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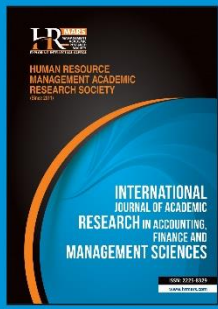
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The Impact of Green R&D Investment on Corporate Performance and ESG Evaluation

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Abstract

Companies are becoming more concerned with environmental, social, and corporate governance (ESG) performance as the notion of sustainability gains mainstream. The paper aims to explore the influence of green R&D investment on corporate performance and ESG evaluation, and it employs digital transformation, corporate growth, firm size, and firm age as control variables. The data is collect from Chinese listed companies between 2016 to 2021. Based on sustainability and social responsibility theories, the empirical regression analysis shows that a significant positive impact of green R&D investment on corporate performance and ESG evaluation. Simultaneously, companies that are longer established and have a higher pace of growth might encounter issues that result in resource misallocation and challenges with strategy transition, both of which hinder their sustainable development.

Keywords: Corporate Performance, ESG Evaluation, Green R&D Investment, Digital Transformation, Sustainable Development

Introduction

The performance of a company's environmental, social, and corporate governance (ESG) has progressively come to the attention of investors, customers, and regulators in recent years as the idea of sustainable development continues to gain traction (Liu et al., 2019). Current studies and practice place a lot of emphasis on the connection between corporate profitability and ESG evaluation. At the same time, there has been much interest in the effects of green R&D investment, one of the key strategies for sustainable development, on corporate performance and ESG evaluation (Nazir et al., 2022). According to sustainability theory, companies should expand in a manner that is balanced in the economic, social, and environmental spheres in order to achieve long-term sustainable growth (Alam et al., 2019). Simultaneously, the social responsibility theory places a strong focus on the need for companies to practice social responsibility in their operations and enhance their social and environmental performance by adopting the necessary steps (Pulino et al., 2022).

ESG evaluation is the process of assessing a company's performance in terms of its environmental, social, and corporate governance (Taliento et al., 2019), while corporate performance analyses a company's performance in terms of its financial position and operational performance (Suganthi, 2019). Outstanding corporate performance demonstrates a company's commitment to sustainable development, as well as its social and environmental responsibility (Ren et al., 2022). In addition, a profitable company is often better equipped to uphold its social obligations by actively supporting community development, ensuring the welfare of its workers, monitoring product safety and quality, etc. (Wang, 2021). Additionally, strong corporate governance and internal control mechanisms are often present in conjunction with outstanding performance by the company (Lin et al., 2019). A practical corporate governance framework promotes effective decision-making, transparency and compliance, efficient risk management, and protection against corruption (Baraibar-Diez and Odriozola, 2019).

Investment in green R&D refers to the spending of assets and finances on environmentally friendly research and development projects carried out by companies to meet their objectives for sustainable development (Wu and Li, 2023). It comprises financial contributions to the advancement of environmental management systems, renewable energy research, and green technology innovation (Xu et al., 2021). Green R&D expenditures are made with the goal of enhancing a company's reputation for social responsibility while also enhancing its environmental performance and resource consumption (Wu and Li, 2023). At the same time, digital transformation is one of the main opportunities and challenges companies are currently confronting (Sabokro et al., 2021). Companies may employ digital technology to boost productivity, improve their goods and services, and provide more ESG transparency and traceability (Yang and Han, 2023). Firm size, corporate growth, and firm age are also considered possible influences on financial performance and sustainability evaluations (Xie et al., 2019; Ren et al., 2023).

Sustainability and social responsibility theories provide a crucial theoretical framework for examining the connection between corporate performance, ESG evaluation, and green R&D investment (Nguyen et al., 2021; Ren et al., 2023). According to sustainability theory, companies should consider economic effectiveness, social responsibility, and environmental preservation while conducting operations (Sabokro et al., 2021; Nguyen et al., 2021). A company's performance is one of the metrics used to evaluate how well it is doing in each of the three areas. A company with strong corporate performance is one that is profitable, growing, and more likely to prioritize social responsibility and environmental sustainability (Sarfraz et al., 2020). A company's investment in green R&D also demonstrates its commitment to sustainability and social responsibility and is strongly related to the social responsibility concept (Oprean-Stan et al., 2020; Ren et al., 2023).

Despite the fact that many academics have presently done independent research on corporate performance, ESG evaluation, and green R&D investment (Nirino et al., 2021; Huang, 2021; Saha et al., 2020), a thorough knowledge of their interactions and moderating roles has not yet been achieved. Particularly, there is a dearth of in-depth studies on how digital transformation affects the link between green R&D investment, corporate performance, and ESG evaluation. This paper aims to fill the research gap by investigating how corporate performance affects ESG evaluation and taking into account the moderating effect that green R&D evaluation has on that. In addition, by adjusting for factors including digital transformation, firm size, corporate growth, and firm age, this paper will provide a thorough examination of their significance in the link between

corporate performance and ESG evaluation. Overall, the effect of green R&D investment as a moderator on the association between corporate performance and ESG evaluation will be examined in this paper.

