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Green Innovation and Financial Performance: The Role of ESG Fund Shareholding

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Abstract

This paper focuses on the relationship between green patent output, ESG-themed fund holdings, and corporate financial performance. By constructing a fixed-effect model and using multi-source data, it deeply analyzes the internal connections among the three. The empirical results show that for every 1% increase in green patent applications, the corporate return on assets increases by 0.2%; for every 10% increase in the shareholding ratio of ESG funds, the performance conversion efficiency of green patents increases by 21%. The study reveals the value catalysis mechanism of capital markets for green innovation, providing a theoretical basis for corporate strategic decision-making and regulatory policies.

1 Introduction

Against the backdrop of accelerating global climate governance and the deepening implementation of dual-carbon goals, sustainable development has emerged as a core proposition for economic transformation worldwide (Howard-Grenville, Buckle, Hoskins, & George, 2014; Zhu, 2025). As the basic units of socioeconomic activity, enterprises' green transformation processes directly impact the achievement of global ecological objectives (X. Liu, Jia, Zhu, Wang, & Yao, 2025). Within this macro trend, the central challenge facing enterprises has become clear: how to balance technological innovation efficiency with capital support mechanisms, and find a sustainable equilibrium between environmental investments and economic returns.

Zooming in to the micro level of enterprises, green technological innovation stands as a key driver for breaking through transformation bottlenecks (Benkraiem, Dubocage, Lelong, & Shuwaikh, 2023), and green patents, as the core vector of such innovation outcomes, are growing in significance. They not only directly reflect an enterprise's R&D capabilities in environmental protection technologies (W. Liu & Zhu, 2024) but also can translate technological advantages into market gains through optimizing production processes and enhancing the green competitiveness of products, emerging as a potential engine for improving corporate financial performance (Cheng, Lin, & Yang, 2024).

Concurrently, the capital market's response to sustainable development has spurred the rise of ESG investment idea (Bassen, Kordsachia, Lopatta, & Tan, 2025; Otchere, Abdulrahman, & Wang, 2025). ESG-themed funds screen investment targets through systematic assessments of enterprises' environmental, social, and governance (ESG) performance. They not only provide differentiated capital support to enterprises but also, through their shareholding behavior, push enterprises to strengthen ESG practices and optimize operational management—forging a new dynamic between capital and corporate strategy (Inderst & Opp, 2025; Martin-Melero, Gomez-Martinez, Medrano-Garcia, & Hernandez-Perlines, 2025).

However, when green patents, ESG fund holdings, and corporate financial performance intersect, existing literature has yet to establish a clear analytical framework. First, empirical examinations of the conversion path from green patents to financial performance remain insufficient; the mechanisms through which technological advantages translate into economic value remain unclear. Second, the governance role of ESG funds as institutional investors has been overlooked—whether their shareholding behavior influences the value realization of green patents remains underexplored. Third, heterogeneous characteristics across industries and firm sizes may lead to variations in the relationships among these three factors, yet relevant research remains scarce.

Against this backdrop, this study takes Chinese A-share listed companies from 2009 to 2023 as its sample, focusing on the intrinsic connections between green patent output, ESG-themed fund holdings, and corporate financial performance. Through empirical analysis, it aims to unravel the interaction mechanisms among the three. This research not only helps fill gaps in existing theory but also provides a scientific basis and practical guidance for enterprises to optimize green innovation strategies, for investors to refine ESG investment logic, and for policymakers to advance the green transformation of capital markets.

Existing literature focuses more on the direct relationship between green innovation and corporate performance, but there is a gap in the discussion of the mechanism of ESG funds as the dual role of capital and governance. This paper integrates the Resource-Based View and Signaling Theory to construct a transmission path of "green patent output - ESG fund governance - financial performance", revealing the mechanism in which the capital market catalyzes the transformation of green innovation value through the dual mechanism of "certification signal" and "resource empowerment". Compared with existing research, the marginal contribution of this paper's theory is reflected in two aspects: First, the ESG fund holdings are included in the analytical framework of the consequences of green innovation economy for the first time, verifying its governance effect on the commercialization efficiency of green patents in enterprises; second, discovering the amplification effect of green patent quality (GPQ) on financial performance provides a new

theoretical perspective for cracking the "failure of green innovation market".

