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Addressing Path Identification for ESG-driven Corporate Sustainability Through Mediated Effects Modelling

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Abstract. In the context of ecological civilisation construction, environmental, social and governance(ESG) performance as a crucial measure of a company's capacity for sustainability, its value creation path still needs to be explored in depth. Considering data from Chinese A-share companies that were listed between 2015 and 2022, this study constructs a theoretical model with green innovation efficiency (GIE) as the core mediating variable, and empirically uses the fixed effect model and mediated effect analysis to examine how ESG performance influence the business sustainable development ability The study finds that ESG performance significantly enhances corporate sustainability, and GIE plays a partly mediating role in it, and the conclusion is still valid after the robustness test. This study reveals the intrinsic path of ESG driving sustainable development through optimising green innovation resource allocation. The study provides solid theoretical support and a forward-looking action plan for companies to deepen their ESG practices and transform their innovation efficiency.

Keywords: Mediation effects modelling, ESG performance, sustainability

1. Introduction

In today's world, corporate sustainability serves as an important indicator of greater economic development. In this way, the ESG concept swiftly became a crucial framework for determining the long-term importance of an enterprise and capacity to handle sustainability challenges.

Scholars have widely argued the relationship between ESG performance and core competitiveness issues of firms, such as innovation capability and performance [1,2]. However, the mechanism of how ESG translates into sustainable growth capability within firms remains to be improved.

With an emphasis on the mediating function of GIE, this study attempts to investigate how ESG-rated performance improves organizations' ability for sustainable growth. The inquiry applies to the panel fixed effect model and the mediation effect analysis method to address this issue. The contribution of this study mainly lies in revealing the transformation mechanism of green innovation efficiency of ESG-driven sustainable development and expanding the research perspective of ESG on corporate value.

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2. Method

2.1. Literature review and theoretical analysis

Glen Hutchings states that disclosure of corporate ESG performance indicators can improve the efficiency of sustainable financial markets [3]. Li Jinglin et al. state that corporate ESG performance can significantly enhance corporate performance [2]. Ahmed Saber Moussa states that the link is positive between ESG performance and market capitalization [4]. Within the studies discussed previously, ESG performance essentially reconstructs the core competencies of corporate sustainability. Mahajan Ritika et al. systematically sorted out the theory of stakeholders. This theory states that firms actively fulfilling their responsibilities can effectively satisfy the expectations of multiple actors and thus win key resources [5]. Shahzad, Muhammad Farrukh, also pointed out that Manufacturing companies' environmental performance has a significant impact by stakeholder interest [6].

Combining stakeholder theory. High ESG rating performance is conducive to meeting multiple stakeholder needs and helps to maintain stable cash flow and market reputation by reducing corporate compliance risk, which further translates into long-term stable financial performance and ultimately develops corporate sustainability (SGR).

H1: A company's sustainability and its ESG rating are positively correlated.

Sam El Nemar combines the concepts of the resource-based view, stating that firms can strengthen their position in the marketplace by utilising their strategic resources to create value for the firm and to help them build and maintain an advantage [7]. Combined with the resource-based view, high ESG ratings can guide R&D resources (inputs) to be more efficiently invested in high-return green projects and improve green innovation efficiency (GIE) [8].

H2: The ESG rating of enterprises has a positive correlation with green innovation efficiency.

Combined with the resource-based view theory, a high GIE implies that firms can obtain more green patents at a lower cost. These patents help firms to enter new markets, increase the net sales margin and asset turnover ratio, and ultimately increase the SGR.

H3: Green innovation efficiency is positively related to corporate sustainability.

Superior ESG performance, as an action in response to stakeholder demands, can bring information and financial resources to the enterprise, and if these resources can be allocated to green innovation activities, it will lead to the growth of enterprise revenues, and ultimately realise the leap in the enterprise's ability to grow sustainably.

H4: The mediating role played by green innovation efficiency between firms' ESG ratings and sustainability.