Literature review and Hypothesis Development

Corporate Performance and ESG Evaluation

The link between corporate performance and ESG evaluation is a field of study that has drawn a lot of interest in regard to the overall performance and sustainability of companies in the economic, social, and environmental aspects (Liu et al., 2019). A discussion of relevant literature is presented below to understand how corporate performance affects the evaluation of ESG.

Corporate performance and evaluations of ESG are positively correlated, according to numerous studies (Radu and Smaili, 2021; Pulino et al., 2022; Zhu et al., 2022). For instance, Li and Wan (2021) discovered in their research that high-performing companies often perform higher on ESG indices. They contend that this is the case because high-performing companies place a greater emphasis on sustainability and social responsibility and are dedicated to establishing a balance between economic, social, and environmental factors. Additionally, Zhu et al. (2022) discovered that companies' return on equity and market value was greater for those with higher ESG rankings. As a result, it is possible to utilize ESG ratings as a significant gauge of company success. Liu et al. (2019) observed in their research that companies with strong ESG performance operated better in terms of financial performance, market value, and risk management. This suggests that having strong corporate performance might help companies get better ESG ratings.

However, some research has found that corporate performance may have adverse effects on ESG evaluation (Huang, 2021; Lin et al., 2019). According to Huang's (2021) research, companies score better in ESG evaluations when their financial performance is subpar. When companies experience financial difficulties, they may place more emphasis on social responsibility and environmental concerns to make up for their poor financial performance (Lin et al., 2019). Additionally, several studies note that industry traits and geographical variations may have an effect on how corporate performance affects ESG ratings. According to ESG evaluations, corporate performance may vary between industries and geographical areas (Wu and Li, 2023; Sarfraz et al., 2020). For instance, Kraus et al.'s research in 2020 indicated that firm size and industry characteristics had a moderating effect on the effect of corporate performance on ESG scores. They contend that across companies of various sizes and industries, the effect of their performance on ESG ratings may vary. According to research by Li and Wan (2021), a company's success in ESG ratings is significantly impacted by the industrial context in which it works.

According to sustainability theory, corporate expansion should be compatible with social and environmental sustainability (Zhang et al., 2021). According to this theoretical model, corporate performance and ESG evaluation are positively correlated (Jiang and Fu, 2019). Companies that concentrate on upholding their ethical and environmental obligations while developing their financial standing are said to be doing well on the corporate front (Alwaysheh et al., 2020). This well-balanced development aids companies in achieving better ESG ratings. For instance, by means of sustainable development practices, including environmental pollution reduction, resource conservation, and community participation, companies have raised their performance ratings in ESG evaluations. According to social responsibility theory, companies have social obligations to safeguard the environment, care for their employees,

and give back to the community (Rezende et al., 2019). Corporate performance and evaluations of ESG are positively correlated under this paradigm. The complete application of social responsibility is often linked to excellent corporate performance, raising the performance level in the ESG evaluation (Alam et al., 2019). For instance, companies may enhance their social responsibility fulfillment, which in turn raises their overall rating in the ESG evaluation (Zeng and Jiang, 2023), by actively taking part in socially sound projects, encouraging employee welfare, and embracing multiculturalism (Jiang et al., 2020).

In order to further explore the connection between corporate performance and ESG evaluation, this paper proposes hypothesis H_1 , taking into consideration both the scope of current academic research as well as conceptions of sustainable development and social responsibility.

H_1 : Corporate performance promotes ESG evaluation.

Green R&D Investment and ESG Evaluation

An area that has attracted a lot of academic interest is the impact of green R&D investment on ESG evaluation, which includes companies' innovation and sustainability initiatives in the environmental dimension (Alam et al., 2019). In this paper, a review of the relevant literature that has already been published concludes that most academics recognize the link between the two favorably (Carnini et al., 2022; Alam et al., 2019). According to the research by Carnini et al (2022), companies foster technological innovation in the green sector by investing in green R&D, which enhances environmental performance and raises ESG ratings. According to Yang and Han (2023), a company's improvement in environmental performance metrics is strongly correlated with a rise in green R&D spending. This further demonstrates the beneficial effect green R&D investment has on the environmental component of the ESG evaluation. At the same time, Nguyen et al (2021) discovered that green investment in research and development might also help a company perform effectively in the development of green products and services, raising its rating in the ESG evaluation. The research demonstrates that companies can satisfy customer demand for environmentally friendly products, boost market competitiveness, and enhance the environmental performance of their goods and services by investing in green R&D (Jiang and Fu, 2019). The green product and service innovation boosts the company's financial performance while simultaneously enhancing the environmental and social factors included in the ESG analysis.

According to sustainability theory, companies should conserve the environment and uphold their social obligations while seeking economic gains (Carnini et al., 2022). It also underlines the coordinated growth of the economy, environment, and society (Li and Wan, 2021). Sustainability theory serves as an essential theoretical foundation for research on how green R&D investments affect ESG evaluation (Wang, 2021). Green R&D investment can be viewed as a corporate practice for sustainable development in the environmental sphere. This practice is consistent with the idea of sustainable development and involves developing green technologies and products to reduce resource consumption and environmental pollution, improving the company's environmental performance in the process (Nair and Bhattacharyya, 2019). In addition, green R&D investment takes into account the social component, which includes satisfying societal demands for environmentally friendly goods and services, promoting social welfare, and enhancing people's quality of life (Nazir et al., 2022).

