

THE GREEN INNOVATION AND ESG PERFORMANCE: THE MODERATING ROLE OF SUSTAINABILITY STRATEGY IN THE NEW GENERATION OF INFORMATION TECHNOLOGY IN CHINA

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ABSTRACT

In light of growing environmental and social concerns worldwide, environmental, social, and governance (ESG) disclosure is an issue of transparency and shows a firm's commitment to sustainable development. This study examines the relationship between green innovation, sustainability strategy, and ESG performance, focusing on the moderating role of sustainability strategies. Using a sample of 381 new-generation information technology firms in China from 2018 to 2023, our results suggest the following: (1) Strong evidence of a positive relationship between green innovation and ESG performance. (2) The sustainability strategies significantly improve the performance of ESG. (3) The sustainability strategies positively strengthen the correlation between green innovation and ESG performance. This research also contributes to stakeholders' consideration of investing in green innovation and setting up long-term sustainability strategies in their firms to improve ESG performance.

Keywords: New-generation Information Technology Industries, Green Innovation, Sustainability Strategy, ESG performance

1.0 INTRODUCTION

With global climate change and resource constraints becoming increasingly prominent problems, corporate sustainable development and ESG performance have received more and more attention (Jahanshahi & Brem, 2017). China has followed a new development philosophy over the last five years, driven by transforming China into a cyber and manufacturing power. It has also taken advantage of the opportunities presented by the latest wave of scientific and technological revolution and industrial transformation, and it has furthered the integrated development of digital, networked, and intelligent technologies (Shen et al., 2023).

The China State Council places a high value on green development in order to incentivise businesses to adopt green innovation and sustainability strategies, as well as cloud computing, artificial intelligence, the Internet of Things, chain blocks, and 5G (Zeng et al., 2023). They have made several strategic deployments, focusing on key areas and weak links with accurate

strength, and they are actively pushing the development of new information technology breakthroughs in our nation (Li et al., 2023).

ESG performance is a crucial indicator for measuring the sustainable ability of firms (Ahmad et al., 2023). It comprehensively assesses firms' performance in the areas of environmental protection, social responsibility and corporate governance, focusing not only on economic benefits but also on firms' positive impact on society and their contribution to sustainable development. Excellent ESG performance helps firms improve their brand image, attract investors and consumers, and stand out in increasingly fierce market competition (Ahmad et al., 2023; Tang & Loang, 2024).

Green innovation focuses on technological innovation and emphasises integrating environmental protection elements in product design, production process and marketing to reduce the environmental impact (Zheng et al., 2022). The sustainability strategy is committed to realising the coordinated advancement of the economic, social, and environmental fields to guarantee the harmonious coexistence of the development of human society and the natural environment (Wang et al., 2022). Green innovation and sustainability strategy have become essential concepts leading the trend of The Times, which coincides with firms' practice of ESG.

New generation information technology refers to the emerging technologies of big data, the Internet of Things, cloud computing, and artificial intelligence. It is the vertical modernisation of information technology and the horizontal penetration and integration of information technology. In 2022, China's new generation of information technology industry scaled more than 6 trillion yuan¹. The industry chain will gradually improve as the technology matures for the future 5G network, Internet of Things, cloud computing, integrated chips and artificial intelligence segmentation. A new generation of information technology is expected to enter a high-speed development phase in 2023-2028, with an annual average growth rate of 19%. By 2028, the market size in China for this new generation of information technology is expected to exceed 17 trillion yuan².

The development of strategic emerging industries has become a significant strategy for major countries to take the lead in a new round of economic, scientific and technological development (Al-Hiyari et al., 2023). The new generation of information technology, as one of the strategic emerging industries, has grown into a critical, strategic, and leading sector that supports the excellent growth of the national economy. The sustainable development of the entire industry depends significantly on the implementation of green innovation and sustainability strategies (Wu et al., 2024). However, a systematic theoretical framework and empirical support are lacking from the few studies on the effects of sustainability strategy and green innovation on the ESG performance of IT firms.

