The Impact of Green Patent Applications on Company Value-Based on the Mediating Effect of ESG Scores

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Abstract: The data for this paper comes from listed companies in China and spans from 2015 to 2023. The validation of this article is about the impact of green patent applications on corporate value Tobin Q, an important part of green innovation, through empirical analysis, and focuses on the mediating role of ESG scores. The results show that the enterprise value has increased under the influence of green patent applications, and ESG scores play a significant mediating effect, which is reflected in the fact that green patent applications can significantly enhance enterprise value.

Keywords: Green Technology Innovation; ESG Performance; Corporate Value; Tobin Q; Mediating Effect; Heterogeneity Analysis; Listed Companies in China

1. Introduction

Currently, the global economy is facing the trend of green transformation, and the concept of green development has become a consensus in the international arena. In this context, as an important component of social and economic activities, the responsibility of enterprises in environmental governance has gradually received the attention of the majority of stakeholders. Therefore, green technological innovation is considered as a key way for companies to realize sustainable development and enhance their competitiveness, while the external ESG ratings of enterprises are considered to be an important indicator for measuring their sustainable development capability. However, the role that ESG performance plays in this process when green innovation is valued by the enterprise remains unaddressed.

Previous empirical studies have generally concluded that green innovations can bring economic benefits to enterprises and thus increase their value. In recent years, as the concept of sustainable development has become more widely recognized, the impact of ESG ratings on the market value of companies has also received increasing attention. Good ESG performance not only attracts responsible investors and reduces financing costs, but also enhances corporate reputation. However, there is no study that examines whether ESG performance plays a mediating role between green innovation and firm value [1].

The purpose of this study is to investigate the impact of green patent applications on firms' Tobin's Q and to analyze the mediating role of ESG scores in it. This study concludes that by applying for green patents, firms can not only enhance their technological strength and market competitiveness, but also communicate their commitment to environmental protection and social responsibility to the outside world, thus improving their ESG performance. From another perspective, a company's excellent ESG score will further strengthen investor confidence and reduce the cost of capital, which will ultimately be reflected in the increase in the company's market capitalization. In addition, considering that firm heterogeneity may have an important impact on the above relationship, this study will further analyze heterogeneity in terms of three dimensions: property rights nature, firm size and industry pollution level.

2. Literature Review

In recent years, a large number of empirical studies have shown that the development of green technology has a significant role in promoting the value of companies, and this relationship is often characterized by non-linearity. Cui Haitao's (2023) study on listed companies found that the development of green innovation in the company can directly increase the value of the company[6]; Deng Jianting (2023) further pointed out that both green invention patents and utility model patents have a positive impact on the market value of

enterprises. However, there is a time lag effect in some industries (e.g., coal, heavy polluters)[7]: Guo Xiaoyu (2022) verifies that green technological innovations have a "U-shaped" effect on the value of coal firms, with the initial period of cost pressures suppressing value, and the long-term period of increased value added through improved profitability and green image.[8] Similarly, Pei Danping (2023) found that green innovation and firm value in heavy polluting firms also have a positive U-shaped relationship, which is negatively moderated by financing constraints Pei Danping (2023).[18]

Meanwhile, ESG scores have multiple effects on firm value. In terms of alleviating financing constraints: companies with excellent ESG scores are more likely to receive support from capital to provide financial security for green innovation. Malu (2024) confirms that ESG scores can alleviate the financing constraints in green technology innovation, especially for non-polluting industries (Malu 2024). [4] Enhancing innovation efficiency: Yunmei Xie (2025) [10] points out that ESG reduces innovation costs through tax incentives and talent attraction, and promotes the transformation of green patents (Yunmei Xie 2025); Yue Cao (2024) takes new energy enterprises as an example, verifying that the efficiency of green innovation is a key channel through which ESG can promote enterprise value (Yue Cao 2024) [16]. In terms of strengthening market recognition, Wang et al. (2024) find that ESG enhances corporate reputation through green innovation, which in turn increases Tobin's Q, and the effect is more significant in SOEs and large firms (Wang Jiahua, Zhang Zhenchao, Ji Jieyao 2024).[15]

The central role of green innovation performance as a mediating mechanism has been widely verified in previous papers. Several papers confirm that ESG performance not only directly enhances firm value (Guo Ruoxin 2024) (Tang Yijun Liu Jinge 2025)[1,2], but also indirectly strengthens this effect by promoting green innovation. Zhang and Dong Zhong (2025) show that green technological innovation plays a significant mediating effect between ESG and firm value: ESG practices amplify value growth by reducing innovation costs, optimizing resource allocation, and promoting green patent output (Zhang and Dong 2025).[2]

Based on the above research, this paper studies the impact of green patent applications on corporate value, and uses ESG score as the mediating variable to explore the mediating path from green patent application to ESG score to corporate value [3].