The social responsibility theory, which emphasizes that companies should be responsible for satisfying societal expectations and resolving social issues, focuses on the influence and reaction of companies to society at the same time (Jiang et al., 2020). Social responsibility theory views green R&D investment as a tool for companies to uphold their environmental obligations (Kraus et al., 2020). Companies express their dedication to and care for environmental preservation by allocating R&D resources and funding to green initiatives. With this green R&D investment, the company not only avoids environmental hazards and improves its environmental performance, but also shows that it cares about its stakeholders and wants to contribute to the long-term advancement of society (Ren et al., 2023). According to social responsibility theory, a company's investment in ESG evaluation through green R&D has a positive effect primarily on the environmental and social dimensions by enhancing the company's environmental reputation, advancing social welfare, and cultivating stakeholder relationships, all of which help improve the company's ESG evaluation (Taliento et al., 2019). By integrating the discussion above, this paper suggests hypothesis H₂ to further investigate the influence of green R&D investment on ESG evaluation for Chinese listed companies

H₂: Green R&D investment promotes ESG evaluation.

The Role of Green R&D Investment

A company's overall performance is impacted by investments in green R&D, which is a crucial part of corporate sustainability (Nair and Bhattacharyya, 2019). The link between green R&D investment, corporate performance, and ESG evaluation has been an ongoing topic of discussion among researchers. According to Xie et al (2019), a company's strategic stand moderates the link between green R&D investment, corporate efficiency, and ESG evaluation. According to a study by Saha et al (2020), when companies regarded sustainability as a fundamental strategy and incorporated green R&D investment as part of their strategic choices, the beneficial impact of green R&D investment on corporate performance and ESG ratings was more substantial. This is due to the fact that a company's long-term objectives and strategic positioning may direct the efficient implementation of green R&D expenditures, improving performance on both an environmental and social level (Xu et al., 2021).

Investing in green R&D was shown to favorably improve the association between company efficiency and ESG scores, according to research by (Taliento et al., 2019). Their study of Swedish manufacturing companies identified a substantial positive correlation between green R&D investment and companies' economic, environmental, and social achievements (Kraus et al., 2020). According to the findings, companies may increase the environmental friendliness of their goods and manufacturing processes by spending more on green R&D (Wu and Li, 2023). This leads to the harmonic growth of economic efficiency and social responsibility. According to a study by Liu et al (2019), the moderating influence of green R&D investment varies across industries and market environments. They discovered that industries with strict environmental laws had a greater benefit from green R&D investments on overall profitability. In contrast, in highly competitive and less environmentally sensitive companies, green R&D investment had a somewhat lesser impact on total business outcomes (Lin et al., 2019).

In order to create a harmonious development of the economy, environment, and society, companies should consider their influence on the environment and society while they pursue economic growth (Chen et al., 2019). Green R&D investment seeks to advance environmentally friendly product and technology innovation in order to lessen the adverse

effects on the environment (Alam et al., 2019). According to studies, green R&D spending and corporate achievement are positively correlated (Sarfraz et al., 2020; Sabokro et al., 2021). One way to increase a company's market share, revenue, and profitability is, for instance, to spend more on green R&D, this may result in better product quality and innovation (Zeng and Jiang, 2023; Sarfraz et al., 2020). The philosophy of sustainable development is reflected in how green R&D investments improve corporate performance (Kotsantonis and Serafeim, 2019). Additionally, the social responsibility theory explains how investments in green R&D affect company results and ESG evaluation (Li and Wan, 2021). According to social responsibility theory, companies have duties to their customers, suppliers, workers, communities, and the environment (Kraus et al., 2020). Investment in green R&D is seen as a socially responsible action that satisfies stakeholder expectations and demands by enhancing the environmental performance and social impact of products (Lin et al., 2019). According to studies, companies who engage in green R&D are able to grow sales and market share by improving the quality and safety of their goods, as well as the trust and loyalty of their customers (Mazzucchelli et al., 2022; Liu et al., 2019). Additionally, by making investments in green R&D, companies may enhance the welfare and working conditions of their staff, boosting their feeling of community and motivation, which in turn boosts output and overall profitability (Jiang et al., 2020). A company's ESG evaluation, which develops a favorable social image for the company (Huang, 2021), eventually reflects the related positive impacts. In conclusion, this paper brings out hypothesis H₃ to further investigate the moderating impact of green R&D investment on the association between corporate performance and ESG evaluation for Chinese listed companies.

H₃: The relationship between corporate performance and ESG evaluation is positively moderated by green R&D investment.

The research framework of this paper is shown in Figure 1.

