Can ESG ratings promote corporate greening? --Validation based on the double difference method

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Abstract. Drawing on comprehensive data from China's A-share listed companies over the 2009 to 2021 period, this study utilizes a multi-period difference-in-differences (DiD) model to investigate corporate green transformation in detail. This approach is innovative in its use of green patent licenses and core green licenses as primary indicators, chosen to accurately assess the degree of transformation in environmental sustainability initiatives. The analysis reveals that the introduction of ESG ratings exerts a significant positive influence on corporate green development, as reflected in marked improvements in these green indicators after ESG ratings are adopted. Such findings underscore the important role of ESG ratings in driving sustainable business practices and provide robust evidence that ESG mechanisms are essential in promoting green transformation across enterprises. Based on these insights, it is recommended that governmental bodies intensify the promotion and implementation of green financial policies, which would offer more substantial policy backing for enterprises striving toward green and sustainable growth.

Keywords: ESG rating; green transition; multi-temporal double difference model.

1. Introduction

Chinese economic expansion has increasingly conflicted with environmental priorities, shifting the focus from rapid growth to sustainable, high-quality advancement. Driven by a commitment to sustainability, corporate ESG performance has gained considerable attention. ESG, encompassing Environmental, Social, and Governance principles, serves as a comprehensive benchmark for assessing a company's dedication to sustainable practices, reflecting their contributions to ecological and societal goals on a detailed, micro-level scale [1]. Under the guidance of the national goal of "carbon peak and carbon neutrality", it is a must for enterprises to practice ESG sustainable management and achieve high-quality development with green and low-carbon [2].

In 2004, the Principles for Responsible Investment, a United Nations-supported initiative, first introduced the idea of incorporating Environmental, Social, and Governance (ESG) factors into the investment decision-making process. Since then, ESG investing has gradually become mainstream, and more and more investors and financial institutions around the world have begun to adopt ESG criteria to assess the long-term value and risk of companies. Numerous studies have explored the impact of green finance on enterprise development, though they primarily focus on macro-level indicators, such as national policy. For instance, some suggest that central bank-backed green financial policies encourage corporate green transformation by lowering financing costs for environmentally sustainable enterprises [3]; from an environmental regulation perspective, it is noted that environmental taxes, serving as a form of economic incentive regulation, can raise corporate governance costs and compel companies to pursue green transformation [4]. Additionally, an analysis of environmental, social, and governance disclosures on the green innovation performance of highly polluting companies found a U-shaped correlation between these factors and performance [5]; the impact of ESG ratings on corporate green innovation reveals that, although ESG ratings increased the quantity of green innovations, they were associated with a decline in their quality [6]. However, a growing number of scholars argue that ESG positively influences corporate green transformation, with research indicating that a robust ESG framework can effectively support this transition [7], and robust ESG performance can also create moral capital, offering an insurance-like benefit that helps

mitigate corporate risk [8], and in turn, lowers the compensation expectations of investors and creditors, thereby reducing both the cost of equity and the cost of debt for the company [9,10].

Based on this this paper selects a sample of listed companies in China from 2009-2021 to explore whether the emergence of ESG ratings has increased the degree of green transformation of enterprises. The possible marginal contribution is that this paper will explore whether the development of ESG ratings increases the degree of greenness of enterprises from the perspective of green transition, enriching the literature in the field of "microeconomic consequences of green finance". On a practical level, the paper emphasizes that the emergence of ESG ratings has a facilitating effect on the green transition of firms and may contribute to the construction of ESG ratings.