This study fills this research gap by analysing 381 new-generation IT firms in China between 2018 and 2023 and using the data as a foundation for a comprehensive examination

¹ Resource from: National Bureau of Statistics, <https://www.stats.gov.cn>

² Resource from: Prospective Industry Research Institute, <https://bg.qianzhan.com/report/detail/2005131811234955.html?v=title>

of the definition and traits of green innovation and sustainability strategies. With an emphasis on the moderating role of sustainability strategy, regression analysis is then utilised to investigate the impact of the ESG performance mechanism and path.

After introducing the research background, significance, and purpose in the introduction section, this study will be conducted according to the following framework and structure: firstly, in the theoretical review, summarise the theories and research progress of green innovation and sustainability strategy and ESG performance; secondly, introduce methods and data sources; then use statistical methods and analysis models to discuss the impact of green innovation and sustainability strategy on ESG performance; lastly, in the conclusion and outlook section, summarise the research results and offer targeted optimisation strategies and recommendations, as well as future research direction and application prospects.

2.0 LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 Theoretical Framework

2.1.1 Resource-based View (RBV) Theory

RBV theory emphasises the uniqueness of firm resources and capabilities and how those resources and capabilities translate into competitive advantage (Barney, 2001; Ferreira et al., 2023; Galbreath, 2005). Green innovation and sustainability strategies have become essential for firms to gain a competitive edge in the modern business climate (Chen & Liang, 2023). By adopting advanced green technology and developing environmentally friendly products and services, firms can not only meet the needs of society for sustainable development but also reduce operating costs and improve resource utilisation efficiency to create a win-win scenario of social and economic benefits.

However, firms must have a particular resource and capacity base to implement a green innovation and sustainability strategy successfully. It covers many aspects, including capital, technology, talent, and brand. For example, firms need to invest much money in the research development and promotion of green technologies. At the same time, to enable the smooth implementation of the plan, it is essential to foster a workforce that is innovative and environmentally conscious.

2.1.2 Upper Echelon Theory

The upper echelon theory focuses on the influence of elements such as values and leadership style on organisational performance and also emphasises management's ability to make strategic decisions (Hambrick, 2007; Jahanshahi & Brem, 2017). When driving green innovation and sustainability strategies, the management team's insight, attitude and implementation impact firms' strategy execution and ESG performance. A good leadership team can develop forward-looking strategies, stimulate employee creativity, strengthen team cohesion and make the right decisions in a complex market environment (Syuhada & Jasni, 2021). When promoting green innovation and sustainable development, the management team must clarify green strategies, promote technological innovation, optimise resource allocation and collaborate with external stakeholders to improve ESG performance and gain social and market recognition.

In summary, the RBV theory and the upper echelon theory represent a paradigm for a comprehensive understanding of the implementation of green innovations and firms' sustainability strategies and their impact on ESG performance. Firms need to understand their resource and capability base as well as their strategic decision-making skills, as well as combine management leadership skills to develop and implement practical green innovation and sustainability strategies to achieve sustainable development goals.

2.2 Hypotheses Development

This study also creatively proposes two potential factors for improving ESG performance: green innovation and sustainability strategy, based on the previous analysis (Ren et al., 2023; Xu et al., 2021).

2.2.1 Green Innovation and ESG Performance

Xu et al. (2021) have emphasised the importance of green innovation in various aspects of business operations, including product research and development, production, marketing and other important links. This approach highlights the importance of technological and model advances aimed at achieving efficient resource use, reducing pollution and promoting sustainable development. In the field of information technology, green innovations have become an essential factor for firms to increase their competitive advantage and secure long-term growth.

Green innovation embodies corporate social responsibility and advocates for green development strategies that enable sustainable progress (Chen & Liang, 2023). It creates economic, environmental and social value and promotes harmony and unity between economic and social benefits. Optimising production processes, reducing environmental damage and improving employee well-being not only improves environmental and social outcomes but also creates a robust governance structure and culture, thereby increasing governance performance (He et al., 2020).