2 Theoretical Analysis and Research Hypotheses

2.1 Impact of Green Patent Output on Corporate Financial Performance

According to innovation theory, corporate innovation activities are the key driving force for economic growth and competitiveness improvement (Zhong, 2018). As the core achievement of corporate green technological innovation, green patent output represents enterprises' breakthroughs and innovations in environmental protection technology. On one hand, green patents help enterprises develop products or services with more environmental advantages, meeting market demand for green products (Ozaki & Sevastyanova, 2011), thereby increasing product added value and market competitiveness. For example, new energy vehicle enterprises develop more efficient battery technology through green patents, which can improve product range, attract more consumers, and thus increase sales revenue and profits. On the other hand, green patents can help enterprises optimize production processes(S. Liu, Yu, & Feng, 2025), reduce energy consumption and environmental pollution costs (Li, Zhu, Tan, Qi, & Huang, 2024), achieve efficient resource utilization, and improve operational efficiency and economic benefits.

Based on this, hypothesis H1 is proposed: Green patent output has a significant positive impact on corporate financial performance.

2.2 Moderating Role of ESG-themed Fund Holdings

Signaling theory points out that corporate behaviors and decisions will send signals to the market, affecting investors' expectations and decisions (Ghosh, 2025). ESG-themed funds focus on corporate ESG performance when selecting investment targets (Liang, Zhang, & Li, 2024). When ESG-themed funds hold shares of an enterprise, it sends a positive signal to the market that the enterprise performs well in environmental, social, and governance aspects, enhancing the enterprise's reputation and market recognition. At the same time, ESG-themed funds usually conduct active supervision and intervention on holding enterprises (Mallios & Mavruk, 2024), urging them to increase investment in green technological innovation and improve the quality and quantity of green patent output. Resource-based theory emphasizes the role of enterprises' unique resource combinations in building competitive advantages. ESG-themed fund holdings bring key resources such as capital, technology, and management experience to enterprises, helping them better integrate internal resources, optimize the innovation environment, and thus strengthen the positive impact of green patent output on corporate financial performance.

Therefore, hypothesis H2 is proposed: ESG-themed fund holdings play a positive moderating role in the relationship between green patent output and corporate financial performance.

3 Research Design

3.1 Sample Selection and Data Sources

This study selects A-share listed companies in China from 2009 to 2023 as the initial sample. To ensure the quality and validity of sample data, the following screening processes are conducted: excluding company samples with missing or incomplete data in relevant databases; excluding ST and *ST companies, as their special financial conditions may affect the accuracy of research results;

truncating continuous variables at the 1% level to reduce the interference of extreme values on research results, and finally obtaining 17,005 valid observations. Green patent data are from the CNRDS database, obtaining information on the number of applications and authorizations of corporate green invention patents and utility model patents through precise retrieval and screening; ESG-themed fund holdings data are from the Wind database, detailing the shareholding ratio and time of each fund in listed companies; corporate financial data are from the CSMAR database, including key financial indicators such as balance sheets, income statements, and cash flow statements.

3.2 Variable Definition

3.2.1 Explanatory Variable: Green Patent Output

Drawing on existing studies, the number of corporate green patent applications is used as the main indicator to measure green patent output (Block, Lambrecht, Willeke, Cucculelli, & Meloni, 2025). The number of green patent applications can directly reflect enterprises' investment and achievements in green technological innovation, embodying their innovation ability and enthusiasm. Meanwhile, to further explore the impact of green patent quality on research results, the proportion of green invention patents is introduced as an auxiliary variable, which can measure the technical content and innovativeness of corporate green patents.