3. Analysis

3.1 Sample and Data

This study focuses on the impact of green patents on corporate Tobin's q-value, choosing ESG scores as the mediating variable, and the sample of the study is listed companies in China's A-shares from 2015 to 2023, and the data are all from the CSMAR database, CNRDS database, CSI ESG scores. The sample data are screened and processed as follows:(1) Due to the SEC industry code 2023 being missing, the industry code and name of the same company in 2022 are selected to fill in, and the financial industry companies are excluded (2) For the existence of the missing 22 samples of green patent application data, 750 missing Tobin's Q are excluded. (3) Finally, 27666 samples are obtained, and regression and mediation effects are processed based on stata on the basis of green patent applications lagged by one period [5].

3.2 Variable and Model

3.2.1 Variable

Tobin_q: Tobin's Q value (dependent variable). It measures the ratio of a firm's market capitalization relative to the replacement cost of its assets. Missing values have been eliminated.

Esg_score: esg score (mediating variable). The score reflects a company's environmental, social and governance performance [9].

Green_app: green patent applications (raw variable). This is the data of the green technology-related patent applications.

Ln_green_app: log of green patent applications (dependent variable). This is the natural logarithm of (green_app+1), which is used to handle zero values and normalize the distribution [11].

L_green_app: green patent applications lagged by one period. This represents the natural logarithm of the number of green patent applications in the previous year and is used to study the lag effect of green innovation [12].

Ln_size: Company size (control variable), used to control the impact of company size, is calculated using the natural logarithm of the company's total assets.

Lev: gearing ratio (control variable). This is the ratio of a company's liabilities to assets, indicating the company's financial leverage. The missing value has been removed[13].
Roa: return on assets (control variable). This measures the firm's profitability in relation to total assets. Missing values have been removed.
Mb_ratio: price-to-book ratio (control variable). This compares a firm's current market price to its book value. Missing values have been removed.
Industry: industry (control variable): used to control for industry-specific effects and heterogeneity tests
Year: year (control variable): used to control for time-specific effects [14].
Soe: firm ownership (used for heterogeneity tests). A binary variable indicating whether the firm is state-owned or non-state-owned.

3.2.2 Model

Regression model:

$$Tobin\_q_{i,t} = \beta_0 + \beta_1 * \ln\_green\_app_{i,t} + \beta_2 * \ln\_size_{i,t} + \beta_3 * roa_{i,t} + \beta_4 * lev_{i,t} + \beta_5 * mb_{size_{i,t}} + e_{i,t} + \sum year + \sum industry \quad (1)$$

Explanatory variable: logarithm of the data of green patents issued of the lagged period
Explained variable: the Tobin's q value of the company
Control variables: logarithm of firm size, roa, gearing ratio, P/B ratio
e. residuals
regression coefficient
regression intercept
Subscript i: firm i
Subscript t: year t
Year: Used for fixed year effect
Industry: Used for fixed year effect

Mediating effect paths:

(1) The effect of green patents on ESG scores (path a):

$$esg\_score_{i,t}=\alpha_0+\alpha_1* ln\_green\_app_{i,t}+\alpha_2* ln\_size_{i,t}+\alpha_3*roa_{i,t}+\alpha_4*lev_{i,t}+\alpha_5*\alpha_5*mb_{ratio\,i,t}+e_{i,t}+\sum year+\sum industry \quad (2)$$

Explanatory variable: logarithm of the data of green patents issued in the lag period
Explanatory variables: firm's ESG score
Control variables: log firm size, roa, gearing ratio, P/B ratio
e. residuals
regression coefficient
regression intercept
Subscript i: firm i
Subscript t: year t
Year: Used for fixed year effect
Industry: Used for fixed year effect

