# The Impact of Corporate ESG Performance on Green Innovation Efficiency —— Evidence from China

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**Abstract.** Green innovation is essential for companies to meet their social obligations, drive industrial advancement, and improve market competitiveness. Good environmental, social, and governance (ESG) performance may increase corporate value and reputation, open up new business opportunities, lower risks, and drive green innovation. This study examines how ESG impacts corporate green innovation efficiency using sustainable development theory and stakeholder theory with a sample of Chinese A-share listed enterprises. Using a high-dimensional fixed-effects regression model, this paper investigates the impact of firms' ESG performance on green innovation efficiency and examines the mediating roles of corporate financial constraints and corporate social responsibility.. The findings indicate that strong corporate ESG performance improves corporate green innovation efficiency. Financing restrictions and corporate social responsibility also have a notable impact on the advancement of corporate green innovation efficiency. The findings of this paper support enhancing green innovation efficiency and achieving sustainable development.

**Keywords:** ESG, green innovation, sustainable development.

## 1. Introduction

Green innovation is a crucial factor in advancing sustainable development by facilitating energy conservation and emission reduction, ultimately contributing to achieving the "dual-carbon" goal. Enterprises tend to prioritize green innovation projects that combine social responsibility and environmental awareness due to the high risk, big investment, and long payback period associated with such operations. Green innovation efficiency is a crucial factor in the development of a sustainable and contemporary society in China, as it evaluates the ecological advantages and economic gains of innovative aspects in a comprehensive manner.

ESG encompasses business ethics and conduct related to environmental, social, and governance factors. Research indicates that analyzing both the quantitative and qualitative aspects of green innovation can offer a more thorough understanding of how ESG ratings impact firms' green innovation efforts. ESG ratings assist financial institutions in assessing the risks associated with investing in green innovation, thereby fostering trust in managers' decisions and encouraging the pursuit of green innovation. ESG ratings may cause managers to withhold information in green innovation activities, hindering the development of firms' green innovation.[1]

Reviewing existing literature, the majority of debates on the factors that influence green innovation center around environmental regulation, R&D investment, and economic development. Xu et al. (2021)[2] demonstrated that ESG performance positively influences the number of green patents, and that ESG practices and disclosure are valuable tools for financial institutions to assess the risk of investing in green innovation. (Ansong, 2017; Reber et al., 2021)[3][4]. There is limited research on how ESG performance affects the efficiency of green innovation. Exploring the impact of ESG performance on green innovation efficiency at the enterprise level is crucial for promoting the transformation of a low-carbon economy in developing countries.

# 2. Theoretical background and hypotheses

## 2.1. Corporate ESG performance and green innovation efficiency

Corporate environmental, social, and governance (ESG) factors impact the efficiency of corporate green innovation. Corporate ESG involves enterprises taking responsible actions in environmental, social, and governance aspects to meet the expectations of stakeholders. This has led businesses to shift their objectives from solely pursuing profit maximization to pursuing both economic and social benefits. This change assists businesses in recombining their resources and networks of relationships, so enhancing the extent of environmentally friendly innovation[5]. Enterprises with strong ESG performance in the labor market prioritize the well-being and professional growth of their employees, leading to the attraction and retention of top researchers. Enhanced employee satisfaction and work motivation can directly improve a company's ability to innovate in environmentally friendly ways. Additionally, companies with strong ESG performance are more likely to earn the trust of financial institutions and creditors, leading to preferential treatment in obtaining green credit and more favorable financing terms. This financing support ensures a reliable resource for enterprises to facilitate their transition to green practices, enabling them to boost investments in eco-friendly innovation.[6] Additionally, an enterprise's ESG performance impacts not only its reputation but also its influence within the industrial and supply chain. Suppliers and customers typically collaborate with companies that have strong ESG performance to maintain supply chain stability and reputation[7]. Forming these alliances ensures a consistent supply of raw materials and expands the market for the companies' environmentally friendly and innovative products and services.