3.2.2 Explained Variable: Corporate Financial Performance

Return on assets (ROA) is selected as the core indicator to measure corporate financial performance (Vu, Phan, & Le, 2018). ROA comprehensively considers enterprises' asset operation efficiency and profitability, and can fully reflect their ability to obtain profits using all assets. In addition, to ensure the robustness of research results, return on equity (ROE) is selected as a substitute indicator for robustness testing.

3.2.3 Moderating Variable: ESG-themed Fund Holdings

The shareholding ratio of ESG-themed funds in enterprises is used as the moderating variable. A higher shareholding ratio indicates a greater influence of ESG-themed funds on enterprises, and their moderating role on corporate green technological innovation and financial performance may be more significant.

3.2.4 Control Variables

Referring to previous research results (Vu et al., 2018), enterprise size (Size), financial leverage (Lev), growth ability (Growth), industry (Industry), and year (Year) are selected as control variables. Enterprise size is measured by the natural logarithm of total assets at the end of the year, financial leverage is represented by the asset-liability ratio, growth ability is calculated by the operating income growth rate, and industry and year set dummy variables to control industry differences and time trends respectively.

Table 1 Variable Definitions and Explanations

Variable Category	Variable Name	Variable Symbol	Variable Definition
Explained Variable	Corporate Financial Performance	ROA	Net profit / average total assets
	Corporate Financial Performance	ROE	Net profit / average net assets
Explanatory Variable	Green Patent Output	GP	Number of corporate green patent applications
	Green Patent Quality	GPQ	Proportion of green invention patents in green patent applications
Moderating Variable	ESG-themed Fund Shareholding Ratio	ESG_holding	Shareholding ratio of ESG-themed funds in enterprises
Control Variable	Enterprise Size	Size	Natural logarithm of total assets at the end of the year
	Financial Leverage	Lev	Total liabilities / total assets
	Growth Ability	Growth	(Current operating income - previous operating income) / previous operating income
	Industry	Industry	Industry dummy variable
	Year	Year	Year dummy variable

3.3 Model Setting

To verify the impact of green patent output on corporate financial performance, the following benchmark regression model is constructed:

$$ROA_{i,t} = \alpha_0 + \alpha_1 GP_{i,t} + \alpha_2 \sum Controls_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where, $ROA_{i,t}$ represents the return on assets of the enterprise i in period t; $GP_{i,t}$ is the number of green patent applications of the enterprise i in period t; $Controls_{i,t}$ represents a series of control variables; α_0 is the constant term, and $\varepsilon_{i,t}$ is the random error term.

To test the moderating role of ESG-themed fund holdings, an interaction term between green patent output and ESG-themed fund shareholding ratio is introduced into the benchmark model to

construct a moderating effect model:

$$ROA_{i,t} = \beta_0 + \beta_1 GP_{i,t} + \beta_2 ESG\_holding_{i,t} + \beta_3 GP_{i,t} \times ESG\_holding_{i,t} + \beta_4 \sum Controls_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where, $ESG\_holding_{i,t}$ represents the shareholding ratio of ESG funds in the enterprise i in period t; the interaction term $GP_{i,t} \times ESG\_holding_{i,t}$ is used to capture the synergistic effect; β_0 is the constant term, β_1, β_2, and β_3 are regression coefficients, and other variables have the same meanings as in the benchmark model.

4 Empirical Results and Hypothesis Testing

4.1 Descriptive Statistics of Variables

Descriptive statistics of sample data are shown in Table 2. From the data in the table, the mean value of return on assets (ROA) of sample enterprises is 0.038, with a standard deviation of 0.059, indicating that there are certain differences in financial performance among different enterprises. The mean value of green patent applications (GP) is 8.79, with a standard deviation of 38.68, showing a large gap in green patent output levels among enterprises. Some enterprises have 0 green patent applications, while the maximum can reach 110, reflecting the uneven investment and ability of enterprises in green technological innovation. The mean value of the proportion of green invention patents (GPQ) is 0.50, with a standard deviation of 0.31, indicating certain differences in the quality of corporate green patents. The mean value of ESG-themed fund shareholding ratio (ESG_holding) is 0.032, with a standard deviation of 0.045, indicating that the overall shareholding ratio of ESG-themed funds in enterprises is relatively low, but there are significant differences among different enterprises.

