

# Corporate ESG Ratings and Green Innovation: Evidence from China's A-Share Manufacturing Firms

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## ABSTRACT

In the new stage of economic development, environmental, social, and governance (ESG) is an important sustainability-oriented concept for corporate operations. Under the green development agenda, how to embed a firm's multiple responsibilities-environmental, social, and corporate governance-into its innovation system to drive the transformation from conventional innovation to green innovation has become a key research topic. Using data on China's A-share listed manufacturing firms from 2009 to 2021, this study empirically examines the effect of ESG ratings on firms' green innovation output. The results show that higher ESG ratings are associated with greater green innovation output, and the conclusion remains robust across multiple robustness checks. Mechanism analysis further suggests that improved ESG ratings can alleviate financing constraints, thereby promoting green innovation. This study provides policy implications for strengthening ESG practices and integrating sustainability and corporate social responsibility into firms' innovation systems, ultimately facilitating green transformation and the co-development of firms, society, and the environment.

## KEYWORDS

Corporate ESG; Green Innovation; Financing Constraints; Manufacturing Firms.

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## 1. INTRODUCTION

With the continuous development of China's economy, energy consumption and carbon dioxide emissions have kept increasing, bringing mounting international pressure for energy conservation and emission reduction. As a responsible major country, China has committed to reducing carbon emissions and achieving green development. China is actively addressing global climate change and has incorporated new development concepts such as "innovation-driven", "green development", and sustainability into national strategies.

In the literature, a large body of work has focused on measuring corporate green innovation. Many studies use green patent applications as a common proxy due to data availability and comparability [1,2]. For example, Wang et al. [3] measured green innovation using a two-stage DEA approach from R&D, market, and overall efficiency perspectives.

Regarding the determinants of green innovation, prior studies often emphasize environmental regulation. Conrad and Wastl [4] find that environmental regulation plays a crucial role in stimulating firms' green innovation.

Against this backdrop, the impact of ESG on firms' green development has become a research hotspot. ESG evaluates a firm's performance in balancing environmental, social, and governance dimensions, aligning closely with national green development strategies. However, ESG disclosure is not yet

mandatory in China, and third-party ESG rating agencies (e.g., Huazheng ESG Index) play a key role in market supervision. This raises practical questions: Does ESG information positively affect firms' green innovation? Through what mechanisms does it work?

## 2. HYPOTHESIS DEVELOPMENT

### ESG Performance and Green Innovation

Compared with general innovation, green innovation is typically riskier and has a lower success rate. ESG ratings transmit information about a firm's responsibilities and governance status to external stakeholders, which can strengthen reputation and brand image [5]. More complete disclosure and stronger environmental responsibility can help firms obtain external financing at lower cost. Credit rating agencies influence investors' decisions in equity and debt markets; higher-quality ratings improve information efficiency and can be crucial for whether innovation activities obtain financing [6]. As firms improve social responsibility performance, they may gain recognition, improve creditworthiness, and reduce financing difficulty. Better social responsibility performance is associated with higher credit ratings [7], which can lower credit thresholds and borrowing costs. Based on the above analysis, we propose the following hypothesis:

Hypothesis 1: Firms with higher ESG ratings are more likely to achieve higher levels of green innovation.

## 3. DATA AND METHODOLOGY

### 3.1. Sample Selection and Data Sources

This study uses data on China's A-share listed manufacturing firms from 2009 to 2021. Green innovation is particularly important in manufacturing because it is a key means of achieving sustainable development; relative to other industries, green innovation is often a necessary pathway for manufacturing firms to pursue sustainability [8]. Following common practice, we exclude ST and \*ST firms and observations with missing key variables. We retain firm-year observations for firms with at least three consecutive years of data, resulting in 27,026 firm-year observations. Financial data are obtained from the CSMAR database, and green patent data are collected from the China National Intellectual Property Administration (CNIPA).

### 3.2. Variable Definitions

Core explanatory variable: ESG rating. Following prior work, we use the Huazheng ESG evaluation system to obtain firms' ESG ratings. The nine-tier rating from C to AAA is coded from 1 to 9, and we use the annual average as the ESG score. Dependent variable: green innovation. We measure green innovation by the number of green patent applications, constructed following the green patent classification method used in prior studies. Specifically, we consider green invention patents and green utility model patents. We construct three indicators: total green patents (GreenPat = green invention + green utility model), green invention patents (GreenPatInv), and green utility model patents (GreenPatUty). Each count is transformed as  $\ln(1 + \text{count})$ .

### 3.3. Model Specification

Based on the above variables, we estimate the following baseline model:

$$\text{GreenInnovation}_{it} = \beta_0 + \beta_1 \text{ESG}_{it} + \beta_2 \text{Controls}_{it} + \text{Year} + \text{Industry} + \varepsilon_{it} \quad (1)$$

GreenInnovation<sub>it</sub> denotes the number of green patents for firm *i* in year *t* (GreenPat, GreenPatInv, or GreenPatUty). ESG<sub>it</sub> is the ESG rating score of firm *i* in year *t*. Control variables include firm size (total assets), leverage, return on assets, revenue growth, fixed-asset ratio, CEO duality, independent director ratio, managerial shareholding, and institutional shareholding. YearFE and IndustryFE denote year and industry fixed effects, and  $\epsilon_{it}$  is the error term.