To take advantage of green innovations, firms must develop innovative spirit and ability. This requires the creation of a more scientific, democratic and transparent governance framework. Through green innovation, firms can refine decision-making mechanisms, strengthen internal oversight, and ultimately improve corporate governance. Critical components in measuring firms' ESG performance include environmental protection and sustainable development, which are the focus of green innovation. They are inherently positively correlated with each other (Ren et al., 2023).

The following research hypotheses are put forth in light of the analysis above:

H1: Firms can improve ESG performance by implementing green innovation.

2.2.2 Sustainability Strategies and ESG Performance

The sustainability strategy is the central focus of the firm's long-term development and includes economic, ecological and social goals for sustainable development (Zhou et al., 2022). It requires firms to pay attention to environmental protection and social responsibility while pursuing economic benefits and realising harmonious coexistence with nature and society.

A sustainability strategy reflects a firm's future-oriented and long-term vision (Galbreath et al., 2023). The formulation and implementation of sustainability strategies by firms can help adapt to changes in the external environment, exploit market opportunities and achieve sustainable development goals in the context of increasingly severe global environmental problems and growing attention to social responsibility (Zhou et al., 2022).

Firms can increase their contribution to society, minimise pollution to the environment, and optimise resource allocation by creating and implementing sustainability strategies. A sustainability strategy also aids businesses in building a positive reputation and brand image. (Ahmad et al., 2023), enhance market competitiveness, and achieve sustainable development (Ilyas & Osiyevskyy, 2022).

Thus, the following research hypotheses are put forth in this paper:

H2: Firms can enhance their ESG performance by formulating and implementing sustainability strategies.

2.2.3 Synergistic Effect of Green Innovation and Sustainability Strategy

Green innovation promotes the efficient use of resources and environmental improvement through technological and model innovation (Xu et al., 2021), While the sustainability strategy is a broader framework that supports firms in achieving balanced development in the three dimensions of economy, environment and society (Zhou et al., 2022). The two echo each other in terms of goals and jointly promote the development of information technology firms in a greener and more sustainable direction.

When firms simultaneously implement green innovation and sustainability strategies, synergies are reflected in many aspects. Firstly, green innovation can provide specific implementation paths and technical support for sustainability strategies, making sustainability strategies more operable and realisable (Ilyas & Osiyevskyy, 2022). Secondly, the sustainability strategy provides clear goals and guidance for green innovation, making green innovation better aligned with the long-term development direction of firms. Finally, the two work together to promote the formation of a more environmentally friendly and sustainable business model and culture and enhance the overall competitiveness of the enterprise.

In light of this, the research hypotheses presented in this paper are as follows:

H3: Sustainability strategy has a moderating effect on green innovation and ESG Performance.

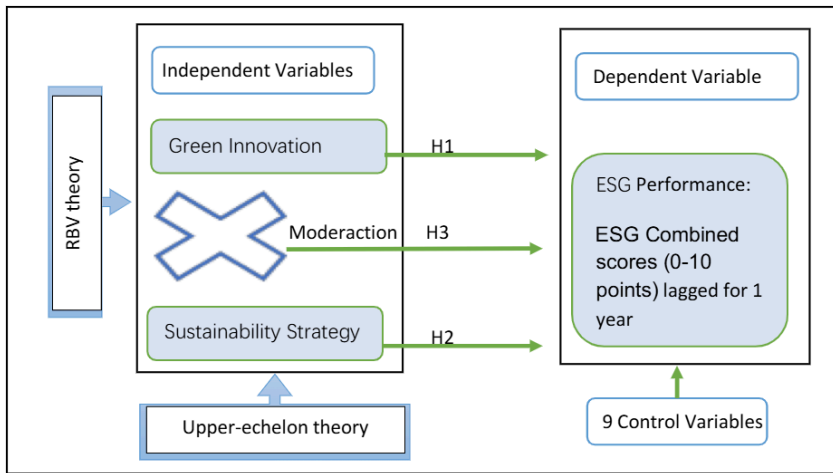


Fig. 1 The Conceptual Framework of Study

This research builds the theoretical framework of previous studies by combining RBV and upper-echelon theories. It is predicated on the idea that sustainability strategy and green innovation both greatly enhance a firm's ESG performance; in addition, the use of sustainability strategy as a moderating variable strengthens the relationship between green innovation and ESG performance. Fig. 1 depicts the conceptual theoretical framework.

