifested in the fact that the total cost (i.e., social cost) caused by the enterprise's pollution emission is much higher than the cost paid for the pollution emission. The pricing mechanism in China's pollution emission market is imperfect, and the construction of a market for emissions trading is progressing slowly. The cost of externalities cannot be fully internalized, which will lead to insufficient motivation for enterprises in green innovation. Green innovation is characterized by large investments, long cycles, and high risk compared with ordinary innovation. Enterprises must have sufficient financial support to enhance their green innovation capability. Based on the above analysis, by alleviating the double externality as well as financing constraints, this paper proposes three mechanisms by which ESG influences enterprises' green innovation.

First, ESG, as a green incentive, spreads across the industry, pushing peer companies to actively implement green innovation strategies and generating green spillover effects in the industry. Managers are incentivized to engage in green innovation in their development as well as in competition with their peers. The spillover effect among firms refers to the fact that in an environment of information uncertainty, decision-makers will follow or learn from the choices of others in the same group[20]. To survive and thrive in competition, firms need to obtain information from their peers and learn from their strategies[21]. ESG is increasingly recognized as an advanced concept that can balance environmental protection, social responsibility, and corporate governance. This paper argues that ESG motivates firms to engage in green innovation by promoting the implementation of green innovation strategies by peer firms. We propose the

following hypothesis:

- H2a: ESG incentivizes companies to innovate green by raising the level of green innovation of companies in the same industry.

Second, ESG as a kind of green regulation improves the constraints on firms from external monitoring. It forces enterprises to internalize the externality cost of pollution and enhance their green innovation ability. Accounting firms and investors are important participants in the financial market, as well as an important part of the external supervision of listed companies. Compared with the public, accounting firms and institutional investors are more concerned about the environmental performance and long-term development of enterprises[22]. The greater the share of institutional investors, the more firms are required to make environmental disclosures and raise environmental and social concerns. The more a firm's ESG performance comes to be valued by stakeholders, the more it can increase the intensity of the firm's external monitoring. ESG compels firms to engage in green innovation through enhanced external monitoring. We propose the following hypothesis:

- H2b: ESG forces companies to innovate green by strengthening external oversight.

Third, ESG, as a green signal, can alleviate the information asymmetry between investors and enterprises. By alleviating the financing constraints faced by enterprises, it stimulates enterprises to carry out green innovation. When facing high financing constraints, enterprises will increase pollutant emissions[23]. Financing constraints limit the green innovation behavior of enterprises. Due to information asymmetry in the capital market, enterprises can obtain support from stakeholders by disclosing high-quality information. ESG rating, as an emerging information disclosure mechanism, not only focuses on corporate governance, management capability, and financial status, it also considers corporate social responsibility and long-term sustainable development, which can effectively reduce the information asymmetry between stakeholders and enterprises. ESG helps financial institutions to better understand the financial and non-financial information of enterprises and can provide green funds for enterprise development during the assessment period[24]. We propose the following hypothesis:

- H2c: ESG enhances enterprises' green innovation ability by alleviating financing constraints.

In practice, the factors affecting firms are complex. National culture affects the IPO suppression of enterprises[25] and also affects the daily business decisions of enterprises. The impact of ESG performance on green innovation will also be affected by informal systems such as culture. Culture, as an important informal system, will have a subtle influence on the process of making decisions by enterprises. Confucianism, as a representative of traditional Chinese culture, has had a far-reaching influence on Chinese society. Of course, Confucianism also influences the values of China's corporate managers and is reflected through daily business decisions. With the continuous enrichment of ESG practice in China, an emerging market, Confucianism is likely to have a significant moderating effect on the relationship between corporate ESG performance and green innovation capability.

Confucianism has rich connotations, and its ethical thinking of "loyalty and trust" and its concept of "righteousness and profit" can help to reduce agency conflicts, motivate managers to innovate, and increase the R&D investment of Chinese private enterprises[26]. However, the middle-of-the-road thinking, hierarchical order, and authoritarianism it advocates may cause corporate managers to stick to the old ways and not catch up with new trends, and they may be fearful of emerging ESG concepts and riskier green innovations. We propose the following hypothesis:

- H3: The positive impact of ESG performance on corporate green innovation can be inhibited by Confucianism.

# 3. Research method

## 3.1. Sample

The Shenzhen Stock Exchange and Shanghai Stock Exchange issued guidelines on social responsibility disclosure of listed companies in 2006 and 2008, respectively; the Ministry of Environmental Protection (MEP) issued the Guidelines on Environmental Information Disclosure of Listed Companies in 2010, which require listed companies in heavily polluting industries to publish annual environmental reports. Since 2011, Chinese listed companies have gradually started to disclose environmental and social responsibility information, so 2011 is selected as the starting year of the sample data. Due to the availability of data in the year of the study, the sample in this paper ends in 2021. This paper selects the data of A-share listed companies from 2011 to 2021 and screens the data as follows: (1) exclude samples from the financial industry; (2) exclude samples with abnormal statuses such as ST, *ST, and PT; (3) exclude samples with insolvency; (4) exclude samples with missing financial indicators; and (5) delete samples with missing ESG data. After screening, a total of 10,448 sample data were retained. To minimize the effect of extreme values, all continuous variables were reduced-tailed at the 1% and 99% levels.

## 3.2. Measure of variables

### 3.2.1. Green innovation capability

This paper draws on previous studies on the green innovation capacity of enterprises and selects the number of green innovation patents of listed companies to measure green innovation capacity[27,28]. To further explore the differences in green innovation, green patents can be subdivided into green invention patents and green utility model patents[29]. Green utility model patents are innovations in the shape and structure of products and are low-level innovations that cater to the government and the market. Utility model patents are granted at a higher rate, have low technological innovation content, and only need to pass the formal examination. Compared with green utility model patents, green invention patents mainly refer to the research and development of new products with the highest technological content and innovativeness, and need to go through substantive examination in the granting process. As a result, this paper chooses the number of green invention patents of listed companies to measure the substantial green innovation behavior of enterprises.