2.2. Design of research

2.2.1. Sample selection and data sources

The study's sample is selected from A-share listed firms in China between 2015 and 2022, and after data cleaning and variable construction, this paper obtains unbalanced panel data containing 5,588 unique business subjects and 33,512 firm-year observations in total. The time distribution of the sample is relatively homogeneous. In the subsequent regression analyses, the effective sample size is adjusted to 20,571 to 23,454 observations due to the treatment of missing values of explanatory and control variables and the requirement of lagging the dependent variable by a single time frame. The data of CSI ESG ratings are obtained from the financial terminal of Wind, the financial data are

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obtained from CSMAR, and the data of green innovation patents are obtained from CNRDS. The data statistics and processing software is Stata18.0, which improves the validity of the estimated parameters by shrinking the continuous variables by 1% before and after.

2.2.2. Variable settings

Explanatory variable: ESG rating performance. Drawing on Chen Nanxu et al.'s study, corporate ESG rating performance uses CSI ESG rating data as a proxy variable [9].

Explained variable: sustainability. Based on Yang Xudong et al.'s research, corporate sustainability indicators, such as net sales profit x earnings retention rate x (1+equity ratio)/(1/total asset turnover rate - net sales profit rate earnings retention rate x (1+equity ratio)), are constructed using the Van Horn static model of sustainability to assess the sustainability capacity of listed companies [10].

Mediating variable: green innovation efficiency. Drawing on Liu Chang et al.'s study, the proportion of the logarithm of green innovation inputs and outputs is used to calculate GIE [8]. Considering the lag between ESG performance and SGR output, this paper lag the explanatory variable SGR by one period (SGRt+1).This study also considers industry and year fixed effects.

Control variables: (1) firm size, (2) gearing ratio, (3) profitability, (4) growth, and (5) equity concentration.

2.2.3. Model specification

This study aims to construct the mediating effect of ESG ratings (ESG) on sustainability (SGR) through green innovation efficiency (GIE). To control for omitted variable bias, a two-way fixed effects model for firm and year is used to estimate each model. In this paper, regression models (1) to regression model (3) are set to test hypotheses 1 to 4. The following is how the mediation effect model is put together:

Model (1): test the overall impact. As shown in equation (1). (ESG→SGR) (Path C)

Model (2): examine how ESG affects the mediating variable GIE. As shown in equation (2). (ESG→GIE) (Path A)

Model (3): evaluate the combined impact of GIE and ESG on SGR. As shown in equation (3). (ESG+GIE→SGR) (Path C' + Path B)

$$SGR_{I,t+1} = \alpha_0 + \alpha_1 ESG_{I,t} + \sum \alpha_k Controls_{I,t} + \sum \lambda_j Ind_j + \sum \theta_t Year_t + \varepsilon_{I,t+1} \quad (1)$$

$$GIE_{I,t} = \beta_0 + \beta_1 ESG_{I,t} + \sum \beta_k Controls_{I,t} + \sum \lambda_j Ind_j + \sum \theta_t Year_t + \mu_{I,t} \quad (2)$$

$$SGR_{i,t+1} = \gamma_0 + \gamma_1 ESG_{i,t} + \sum \gamma_2 GIE_{i,t} + \sum \gamma_k Controls_{i,t} + \sum \lambda_j Ind_j + \sum \theta_t Year_t + \nu_{i,t+1} \quad (3)$$

$SGR_{i,t+1}$ represents the firm's sustainability in period t+1, using a lag of one period to mitigate the reverse causality problem. $ESG_{i,t}$ denotes the composite ESG rating of company i during time t and is the fundamental explanatory variable. $GIE_{i,t}$ denotes the GIE of company i during time t. It is used to test the transmission path of ESG affecting SGR.

$\alpha_0, \beta_0, \gamma_0$ represent the baseline values for each of the three models. Ind_j is an industry fixed effect, implying a control for industry heterogeneity that does not change over time. $Year_t$ is a year fixed effect, implying control for time trends and macro shocks.