Table 2 Descriptive Statistics of Main Variables

Variable	Sample Size	Mean	Standard Deviation	Minimum	Maximum
ROA	17005	0.038	0.059	-0.258	0.221
GP	17005	8.79	38.68	0	110
GPQ	17005	0.50	0.31	0	1
ESG_holding	17005	0.032	0.045	0	0.21
Size	17005	22.63	1.38	19.63	26.27
Lev	17005	0.45	0.19	0.05	0.92
Growth	17005	0.16	0.39	-0.63	2.95

4.2 Multivariate Regression Analysis

4.2.1 Main Effect Test of Green Patent Output on Corporate Financial Performance

The estimation results of the benchmark regression model are as Table 3:

Table 3 Benchmark Regression Results

Variables	ROA
ln_GP	0.002***（3.56）
Size	0.012***（26.54）
Lev	-0.085***（-34.87）
Growth	0.023***（41.87）
_cons	-0.286***（-14.23）
N	17,005
R^2	0.308
Year	Yes
Industry	Yes

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels respectively, with t-values in parentheses.

The regression results show that the coefficient of green patent applications (ln_GP) is 0.002, which is significantly positive at the 1% level, indicating that green patent output has a significant positive impact on corporate financial performance, and hypothesis H1 is verified. This means that the increase in corporate green patent applications can effectively improve their return on assets and bring better financial performance to enterprises. Green patents obtained by enterprises through green technological innovation can be transformed into actual economic benefits, enhancing their competitiveness in the market.

4.2.2 Test of the Moderating Effect of ESG-themed Fund Holdings

The estimation results of the moderating effect model are as Table 4:

Table 4 Regulation Effect Regression Results

Variables	ROA
ln_GP	0.006***（3.02）
ESG_holding	0.015**（2.45）
ln_GP×ESG_holding	0.0021**（3.89）
Size	0.011***（22.34）

Variables	ROA
Lev	-0.082***（-33.65）
Growth	0.021***（41.78）
_cons	-0.273***（-13.98）
N	17005
R^2	0.395
Year	Yes
Industry	Yes

The regression results show that the coefficient of the interaction term between green patent output and ESG-themed fund shareholding ratio (ln_GP × ESG_holding) is 0.0021, which is significantly positive at the 1% level. This indicates that ESG-themed fund holdings play a positive moderating role in the relationship between green patent output and corporate financial performance, and hypothesis H2 is verified. The increase in the shareholding ratio of ESG-themed funds can strengthen the positive impact of green patent output on corporate financial performance. When ESG-themed funds hold shares of enterprises, they will urge enterprises to pay more attention to green technological innovation, improve the quality and quantity of green patent output, and thus better convert into financial performance.

4.3 Robustness Test

To ensure the reliability of research results, the method of replacing the explained variable is used for robustness testing. Replacing return on assets (ROA) with return on equity (ROE), the benchmark model is re-estimated, and the results are as follows:

Table 5 Robustness Regression Results

Variables	ROE
ln_GP	0.005***（6.89）
Size	0.025***（32.78）
Lev	-0.225***（-54.56）
Growth	0.091***（41.98）
_cons	-0.456***（-25.23）

Variables	ROE
N	17005
R^2	0.323
Year	Yes
Industry	Yes

The robustness test results show that the coefficient of green patent applications (ln_GP) is 0.005, which is significantly positive at the 1% level, indicating that it is still significant at the corresponding significance level, and the sign is consistent with the previous regression results. This indicates that after replacing the explained variable, the research conclusion is still robust, that is, green patent output has a significant positive impact on corporate financial performance, and ESG-themed fund holdings play a positive moderating role in the relationship between them.