3.0 RESEARCH METHODOLOGY

3.1 Data and Sample

In this study, using the secondary data of the Wind database, 381 new-generation information technology firms belonging to China's strategic emerging industries are taken as the research sample, and 2018-2023 as the research period. Wind is China's leading domestic provider of financial data and ESG ratings. Its ESG rating services leverage professional teams and scientifically constructed rating models to analyse corporate ESG performance (Liu & Lyu, 2022). In order to ensure the accuracy and dependability of the data, we consult pertinent data and reports published by reputable research institutions. We also obtain public information through a variety of channels, such as firm annual reports and social responsibility reports.

The data collection and statistical analysis in this work, which included regression, correlation, and descriptive statistics, were conducted using STATA software. After excluding samples of ST and *ST³ stocks and firms with severely insufficient data, the data were 1% and 99%, respectively, to avoid the impact of extreme values for individual firms in a given year. We have used three different types of tests to evaluate the validity and reliability of the models: (1) data diagnostics, which include skewness and kurtosis; (2) variable diagnostics,

³ "Special Treatment": Indicates financial risks or issues with a stock, subjecting it to trading restrictions. *ST: Variant of ST, indicating prolonged or severe issues with the stock, leading to stricter trading restrictions.

which include collinearity and the variance inflation factor (VIF) test; and (3) model diagnostics, which include autocorrelation heteroscedasticity and the Breusch–Pagan and Koenker tests.

3.2 Variable definition

In this study, ESG performance as a dependent variable is measured by the Wind's ESG rating combined scores for Chinese listed firms, which lagged for one year, in line with previous studies in the area suggested (Cai et al., 2023; Zhang & Zhang, 2024). The ESG combined score is normalised to range between 0 and 10 and comprehensively evaluates a firm's performance in four dimensions: environment, society, governance, and controversy.

Green innovation(GI) was introduced as an independent variable. Following Xu and Cui (2020), GI was calculated by taking the logarithm of the total number of firm green patent applications increased by one (Li et al., 2023). Meanwhile, sustainability strategy (SS) was introduced as an independent and moderating variable assessed by content analysis (Awang et al., 2023). The binary approach measures the existence of a sustainability strategy in its vision and mission, 1 for its existence and 0 for its absence (Rahman et al., 2021).

In order to accurately assess the impact of sustainability strategy and green innovation on ESG performance and to mitigate the impact of missing important variables, a number of control variables were included to account for potential bias in the estimates, including return on total assets (ROA), R&D expenses (RD), Total inventories to total assets (INVINT), the dual role of CEO and Chairman (DUAL), whether Big 4 auditors conducted the external audit (BIG 4), leverage ratio (LEV), firm size (SIZE), firm age (AGE), growth (GRW), aligning with previous studies (Qureshi et al., 2021; Shahrun et al., 2024; Shahzad & Sharfman, 2017). Furthermore, we controlled for fixed effects of both firm and year.

3.3 Empirical Research Model

As the effects of sustainability and green innovation on ESG performance take time to materialise, future gains could result from them (Junius et al., 2020). Finally, the following panel data model was developed to evaluate the impact of green innovation and sustainability strategy on ESG performance:

$$ESGC_{it} = \beta_0 + \beta_1 GI_{it-1} + \beta_2 SS_{it-1} + \sum \beta_k Controls_{i,t,k} + \omega_j + \delta_t + \varepsilon_{it} \tag{model 1}$$

$$ESGC_{it} = \beta_0 + \beta_1 GI_{it-1} * SS_{it-1} + \sum \beta_k Controls_{i,t,k} + \omega_j + \delta_t + \varepsilon_{it} \tag{model 2}$$

Here, the symbols for *i* and *t* denote firm and year, respectively. Control variables at the firm level, *i*, *t*, and *k*, have the potential to impact ESG performance. Firm-fixed effects are represented by ω_j , while year-fixed effects are represented by δ_t . ε_{it} represents the error term, and β_0 is the constant term.