The green innovation patent data are from the China Research Data Service Platform (CNRDS). In the baseline regression, this paper uses the number of green innovation patents (*GPatern*) and the number of green invention patents (*GInvia*) independently applied by listed companies in the same year to measure the green innovation capability and substantive green innovation behavior of enterprises, respectively. In the robustness test, this paper uses the number of green innovation patents (*GPaterns*) and the number of green invention patents (*GInvig*) independently obtained by listed companies in the same year for regression.

### 3.2.2. ESG performance

Bloomberg calculates corporate ESG scores by analyzing corporate responsibility reports, annual reports, ESG news reports, and corporate governance reports of more than 11,800 companies worldwide. Sino-Securities Index Information Service (Shanghai) Co., Ltd. takes into account the actual situation of the Chinese market and constructs a three-tier index system from top to bottom to provide ESG ratings in four aspects: overall rating, environmental performance, social responsibility, and governance performance. In this paper, the ESG score (*ESG*) from Bloomberg is chosen to represent the ESG performance of companies. In the robustness test, this paper chooses the ESG rating data (*ESG_hz*) of Sino-Securities Index Information Service (Shanghai) Co., Ltd. from the Wind to represent the ESG performance of enterprises. The nine grades of ESG rating results C-AAA are assigned as 1–9, respectively, and the larger value indicates that the ESG performance of the enterprise is better.

### 3.2.3. Control variables

According to previous studies, there are many factors affecting the green innovation capability of enterprises. In this paper, firm size (*Size*), leverage ratio (*Lev*), return on asset (*ROA*), cash holding (*Cash*), and the growth rate of operating income (*Grow*) are selected as control variables. **Table 1** demonstrates the definitions of the variables.

**Table 1.** Variable definition.

| Variable name | Variable symbol | Definition |
|---|---|---|
| Green Innovation Capability | *GInvia* | The number of green invention patents independently applied by listed companies in the year |
| | *GPatern* | Total number of green innovation patents applied by listed companies in the year |
| | *GInvig* | The number of green invention patents independently granted by listed companies in the year |
| | *GPaterns* | Total number of green innovation patents granted to listed companies in the year |
| ESG Performance | *ESG_pb* | ESG score released by Bloomberg |
| | *ESG_hz* | ESG score issued by Sino-Securities Index Information Service (Shanghai) Co., Ltd, with each of the nine grades C-AAA assigned a value of 1–9 |
| Control variables | *Size* | The Logarithm of Enterprise's Assets |
| | *Lev* | Leverage Ratio |
| | *ROA* | Return on Assets |
| | *Cash* | Cash Flow Ratio |
| | *Grow* | Revenue Growth Rate |

## 3.3. Empirical design

First, referring to the study of Li et al.[30], this paper determines to use a regression model to investigate the relationship between ESG performance and corporate green innovation. Second, through the Hausman test, it is determined to use a fixed effects regression model. Finally, considering the unobservable individual and time effects, this paper adopts the individual-year two-way fixed model, as shown in Equation (1).

$$Grenn\ Innovation_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum \alpha_k\ Controls_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t,} \quad (1)$$

where $Grenn\ Innovation_{i,t}$ is green innovation capability of firm *i* in year *t*, $ESG_{i,t}$ is the ESG performance of firm *i* in year *t*, and $Controls_{i,t}$ are the control variables selected at the firm level $\mu_i$ and $\delta_t$ denote the firm fixed effect and year fixed effects, and $\varepsilon_{i,t}$ is the random error term.

In the mechanism test, referring to the study of Li et al.[31], this paper chooses the moderating effect model, as shown in Equation (2), to explore whether the positive impact of ESG performance on corporate green innovation is affected by moderating variables.

$$Grenn\ Innovation_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 M_{i,t} \times ESG_{i,t} + \beta_3 M_{i,t} + \sum \beta_k\ Controls_{i,t} + \mu_i + \delta_t + \varepsilon_{it}, \quad (2)$$

where $M_{ij}$ is the moderating variable in this paper, and the meaning of other variables remains unchanged. If $\beta_2$ is significant, it will prove that the moderator variables can mediate between ESG performance and green innovation capability.

# 4. Empirical results

## 4.1. Descriptive statistics

**Table 2** shows the descriptive statistics of the main variables. The mean value of the total number of listed green innovation patent applications *(GPatern*) is 2.266, and the number of green invention patent

applications (*GInvia*) is 1.33, indicating that green innovation is still in the beginning stage in China; the standard deviation values are large, respectively 6.819 and 4.203, indicating that there is a large difference in the level of green innovation among enterprises. The mean value of the total number of listed green innovation patents obtained (*GPaterns*) is 1.425 and the number of green invention patents obtained (*GInvig*) is 0.462, which are significantly smaller than the mean value of the number of applications, indicating that green patents need to be scrutinized rigorously from the time of application to the final grant. Based on the descriptive results, we can get that only roughly 25% of the companies have green innovation capability. The mean value of ESG performance (*ESG_pb*) is 28.1, and the standard deviation is 8.914, which indicates that the overall level of ESG of China's listed companies is low, and there are large differences in ESG performance between companies.

**Table 2.** Descriptive statistics.

| Variable | Mean | SD | Min | Max |
|---|---|---|---|---|
| *GPatern* | 2.266 | 6.819 | 0 | 37 |
| *GPaterns* | 1.425 | 4.324 | 0 | 24 |
| *GInvia* | 1.330 | 4.203 | 0 | 23 |
| *GInvig* | 0.462 | 1.588 | 0 | 9 |
| *ESG_pb* | 28.10 | 8.914 | 6.198 | 68.92 |
| *Size* | 23.19 | 1.285 | 19.91 | 26.21 |
| *Lev* | 0.479 | 0.199 | 0.056 | 0.887 |
| *ROA* | 0.049 | 0.062 | −0.239 | 0.211 |
| *Cash* | 0.058 | 0.068 | −0.157 | 0.238 |
| *Grow* | 0.177 | 0.385 | −0.552 | 2.501 |

For the control variables, the minimum value of enterprise size (*Size*) is 19.91, the maximum value is 26.21, and the standard deviation and mean are 1.285 and 23.19 shows that there is a small gap between the enterprise size of listed companies; the minimum value of liability ratio (*Lev*) is 0.056, and the maximum value is 0.887, and it shows that there are different degrees of enterprise's financial risk preference; the minimum value of return on assets (*ROA*) of the minimum value of −0.239, the maximum value of 0.211, the standard deviation of 0.062, indicating that there is a small gap between the profitability of enterprises; cash ratio (*Cash*) minimum value of −0.157, the maximum value of 0.238, the standard deviation of 0.068, indicating that the gap between the ability of enterprises to obtain cash flow from operating activities is relatively small; The minimum value of the growth rate of operating income (Grow) is −0.552, and the maximum value is 2.501, which indicates that there is a big gap between the business development status of listed companies.