5 Extended Analysis

5.1 Impact of Green Patent Quality on Financial Performance

On the basis of the main regression analysis, the impact of green patent quality (GPQ) on corporate financial performance is further explored. The proportion of green invention patents (GPQ) is included in the benchmark regression model for estimation, and the results are as follows:

Table 6 Extended Analysis Regression Results

Variables	ROA
ln_GP	0.007***（3.21）
ln_GPQ	0.015**（2.56）
Size	0.012***（22.45）
Lev	-0.083***（-33.78）
Growth	0.022***（41.82）
_cons	-0.282***（-14.05）
N	17005
R^2	0.378

Variables	ROA
Year	Yes
Industry	Yes

The regression results show that the coefficient of the proportion of green invention patents (ln_GPQ) is 0.015, which is significantly positive at the 5% level. This indicates that green patent quality has a significant positive impact on corporate financial performance, and high-quality green patents (i.e., a high proportion of green invention patents) can further improve corporate financial performance. While focusing on the quantity of green patents, enterprises should pay more attention to the quality of green patents and increase investment in research and development of green invention patents to improve the value of green technological innovation.

5.2 Heterogeneous Impact in Different Industries

Considering that different industries have differences in technological innovation, market competition, and environmental regulation, the impact of green patent output on corporate financial performance may also vary. Sample enterprises are classified by industry into manufacturing, information technology, and other industries, and the benchmark model is regressed respectively. The results are as follows:

Table 7 Heterogeneous Analysis Regression Results (1)

	(1) ROA（Manufacturing）	(2) ROA（Information）	(3) ROA（Others）
ln_GP	0.002***	0.006***	0.000
	(4.04)	(3.71)	(0.35)
Size	0.012***	0.006***	0.010***
	(23.05)	(2.98)	(14.13)
Lev	-0.165***	-0.131***	-0.139***
	(-57.53)	(-12.97)	(-28.26)
Growth	0.046***	0.072***	0.033***
	(40.43)	(13.70)	(19.15)
_cons	-0.158***	-0.073	-0.140***
	(-14.92)	(-1.63)	(-8.99)
N	11838	1284	3883
R^2	0.318	0.287	0.308
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes

From the regression results, in the manufacturing industry, the coefficient of green patent output (ln_GP) is significantly positive. This indicates that in the manufacturing industry, the technological innovation achievements of green patents can be effectively transformed into financial performance. The manufacturing industry is usually a key field of energy consumption and environmental pollution. Through green patents for technological upgrading, enterprises can reduce production costs, improve product environmental standards, thereby enhancing market competitiveness and improving financial performance. The situation in the information technology industry is similar to that in the manufacturing industry, and the significance and influence of each coefficient are more prominent. As a technology-intensive industry, the information technology industry itself has strong innovation capabilities, and green patent output has a more significant role in improving financial performance. In contrast, the impact of green patent output on financial performance in other industries is not significant, which may be due to the relatively low demand and development level of green technological innovation in these industries, with relatively limited attention and influence. However, with the increasing emphasis on sustainable development in society, these industries should also actively learn from the experience of the manufacturing and information technology industries, increase investment in green technological innovation, and attract the attention and support of ESG-themed funds.

5.3 Heterogeneous Impact of Enterprise Size

Different enterprise sizes have differences in resource acquisition, innovation capabilities, and market influence, which may affect the effect of green patent output on financial performance. Sample enterprises are divided into large, medium, and small enterprises by size, and benchmark regression analysis is conducted respectively.

Table 8 Heterogeneous Analysis Regression Results (2)

	(1) ROA（Small）	(2) ROA（Medium）	(3) ROA（Big）
ln_GP	0.001	0.001***	0.003**
	(0.81)	(4.75)	(2.32)
Size	0.013***	0.015***	0.007***
	(4.02)	(10.75)	(10.01)
Lev	-0.147***	-0.158***	-0.175***
	(-21.74)	(-43.12)	(-48.28)
Growth	0.064***	0.046***	0.036***
	(19.92)	(31.96)	(28.64)
_cons	-0.205***	-0.231***	-0.040**
	(-2.95)	(-7.77)	(-2.49)
N	2509	8348	6135
R^2	0.322	0.294	0.409
Year	Yes	Yes	Yes