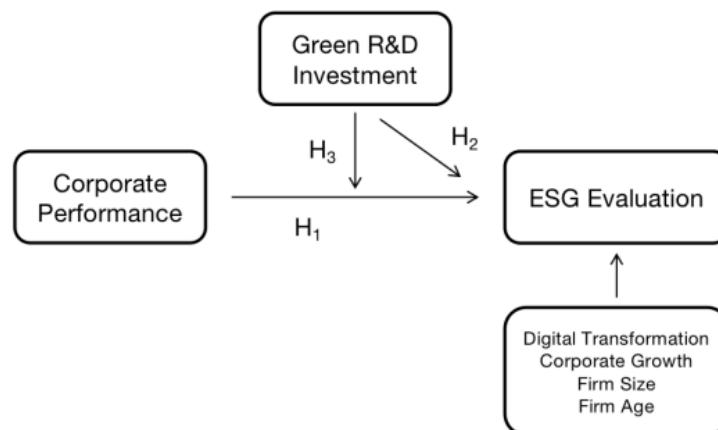


Figure 1. Research framework

Methodology

Data and Sample Selection

This paper's study sample comprises Chinese A-share listed companies from 2016 to 2021. To ensure the accuracy and representativeness of the data, the sample data has been subjected to the following treatments: the financial industry has been excluded, along with companies with abnormal or missing financial data, companies that do not disclose any information to fulfill their ESG obligations (or whose examination is not covered by ESG rating agencies),

listed companies that were ST or *ST during the observation period (Zhu et al., 2022; Liu et al., 2019). The variables were then treated to extreme value tailoring at the top and bottom 1% (Nazir et al., 2022). With 28,755 observations, the final data were collected from 4,197 companies. The Wind database, CSMAR database, and companies' annual reports were used to collect the data for each variable indicator.

Independent Variable

This paper uses return on assets (ROA) as the independent variable to assess the corporate performance of Chinese listed companies (Nassani et al., 2022). The ROA, which measures how effectively and profitably a company uses its assets, is calculated as the ratio of net profit to total assets (Ren et al., 2023). A higher ROA amount shows a company's capacity to utilize its resources effectively and generate greater profitability (Huang, 2021). This relates to the effective use of resources and economic efficiency in sustainability theory, which emphasizes the significance of maximizing the efficiency of resource usage in a company's commercial operations (Yang and Han, 2023). At the same time, ROA is a typical indication in companies' financial statements and is generally relevant and comparable. It is essential and straightforward to calculate and accessible from financial statements (Carnini Pulino et al., 2022). It additionally makes it simpler to undertake cross-company and cross-industry comparisons and analyses because of the great availability of ROA data, hence increasing the reliability and interpretability of the study.

Dependent Variable

The ESG evaluation of a company is used in this study as the dependent variable to evaluate the company's overall performance in terms of governance, social, and environment (Taliento et al., 2019). The findings from the China ESG Evaluation System are used in this paper to measure corporate social responsibility performance more accurately (Li and Wan, 2021). The technique is based on a number of factors, including the evaluation of environmental management, social responsibility, and governance structure (Jiang and Fu, 2019). The system then scores the company's actual performance to provide a full ESG evaluation result (Huang, 2021). In the Chinese financial market, the China ESG Evaluation System is one of the most well-known and commonly used ESG evaluation methods (Jiang and Fu, 2019). It has a high level of credibility and dependability since it is based on strict methodology and data and has been reviewed and monitored by professional associations. As a result, ESG data from various companies are more comparable since it is based on common assessment criteria and procedures (Li and Wan, 2021). Rapid data updates are also helpful when observing the dynamic changes in a company's ESG performance and assessing its efficacy.

Moderator

The amount of money spent by a company on R&D initiatives in the environmental field is known as green R&D investment (Oprean-Stan et al., 2020). It shows how much money a company spends on doing R&D on eco-friendly goods or technologies, effective resource usage, waste management, and emission reduction (Arvidsson and Dumay, 2022). In further detail, the amount of green R&D investment may include costs for R&D tools, staff training, lab setup, R&D project costs, etc. The company allocates and controls the amount of green R&D investment in accordance with its own objectives and choices, and it may be more specifically targeted to manage the link between profitability and ESG evaluation (Augustine et al., 2021). The amount of green R&D expenditure also reveals how much significance the

company places on environmental sustainability (Huang, 2021). Companies may advance environmental technological innovation, product greening, and resource efficiency by funding green R&D. The outcomes of these green innovations may improve corporate performance and ESG evaluations, which may, in turn, improve the company's competitiveness and sustainability.

Control Variable

The control variables in this paper include digital transformation (DT), corporate growth (Grow), firm size (Size), and firm age (Age). Firstly, digital transformation is the process by which companies employ information technology and digital tools to change and optimize their business operations and raise the effectiveness of their management (Kraus et al., 2020). In the growth of contemporary companies, digital transformation is a significant trend. The possible influence of digital transformation on the link between corporate performance and ESG evaluation is eliminated in this paper by including control for digital transformation. Firm size is a representation of a company's size and resource allocation, while firm age relates to how long a company has been in operation (Xie et al., 2019). Corporate growth represents how much a company has expanded and grown in the marketplace (Nguyen et al., 2021). These factors may be related to corporate performance and ESG evaluation. In order to assure the accuracy and reliability of the findings, this paper manages to exclude the influence of dimensions on the link between corporate performance and ESG evaluation by controlling for digital transformation, corporate growth, firm size, and firm age.

A summary of the selected variables in this paper is shown in Table 1.