## 4.2. Difference-in-means test

In this paper, 17,956 samples without Bloomberg-disclosed ESG score data are excluded, and the remaining 10,448 samples with Bloomberg-disclosed ESG score data are the final selected sample data. **Table 3** shows the results of the one-way two-water mean difference-in-difference test based on whether the firms have Bloomberg-disclosed ESG score data or not.

**Table 3.** Difference-in-means test.

| Variable | No-disclosed | Mean1 | Disclosed | Mean2 | Mean difference |
|---|---|---|---|---|---|
| *GPatern* | 17,956 | 1.041 | 10,448 | 2.266 | −1.225*** |
| *GInvia* | 17,956 | 0.537 | 10,448 | 1.330 | −0.793*** |
| Size | 17,956 | 21.68 | 10,448 | 23.19 | −1.503*** |
| Lev | 17,956 | 0.397 | 10,448 | 0.479 | −0.082*** |
| ROA | 17,956 | 0.0330 | 10,448 | 0.0490 | −0.016*** |
| Cash | 17,956 | 0.0390 | 10,448 | 0.0580 | −0.020*** |
| Grow | 17,956 | 0.172 | 10,448 | 0.177 | −0.00400 |

Notes: The symbols *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, similarly hereinafter.

The means of total green innovation patent applications (*GPatern*) and green invention patent applications (*GInvia*) in the group without disclosed ESG score data are significantly lower than those in the group with disclosed ESG scores, from which we get that the ESG performance of enterprises has a certain positive effect on the enhancement of green innovation capability.

## 4.3. Benchmark regression results

In this paper, we perform multiple linear regression on Equation (1), controlling for individual and time effects, and the results are shown in **Table 4.**

**Table 4.** Benchmark regression results.

| **Variable** | ***GPatern*** | | ***GInvia*** | |
|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** |
| *ESG_pb* | 0.029*** | 0.026** | 0.027*** | 0.025*** |
| | (0.010) | (0.010) | (0.006) | (0.006) |
| *Size* | | 0.261** | | 0.130* |
| | | (0.117) | | (0.074) |
| *Lev* | | −0.017 | | −0.157 |
| | | (0.516) | | (0.323) |
| *ROA* | | 2.335** | | 1.307* |
| | | (1.076) | | (0.674) |
| *Cash* | | −1.300* | | −0.906* |
| | | (0.782) | | (0.490) |
| *Grow* | | −0.083 | | −0.033 |
| | | (0.113) | | (0.071) |
| *_cons* | 0.850*** | −4.478* | 0.233 | −2.321 |
| | (0.249) | (2.606) | (0.156) | (1.633) |
| Firm | YES | YES | YES | YES |
| Year | YES | YES | YES | YES |
| *N* | 10,448 | 10,448 | 10,448 | 10,448 |
| $R^2$ | 0.023 | 0.026 | 0.023 | 0.025 |

Columns (1) and (2) in **Table 4** are the results of the total number of green patent applications (*GPatern*) and enterprises' ESG scores without and with control variables, respectively. The coefficients of ESG are both significantly positive, indicating that ESG can significantly enhance enterprises' green innovation capability, thus validating H1. Columns (3) and (4) in **Table 4** are the results of the total number of green invention patent applications (*GInvia*) and enterprises' ESG scores without and with control variables, respectively. The coefficients of *ESG_pb* are also both significantly positive, further indicating that ESG can motivate enterprises to carry out substantial green innovation.

## 4.4. Robustness check

### 4.4.1. Endogeneity test

This paper uses the first-order lagged terms of the explanatory variable ESG score data as instrumental variables[30]. Next, this paper uses two-stage least squares to address possible endogeneity. **Table 5** demonstrates the results of the second-stage regression using the instrumental variable method. Columns (5) and (6) in **Table 5** show the results of the second-stage regression of the 1st-order lagged term of ESG as an instrumental variable with the total number of green innovation patent applications (*GPatern*) without and

with control variables, respectively. The coefficients of ESG are 0.556 and 0.273, which are significant, and it can prove once again that ESG can significantly enhance the green innovation capability of the enterprises and thus validate the robustness of hypothesis H1. Columns (7) and (8) in **Table 5** show the second-stage regression results of total green invention patent applications (*GInvia*) without and with control variables, and the coefficients of ESG are 0.427 and 0.247, respectively, which are both significant at the 1% level, indicating that ESG can promote enterprises to carry out substantive green innovations rather than just formal green innovations.