A company's strong ESG performance boosts its reputation with the market and stakeholders, while also acting as a monitoring tool and incentive to encourage companies to proactively engage in environmentally friendly practices and enhance green innovation efficiency. Corporate ESG performance can aid in mitigating information asymmetry in market supervision[8].Good ESG performance can lower stakeholders' monitoring costs by influencing business behavior in environmental, social, and governance aspects, which directly impact stakeholders' interests. Timely and effective ESG disclosure allows stakeholders to promptly identify environmental problems or other ESG-related hazards in a firm, enabling them to take suitable action. Enterprises will be compelled to implement green transformation to enhance their green innovation efficiency to prevent reputational damage and loss of stakeholder confidence[9]. Additionally, incentive mechanisms are significant.Enterprises that demonstrate strong ESG performance often receive acknowledgment from the government and society, which can result in tangible advantages like tax incentives and policy backing. Companies might obtain tax incentives for their strong ESG performance or have extra carbon credits that can be sold to other companies, resulting in increased revenue. These resources and grants can support green innovation efforts, offering firms additional incentives and resources to further the development and implementation of green innovations. According to the analysis provided, this publication suggests Proposition 1: Strong ESG performance by companies can improve the effectiveness of environmentally friendly innovation.

## 2.2. The mediating role of corporate finance constraints

Financing limitations are obstacles that hinder an enterprise's ability to secure adequate financial backing, hence restricting its capability for development and innovation. Companies with strong ESG performance often find it easier to secure financial backing, which helps drive their environmentally friendly innovation efforts. Enhancing credibility and reputation, appealing to long-term investors, and gaining government and societal support can help ESG-performing companies overcome financing limitations, secure more financial and resource backing for green innovation initiatives, and steer their businesses towards sustainable growth.

Effective ESG performance can boost the credibility and reputation of a company. An enterprise's reputation significantly influences financing circumstances in the financial sector.Enterprises that demonstrate strong ESG performance are typically seen as more responsible and sustainable, leading

investors to be more inclined to offer financial backing[10]. Having a good reputation can assist businesses in lowering financing expenses and expanding financing options, which in turn alleviates financial restrictions and offers greater financial backing for their environmentally friendly innovations.

Companies with strong ESG performance are more likely to catch the interest of long-term investors. Long-term investors prioritize the enduring value and sustainability of companies, showing a preference for investing in companies with strong ESG performance. Long-term investor assistance offers a reliable source of financing for firms and strategic guidance to assist in planning and implementing green innovation plans. Furthermore, organizations that demonstrate strong ESG performance are more inclined to garner support from both the government and society. Government typically offers legislative assistance and incentives to promote green development and innovation, including tax breaks and subsidies. Companies with strong ESG performance are more likely to receive policy assistance, leading to lower operational costs, reduced innovation risks, and alleviation of finance limitations. Hence, this article suggests hypothesis 2: Corporate ESG performance improves corporate green innovation efficiency by alleviating corporate financial restrictions.

### 2.3. The mediating role of CSR

Corporate Social duty (CSR) is the deliberate social duty that businesses assume in their operations, encompassing their obligations to the environment, society, and stakeholders. Corporate Social Responsibility (CSR) can improve Environmental, Social, and Governance (ESG) dimensions, support green innovation activities, and drive corporations towards sustainable development by increasing environmental and social awareness, strengthening relationships with stakeholders, and enhancing brand image and reputation.

Engaging in CSR can enhance the enterprise's commitment to environmental and social issues. By proactively fulfilling social responsibility, firms will focus more on environmental preservation, social welfare, and other issues, thereby enhancing their performance in ESG[11]. The heightened focus encourages businesses to acknowledge the significance of green innovation, leading them to invest in and engage in green technology research and development, product innovation, and other facets of green innovation to enhance its effectiveness.

Simultaneously, engaging in Corporate Social Responsibility (CSR) helps strengthen the trust and collaboration between businesses and stakeholders. CSR include environmental preservation as well as the well-being of employees, consumers, suppliers, and other stakeholders. Developing strong relationships with stakeholders enables firms to access increased resource support, feedback, and collaboration opportunities, which can benefit their green innovation efforts[12]. Stakeholders' assistance and participation can offer firms more innovation ideas and resources, leading to improved green innovation efficiency. Moreover, engaging in CSR can improve the brand image and reputation of the company. Consumers and investors in modern society prioritize the social responsibility and ethical standards of businesses when making purchasing and investment decisions. Engaging in Corporate Social Responsibility (CSR) allows firms to build a positive brand image, appeal to a larger consumer and investor base, generate additional business prospects and resources, and ultimately boost the efficiency of green innovation within the enterprise. This study suggests Hypothesis 3: Corporate ESG performance boosts corporate green innovation efficiency through the enhancement of corporate social responsibility.