Table 1
Summary of the selected variables

Variable	Calculation	Acronym
Independent Variable		
ESG Evaluation	China ESG evaluation system results assignment	ESG
Dependent Variable		
Corporate Performance	Ln(ROA)	ROA
Moderator		
Green R&D Investment	Ln(green R&D investment/operating revenue)	RD
Control Variable		
Digital Transformation	Dummy variable based on the reported text, Yes=1 No=0	DT
Corporate Growth	Ln(current period change in operating income/prior period occurrence in operating income)	Grow
Firm Size	Ln(total assets)	Size
Firm Age	Number of years the company has been in establishment	Age

Model Construction

The following three models have been developed to validate the relationships between corporate performance and ESG evaluation (model 1), green R&D investment and ESG evaluation (model 2), and the moderating role of green R&D investment (model 3). All of these models is based on the previous discussion and theoretical underpinning.

$$\text{Model 1: } ESG_{i,t} = \alpha_0 + \alpha_1ROA_{i,t} + \alpha_2DT + \alpha_3Grow + \alpha_4Size + \alpha_5Age + \varepsilon$$

(1)

$$\text{Model 2: } ESG_{i,t} = \alpha_0 + \alpha_1RD_{i,t} + \alpha_2DT + \alpha_3Grow + \alpha_4Size + \alpha_5Age + \varepsilon$$

(2)

$$\text{Model 3: } ESG_{i,t} = \alpha_0 + \alpha_1ROA_{i,t} + \alpha_2RD_{i,t} + \alpha_3(ROA_{i,t} \times RD_{i,t}) + \alpha_4Grow_{i,t} + \alpha_5Size_{i,t} + \alpha_6Age_{i,t} + \varepsilon$$

(3)

Where ESG denotes ESG evaluation, ROA denotes corporate performance, RD denotes green R&D investment, DT denotes digital transformation, Grow denotes corporate growth, Size denotes firm size, Age denotes firm age, α_0 denotes the constant term, α_i denotes the coefficient of each variable, i denotes the sample companies, t denotes the year, and ε denotes the random error term.

Results

Table 3 shows that the sample companies performed well overall in terms of ESG obligation fulfillment evaluations, with values ranging from 1 to 8 and a mean value of 4.089, but were generally worse in terms of profitability. The average amount spent on green R&D is 17.774, however, there are some variations. The majority of companies have undergone a form of digital transformation. Although there are some general development tendencies among the sampled companies, the rates of growth differ greatly. Although there is a broad range in firm size, the scale of the companies generally operates on a certain scale. While the highest value for a company's establishment years is 32, the firm age varies greatly across different companies. The outcomes of these descriptive analyses reveal the general characteristics and distinctions among the sample companies on different factors, laying the groundwork for further studies exploring the relationship between corporate performance, ESG assessment, and green R&D investment.

The relationships among the variables in the panel data were investigated by Pearson correlation analysis. Table 2 shows that there is a substantial positive association ($p < 0.001$) between ESG evaluation and corporate performance, green R&D investment, digital transformation, and firm size. Accordingly, increased corporate performance, green R&D investments, levels of digitalization, and company scale may all have a favorable effect on the extent that companies meet their ESG obligations in their pursuit of ESG goals. However, the association between ESG evaluation and corporate growth is limited. In addition, there is a negative correlation between ESG evaluation and firm age, meaning companies with a longer duration of operation are more likely to struggle with ESG compliance. These correlation analysis results show a relationship between corporate ESG evaluation and corporate performance, green R&D investment, digital transformation, firm size, and firm age, providing a foundation for a deeper understanding of the interaction between corporate ESG performance and related factors.

Table 2

Descriptive statistics and correlation matrix

Variable	Mean	SD	Min	Max	1	2	3	4	5	6	7
1 ESG	4.089	1.062	1	8	1						
2 ROA	-3.35	1.034	-10.836	4.686	0.131***	1					
3 RD	17.774	1.593	5.094	25.025	0.186***	0.069***	1				
4 DT	0.613	0.487	0	1	0.079***	0.037***	0.184***	1			
5 Grow	0.212	0.58	-6.9	10.992	0	-0.028***	-0.003	0.014***	1		
6 Size	22.195	1.517	11.348	31.191	0.266***	-0.191***	0.530***	0.142***	-0.018***	1	
7 Age	11.066	7.529	1	32	-0.125***	-0.224***	0.118***	0.006	0.033***	0.321***	1

Colinearity is an important issue that can cause instability in the estimates and misrepresent the effects of the variables that explain the results when conducting multiple regression analysis (Ren et al., 2023). A common method for determining the level of colinearity is the Variance Inflation Factor (VIF). In general, a higher VIF score denotes a co-linearity issue that is more severe (Nirino et al., 2021). The VIF for all variables is between 1.008 and 1.867, with an overall low level of co-linearity across the variables, according to the VIF data retrieved from Table 3. In conclusion, based on the VIF results, it is possible to infer that there are no substantial co-collinearity concerns between the variables in this paper and that further regression analysis and robustness testing could be performed. The Hausman test findings in Table 3 show that all three models have p-values that are less than 0.001, denying the original hypothesis that the fixed effects model produces more accurate estimates (Mazzucchelli et al., 2022).