For a detailed overview of these variables and their roles in this study, **Table 1** summarises them and their corresponding meanings.

Table 1. The Variables Summaries

Type of variable	Name of variable	ABV	Variable description
Dependent variable	ESG Combine score	ESGC	Measure ESG Combined scores (0-10 points)
Independent variables	Green innovation	GI	The natural logarithm of the total number of firm green patent applications incremented by one.
Moderating variables	Sustainability Strategy	SS	Value of 1 if the firm incorporates sustainability strategy in its vision and mission, 0 otherwise
Control variables	Return on total assets	ROA	The ratio of net income to total assets
	R&D expenses	RD	The ratio of Research and development expenses to total revenues
	Total inventories to total assets	INVINT	The ratio of the total inventories to total assets
	Dual role of CEO and chairman	DUAL	Take 1 if the CEO and chairman are the same person; 0 otherwise.
	Big four	BIG4	A dummy variable that takes a value of 1 if Big 4 auditors conducted the firm's external audit and 0 otherwise
	Leverage	LEV	The ratio of total liabilities to total assets
	Firm Size	SIZE	Natural logarithm of total assets
	Growth	GRW	The annual change in total revenue
	Firm Age	AGE	Firm's age since its IPO (year)

Source: author's calculation.

4.0 RESULTS AND DISCUSSION

4.1 Descriptive Statistic

The descriptive statistics for each variable are displayed in Table 2. The ESG combined score (ESGC) has a mean value of 6.266, ranging from 4 to 9.07 from 2019 to 2023. It suggests that the new generation of IT industries has reasonable ESG performance. To prevent variable skewness, this study's calculation of green innovation (GI) is based on the log of one plus the total number of two types of green patents from 2018 to 2022. This metric allows us to utilise the sample with no patents for certain firms to the fullest.

Table 2. Descriptive Statistics

Variables	Obs	Min	Max	Mean	Std.Dev.	Skew.	Kurt.
ESGC	1905	4	9.07	6.266	.771	.595	3.365
GI	1905	0	6.27	.817	1.218	1.434	4.361
ROA (%)	1905	-23.72	20.411	3.168	6.914	-1.413	7.315
RD (%)	1905	6.227	36.16	8.184	6.227	1.993	8.142

INVINT (%)	1905	0	57.77	12.643	8.349	1.08	4.865
LEV (%)	1905	2.974	87.751	38.015	17.681	.1	2.126
SIZE	1905	19.51	26.83	22.342	1.172	.635	3.579
GRW (%)	1905	-28.085	89.542	11.651	19.56	1.357	6.072
AGE	1905	-23.72	20.411	11.467	6.488	.859	3.071
Frequencies				YES	NO	%YES	%NO
SS	1905	0	1	563	1342	29.6	29.6
DUAL	1905	0	1	711	1194	37.3	37.3
BIG4	1905	0	1	76	1829	3.99	3.99

Notes: ESGC is the ESG combined score of the four dimensions; GI is the natural logarithm of the total number of firm green patent applications incremented by one; ROA is the ratio of net income to the total asset; RD is the ratio of research and development expenses to total revenues; INVINT is the ratio of the total inventories to total assets; LEV is the ratio of total liabilities divided by total assets; SIZE is the natural logarithm of total assets; GRW is the annual change in total revenue; AGE is the firm's age since its IPO, SS is dummy value of 1 if the firm incorporates sustainability strategy in their vision and mission, 0 otherwise; DUAL is a dummy variable that takes a value of 1 if the chairman and CEO are the same people, and 0 otherwise; BIG4 is a dummy variable that takes a value of 1 if the firm is audited by one of the Big Four auditors and 0 otherwise.