## 3. Methodology

### 3.1. Modeling

In order to investigate the impact of corporate ESG performance on corporate green innovation efficiency, the following regression model is constructed:

$$GIE_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \alpha_2 \sum CONTROL_{i,t} + \alpha_3 \sum Cid + \alpha_4 \sum Iid + \alpha_5 \sum Year + \varepsilon_{i,t} \quad (1)$$

Where.$GIE_{i,t}$ is the explanatory variable representing firm i's green innovation efficiency in year t;$ESG_{i,t}$ is the explanatory variable, representing ESG performance of firm i in year t;$CONTROL_{i,t}$ is the ensemble of control variables; Cid, Iid, and Year denote the city code, industry code and year control variables, respectively;$\varepsilon_{i,t}$ represents the random error term.

In order to investigate the internal transmission mechanism of "corporate ESG performance - corporate green innovation efficiency", the following recursive equation system is constructed to investigate the internal mechanism between the two:

$$GIE_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum CONTROL_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$MED_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \sum CONTROL_{i,t} + \tau_{i,t} \quad (3)$$

$$GIE_{i,t} = \gamma_0 + \gamma_1 ESG_{i,t} + MED_{i,t} + \sum CONTROL_{i,t} + \omega_{i,t} \quad (4)$$

Among them, MED represents the mediating variable group, which contains financing constraints (KZ) and corporate social responsibility (CSR). Where financing constraints are measured using the KZ index; CSR is measured using the results of the five-pronged weighted scores for shareholder responsibility, employee responsibility, supplier, customer and consumer rights responsibility, environmental responsibility, and social responsibility. If the ESG coefficients in Eq. (3) and Eq. (5) are significant, it indicates that there is a mediating effect between the explanatory variables and the explained variables, and vice versa, it indicates that there is no mediating effect between the two.

### 3.2. Measures

#### 3.2.1 Dependent variable: green innovation

Green Innovation Efficiency. In this paper, we refer to Yao,Zhou (2018)[13] and use the number of firms' green invention patent applications plus one to take the natural logarithm and divide it by the firms' R&D investment in the current year and the previous year plus one to take the natural logarithm to measure the green innovation efficiency.

#### 3.2.2 Independent variable:ESG

Corporate ESG Performance. In this paper, referring to Fang,Hu (2023)[14], we use the Huazheng index ESG ratings to measure corporate ESG performance. The explanatory variables ESG performance indicators include nine grades of AAA, AA, A, BBB, BB, B, CCC, CC, and C. The corporate ESG ratings are assigned a value of 9 to 1 in descending order.

#### 3.2.3 Control variables

In this paper, we choose six items as control variables: amount of R&D investment, two positions, percentage of independent directors, total assets, age of the firm, gearing ratio, and profitability. At the same time, this paper also by controlling the city code, industry code and year, in order to effectively avoid omitted variable bias. Specific variables are defined as shown in Table 1 below.

**Table.1.** Definition of variables

| Variable type | variable name | notation | Description of variables |
|---|---|---|---|
| Explanatory variable | Green innovation efficiency of enterprises | GIE | ln(number of patent applications for green inventions + 1)/ln(R&D expenditures in the two previous periods + 1) |
| Explanatory variable | Corporate ESG performance | ESG | AAA to C grades are assigned a score of 9 to 1, in that order. |
| Control variable | Amount of R&D investment | RDia | Total amount invested by the company in R&D |
| | two jobs in one | Dual | Whether the president and general manager are the same person; 0: No; 1: Yes. |
| | Percentage of independent directors | Pct Indep | Ratio of the number of independent directors to the size of the board. |
| | Total assets | TA | Sum of all assets of the enterprise |
| | Age of business | Time | Founding Years |
| | gearing | Roe | Total liabilities/total assets<br>If the numerator is empty, zero value is substituted; if the denominator is empty or zero value, the result is NULL. |
| | profitability | Loar | Ratio of total assets to total assets at the end of year |

### 3.3. Sample and data collection

In this paper, the data of Chinese A-share listed companies in Shanghai, Shenzhen and Beijing from 2012 to 2021 are selected as the research sample. Among them, the ESG rating data of Huazheng comes from wind database, the corporate green patent data comes from China Research Data Service Platform (CNRDS), and all the company-level financial data comes from CSMAR database. Meanwhile, in order to effectively improve the data quality, this paper carries out the following screening process on the raw data: first, excluding the samples of financial and insurance industries and ST,*ST,PT labeled enterprises; second, shrinking the tail of the sample data by 1% and 99%, and then obtaining 15924 observations as a way of reducing the singular value interference.