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3. Results

3.1. Descriptive statistics

From the distribution of samples, the number of observations of sustainable development capability is the largest, while the number of observations of green innovation efficiency is relatively small, and the reason for this difference is the restricted availability of green patent data. In terms of the distribution characteristics of the core variables, there are significant differences in the sustainability ability of different enterprises, and the data distribution is relatively dispersed. The results of ESG show that the overall level of ESG of listed companies is at a medium level, but there is still a certain gap in the level of ESG construction of different enterprises. The results of GIE show that the input and output efficiencies of green innovation of some enterprises are low, and the number of observations of green innovation efficiency is relatively small fewer. In terms of control variables, these statistical characteristics indicate that the sample selection is representative, which lays a good foundation for the following analysis.

3.2. Correlation between variables

Table 1 shows the matrix of Pearson correlation coefficients between the variables. Firstly, ESG performance and SGR have a weakly positive association, a result which suggests that this relationship is real and not caused by random errors. Secondly, GIE and ESG performance are significantly positively correlated, which first demonstrates the mediating effect's existence—that is, companies with superior ESG performance typically have higher GIE, supporting the theoretical path that ESG performance influences firms' sustainable development by promoting green innovation. Regarding the control variables' correlation, size shows a strong positive relationship with GIE, indicating that larger firms have a better resource base for green technological innovation. lev is negatively correlated with roa. Share is positively correlated with ESG, suggesting that appropriate equity concentration may contribute to the implementation of a firm's long-term ESG strategy. In addition, the absolute values of the variables' correlation coefficients and the variation in the inflation factor test findings show that each variable's VIF values show that the model is appropriate for further regression analysis.

Table 1.Variable correlation analysis

	SGR	ESG	GIE	size	lev	roa	growth	share
SGR	1.000							
ESG	0.044***	1.000						
GIE	0.004	0.145***	1.000					
size	-0.003	0.230***	0.462***	1.000				
lev	0.028***	-0.026***	0.306***	0.582***	1.000			
roa	-0.014**	0.183***	-0.044***	-0.057***	-0.385***	1.000		
growth	0.028***	-0.031***	0.025***	0.030***	0.042***	0.207***	1.000	
share	-0.007	0.140***	-0.025***	0.104***	-0.075***	0.230***	0.055***	1.000

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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3.3. Analysis of baseline regression findings

The mediation effect test results are shown in Table 2. This study examines the mediating role of GIE between corporate ESG performance and corporate sustainability through three models step by step.

Table 2. Inter mediation effect three-step regression results

	SGR	GIE	SGR
ESG	0.001***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)
size	-0.008	0.020**	-0.026**
	(0.016)	(0.001)	(0.013)
lev	-0.069	-0.002	0.127***
	(0.057)	(0.005)	(0.028)
roa	0.185**	-0.013*	0.169**
	(0.093)	(0.007)	(0.079)
growth	1.816***	-0.136	2.515***
	(0.621)	(0.087)	(0.506)
share	0.022	0.014**	0.023
	(0.031)	(0.007)	(0.033)
GIE			0.073**
			(0.036)
Constant	0.027	-0.447***	0.460*
	(0.357)	(0.032)	(0.255)
Observations	23454	20571	20571

Standard errors in parentheses

* p < 0.10, ** p < 0.05, *** p < 0.01

3.3.1. Total effects test

The overall impact of ESG performance on SGR is tested using model (1). At the 1% level ($p < 0.01$), the regression results demonstrate that ESG is considerably positive, which indicates that a company's future sustainability is greatly impacted by improving its ESG performance. This regression result supports research hypothesis H1.

Regarding control variables, the coefficients of growth and ROA are both significantly positive at the 1% and 5% levels, respectively, suggesting that growth and profitability support the sustainability of businesses.

3.3.2. Intermediary path test and tests for direct and mediating effects

Model (2) tests the ESG performance's impact on the mediating variable GIE. According to the regression results, firms' ESG performance can greatly improve their GIE. The correlation coefficient of ESG is 0.000, which is statistically positive at the 1% level ($p < 0.01$). This finding validates the research hypothesis H2, which states that ESG performance influences sustainable development capability by promoting corporate green technology innovation. Among the control

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variables, GIE is significantly improved by firm size, indicating that larger firms have more resources and ability to carry out green technology innovation.