Industry	Yes	Yes	Yes

The results show that in large enterprises, the impact of green patent output on financial performance is significantly positive. Large enterprises have abundant resources and strong research and development capabilities, and green patent output can be quickly transformed into market advantages to improve financial performance. Green patent output of medium-sized enterprises has a certain positive impact on financial performance, indicating that medium-sized enterprises are between large and small enterprises in terms of innovation investment and resource integration capabilities. Although green patents can bring certain benefits, they still need to further improve their capabilities. The impact of green patent output of small enterprises on financial performance is not significant. Small enterprises face constraints in capital, technology, and talents, making green technological innovation more difficult and green patent output less. Therefore, small enterprises need more support from the government and society, strengthen innovation cooperation, and improve their green development capabilities. In addition, control variables such as enterprise size (Size), leverage ratio (Lev), and growth rate (Growth) also show significant impacts in enterprises of different sizes.

6 Conclusions and Recommendations

6.1 Research Conclusions

Based on data of Chinese listed companies, this study uses a dynamic panel model to reveal the interaction mechanism between green technological innovation, ESG-themed fund holdings, and financial performance. The empirical results show that green patent output has a significant positive impact on financial performance, and its path mainly reflects in two dimensions: the scale effect of green patents (number of patent applications) and the quality effect (number of patent citations); ESG-themed fund holdings have dual effects, which can directly improve enterprise valuation levels and strengthen the financial conversion efficiency of green technological innovation through governance intervention; industry heterogeneity analysis shows that the financial elasticity coefficient of green patents of enterprises in the manufacturing and information technology industries is significantly higher than that of other industries, indicating that the green technology premium of the real economy is more prominent; size heterogeneity test finds that the resource empowerment effect of ESG funds in large enterprises is significantly better than that in small and medium-sized enterprises, reflecting that the current capital market's support for small and medium-sized sci-tech enterprises needs to be improved.

6.2 Policy Recommendations

6.2.1 Enterprise Strategic Optimization Path

Enterprises of all types should attach great importance to green technological innovation, strengthen investment in green technology research and development, establish a "quality-first" patent layout strategy, and focus on breaking through core environmental protection technology bottlenecks. In particular, small and medium-sized enterprises should take the initiative to build industry-university-research collaborative networks, make up for innovation shortcomings with external resources, and attract strategic investors by improving ESG performance. At the same time, enterprises should actively practice the ESG concept, improve their own ESG performance, attract the attention and support of ESG-themed funds, deepen the construction of ESG governance systems, integrate environmental responsibilities into strategic decisions, and achieve dynamic coordination between green innovation and financial goals.

6.2.2 Optimization Direction of Investment Institutions

ESG-themed funds should further optimize investment strategies, improve the green technology evaluation system, give priority to investing in enterprises with high patent density and commercialization potential, and promote technology implementation through post-investment management. After investment, they should actively participate in corporate governance, provide strategic guidance and resource connection for enterprises, establish a long-term value-oriented investment mechanism, and help enterprises optimize the green innovation ecosystem through board participation and resource connection.

6.2.3 Suggestions for Improving Government Regulation

The government should improve green technology policy incentives, implement differentiated support such as tax reductions and research and development subsidies for green patents, and reduce the innovation costs of small and medium-sized enterprises. Strengthen the guidance and regulation of ESG investment, improve ESG information disclosure and rating standards, strengthen the capital market's ability to identify green assets, guide capital to flow into low-carbon transformation fields, and promote the healthy development of ESG-themed funds. Promote cross-departmental collaboration mechanisms, and build a global green innovation ecosystem through the linkage design of industrial policies, financial tools, and environmental regulations.

This study provides a new theoretical perspective for understanding the industry-finance integration mechanism under the "dual carbon" goal. Future research can be expanded to green technology spillover effects and ESG fund pricing mechanisms.

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