Furthermore, 29.6% represent the values of sustainability strategy (SS); this suggests that not more than one-third of the sample firms developed and implemented sustainability strategies to pursue their sustainable initiatives. 37.3% represent the percentage of the dual role of chairman and CEO (DUAL), and only 3.99% of the information technology firms were audited by one of the Big Four auditors (BIG 4).

The control variables of return on total assets (ROA), research and development expenses to total revenues (RD), total inventories to total assets (INVINT), leverage (LEV), firms' size (SIZE), growth (GRW) and age (AGE) have mean values of 3.168%, 8.184%, 12.643%, 38%, 22.342, 11.7% and 11.467, respectively. Additionally, Table 2's Skewness and Kurtosis statistics do not indicate a severe problem with non-normality because every value is below the recommended ± 10 threshold. (Zahid et al., 2020).

4.2 Correlation Matrix

Table 3 reports Pearson's correlation matrix for checking whether and how two variables are associated or vary. The correlation coefficient between ESGC and other variables ranged from -0.311 to 0.525, showing different degrees of correlation. The bivariate statistics show that green innovation (GI), sustainability strategy (SS), return on total assets (ROA), development expenses to total revenues (RD), total inventories to total assets (INVINT), audited by one of the Big Four auditors (BIG 4), firms' size (SIZE) and growth (GRW) have a significant positive correlation with the ESG combined score (ESGC). In contrast, the dual role of chairman and CEO (DUAL) correlates significantly negatively with ESGC. Besides, leverage (LEV) and age (AGE) have an insignificant correlation with ESGC.

Table 3. Pearson's correlation matrix

	ESGC	GI	SS	ROA	RD	INVINT	DUAL	BIG 4	LEV	Fsize	GRW	AGE
ESGC	1											
GI	0.212***	1										
SS	0.449***	0.131***	1									
ROA	0.187***	0.102***	0.147***	1								
RD	0.170***	0.013	-0.007	0.046**	1							
INVINT	0.088***	-0.008	0.061***	0.043*	-0.082***	1						
DUAL	-0.084***	-0.019	-0.069***	-0.046**	0.119***	-0.070***	1					
BIG 4	0.206***	0.112***	0.138***	0.106***	-0.032	0.02	-0.102***	1				
LEV	0.004	0.126***	0.134***	-0.242***	-0.323***	0.230***	-0.068***	0.065***	1			
SIZE	0.269***	0.189***	0.526***	0.131***	-0.195***	0.006	-0.092***	0.275***	0.438***	1		
GRW	0.120***	0.088***	0.073***	0.458***	-0.004	0.102***	0.050**	0.046**	0.077***	0.198***	1	
AGE	0.007	-0.064***	0.302***	-0.100***	-0.169***	0.029	-0.189***	0.053**	0.226***	0.400***	-0.156***	1

Notes: ESGC is the ESG combined score of the four dimensions; GI is the natural logarithm of the total number of firm green patent applications incremented by one; ROA is the ratio of net income to the total asset; RD is the ratio of research and development expenses to total revenues; INVINT is the ratio of the total inventories to total assets; LEV is the ratio of total liabilities divided by total assets; SIZE is the natural logarithm of total assets; GRW is the annual change in total revenue; AGE is the firm's age since its IPO, SS is dummy value of 1 if the firm incorporates sustainability strategy in their vision and mission, 0 otherwise; DUAL is a dummy variable that takes a value of 1 if the chairman and CEO are the same people, and 0 otherwise; BIG4 is a dummy variable that takes a value of 1 if the firm is audited by one of the Big Four auditors and 0 otherwise.