**Table 5.** Endogeneity test: Using the first-order lagged terms of ESG as the instrumental variable.

| **Variable** | ***GPatern_1*** | | ***GInvia_1*** | |
|---|---|---|---|---|
| | **(5)** | **(6)** | **(7)** | **(8)** |
| *ESG_pb* | 0.556*** | 0.273*** | 0.427*** | 0.247*** |
| | (0.085) | (0.103) | (0.063) | (0.071) |
| *Size* | | 4.338*** | | 2.886*** |
| | | (0.759) | | (0.486) |
| *Lev* | | −3.000** | | −2.678*** |
| | | (1.469) | | (1.031) |
| *ROA* | | −4.135 | | −5.429 |
| | | (5.966) | | (4.127) |
| *Cash* | | 12.720*** | | 8.564*** |
| | | (4.885) | | (3.229) |
| *Grow* | | −2.278*** | | −1.507*** |
| | | (0.554) | | (0.365) |
| *_cons* | −18.478*** | −106.134*** | −14.162*** | −72.140*** |
| | (3.225) | (15.438) | (2.376) | (9.615) |
| Firm | YES | YES | YES | YES |
| Year | YES | YES | YES | YES |
| *N* | 8717 | 8717 | 8717 | 8717 |
| $R^2$ | 0.018 | 0.045 | 0.022 | 0.048 |

### 4.4.2. Replacement of variables

In this paper, the explanatory variables are replaced with the ESG score (*ESG_hz*), which is from Sino-Securities Index Information Service (Shanghai) Co., Ltd., and the results are shown in **Table 6**. Columns (9) and (10) in **Table 6** are the regression results of total green innovation patent applications (*GPatern*) with *ESG_hz* without and with control variables, and columns (11) and (12) in **Table 6** are the regression results of green invention patent applications (*GInvia*) without and with control variables. The regression coefficients for the robustness tests in **Table 6** are all significantly positive, a result that again supports H1.

**Table 6.** Robustness test: Replacement of ESG scoring data.

| **Variable** | ***GPatern*** | | ***GInvia*** | |
|---|---|---|---|---|
| | **(9)** | **(10)** | **(11)** | **(12)** |
| *ESG_hz* | 0.081*** | 0.069*** | 0.059*** | 0.051*** |
| | (0.024) | (0.025) | (0.015) | (0.015) |
| *Size* | | 0.207*** | | 0.129*** |
| | | (0.054) | | (0.033) |

**Table 6.** (*Continued*).

| Variable | *GPatern* | | *GInvia* | |
|---|---|---|---|---|
| | **(9)** | **(10)** | **(11)** | **(12)** |
| *Lev* | | 0.173 | | 0.020 |
| | | (0.214) | | (0.131) |
| *ROA* | | 1.179*** | | 0.635** |
| | | (0.445) | | (0.273) |
| *Cash* | | −0.442 | | −0.304 |
| | | (0.352) | | (0.216) |
| *Grow* | | −0.123** | | −0.081** |
| | | (0.051) | | (0.031) |
| *_cons* | 0.663*** | −3.841*** | 0.250*** | −2.517*** |
| | (0.124) | (1.164) | (0.076) | (0.712) |
| Firm | YES | YES | YES | YES |
| Year | YES | YES | YES | YES |
| *N* | 10,448 | 10,448 | 10,448 | 10,448 |
| $R^2$ | 0.017 | 0.019 | 0.014 | 0.015 |

**Table 7.** Robustness test: Replace the explanatory variables with number of green patents obtained.

| Variable | *GPaterns* | | *GInvig* | |
|---|---|---|---|---|
| | **(13)** | **(14)** | **(15)** | **(16)** |
| *ESG_pb* | 0.024*** | 0.024*** | 0.011*** | 0.011*** |
| | (0.006) | (0.006) | (0.003) | (0.003) |
| *Size* | | 0.153** | | 0.045 |
| | | (0.072) | | (0.029) |
| *Lev* | | 0.059 | | 0.031 |
| | | (0.318) | | (0.129) |
| *ROA* | | −1.070 | | −0.819*** |
| | | (0.663) | | (0.268) |
| *Cash* | | −0.202 | | −0.010 |
| | | (0.481) | | (0.195) |
| *Grow* | | −0.122* | | −0.028 |
| | | (0.069) | | (0.028) |
| *_cons* | 0.382** | −2.720* | 0.037 | −0.955 |
| Firm | YES | YES | YES | YES |
| Year | YES | YES | YES | YES |
| *N* | 10,448 | 10,448 | 10,448 | 10,448 |
| $R^2$ | 0.019 | 0.021 | 0.018 | 0.021 |

In this paper, the regression is re-run by replacing the explanatory variables with the number of green patents obtained, and the results are shown in **Table 7**.

Columns (13) and (14) in **Table 7** are the results of the regression of the total number of green innovation patent applications (*GPaterns*) with *ESG_pb* without and with control variables, and Columns (15) and (16) in **Table 7** are the results of the regression of the number of green invention patents obtained (*GInvig*) with

*ESG_pb* without and with control variables. The regression coefficients for the robustness tests in **Table 7** are all significantly positive, a result that again supports H1.

### 4.4.3. Panel negative binomial regression

According to the descriptive statistics of the variables, more than 50% of the data on green innovation capacity is 0. To enhance the robustness of the regression results, this paper re-regresses the benchmark model using panel negative binomial regression.

**Table 8** shows the robustness test results of the replacement regression. Columns (17) and (18) in **Table 8** are the results of total green patent applications (*GPatern*) versus firms' ESG scores without and with control variables, respectively.

The coefficients of *ESG_pb* are both significantly positive, indicating that ESG can significantly enhance firms' green innovation capability. Columns (19) and (20) in **Table 8** are the results of total green invention patent applications (*GInvia*) and firms' ESG scores without and with control variables, respectively. The coefficients of *ESG_pb* are also both significantly positive, indicating that ESG can promote firms' substantial green innovation.

**Table 8.** Robustness test: Replace with panel negative binomial regression.

| Variable | *GPatern* | | *GInvia* | |
|---|---|---|---|---|
| | **(17)** | **(18)** | **(19)** | **(20)** |
| *ESG_pb* | 0.016*** | 0.016*** | 0.020*** | 0.018*** |
| | (0.004) | (0.004) | (0.004) | (0.004) |
| *Size* | | 0.060* | | 0.111*** |
| | | (0.037) | | (0.042) |
| *Lev* | | −0.118 | | −0.427* |
| | | (0.213) | | (0.245) |
| *ROA* | | 0.366 | | 0.253 |
| | | (0.496) | | (0.564) |
| *Cash* | | −0.440 | | −0.440 |
| | | (0.369) | | (0.417) |
| *Grow* | | −0.034 | | 0.006 |
| | | (0.059) | | (0.067) |
| *_cons* | −0.711*** | −1.628** | −0.741*** | −2.693*** |
| | (0.109) | (0.780) | (0.126) | (0.891) |
| Firm | YES | YES | YES | YES |
| Year | YES | YES | YES | YES |
| *N* | 5969 | 5969 | 5134 | 5134 |

# 5. Mechanism of ESG performance on firms' green innovation capability

## 5.1. Effect of green innovation in peer-to-peer companies

In this paper, the quality of green innovation in the same industry (*Peer_GIQ*), is measured using the average of the number of green innovation patent applications filed by enterprises in an industry in the same year. It is shown in Equation (3) and regressed using Equation (2) as a moderating variable.

$$Peer\_GIQ_{i,t} = \frac{\sum_{g \in ind} GPatern_{g,t}}{E_t} \quad (3)$$

where *ind* denotes industry, *i* denotes firm, *t* denotes year, *Et* denotes the number of firms in the industry in year *t*, and *g* denotes peer firms in the industry.