The regression analysis's findings demonstrate that corporate performance has a favorable and substantial impact on ESG evaluation in model 1 (coefficient of 0.0521, $p < 0.01$). This suggests that the higher the profitability, the greater the company's ESG obligation fulfillment. Hypothesis H_1 from the previous section is supported by the result. With a coefficient of 0.0887 and a p-value under 0.01, green R&D investment has a significant positive impact on ESG evaluation in Model 2. In both the fixed and random effects models, the coefficient of green R&D investment is positive and has a high t-value. This shows that an increase in corporate investment in green R&D is associated with an increase in their degree of ESG obligation fulfillment, thus the findings are in line with Hypothesis H_2 . Additionally, the previous hypothesis H_3 , which states that the interaction between corporate performance and green R&D investment has a positive effect on the level of ESG evaluation, is confirmed by the significant positive effect in model 3 (coefficient of 0.123, $p < 0.01$).

According to the findings of the three models, digital transformation can help companies perform better in terms of their ESG obligations by enhancing information transparency, maximizing resource use, fostering technological innovation in environmental protection, boosting social engagement, and enhancing governance mechanisms (Oprean-Stan et al., 2020). Firm size has a considerable influence on ESG evaluation due to the availability of greater funds and resources for ESG operations, the necessity to uphold a company's reputation and brand, the pressure and expectations of its stakeholders, and the emphasis on long-term sustainability initiatives (Taliento et al., 2019). Due to such factors, larger

companies are more likely to pursue proactive ESG responsibility fulfillment strategies and to improve their ESG performance (Xie et al., 2019).

Furthermore, in all three models, a company's ESG evaluation is adversely and significantly impacted by its age as well as its rate of growth. Companies that are rapidly expanding may be subject to intense operational and financial demands (Nguyen et al., 2021). In an effort to expand quickly and increase profits, these companies may put ESG problems on the back burner, which results in inadequate allocation to ESG compliance (Liu et al., 2019). Rapid expansion may also result in constrained resources, making it difficult for companies to manage their development and ESG fulfillment requirements, which lowers ESG evaluation (Zhang et al., 2021). Causes for poorer evaluations of ESG, however, could vary depending on how old the company is. These may include institutional and cultural concerns, stakeholder pressure, historical legacy difficulties, or technical developments which aren't keeping up (Xie et al., 2019). These factors affect how companies' ESG evaluations turn out and contribute to their generally underwhelming ESG performance.

Table 3

Results of relationship between ESG and ROA, ESG and RD, and moderating role of RD

	VIF	1/VIF	(M ₁)		(M ₂)		(M ₃)	
			FE	RE	FE	RE	FE	RE
ROA	1.09	0.917	0.0521*** (10.11)	0.0750*** (15.25)			-0.0461*** (-6.15)	-0.0505 (-0.89)
RD	1.495	0.669			0.0887*** (12.59)	0.0570*** (10.51)	0.0864*** (6.04)	0.0511*** (4.09)
RPAXRD							0.123*** (6.48)	0.164*** (8.85)
DT	1.042	0.96	0.0232** (1.98)	0.0446*** (4.27)	0.0459*** (3.45)	0.0244** (2.03)	0.0378*** (2.76)	0.0392*** (3.21)
Grow	1.008	0.992	-0.0521*** (-6.19)	-0.0452*** (-5.55)	- 0.0401*** (-3.54)	- 0.0298*** (-2.75)	-0.0651*** (-5.19)	-0.0551*** (-4.66)
Size	1.867	0.536	0.173*** (19.5)	0.195*** (32.3)	0.155*** (12.83)	0.172*** (19.86)	0.113*** (8.66)	0.160*** (17.99)
Age	1.379	0.725	-0.0268*** (-15.30)	-0.0311*** (-26.87)	- 0.0579*** (-27.03)	- 0.0465*** (-34.11)	-0.0356*** (-15.10)	-0.0346*** (-24.62)
_cons			0.778*** (4.2)	0.420*** (3.3)	-0.327 (-1.43)	-0.193 (-1.19)	0.690** (2.21)	0.375 (1.51)
adj. R ²			0.1656	0.1736	0.1262	0.1349	0.1401	0.1568
F			100.90***		162.11***		62.38***	
Hausman			Prob>chi2=0.0000		Prob>chi2=0.0000		Prob>chi2=0.0000	

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Robustness Test

The regression analysis of the three models utilising one-period lagged variables was performed independently in order to further evaluate the hypotheses of this study, and the

robustness test findings were generally consistent with those of the previous section. The results of Table 4 show that the coefficients of lagged corporate performance, green R&D investment, and the interaction between them on ESG evaluation are significantly positive in all three models ($p < 0.01$), which further validates the positive relationship between higher levels of corporate performance and green R&D investment and better ESG evaluation. Additionally, the coefficient of digital transformation on ESG evaluation also shows a statistically significant positive influence under all three models ($p < 0.01$), showing that the greater the degree of digital transformation, the better the ESG performance of the company.