## 4. Analysis of empirical results

### 4.1. Benchmark regression analysis

Table 2 demonstrates the empirical results of the impact of corporate ESG performance on corporate green innovation efficiency. Among them, columns (1), columns (2), columns (3), and columns (4) are the regression process of adding control variables, and by gradually adding fixed effects, the regression coefficients of corporate ESG performance are 0.047, 0.048, 0.047, 0.047, and 0.047, which are all significantly positive at 1% level; columns (5), columns (6), and columns (7) are the regression results of not adding control variables, and by gradually reducing fixed effects, the regression coefficients of corporate ESG performance are 0.075, 0.074, 0.074 respectively, which are also significantly positive at 1% level. The results show that corporate ESG performance can significantly improve corporate green innovation efficiency.

Among the control variables, the coefficients of RDia,TA,Loar are significantly positive. It means that the more generous the amount of R&D investment, the more the company's assets total, the higher the gearing ratio, the more it can promote the enterprise's green innovation efficiency, and the stronger the willingness to have carried out green innovation. The reason why the coefficient of PctIndep,Time is significantly negative is that the demand for green innovation activities is not strong when the proportion of independent directors of the enterprise is higher and the age of the company is shorter, which is consistent with common sense.

It is worth mentioning that with the addition of control variables, the coefficient of Dual,ROE gradually changes from negative to positive with the increase of the number of fixed variables, indicating that over time, certain industries and regions may be more conducive to enterprises to

achieve a balance between ESG performance and green innovation efficiency, and continuously optimize the relationship between Dual and ROE in continuous learning and adjustment, and this dynamic change makes the coefficient of Dual and ROE coefficients gradually show positive values, reflecting the positive impact of ESG performance on green innovation efficiency.

**Table.2.** Benchmark regression results

| | GIE (1) | GIE (2) | GIE (3) | GIE (4) | GIE (5) | GIE (6) | GIE (7) |
|---|---|---|---|---|---|---|---|
| ESG | 0.047*** | 0.048*** | 0.047*** | 0.047*** | 0.075*** | 0.074*** | 0 .074 *** |
| | (12.89) | (12.83) | (12.44) | (20.28) | (20.28) | ( 19.91) | (19.28) |
| RDia | 0.077*** | 0.075*** | 0.043*** | 0.051*** | | | |
| | (25.70) | (23.10) | (10.67) | (12.38) | | | |
| Dual | −0.012 | −0.008 | 0.001 | 0.007 | | | |
| | (-1.62) | (-1.05) | (0.18) | (1.01) | | | |
| PctIndep | −0.002*** | −0.002*** | −0.002*** | −0.002** | | | |
| | (-3.09) | (-2.79) | (-3.24) | (-2.84) | | | |
| TA | 0.031*** | 0.032*** | 0.066*** | 0.062*** | | | |
| | (5.92) | (5.85) | (11.00) | (10.24) | | | |
| Time | −0.008*** | −0.008*** | −0.006*** | −0.005*** | | | |
| | (-14.30) | (-14.22) | (-10.06) | (-8.44) | | | |
| ROE | −0.032 | -0.001 | 0.034 | 0.026 | | | |
| | (-0.80) | (-0.01) | (0.89) | (0.69) | | | |
| Loar | 0.246*** | 0.222*** | 0.118*** | 0.119*** | | | |
| | (11.06) | (9.57) | (5.28) | (5.32) | | | |
| Cid | NO | YES | YES | YES | YES | YES | YES |
| Iid | NO | NO | YES | YES | YES | YES | NO |
| Year | NO | NO | NO | YES | YES | NO | NO |
| P > F(chi2) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| obs | 19393 | 19360 | 19358 | 19358 | 19358 | 19358 | 19358 |
| Adj $R^2$ | 0.1223 | 0.1708 | 0.2537 | 0.2674 | 0.2103 | 0.2164 | 0.1034 |

### 4.2. Robustness Tests

Replacement of explanatory variables. This paper conducts a regression of corporate green innovation efficiency by replacing the core explanatory variable ESG from the annual mean of the score to the annual median. The results show that the explanatory variables still pass the significance test at the 1% level and are positive, indicating that the benchmark regression results are relatively robust.

Replacement of explanatory variables. The regression was conducted with the firm's green innovation efficiency after shrinking as the explanatory variable. The results show that the explanatory variables still pass the significance test at the 1% level, indicating that the research findings remain unchanged.

Table 3 demonstrates the results of the above stability tests.