2. Literature Review and Research Hypothesis

2.1. Theoretical Analysis

As global demands for environmental responsibility intensify, ESG ratings have gained increasing importance among companies. Serving as a critical bridge between businesses and the market, ESG ratings play a pivotal role in guiding corporate transformation and advancement. According to signaling theory, ESG ratings communicate a company's commitment to environmental stewardship, social responsibility, and strong governance to external stakeholders. By enhancing transparency through third-party validation, ESG ratings help reduce information asymmetry between firms and the public, encouraging informal environmental oversight from stakeholders. This process creates market-based incentives that foster corporate green transformation. It also establishes a market-based governance mechanism aligned with incentives to drive corporate green transformation [11]. In advancing corporate green transformation, the adoption of green policies and the development of green patents and innovations are essential. Green policies often strengthen an enterprise's commitment to sustainable practices, boosting its motivation to pursue green innovations.

Based on the above analysis, this paper proposes the following research hypotheses：

Research Hypothesis 1: ESG ratings enhance the frequency of green patents among companies.

Research Hypothesis 2: SG ratings contribute to an increase in authorized green innovations within firms.

2.2. Model Methodology

Currently, official ESG rating standards have not yet been established by regulatory authorities. Instead, ESG data are primarily issued by independent rating agencies and closely monitored by investors and stakeholders within the capital market. As such, ESG ratings function as an external governance mechanism, encouraging corporate transformation and reform with considerable influence on business practices. To examine whether the introduction of ESG ratings improves corporate efficiency (Research Hypothesis 1), this study constructs a model that utilizes the exogenous shocks generated by Shangdao Ronglv's initial release of ESG ratings for listed companies. Employing a multi-period difference-in-differences approach, the model is designed to capture the impact of ESG ratings over time. The structure of the model is outlined below:

$$patent_{it}=\lambda_0+\lambda_1 ESG_DID_{it}+\gamma X_{it}+u_i+\eta_i+\varepsilon_{it} \quad (1)$$

Included among these $patent_{it}$ is the return on assets of firm i in year t in place； $ESG_DID_{it}$is the core explanatory variable, and if the Business Way Ungreen publishes data on firm i's ratings in year t, then ESG_DID_{it}=1, otherwise$ESG_DID_{it}=0$. The model also includes X_{it}, a set of control variables accounting for other relevant firm characteristics. Additionally, u_i represents an individual fixed effect for each firm, η_i denotes a time fixed effect to control for temporal factors, and ε_{it} is the random error term. $invent_{it}$is the number of green inventions licensed by firm i in year t. The rest of the variables are consistent with the above and are explored using the same model.

To gain deeper insights into the dynamic impact of ESG ratings and to test for parallel trends, this study employs a dynamic difference-in-differences model. This approach allows for an examination of how ESG ratings influence corporate outcomes over multiple time periods, providing a nuanced understanding of the ratings' effects. The model specification is detailed below:

$$patent_{it}=\alpha+\beta^{precut}[D_i*\mathrm{I}(\text{t-}T_D<-3)]+\sum_{s=-3}^{-2}\beta^{pre}[D_i*\mathrm{I}(\text{t-}T_D=\mathrm{S})]+\sum_{s=-0}^{2}\beta^{post}[D_i*\mathrm{I}(\text{t-}T_D=\mathrm{S})]+\beta^{postcut}[D_i*\mathrm{I}(\text{t-}T_D>2)]+\gamma X_{it}+u_i+\eta_i+\varepsilon_{it} \quad (2)$$

In this model, D_i=1 indicates firm i belongs to the treatment group, while D_i=0 designates it as part of the control group; the function I() serves as a schematic indicator, and T_D presents the current period of the ESG rating, measured relative to the ESG release date（t-T_D=S）, with s=-1 as the base period. All other variables are consistent with those in equation (1). The key coefficient, β, captures the dynamic effect of ESG ratings on corporate performance, allowing us to evaluate whether the multi-period difference-in-differences model constructed here meets the parallel trend assumption.