Table 4
Robustness test

	(M ₁) ESG	(M ₂) ESG	(M ₃) ESG
L.ROA	0.1844*** (33.0341)		0.0523*** (5.5662)
L.RD		0.0561*** (11.2995)	0.0474*** (8.9767)
L.ROAxRD			0.0070*** (12.6036)
DT	0.0713*** (6.2205)	0.0416*** (2.9974)	0.0820*** (5.938)
Grow	0.0415*** (4.2549)	0.0640*** (4.5856)	-0.0407*** (-2.8097)
Size	0.2349*** (58.7325)	0.1914*** (28.8131)	0.1741*** (25.9695)
Age	-0.0183*** (-22.2113)	-0.0282*** (-27.1732)	-0.0228*** (-21.2967)
_cons	-0.2871*** (-3.3694)	-0.8972*** (-7.4365)	0.2697** (2.1417)
adj. R ²	0.132	0.076	0.084

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Discussion and Conclusion

This paper examines the relationship between corporate performance, ESG evaluation, and green R&D investment from the perspectives of sustainability and social responsibility theories, and analyses the moderating effect of factors such as digital transformation on the relationship using Chinese A-share listed companies from 2016 to 2021.

ESG evaluation has a strong and favorable relationship with corporate performance. From the standpoint of sustainability theory, the positive correlation between corporate achievement and sustainability indicators can be seen as the accomplishment of the 2030 Agenda for Sustainable (Ren et al., 2022). Sustainable development focuses on addressing current demands without compromising the capacity of future generations (Xu et al., 2021). Therefore, high-performing companies indicate that they are economically successful but also need to exhibit ethical behavior towards others and the environment (Taliento et al., 2019). The beneficial influence of corporate performance on ESG evaluation can be viewed from the standpoint of social responsibility theory as an illustration of corporate duty to stakeholders

as well as society (Wu and Li, 2023). A company's capacity to balance the interests of various stakeholders and actively uphold its social duty may be reflected in its outstanding corporate performance, which might raise its score in the ESG evaluation (Suganthi, 2019). Therefore, accomplishing good corporate performance involves more than simply achieving financial goals; it also involves fulfilling social obligations and advancing sustainable development (Lin et al., 2019). Companies are able to perform better in ESG evaluations and achieve a competitive advantage for sustainable growth by balancing the economic, social, and environmental factors (Rezende et al., 2019).

According to Nair and Bhattacharyya (2019), investing in green R&D has a considerable beneficial impact on how ESG evaluations are made. Green R&D investment reveals companies take into account environmental and social aspects in their R&D operations from the standpoint of sustainability theory (Kraus et al., 2020). By allocating funds and resources to green R&D, companies demonstrate their commitment to environmental sustainability and create goods and services that are more resource- and environmentally-conscious (Ren et al., 2023). Due to the fact that the environmental component of ESG evaluations awards such green efforts high marks, the environmentally friendly technologies assist to increase a company's score during ESG evaluations (Wu and Li, 2023). According to the social responsibility concept, companies should actively satisfy their social responsibilities in order to meet the demands of society and its stakeholders, in addition to their financial goals (Chen et al., 2019). Companies that support green R&D reflect that they care about the environment and society as a whole (Huang, 2021). A company's total ESG score increases as a result of its actions of social responsibility by increasing the social and environmental evaluation's weightings (Xu et al., 2021).

The link between corporate performance and ESG evaluation is favorably and significantly influenced by investments in green R&D. First off, according to the theory of sustainable development, green R&D investment could improve a company's capacity for innovation and competitiveness. Companies that spend money and resources on green R&D create goods and services that are efficient and friendly to the environment and satisfy the growing demand from customers for environmentally friendly goods (Jiang et al., 2020). Such environmentally friendly innovation boosts a company's market share and sales while also assisting in lowering manufacturing costs and resource consumption, thus enhancing the company's performance (Mazzucchelli et al., 2022). Environmentally friendly innovation also meets the environmental component of the ESG evaluation, enabling companies to perform better in the process of evaluation. Furthermore, investing in green R&D demonstrates that companies are concerned not solely with the economic rewards of their R&D projects but also with the well-being of society and the environment. The practise of social responsibility can improve the social component of a company's ESG evaluation, particularly for metrics relating to environmental sustainability and social sustainability (Jiang and Fu, 2019). Positive company outcomes in this area can contribute to raising the overall ESG score because CSR is a key component of ESG evaluations (Kraus et al., 2020).

In this paper, the contribution of digital transformation to the long-term success of companies is also a significant factor. The efficiency of operations and output increases as a result of digital transformation in companies (Alam et al., 2019). The use of digital technology may optimize resource allocation, reduce manufacturing costs, enhance productivity, and supply chain management, all of which boost corporate performance (Chen et al., 2019). A company's score in ESG evaluations may also rise as a result of such effective operations, which assists companies in better achieving sustainability objectives including lowering

resource waste and environmental damage (Nguyen et al., 2021). A company's economic performance is enhanced through digital transformation, and this process also shows the company's commitment to its stakeholders and the community as a whole (Li and Wan, 2021). Digital transformation is often accompanied by concerns about information security and privacy protection, and these factors reflect a company's performance in considering the interests of society in the digitalisation process (Nassani et al., 2022).