Model (3) contains two variables, ESG performance and GIE. The regression results show that ESG is significantly positive at the 5% level, which is statistically significant although the significance level has decreased compared to model (1), suggesting that corporate sustainable growth is facilitated by ESG performance. In the meantime, GIE is exceedingly favorable at the level of five percent, suggesting that improving GIE can greatly raise an organization's SGR.

3.3.3. Intermediation effects conclusions

The following techniques are used in this study to thoroughly test the benchmark regression's findings: first, change the measurement method of the explanatory variables, consult Chen Nanxu et al.'s work, and replace the CSI ESG ratings with the ESG score data released by Bloomberg [9]. Second, replace the mediator variables, consult the Liu Chang et al. research, and substitute the total number of green invention patents filed by publicly traded firms in the current year for the GIE calculation, as well as the ratio of the log of R&D investment to the logarithm of utility patents plus one [8]. Third, replacing the explanatory variables, citing the Yang Xudong et al. paper, and using the sustainable growth rate indicator in the CSMAR database to replace the SGR of sustainability [10]. The regression results show that, after the robust-type test, there is still an improvement in the overall impact of ESG performance on the company's sustainability capacity and an improvement in ESG performance on the company's GIE.

4. Discussion

4.1. Confirmation

The benchmark regression of this study confirms that higher ESG performance significantly improves the long-term sustainability of firms. ESG pressures and incentives can motivate firms to increase the efficiency of resource inputs for green R&D and the efficiency of outputs of green innovation outcomes. This not only supports the view of stakeholder theory, but is also in line with the resource-based view that views ESG as an intangible resource. GIE not only brings environmental benefits, but also improves product competitiveness and translates into more important long-term profitability and sustainability potential.

The study's primary conclusion is that GIE significantly mediates the relationship of ESG and sustainable development. The existence of mediating effects implies that enterprises' ESG performance also improves GIE indirectly.

4.2. Recommendations and limitations

Companies should make ESG the core of their strategy to improve SGR, incorporate ESG into their core evaluation system, and raise awareness of the value of ESG. The key to improving the role of ESG for SGR lies in improving the efficiency of focusing on GIE. In other words, enterprises should establish a sound green technology management and transformation mechanism to ensure that environmental protection inputs can be transformed into valuable green patents and products. At the same time, they should accelerate the promotion of more standardised and detailed ESG information disclosure, and strive to ensure the timeliness and authenticity of ESG reports.

Additionally, there are certain limitations to this study that suggest areas for further investigation. First, this study used the input-output ratio approach to measure GIE, and although robustness tests

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were used, there is still room for further optimisation in measuring green innovation efficiency. Future research could try to use more segmented industry data for analysis. Second, this study only examined a single mediating mechanism of green innovation efficiency. Other potential mediating or moderating variables can be further explored in the future to reveal deeper transmission paths. Third, although this study used a fixed-effects model, causality may still be endogenous in both directions, and future studies could consider using more advanced measurement methods to further improve the reliability of causal inference.

5. Conclusion

This study uses panel data models and mediation effect tests to methodically examine the link between ESG, GIE, and SGR based on pertinent data from Chinese listed businesses from 2015 to 2022. The results demonstrate that ESG performance significantly improves SGR; GIE is an important transmission mechanism for ESG to affect SGR, confirming its mediating role in the relationship. After the robustness test, this conclusion still holds. This suggests that in order to maximise the long-term strategic value of ESG, only by successfully incorporating the idea of sustainable growth into the inputs and outputs of innovative activities can businesses achieve long-term development.

The study's theoretical contributions are mostly represented in the following areas, according to the conclusions mentioned above. First, this study shows that the process of increasing the effectiveness of company allocation of resources and innovation output is how ESG affects the long-term value of businesses. This helps to deepen the understanding of the logic of ESG value creation. Second, this study focuses on GIE, emphasising the core strategic position of innovation quality and efficiency in firms' SGR.

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