The regression results in Column (21) of **Table 9** show that the cross-multiplier term (*PeerGIQ* × *ESG*) is positively significant at the 1% level. This proves that ESG, as a green incentive, generates green innovation spillovers, mitigates the positive externality of green innovation knowledge spillovers, and incentivizes firms in the same industry to implement green innovation strategies. This verifies hypothesis H2a.

**Table 9.** Mechanism of ESG performance on firms' green innovation capability.

| **Variable** | ***GPatern*** | ***GPatern*** | ***GPatern*** |
|---|---|---|---|
| | **(21)** | **(22)** | **(23)** |
| *ESG_pb* | −0.008 | 0.014 | 0.326*** |
| | (0.012) | (0.011) | (0.074) |
| *PeerGIQ* × *ESG* | 0.015*** | | |
| | (0.003) | | |
| *PeerGIQ* | −0.036 | | |
| | (0.104) | | |
| *Ex* × *ESG* | | 0.065*** | |
| | | (0.021) | |
| *Ex* | | −1.563* | |
| | | (0.885) | |
| *SA* × *ESG* | | | 0.083*** |
| | | | (0.020) |
| *SA* | | | −2.801*** |
| | | | (0.807) |
| *Lev* | −0.045 | −0.076 | −0.536 |
| | (0.513) | (0.516) | (0.516) |
| *ROA* | 2.548** | 2.340** | 1.915* |
| | (1.070) | (1.076) | (1.065) |
| *Cash* | −1.400* | −1.256 | −1.290* |
| | (0.777) | (0.782) | (0.781) |
| *Grow* | −0.118 | −0.085 | −0.126 |
| | (0.112) | (0.113) | (0.112) |
| *_cons* | −4.721* | −4.735* | −16.421*** |
| | (2.591) | (2.608) | (3.695) |
| Firm | YES | YES | YES |
| Year | YES | YES | YES |
| *N* | 10,448 | 10,448 | 10,448 |
| $R^2$ | 0.038 | 0.027 | 0.009 |

In addition, **Figure 1** is a visualization of the moderating effect of the innovation capacity of the same industry, and we can intuitively observe that ESG can be used as a green incentive to promote the same industry to carry out green innovation and effectively promote the enhancement of green innovation capacity of

enterprises.

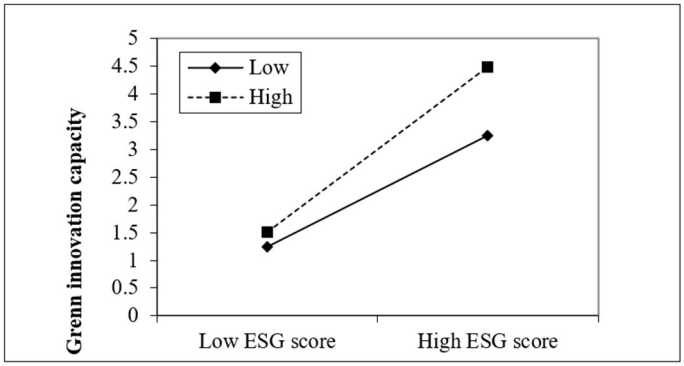


**Figure 1.** The moderating effect of innovation capacity in the same industry.

## 5.2. Effect of external oversight

Accounting firms are responsible for auditing listed companies' financial statements and ESG disclosure statements. If a listed company is audited by one of the Big Four accounting firms, it means that the company is subject to more authoritative external oversight. Institutional investors are more concerned about a company's ESG performance, and they can exercise their voting rights or have more seats on the board of directors through the shareholders' meeting to exercise a certain degree of supervision over the company's business decisions. Therefore, this paper selects the cross-multiplier term between whether the Big Four accounting firms audit it and the proportion of institutional investors' shareholding to measure the external supervision (*Ex*) faced by the firm. As a moderating variable, it is regressed using Equation (2).

The regression results are shown in Column (22) of **Table 9**, and the cross-multiplier term (*Ex* × *ESG*) is positively significant at the 1% level. This suggests that ESG can act as a kind of green regulation by mitigating the negative externalities of green innovation, increasing the intensity of external supervision on firms, partially internalizing the externality costs of pollution, and forcing firms to improve their green innovation capabilities. Thus, hypothesis H2b is verified. In addition, **Figure 2** is a visualization of the regulatory effect of external supervision, and we can intuitively observe that ESG, as a kind of green regulation, strengthens the constraints of external supervision faced by firms and promotes the enhancement of firms' green innovation capability.