## 4. EMPIRICAL RESULTS AND DISCUSSION

### 4.1. Descriptive Statistics

Table 1 reports descriptive statistics. The mean ESG score is 4.087 with a standard deviation of 0.880, indicating substantial variation across sample firms. The mean value of total green patents (GreenPat) is 0.537 (after  $\ln(1 + \text{count})$  transformation), and the median is 0, suggesting that many listed firms have no green patent applications. Although green innovation has improved in recent years, it remains at a relatively low level overall, and the manufacturing sector is still in a transition from traditional factor-driven growth to green-innovation-driven growth.

**Table 1.** Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Median	Max
<b>GreenPat</b>	27026	0.537	0.929	0.000	0.000	4.025
<b>GreenPatInv</b>	27026	0.368	0.753	0.000	0.000	3.638
<b>GreenPatUty</b>	27026	0.330	0.680	0.000	0.000	3.135
<b>ESG</b>	27026	4.087	0.880	1.500	4.000	6.000
<b>Asset</b>	27026	21.860	1.130	19.872	21.711	25.267
<b>Lev</b>	27026	0.387	0.197	0.046	0.377	0.855
<b>Roa</b>	27026	0.045	0.052	-0.152	0.042	0.198
<b>Growth</b>	27026	0.163	0.308	-0.433	0.116	1.593
<b>Fixed</b>	27026	0.234	0.138	0.019	0.208	0.631
<b>Duality</b>	27026	1.707	0.455	1.000	2.000	2.000
<b>Indenp</b>	27026	0.372	0.052	0.333	0.333	0.571
<b>Share</b>	27026	0.163	0.218	0.000	0.014	0.705
<b>Inst</b>	27026	0.356	0.235	0.000	0.354	0.859

### 4.2. Baseline Regression Results

Table 2 reports baseline regression results for total green patents, green invention patents, and green utility model patents. After controlling for firm characteristics and including year and industry fixed effects, the coefficient on ESG is positive and statistically significant at the 1% level across all specifications, suggesting that firms with higher ESG ratings achieve higher green innovation output. Economically, a one-unit increase in ESG score is associated with an average increase of 4.7% in total green patent output, a 4.0% increase in green invention patents, and a 2.9% increase in green utility model patents.

**Table 2.** Baseline Regression Results

Variable	(1) GreenPat	(2) GreenPatInv	(3) GreenPatUty
ESG	0.047*** (0.010)	0.040*** (0.008)	0.029*** (0.008)
Asset	0.155*** (0.017)	0.138*** (0.014)	0.099*** (0.013)
Lev	0.106* (0.059)	0.071 (0.048)	0.085* (0.044)
Roa	0.637*** (0.144)	0.465*** (0.116)	0.430*** (0.114)
Growth	-0.005 (0.017)	-0.001 (0.013)	-0.009 (0.013)
Fixed	0.035 (0.079)	-0.009 (0.062)	0.061 (0.060)
Duality	-0.012 (0.019)	-0.004 (0.016)	-0.009 (0.014)
Indenp	0.084 (0.153)	0.092 (0.127)	0.109 (0.118)
Sharecen	-0.039 (0.053)	-0.057 (0.040)	-0.001 (0.039)
Inst	0.004 (0.038)	0.019 (0.031)	0.004 (0.031)
Constant	-3.532*** (0.381)	-3.160*** (0.320)	-2.289*** (0.279)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Obs.	27026	27026	27026
R <sup>2</sup>	0.254	0.241	0.227

Note: \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

### 4.3. Robustness Checks

Because a large share of firms have zero green patents, OLS estimates may be affected by limited dependent variable issues. We therefore re-estimate the models using Tobit and Poisson regressions. Table 3 shows that the estimated coefficients on ESG remain positive and statistically significant at the 1% level under both alternative specifications, indicating that the main conclusion is robust.

**Table 3.** Robustness Checks with Alternative Models

Model	(1) GreenPat	(2) GreenPatInv	(3) GreenPatUty	(4) GreenPat	(5) GreenPatInv	(6) GreenPatUty
Tobit	0.337*** (0.039)	0.319*** (0.039)	0.279*** (0.038)			
Poisson				0.201*** (0.028)	0.207*** (0.033)	0.206*** (0.034)
Controls / Year & Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	27026	27026	27026	27026	27026	27026
Pseudo R <sup>2</sup> / R <sup>2</sup>	0.109	0.119	0.122	0.169	0.183	0.175

## 5. CONCLUSION AND IMPLICATIONS

This study finds that firms with higher ESG ratings generate significantly higher green innovation output, and the result remains robust to alternative model specifications. Mechanism analysis indicates that improved ESG ratings can alleviate financing constraints, thereby facilitating firms' green innovation.

Implications. First, ESG ratings help firms demonstrate sustainability capability to stakeholders and can promote substantive green innovation and green innovation performance. Higher ESG ratings may improve the financing environment and ease financing constraints, helping secure R&D investment. Policymakers may support third-party agencies to refine ESG assessment methods and enhance their ability to identify firms' long-term value. Second, patent authorities could improve patent evaluation by incorporating assessments of innovation content and potential value beyond existing classifications, providing a more accurate measure of green innovation quality and a stronger basis for ESG evaluation. Relevant departments may accelerate ESG rating system development for firms with high environmental risk and for non-state-owned firms, and consider incentive policies (e.g., tax preferences) to encourage participation in green innovation and strengthen ESG supervision, thereby reducing compliance costs and accelerating green transition.

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