2.3. Variable Settings

2.3.1 Core explanatory variables

ESG ratings have always been launched by third-party organizations, which can be found in the Wind database, such as CSI, FTSE Russell, Shangdao Ronglv, and the Social Value Investment Alliance. Shangdao Ronglv holds the distinction of being the first organization in China to release comprehensive ESG rating data, positioning itself as a pioneering force in responsible investment standards within the country. It was also the first Chinese service provider to formally endorse the United Nations Principles for Responsible Investment (UNPRI), aligning its practices with internationally recognized sustainability principles. Shangdao Ronglv's annual reports on responsible investment in China, along with its ESG rating analyses of A-share-listed companies, have gained considerable attention from capital market stakeholders. Widely regarded as authoritative, these reports highlight Shangdao Ronglv's role in promoting corporate standards for environmental, social, and governance practices in China. Consequently, this study uses the ESG rating data published by Shangdao Ronglv as core explanatory variables. If the data of firm i in year t is released it is the treatment groupESG_DID_{it}=1，Otherwise considered as a control group ESG_DID_{it}=0.

2.3.2 Explanatory variable

The core of the question of whether enterprises have greening behaviors is whether they have truly undergone green transformation. Regarding the green transformation of enterprises, some literatures measure it by constructing a series of green indicators, such as from the perspectives of green culture, green strategy and so on. In this paper, we will measure whether enterprises have carried out transformation from the perspective of green innovation, so we choose green patent authorization and green innovation authorization as the explanatory variables to measure the effect of enterprises' green transformation.

2.3.3 Control variable

In this paper, we control for the size of the firm (asset); the firm's gearing ratio (lev); the proportion of shares held by the first largest shareholder (top1); the firm's fixed assets (fixed); the firm's income; the firm's ROA (roa); the firms income(income); the firm's number of people (people); and the growth rate of the firm's income (growth). The natural logarithm of the fixed assets of the enterprise, the natural logarithm of the income of the enterprise, the natural logarithm of the number of people of the enterprise, and the growth rate of the income of the enterprise to determine the development of the enterprise.

2.4. Data Sources

Given that Business Way R&F began publishing green rating data in 2015, this study examines A-share listed companies over the 2009-2021 period to assess how ESG ratings have influenced

corporate green transformations. The sampling process included specific criteria: (1) financial firms and those categorized as ST, ST*, and PT for any given year were removed; (2) newly listed firms in each year were excluded to mitigate potential disclosure discrepancies due to shorter listing durations; and (3) observations with substantial missing data were omitted, resulting in a final dataset of 26,303 records. To reduce the influence of outliers on the analysis, continuous variables were winsorized at the 1st and 99th percentiles using Stata. This process limits extreme values, enhancing the robustness of the results by keeping the data within a controlled range. ESG ratings were sourced from the Wind database, while data on green innovation metrics were collected from the China Research Data Service Platform (CNRDS). Additional company-related information, such as financial and operational data, was gathered from the CSMAR database.

3. Empirical Findings

3.1. Descriptive Statistics for Variables

Table 1 presents the results of the descriptive statistics. The main explanatory variable, patent, shows a mean of 0.755, with values ranging from a minimum of 0 to a maximum of 4.369, and a standard deviation of 1.063. This suggests that there is a considerable spread in patent activity among the firms studied. The other key explanatory variable, INVENT, has a maximum of 3.367, a minimum of 0, and a standard deviation of 0.677, indicating a generally low level of green innovation across firms. For control variables, the maximum is 26.364, the minimum is 20.071, and the mean is 22.333, showing that the study captures a diverse range of firm sizes. The average enterprise debt ratio is 0.43, suggesting that, on average, liabilities constitute roughly half of the assets, which is considered balanced and manageable (refer to Table 1).