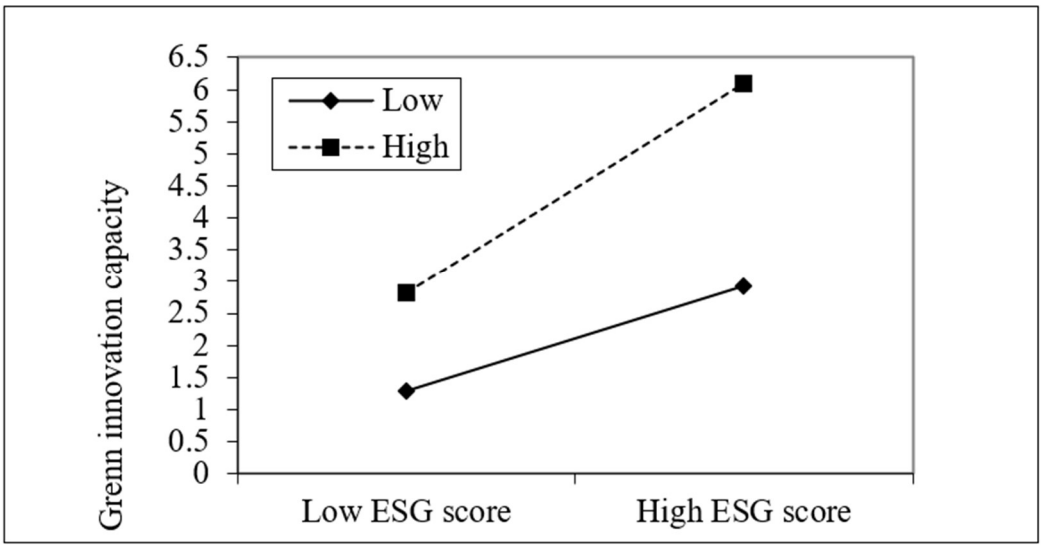


**Figure 2.** The moderating effects of external oversight.

## 5.3. Effect of financing constraints

In this paper, we use the *SA* index proposed by Hadlock and Pierce[32] as shown in Equation (4) to measure the financing constraints faced by firms and regress it as a moderating variable using Equation (2).

$$SA = -0.737 \times Size + 0.043 \times Size^2 - 0.04 \times Age \quad (4)$$

where *Size* is the total assets of the company and *Age* is the yearly difference between the current year and the year of the IPO.

The regression results are shown in Column (23) of **Table 9**, and the cross-multiplied term (*SA* × *ESG*) is positively significant at the level of 1%, which indicates that ESG, as a green signal, can increase the trust of fund providers, alleviate the financing constraints of enterprises, and provide financial support for green innovation. In addition, **Figure 3** is a visualization of the adjustment effect of financing constraints, and we can intuitively observe that ESG can serve as a green signal, alleviate financing constraints faced by enterprises, and effectively enhance their green innovation capabilities.

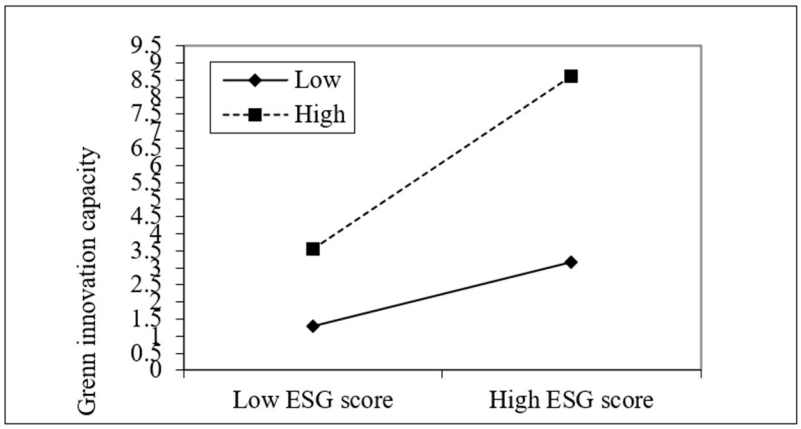


**Figure 3.** The moderating effect of financing constraints.

## 5.4. The inhibiting effects of Confucianism

Based on previous scholars' research on Confucian culture, this paper applies a distance measurement model and uses latitude and longitude data to calculate the number of Confucian temples within a radius of 100 km (*Confu*_100), 150 km (*Confu*_150), 200 km (*Confu*_200), and 250 km (*Confu*_250) of the place of registration of each company, and uses this as a proxy variable for Confucian culture[33]. The addresses of Confucius temples are from the China Research Data Service Platform (CNRDS), and the locations of listed companies' registered locations are from the Cathay Pacific Data Service Center (CSMAR). The greater the number of Confucian temples within the radius of the company's registered location, the more the company's decision-making behavior is influenced by Confucian culture. In this section, Confucian culture is used as a moderating variable, and Equation (2) is still used for regression.

The regression results are shown in columns (24) to (27) of **Table 10**, where the coefficients of *Confu*_100 × *ESG*, and *Confu*_150 × *ESG* are negatively significant at the 10% and 5% levels, respectively, suggesting that Confucian culture plays a negative moderating role between ESG and corporate green innovation.

The coefficients of *Confu*_200 × *ESG* and *Confu*_250 × *ESG* are no longer significant. The coefficients of *Confu*_100 × *ESG*, *Confu*_150 × *ESG*, *Confu*_200 × *ESG*, and *Confu*_250 × *ESG* show a downward trend, indicating that the inhibitory effect produced by the Confucian culture also exists in the process of distance decay at the same time. In addition, the regression coefficient is very small, and this paper concludes that the inhibitory effect of Confucian culture, although significant, does not play a decisive role in the business decisions of enterprises.