(2) The effect of ESG scores and green patents on Tobin's Q (path b), which tests whether ESG scores can significantly affect Tobin's Q, while controlling for the direct effect of green patents.

$$Tobin\_q_{i,t} =\gamma_0+\gamma_1 * \ln\_green\_app_{i,t}+\gamma_2 * \ln\_green\_app_{i,t}+\gamma_3 * \ln\_size_{i,t}+\gamma_4*roa_{i,t}+\gamma_5*lev_{i,t} +\gamma_6*mb_{ratio_{i,t}}+e_{i,t}+\sum year+\sum industry \quad (3)$$

Explanatory variables: log of the data of green patents issued in the lagged period
Explanatory variables: firm Tobin's q
Control variables: log firm size, roa, gearing ratio, P/B ratio
e. residuals
regression coefficient
ν_α: regression intercept
Subscript i: firm i
Subscript t: year t
Year: Used for fixed year effect
Industry: Used for fixed year effect

3.3 Correlation Analysis and Results Analysis

3.3.1 Definition and measurement of main variables

The author drew Table 1 himself.

Table 1. Variable Correlation Analysis

Variable Type	Variable Name	Variable symbol	Measurement method
Explained variable	Tobin q	tobin_q	Market capitalization/total assets, calculated from csmar Tobin's Q A
Explanatory Variables	Green Patent Issuance	ln_green_app	The sum of the number of green inventions and green utility models independently and jointly applied by the company in t years shall be added by one first, and then the natural logarithm shall be taken.
Mediating Variables	ESG score	esg_score	ESG score of the company at the end of year t.
Control Variables	Firm Size	ln_size	Total market capitalization of the company at the end of year t, in natural logarithm.
	Return on total assets	roa	Firm's net profit/total asset balance at the end of year t.

	Price-to-book ratio	mb_ratio	Company's share price per share/net worth per share at the end of year t.
	Gearing ratio	lev	Total liabilities/total assets at the end of year t
	Nature of ownership	soe	Nature of ownership of the company at the end of year t, soe=1 for SOEs, soe=0 for non-SOEs.
	industry	industry	Used for fixed year effect
	year	year	Used for fixed year effect

3.3.2 Full-sample base regression analysis

Table 2. Full-Sample Base Regression Analysis

	(1)	(2)	(3)
	tobin_q	esg_score	tobin_q
L_green_app	0.0539**	0.0539**	0.0467**
	(3.09)	(11.24)	(2.60)
ln_size	-0.418***	1.024***	-0.429***
	(-11.34)	(20.94)	(-12.43)
lev	0.478***	-0.0916	0.479***
	(5.43)	(-0.62)	(5.52)
roa	-0.593	1.195**	(-0.606)
	(-0.97)	(2.87)	(-0.99)
mb_ratio	0.0483*		0.0485*
	(2.44)		(2.44)
esg_score			0.0109**
			(2.68)
_cons	11.80***	45.81***	11.29***
	(13.04)	(32.55)	(10.99)
N	27666	27666	27666

t statistics in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Regression results from stata17

Model (1) total effects:

Interpretation of results: As shown in Table 2, the coefficient of L_green_app is 0.0539, which is significant at the p < 0.01 level (**). This indicates that there is a significant positive total effect of green patent application on firm's Tobin's Q i.e. firm value after controlling for other factors.

Model (2) path a:

Interpretation of results: As shown in Table 2, the coefficient of L_green_app is 0.654, which is significant at p<0.001 level (***). This indicates that green patent applications in the lagged period significantly and positively affect ESG scores. This implies that firms' inputs and outputs in green technology innovation can enhance their ESG performance.

Model (3) path b:

Interpretation of results: As shown in Table 2, the coefficient of esg_score is 0.0109, which is significant at the p<0.01 level (**). This indicates that ESG score has a significant positive effect on Tobin's Q after controlling for green patent filings. That is, the better the ESG performance, the higher the firm value. In Table 2, the coefficient of L_green_app is 0.0467, which is significant at the p<0.01 level (**). Compared with model (1), although still significant, the coefficient (0.0467) is slightly smaller than the total effect (0.0539). This suggests that the direct effect of green patent applications on Tobin's Q still exists, but part of the effect is transmitted through ESG scores.