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
patent	26303	0.755	1.063	0	4.369
invent	26303	0.314	0.677	0	3.367
esg did	26303	0.148	0.355	0	1
roa	26303	0.042	0.057	-0.217	0.197
asset	26303	22.333	1.302	20.071	26.364
lev	26303	0.43	0.204	0.007	1.65
top1	26303	35.152	15.227	2.43	89.99
fixed	26301	20.394	1.679	16.117	24.96
growth	26303	1.366	0.905	0.366	7.245
income	26303	21.665	1.437	18.834	25.78
people	26291	7.818	1.235	4.99	11.267

3.2. Base Regression Analysis

The effect of ESG ratings on green patent licenses compared to green invention licenses is examined next. Initially, a regression analysis using model (1) was conducted, with the findings displayed in Table 2. All regression models incorporate both firm-specific and year fixed effects to control for unobserved heterogeneity across firms and time, ensuring that the results capture more accurate relationships by accounting for factors unique to each firm and year. As shown in Table 2, ESG ratings significantly contribute to increases in both green patent issuance and green innovation activities. Specifically, the results from regressions (1) and (3) indicate that ESG ratings boost green patent approvals by an average of 18.1% in the year following the rating and green invention licenses by 15%, both of which are statistically significant at the 1% level. When control variables are included in the analysis, as shown in regressions (2) and (4), ESG ratings continue to demonstrate a positive effect on both green patent issuance and innovation licensing. This suggests that the favorable impact of ESG ratings on green initiatives remains robust even after accounting for additional factors. Further analysis of control variables reveals that both company asset size and age are critical factors in green

transformation, with larger, more established companies demonstrating stronger engagement in green practices (refer to Table 2).

Table 2. Regression results

	(1) patent	(2) patent	(3) invent	(4) invent
esg_did	0.181***	0.132***	0.169***	0.150***
	(6.555)	(4.846)	(8.125)	(7.238)
asset		0.141***		0.061***
		(4.653)		(3.187)
fixed		0.052***		0.026***
		(3.404)		(2.730)
people		0.062***		0.025**
		(2.873)		(1.970)
growth		0.006		0.005
		(1.062)		(1.418)
income		0.010		-0.012
		(0.460)		(-0.868)
age		0.053***		0.023***
		(14.823)		(9.601)
top1		0.000		-0.000
		(0.291)		(-0.189)
_cons	0.184***	-4.788***	0.049***	-1.805***
	(8.703)	(-9.924)	(3.524)	(-5.719)
N	26303	26290	26303	26290
R2	0.180	0.202	0.091	0.098
F	110.898	82.787	51.416	36.500

* 0.1 ** 0.05 *** 0.01 Values in parentheses are the t-values of the regression results

3.3. Robustness Check

To perform a parallel trend test and gain deeper insights into the dynamic effects of ESG ratings, this study re-assesses the influence of ESG ratings on corporate green innovation and total factor productivity by applying model (2). This approach allows for an examination of how ESG ratings impact these metrics over time. The results, displayed in Figures 1 and 2, indicate that there were no notable differences between the treatment and control groups for up to three years before the introduction of ESG ratings. This finding suggests that prior to the ESG ratings, both groups followed similar trends, supporting the validity of the parallel trend assumption. However, a notable divergence appears in the year before the ratings are implemented, suggesting a potential lag effect. This implies that companies with visible green transformation behaviors are more likely to receive an ESG rating from third-party institutions. Post-ESG rating, there is a significant increase in green patent and invention authorizations within the treatment group, with regression coefficients significantly above zero at the 1% level, confirming the positive influence of ESG ratings on corporate green practices.