**Table.3.** Stability tests

| | GIE (1) Substitution of explanatory variables | GIED (2) Substitution of explanatory variables |
|---|---|---|
| ESG | 0.069*** | 0.0729*** |
| | (19.51) | (20.31) |
| Cid | YES | YES |
| Iid | YES | YES |
| Year | YES | YES |
| P > F(chi2) | 0.0000 | 0.0000 |
| obs | 19358 | 19358 |
| Adj $R^2$ | 0.2089 | 0.2120 |

### 4.3. Mediated effects test

Table 4 displays the experimental results of the mediation effects test. Column (1) shows that the ESG coefficient is notably negative at the 1% level, suggesting that companies with stronger ESG performance would face fewer funding constraints. Firms with strong ESG performance will reduce their finance constraints, resulting in better access to financing, cheaper financing costs, and more diverse funding sources.

Column (2) shows a statistically significant positive ESG coefficient at the 1% level, suggesting a positive impact of ESG on CSR. This shows how corporations are consistent in implementing their plans by achieving ESG targets and performing their social duties. ESG, as a holistic assessment framework, encompasses all facets of CSR. Companies with strong ESG performance often exhibit outstanding CSR performance. Company management's emphasis on social responsibility reflects the increasing market and consumer expectations for corporate social responsibility. This may lead companies to enhance their CSR activities to align with these rising expectations.

In column(3), a negative coefficient of financing restriction suggests that as the level of corporate financing constraint increases, the green innovation efficiency of firms decreases. Financing constraints negatively affect enterprises' green innovation activity. Financing constraints hinder organizations from making long-term green innovation investments, leading to decreased green innovation efficiency due to resource limitations, risk aversion, prioritizing of short-term gains, and market unpredictability.

The coefficient of social responsibility (CSR) in column (4) is statistically significant at the 1% level, suggesting that higher levels of social responsibility lead to improved performance in green innovation. Good social responsibility performance enhances a firm's social image, reputation, and ability to attract talent, increase customer loyalty, and foster partnerships for green innovation. Firms also integrate social responsibility and green innovation into their core strategy to align with policy orientation, market demand for environmental protection, and long-term perspectives. Considering governmental orientations, market demands for environmental preservation and sustainability, and adopting a long-term perspective, firms incorporate social responsibility and green innovation into their fundamental objectives.

**Table.4.** Mediated effects test

| | KZ<br>(1) | CSR<br>(2) | GIE<br>(3) | GIE<br>(4) |
|---|---|---|---|---|
| ESG | $-0.112^{***}$<br>(-7.70) | $1.990^{***}$<br>(19.03) | | |
| KZ | | | $-0.006^{***}$<br>(-2.74) | |
| CSR | | | | $0.001^{***}$<br>(2.73) |
| CONTROL | YES | YES | YES | YES |
| Cid | YES | YES | YES | YES |
| Iid | YES | YES | YES | YES |
| Year | YES | YES | YES | YES |
| P > F(chi2) | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| obs | 15905 | 15905 | 15905 | 15905 |
| Adj $R^2$ | 0.5753 | 0.3986 | 0.2689 | 0.2690 |

## 5. Conclusions and recommendations

This study empirically investigates how corporate ESG performance influences green innovation efficiency and the underlying mechanisms using data from Chinese A-share listed companies in Shanghai, Shenzhen, and Beijing from 2012 to 2021. The study also examines the mediating roles of corporate financing constraints and corporate social responsibility in this relationship. The findings

indicate that strong corporate ESG performance has a beneficial impact on corporate green innovation efficiency. The result remains valid even after replacing explanatory and interpreted variables. Firms' financial limitations and commitment to corporate social responsibility (CSR) significantly influence the advancement of firms' efficiency in green innovation. Corporate ESG performance influences green innovation efficiency by addressing financial limitations and improving corporate social responsibility.

The study results indicate the following development recommendations for enhancing firms' green innovation achievements: Initially, companies should bolster ESG management and improve their performance in environmental, social, and governance areas. Establishing robust ESG systems and policies enables firms to effectively meet their social responsibilities and enhance green innovation efficiency. Secondly, businesses should prioritize addressing financial limitations and actively explore various funding sources to back green innovation initiatives. Simultaneously, companies may bolster green innovation by strengthening their CSR performance and fostering collaborative ties with stakeholders. Companies can prioritize improving their brand image and reputation by promoting green development to gain increased attention and support from consumers and investors. Enterprises can increase business opportunities, enhance green innovation efficiency, and achieve sustainable development goals by implementing CSR and cultivating a positive corporate image.

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