4.3 Multiple Regression Results

Table 4. Multiple Regression Results of ESGC

	Model 1		Model 2	
	Coefficient	t-statistic	Coefficient	t-statistic
GI	0.043**	(2.326)		
SS	0.412***	(3.995)		
GI*SS			0.106***	(3.299)
ROA	0.558**	(2.114)	0.564**	(2.117)
RD	0.009*	(1.345)	0.010*	(1.493)
INVINT	0.006*	(1.436)	0.005*	(1.314)
DUAL	0.986***	(3.245)	1.110***	(2.954)
BIG 4	-0.103**	(-1.768)	-0.110**	(-1.906)
LEV	-0.004**	(-1.821)	-0.004**	(-1.859)
SIZE	0.122*	(1.543)	0.178**	(2.198)
GRW	-0.002**	(-2.127)	-0.002**	(-2.177)
AGE	-0.122***	(-3.507)	-0.114***	(-3.295)
Constant	4.924***	(2.806)	3.712**	
Firm effect	Yes		Yes	
Year effect	Yes		Yes	
R squared (%)	11.4		9.7	
F-statistic	6.964	(0.0000)***	6.525	(0.0000)***
Multicollinearity (VIF)	4.45		4.62	
Heteroskedasticity	49414.66	(0.0000)***	46915.11	(0.0000)***
Serial Correlation	17.058	(0.0000)***	17.058	(0.0000)***
Total observation	1905		1905	

Notes: ***, **, and * represent significance at 1, 5, and 10 per cent levels, respectively (using a one-tailed test) ESGC is the ESG combined score of the four dimensions; GI is the natural logarithm of the total number of firm green patent applications incremented by one; ROA is the ratio of net income to total asset; RD is the ratio of research and development expenses to total revenues; INVINT is the ratio of the total inventories to total assets; LEV is the ratio of total liabilities divided by total assets; SIZE is the natural logarithm of total assets; GRW is the annual change in total revenue; AGE is the firm's age since its IPO, SS is dummy value of 1 if the firm incorporates sustainability strategy in their vision and mission, 0 otherwise; DUAL is a dummy variable that takes a value of 1 if the chairman and CEO are the same person and 0 otherwise; BIG4 is a dummy variable that takes a value of 1 if the firm is audited by one of the Big Four auditors and 0 otherwise.

Table 4 presents the regression results of ESG combined scores for two different models. For Model 1, we first estimated the impact of green innovation (GI) and sustainability strategy (SS) on ESG performance lagged for one year, with return on total assets (ROA), research and development expenses to total revenues (RD), total inventories to total assets (INVINT), Dual role of chairman and CEO (DUAL), Big four (BIG4), leverage (LEV), firm size (SIZE), growth (GRW), and firm age (AGE) as control variables. The result shows that green innovation (GI) has a statistically significant positive coefficient of 0.043 at the 5% level, according to the results. Higher ESG performance is linked to better green innovation, supporting Hypothesis 1.

According to the RBV theory, green innovation, as a strategic resource, is unique and challenging for firms to replicate (Li et al., 2023). As a result, firms may gain a different market position and performance advantage when they excel in environmental protection and green innovation than their competitors. In this case, the positive coefficient relationship between green innovation (GI) and ESG performance supports the assumption of a resource-based

perspective. It means that firms' investment and efforts in green innovation can help improve their ESG performance.

Likewise, a sustainability strategy has a positive significant coefficient of 0.412 at the 1% level. This means that there is a significant positive correlation between a firm's implementation of a sustainability strategy and its ESG performance. This result supports Hypothesis 2, which states that a sustainability strategy has a significant impact on improving ESG performance. When executives integrate sustainability into their strategic decisions and commit to achieving higher levels of ESG performance, they are more likely to understand better and recognise a firm's ESG values, high school theory suggests (Hambrick, 2007; Jahanshahi & Brem, 2017).

Therefore, top management must be actively involved in the development and implementation of sustainability strategies. Furthermore, the results of this study are consistent with previous studies (Ahmad, Palaniappan, et al., 2023; Coelho et al., 2023; Zhao et al., 2018). Further strengthen understanding of the importance of sustainability strategies in improving ESG performance. This also shows that in the current business environment, more and more firms are aware and actively adopting sustainability strategies to achieve long-term business success and social responsibility.