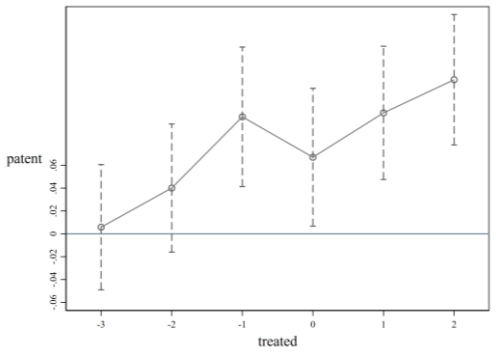


Fig. 1 Patent robustness check

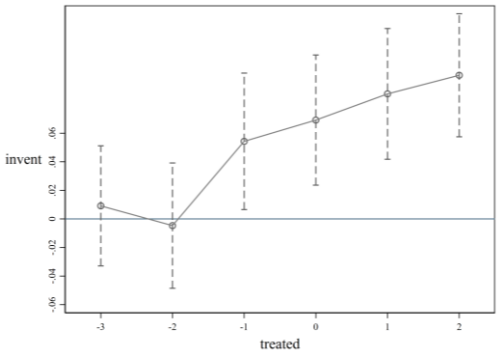


Fig. 2 Invent robustness check

3.4. Placebo testing

To ensure that the observed impact of ESG ratings on corporate green transformation is not merely the result of random chance, a placebo test is used to assess the robustness of the ESG effect. This test includes the creation of "pseudo-policy dummy variables," which are developed according to the distribution patterns of ESG rating variables observed in the baseline regression. By introducing these dummy variables, the placebo test helps to isolate any potential external influences and verify that the positive effect associated with ESG ratings is indeed genuine rather than coincidental or spurious. By drawing 500 random samples, the model (1) is re-estimated to examine the P-value distribution, with results displayed in Figure 3 and Figure 4. The average regression coefficients for green invention and green patent licensing with the pseudo-policy variable are close to zero and notably lower than the original benchmark coefficients. The estimated coefficients exhibit an approximately normal distribution, with most P-values exceeding 0.10. This outcome suggests a lack of statistical significance at the 10% level, indicating that the observed effects are unlikely to be meaningful or attributed to random variation. This confirms that the ESG rating effect on green patent and invention licensing is not influenced by random variables, supporting the reliability of the findings.

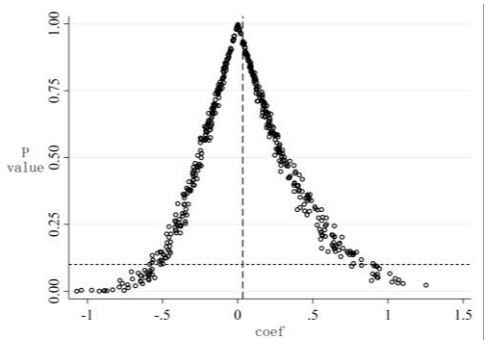


Fig. 3 invent placebo test

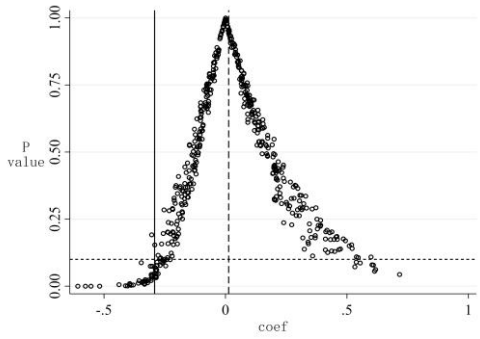


Fig. 4 patent placebo test

4. Conclusions

Amid Chinese shift toward sustainable development, corporate green transformation has become essential in meeting both environmental goals and economic growth targets. This study leverages ESG ratings as a key external factor to demonstrate how these ratings serve as a catalyst for sustainable innovation within companies, encouraging the pursuit of green patents, eco-friendly technologies, and environmentally conscious licensing practices. The findings reinforce the positive influence of ESG frameworks, highlighting their role not only in promoting environmental responsibility but also in aligning corporate actions with national and international sustainability goals. The evidence suggests that, beyond individual company impact, ESG ratings contribute to broader market and policy shifts that prioritize green initiatives. In light of these insights, this study recommends that policymakers and financial institutions work collaboratively to expand green finance policies, which would provide additional support and incentives for companies. A wider adoption of these policies could further accelerate the transition toward a more sustainable, low-carbon economy, positioning China as a leader in corporate sustainability.

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