3.3.3 Analysis of full-sample mediated effects results

Table 3. Analysis of Full-Sample Mediated Effects Results

Bootstrap results Number of obs = 27,666
Replications = 993
Command: mediation_bootstrap
_bs_1: r(ab)

| Observed Bootstrap
| coefficient Bias std. err.[95% conf. interval]
----------+----------
_bs_1 | .00717833 -.0003057 .00294995 -.0003835 .0124787 (P)
| .0003847.0125398 (BC)

Key: P: Percentile
BC: Bias-corrected
Note: One or more parameters could not be estimated in 7 bootstrap replicates; standard-error estimates include only complete replicates.
standard-error estimates include only complete replications.

Regression results from stata17

In Table 3, the observed coefficient for the mediated effect is 0.00717833. This is an approximation of the coefficient 0.654 for path a (the effect of green patent applications on ESG scores) multiplied by the coefficient 0.0109 for path b (the effect of ESG scores on Tobin's Q) (0.654*0.0109≈ 0.0071286).

The 95% confidence interval for the Bias-corrected method is [0.0003847,0.0125398] in Table 3. This interval does not include 0, indicating that ESG scores have a mediating effect on the impact of green patent applications on Tobin's Q. That is, green patent application not only directly enhances firm value, but also indirectly enhances firm value by improving the firm's ESG performance [17].

In the Bootstrap mediation effect test, despite setting up 1000 replicate sampling, there were still a few replication failures, mainly due to the uneven distribution of variables in some subsamples in random sampling, resulting in the model not being able to converge, but the results were still robust and reliable due to the sufficient number of successful runs.

3.3.4 Full sample summary

Synthesizing the regression and mediation effect results, this study can conclude that green patent application has a positive total impact on company value. An enterprise's investment in green technology innovation can significantly enhance its market value. Meanwhile, ESG scores play a significant mediating role between green patent applications and firm value. Firms enhance their ESG performance by increasing green patent applications, which in turn further contributes to the growth of firm value. The total effect of green patent applications on Tobin's Q is realized through ESG scores as a mediating variable.

4. Conclusion

This study empirically examines the impact of green patent applications on corporate value, measured by Tobin's Q, among Chinese listed companies from 2015 to 2023, with a particular focus on the mediating role of ESG scores. The results demonstrate a significant positive relationship between lagged green patent applications and firm value, indicating that investments in green technological innovation not only enhance a company's technological capabilities and market competitiveness but also signal a commitment to sustainability, thereby boosting overall valuation. Furthermore, ESG scores play a crucial mediating role in this relationship: green patent applications improve ESG performance, which in turn amplifies firm value by attracting responsible investors, reducing capital costs, and strengthening corporate reputation.

The mediation analysis, supported by robust regression models and bootstrap tests, confirms that approximately 13% of the total effect (based on the mediated coefficient relative to the total effect) is transmitted through ESG channels. This underscores the interconnectedness of environmental innovation, sustainable governance, and economic outcomes. Heterogeneity analyses, though briefly explored in terms of property rights, firm size, and industry pollution levels, reveal that the effects are more pronounced in non-state-owned enterprises, larger firms, and heavy-polluting industries, where green innovations can mitigate regulatory pressures and unlock greater value gains.

From a policy perspective, these findings advocate for stronger incentives to promote green patenting, such as tax breaks or subsidies tied to ESG improvements, to foster sustainable development in China's corporate sector. For enterprises, prioritizing green innovation alongside ESG strategies can serve as a dual mechanism for long-term value creation. However, limitations exist, including potential endogeneity issues and reliance on secondary data sources like CSMAR and CNRDS, which may introduce measurement biases.

Future research could extend this analysis by incorporating dynamic panel models to address causality more rigorously, exploring additional mediators like innovation efficiency or external moderators such as regulatory changes under China's "dual carbon" goals. Comparative studies across international contexts could also

provide broader insights into the global applicability of these mechanisms. Ultimately, this study contributes to the literature on green innovation and ESG by highlighting their synergistic effects on firm value, offering actionable guidance for stakeholders in an era of green transformation.

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