**Table 10.** The inhibiting effects of Confucianism.

| Variable | *GPatern* | *GPatern* | *GPatern* | *GPatern* |
|---|---|---|---|---|
| | **(24)** | **(25)** | **(26)** | **(27)** |
| *ESG* | 0.030*** | 0.036*** | 0.023* | 0.027** |
| | (0.011) | (0.012) | (0.012) | (0.012) |
| *Confu*_100 × *ESG* | −0.002* | | | |
| | (0.001) | | | |
| *Confu*_100 | −0.018 | | | |
| | (0.068) | | | |
| *Confu*_150 × *ESG* | | −0.002** | | |
| | | (0.001) | | |
| *Confu*_150 | | 0.003 | | |
| | | (0.042) | | |
| *Confu*_200 × *ESG* | | | −0.000 | |
| | | | (0.001) | |
| *Confu*_200 | | | −0.031 | |
| | | | (0.031) | |
| *Confu*_250 × *ESG* | | | | −0.001 |
| | | | | (0.001) |
| *Confu*_250 | | | | 0.001 |
| | | | | (0.024) |
| *Size* | 0.377*** | 0.374*** | 0.370*** | 0.372*** |
| | (0.107) | (0.107) | (0.107) | (0.107) |
| *Lev* | −0.400 | −0.404 | −0.429 | −0.444 |
| | (0.515) | (0.515) | (0.515) | (0.515) |
| *ROA* | 1.851* | 1.827* | 1.816* | 1.819* |
| | (1.059) | (1.058) | (1.058) | (1.058) |
| *Cash* | −1.276 | −1.273 | −1.244 | −1.248 |
| | (0.781) | (0.781) | (0.781) | (0.781) |
| *Grow* | −0.141 | −0.134 | −0.133 | −0.134 |
| | (0.112) | (0.112) | (0.112) | (0.112) |
| *_cons* | −6.172** | −6.288*** | −5.595** | −6.179** |
| | (2.402) | (2.412) | (2.436) | (2.458) |
| Firm | YES | YES | YES | YES |
| *N* | 10,448 | 10,448 | 10,448 | 10,448 |
| $R^2$ | 0.007 | 0.007 | 0.007 | 0.007 |

## 6. Conclusion

By exploring the impact of ESG performance on firms' green innovation mechanisms, this paper draws the following conclusions:

First, good ESG performance can enhance the green innovation ability of listed companies, especially more stimulating companies to carry out substantial green innovation behaviors. Based on the impact of corporate environmental performance on green innovation, enterprises actively improve their environmental performance, which demonstrates their attention to environmental pollution issues and conveys information

about their own good environmental management and performance. The extent of the enterprise's efforts in environmental protection investment and facility construction establishes a positive image of green environmental protection and gains the recognition of the enterprise by external stakeholders. Based on the impact of corporate social responsibility on green innovation, the positive corporate social responsibility helps to establish closer ties with various stakeholders, for example, the greening of the production process and the greening of corporate products, which can gain the preference of investors to invest more money in green innovation activities. Based on the impact of corporate governance on green innovation, an excellent corporate governance mechanism can rationally allocate internal resources and achieve a higher utilization rate, improve the efficiency of capital utilization, promote the rational use of funds by corporate governance, and reduce the pressure of operation.

Second, in the exploration of the impact mechanism, ESG can enhance the green innovation ability of enterprises through three paths: generating industry green innovation spillover effects, strengthening external supervision, and alleviating the financing constraints faced by enterprises. ESG concepts can help enterprises set up innovative development strategies, and the improvement of ESG performance of enterprises in the same industry will generate green spillover effects in the industry, which will push peer companies to actively carry out green innovation. Enterprises with good environmental, social, and corporate governance performance receive high attention and more stringent external monitoring because their positive image is expected by the public, and the information monitoring formed by ESG performance deepens investors' understanding of the enterprise, reduces the risk premium for the enterprise, lowers the cost of financing, alleviates the enterprise's financing difficulties, and enhances the enthusiasm of the enterprise to carry out green innovation. Finally, Confucian culture plays a certain inhibitory role in the influence of ESG on corporate green innovation.

This paper explores the influence mechanism of ESG performance and corporate green innovation capacity, which has important insights for promoting China's sustainable development as well as corporate green transformation. First, ESG can serve as a green incentive to improve the green innovation capacity of enterprises in the same industry and enhance the overall green innovation capacity of the whole industry. Enterprises are the most important subjects in the market economy, and in the context of high-quality economic development, enterprises should deepen the ESG concept and better utilize ESG to empower them. Second, ESG can serve as green regulation, strengthen the constraints of external supervision on enterprises, and promote enterprises to enhance their green innovation capability. Regulators should accelerate the mandatory disclosure of ESG information and establish a perfect ESG evaluation system to ensure that ESG plays a more effective role in the Chinese market. Third, ESG can be used as a green signal to provide non-financial information about enterprises, reduce the information asymmetry between enterprises and investors, alleviate the financing constraints faced by enterprises, and promote enterprises to increase capital investment in enhancing green innovation capabilities. Investors and investment institutions should pay more attention to the ESG aspects of enterprises, increase investment in ESG, better play the role of financial services in the real economy, invest funds where they are needed, and guide enterprises to develop in the direction of sustainable high quality. Fourth, Confucian culture, as a kind of informal system, has a certain impact on the decision-making behavior of enterprises. We should establish a correct understanding of traditional culture, take the essence, and remove the dross so that traditional culture can be better inherited and developed.

## Author contributions

Conceptualization and supervision, XZ; methodology, writing—original draft, software, visualization, HL. All authors have read and agreed to the published version of the manuscript.

## Conflict of interest

The authors declare no conflict of interest.