However, when included as control factors, firm age and growth have a considerable negative impact on the company's ESG evaluation. In the growth stages, particularly in emerging markets and beginning stages, companies may experience higher risks and volatility, in accordance with sustainability theory (Zhu et al., 2022). Because of this unpredictability, companies may operate relatively poorly and score worse in ESG evaluations. During their growth stage, companies may, however, place a greater emphasis on the pursuit of economic gains and pay comparatively less attention to social and environmental responsibilities (Huang, 2021). Additionally, when companies mature and expand, they could adopt more antiquated management practices and corporate philosophies, which might diminish the amount of support for sustainability and social responsibility proposals and impact the degree to which they perform in ESG (Wang, 2021). Some older companies could have found success in traditional industries that might be somewhat in conflict with the idea of sustainability (Liu et al., 2019). For instance, industries with high energy use and emissions may struggle to achieve sustainability standards, which lowers their ESG evaluations (Radu and Smaili, 2021). As a result, companies that are still in the early stages of development should raise their level of social responsibility awareness and encourage the incorporation of it into their business plans and everyday operations (Nguyen et al., 2021). ESG evaluation and corporate performance may both be enhanced by developing and putting into practice sustainable development plans that prioritize resource conservation and environmental preservation (Wu and Li, 2023). In order to boost their performance and scores on ESG, companies should put equal emphasis on developing a strong corporate governance framework and enhancing internal controls and transparency (Ren et al., 2022). Older companies can keep enhancing their governance structure and performance in terms of social responsibility to raise their ESG evaluation (Saha et al., 2020). Companies may improve industry-wide communication and learning, as well as benefit from the most effective practices and successful experiences of other companies, particularly in the fields of sustainable development and social responsibility (Liu et al., 2019). As a result, companies will perform better in ESG evaluations. The implementation of relevant government regulations and programs may also operate as a motivator and support companies to improve their social responsibility and sustainable development practices (Zeng and Jiang, 2023). Tax reductions and other incentives can be utilized to encourage companies to focus more on ESG evaluation, which will enhance their financial results (Rezende et al., 2019).

In conclusion, the positive correlation between corporate performance, ESG evaluation, and green R&D investment reflects the fact that healthy companies prioritize social responsibility and environmental innovation in addition to being profitable. For sustainable corporate development, increased productivity, and environmental innovation, digital transformation is crucial. ESG evaluations may be lower for older companies that are expanding more quickly. Companies are advised to cultivate their social responsibility additionally, support sustainable development initiatives, and draw inspiration from other successful companies. By enacting legislation and providing additional assistance, the government may motivate companies to

improve their ESG evaluations. Gaining a competitive edge requires balancing economic, social, and environmental factors in order to realize sustainable development goals.

This paper explores the relationships between green R&D investments, corporate performance, and ESG evaluation, filling a research gap in this field. From the perspective of sustainable development theory, this study reveals a positive correlation between corporate performance and ESG evaluation, demonstrating that excellent corporate performance contributes to achieving sustainable development goals and fulfilling social responsibilities. Second, by introducing green R&D investment as a moderating variable, this paper demonstrates that green R&D investment significantly moderates corporate performance and ESG evaluation, thus enhancing the application of sustainable development theory. Furthermore, this paper examines the relationship between corporate performance and ESG evaluation by taking into account control variables such as digital transformation, corporate growth, firm size, and firm age. The results provide important academic contributions to corporate sustainability.

Practically speaking, this study contributes in two areas. Firstly, this paper offers practical guidance based on sustainable development theory and social responsibility theory. Enhancing company performance and investing in green R&D can help companies fulfill their social responsibilities, improve their ESG scores, and increase their market competitiveness. Furthermore, it has implications for policy-making and regulation. Governments can formulate relevant policies and measures based on the research results to encourage companies to invest in green R&D and promote digital transformation, thus enhancing the importance of ESG evaluation. As a result, corporate sustainability will be advanced, social responsibilities will be fulfilled, and sustainable development will be promoted throughout society.

Research Limitations

Although this study reveals a positive relationship between corporate performance and ESG evaluation, as well as the positive impact of green R&D investment on ESG evaluation, and highlights the critical role of digital transformation in promoting sustainable corporate development, there exist certain research limitations. First, this paper focuses on how company performance, green R&D investments, and digital transformation affect ESG evaluation, but it ignores other variables like industry characteristics and geographical variances that may have an impact. These elements could have some impact on how well ESG evaluations for companies operate. Further research requires a more detailed look at the numerous impacting elements to better explain variations in evaluations of ESG. Second, while examining the correlation between corporate performance and ESG evaluations, this paper did not account for all possible scenarios which could have been broken down into performance and ESG ratings. ESG evaluation and corporate performance are both complicated, multifaceted concepts with a wide range of distinct indicators and characteristics (Taliento et al., 2019). This study only examines a select group of variables and may not accurately reflect the overall link between corporate performance and ESG evaluation due to data constraints and the approach selection. In conclusion, while this study's findings are useful for understanding the connection between corporate performance and ESG evaluation, as well as the effects of green R&D investment and digital transformation

on ESG evaluation, they still have certain limitations. Future studies will deepen the understanding of how to evaluate a company's ESG performance.

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