## References


1. Cai W, Zhou X. On the drivers of eco-innovation: empirical evidence from China. Journal of Cleaner Production. 2014; 79: 239-248. doi: 10.1016/j.jclepro.2014.05.035
2. Rennings K. Redefining innovation-eco-innovation research and the contribution from ecological economics. Ecological Economics. 2000; 32(2): 319-332.
3. Wan G, Dawod AY. ESG Rating and Northbound Capital Shareholding Preferences: Evidence from China. Sustainability. 2022; 14(15): 9152. doi: 10.3390/su14159152
4. Flammer C, Bansal P. Does a long-term orientation create value? Evidence from a regression discontinuity. Strategic Management Journal. 2017; 38(9): 1827-1847. doi: 10.1002/smj.2629
5. Wan G, Dawod AY, Chanaim S, et al. Hotspots and trends of environmental, social and governance (ESG) research: a bibliometric analysis. Data Science and Management. 2023; 6(2): 65-75. doi: 10.1016/j.dsm.2023.03.001
6. Ouyang X, Li Q, Du K. How does environmental regulation promote technological innovations in the industrial sector? Evidence from Chinese provincial panel data. Energy Policy. 2020; 139: 111310. doi: 10.1016/j.enpol.2020.111310
7. Beise M, Rennings K. Lead markets and regulation: a framework for analyzing the international diffusion of environmental innovations. Ecological Economics. 2005; 52(1): 5-17. doi: 10.1016/j.ecolecon.2004.06.007
8. Blättel-Mink B. Innovation towards sustainable economy-the integration of economy and ecology in companies. Sustainable development. 1998; 6(2): 49-58. doi: 10.1002/(SICI)1099-1719(199808)6:2<49::AID-SD84>3.0.CO;2-I
9. Tan Y, Zhu Z. The effect of ESG rating events on corporate green innovation in China: The mediating role of financial constraints and managers' environmental awareness. Technology in Society. 2022; 68: 101906. doi: 10.1016/j.techsoc.2022.101906
10. Wang J, Ma M, Dong T, et al. Do ESG ratings promote corporate green innovation? A quasi-natural experiment based on SynTao Green Finance's ESG ratings. International Review of Financial Analysis. 2023; 87: 102623. doi: 10.1016/j.irfa.2023.102623
11. Broadstock DC, Matousek R, Meyer M, et al. Does corporate social responsibility impact firms' innovation capacity? The indirect link between environmental & social governance implementation and innovation performance. Journal of Business Research. 2020; 119: 99-110. doi: 10.1016/j.jbusres.2019.07.014
12. Hao J, He F. Corporate social responsibility (CSR) performance and green innovation: Evidence from China. Finance Research Letters. 2022; 48: 102889. doi: 10.1016/j.frl.2022.102889
13. Amore MD, Bennedsen M. Corporate governance and green innovation. Journal of Environmental Economics and Management. 2016; 75: 54-72. doi: 10.1016/j.jeem.2015.11.003
14. Fabrizi A, Guarini G, Meliciani V. Green patents, regulatory policies and research network policies. Research Policy. 2018; 47(6): 1018-1031. doi: 10.1016/j.respol.2018.03.005
15. Leyva-de la Hiz DI, Ferron-Vilchez V, Aragon-Correa JA. Do Firms' Slack Resources Influence the Relationship Between Focused Environmental Innovations and Financial Performance? More is Not Always Better. Journal of Business Ethics. 2018; 159(4): 1215-1227. doi: 10.1007/s10551-017-3772-3
16. Shen C, Li S, Wang X, et al. The effect of environmental policy tools on regional green innovation: Evidence from China. Journal of Cleaner Production. 2020; 254: 120122. doi: 10.1016/j.jclepro.2020.120122
17. Xiang X, Liu C, Yang M. Who is financing corporate green innovation? International Review of Economics & Finance. 2022; 78: 321-337. doi: 10.1016/j.iref.2021.12.011
18. Hu G, Wang X, Wang Y. Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China. Energy Economics. 2021; 98: 105134. doi: 10.1016/j.eneco.2021.105134
19. Zhang P, Zhou D, Guo J. Policy complementary or policy crowding-out? Effects of cross-instrumental policy mix on green innovation in China. Technological Forecasting and Social Change. 2023; 192: 122530. doi: 10.1016/j.techfore.2023.122530
20. Xiong H, Payne D, Kinsella S. Peer effects in the diffusion of innovations: Theory and simulation. Journal of Behavioral and Experimental Economics. 2016; 63: 1-13. doi: 10.1016/j.socec.2016.04.017
21. Fan R, Wang Y, Chen F, et al. How do government policies affect the diffusion of green innovation among peer enterprises?—An evolutionary-game model in complex networks. Journal of Cleaner Production. 2022; 364: 132711. doi: 10.1016/j.jclepro.2022.132711
22. Cheng B, Ioannou I, Serafeim G. Corporate social responsibility and access to finance. Strategic Management Journal. 2013; 35(1): 1-23. doi: 10.1002/smj.2131
23. Zhou X, Tang X. Does financing constraints impact the Chinese companies' pollutants emissions? Evidence from

a sample selection bias corrected model based on Chinese company-level panel data. Environmental Science and Pollution Research. 2022; 29(29): 44119-44134. doi: 10.1007/s11356-022-18907-7
24. Ahmed SU, Ahmed SP, Hasan I. Why banks should consider ESG risk factors in bank lending? Banks & Bank Systems. 2018; 3(13): 71-80.
25. Zhou X, Tang X, Wu S. The impact of national culture on IPO underpricing and its influence mechanism: A cross-border empirical research. Finance Research Letters. 2022; 47: 102543. doi: 10.1016/j.frl.2021.102543
26. Yan Y, Xu X, Lai J. Does Confucian culture influence corporate R&D investment? Evidence from Chinese private firms. Finance Research Letters. 2021; 40: 101719. doi: 10.1016/j.frl.2020.101719
27. Berrone P, Fosfuri A, Gelabert L, et al. Necessity as the mother of 'green' inventions: Institutional pressures and environmental innovations. Strategic Management Journal. 2013; 34(8): 891-909. doi: 10.1002/smj.2041
28. Lian G, Xu A, Zhu Y. Substantive green innovation or symbolic green innovation? The impact of ER on enterprise green innovation based on the dual moderating effects. Journal of Innovation & Knowledge. 2022; 7(3): 100203. doi: 10.1016/j.jik.2022.100203
29. Jiang L, Bai Y. Strategic or substantive innovation?—The impact of institutional investors' site visits on green innovation evidence from China. Technology in Society. 2022; 68: 101904. doi: 10.1016/j.techsoc.2022.101904
30. Li J, Lian G, Xu A. How do ESG affect the spillover of green innovation among peer firms? Mechanism discussion and performance study. Journal of Business Research. 2023; 158: 113648. doi: 10.1016/j.jbusres.2023.113648
31. Li J, Lu Y, Song H, et al. Long-term impact of trade liberalization on human capital formation. Journal of Comparative Economics. 2019; 47(4): 946-961. doi: 10.1016/j.jce.2019.08.002
32. Hadlock CJ, Pierce JR. New Evidence on Measuring Financial Constraints: Moving Beyond the KZ Index. Review of Financial Studies. 2010; 23(5): 1909-1940. doi: 10.1093/rfs/hhq009
33. Chen Y, Lin P, Tsao HT, et al. How does Confucian culture affect technological innovation? Evidence from family enterprises in China. PLOS ONE. 2022; 17(6): e0269220. doi: 10.1371/journal.pone.0269220