For Model 2, we estimate the moderation of sustainability strategy (SS) in the relationship between green innovation (GI) and ESG performance. Statistics show that sustainability strategies have a significantly positive moderating effect on this relationship. In particular, after introducing sustainability strategy (SS) as a moderating variable in the regression model, the significant positive correlation between green innovation (GI) and ESG combination score (ESGC) increased from $\beta = 0.043^{**}$ in Model 1 to $\beta = 0.106^{***}$ in Model 2. This suggests that the adoption of sustainability strategies not only strengthens the positive impact of green innovations on ESG performance but also significantly increases the statistical significance of this relationship.

This result supports Hypothesis 3: sustainability strategies positively mediate the relationship between green innovation and ESG performance. That is, when firms adopt sustainability strategies, the positive impact of green innovation on ESG performance is even more pronounced. Implementing a sustainability strategy is often accompanied by a shift in the firm's culture and values (Dash & Mohanty, 2023). When firms implement sustainability strategies, they will pay more attention to environmental protection, social responsibility and firm governance, which are highly consistent with the goals of green innovation, so that the results of green innovation are more significant and lasting.

For the control variables In models 1 and 2, return on total assets, R & D expense ratio, inventory ratio, chairman and CEO, and firm size positively impact ESG performance. The improvement of ROA indicates strong profitability, which is conducive to investing in sustainable development projects, thus improving ESG performance. This shows that R&D investment may have a positive impact on ESG performance. The DUAL structure helps focus and efficient decision-making, drives firm governance and sustainability, and thus improves ESG scores. In addition, large-scale firms are more likely to implement and report on sustainability plans due to their resource and capacity strengths.

At the same time, the model also found that audit by one of the Big Four (BIG4), leverage (LEV), growth (GRW), and firm age (AGE) showed a significant negative correlation with the ESG composite score (ESGC). Firms audited by the Big Four accounting firms (BIG 4) may be more cautious in ESG disclosure due to strict audit standards, resulting in lower ratings. A high debt ratio (LEV) means limited financial resources and may affect sustainability inputs, reducing ESG performance. Firms with fast annual revenue growth rates (GRW) may neglect

environmental and social responsibility in response to market expansion, leading to a decline in ESG scores. Older age (AGE) firms may lack the flexibility to adapt to the new sustainability requirements, so their ESG performance is relatively low.

Overall, the R-squared values of models 1 and 2 were 11.4% and 9.7%, respectively, indicating that these models can explain a large part of the variance of TBQ with a good fit. The F statistic was 6.964 (model 1, p-value 0.0000) and 6.525 (model 2, p-value 0.0000), respectively, meaning that both models were significant overall. Furthermore, the multicollinearity (VIF) values were 4.45 (Model 1) and 4.62 (Model 2), both within the acceptable range, indicating that the model does not have a severe multicollinearity issue.

In conclusion, the regression results in Table 4 support hypotheses 1,2 and 3, showing the critical role of green innovation and sustainability strategies in improving firm ESG performance. Enterprises should achieve higher ESG performance and long-term competitive advantage through collaborative green innovation and sustainability strategies. At the same time, the support and participation of senior management is crucial in promoting the sustainable development of the enterprise, and firms should thoroughly consider this in the strategy formulation and implementation process. The results verify the theoretical hypothesis and provide valuable guidance for business management practice.

5.0 CONCLUSION

In pursuing the “dual carbon” goal and high-quality economic development, studying the relationship between green innovation, sustainability strategy, and ESG performance is significant. Based on the RBV theory and the upper-echelon theory, this study examines the impact of green innovation on the ESG performance of the new generation of the information technology industry and analyses the moderating role of a sustainability strategy.

First, the empirical results show a significant relationship between ESG performance and green innovation. This shows how firms can achieve their sustainability goals by investing in green innovations that can significantly improve their ESG performance.

Second, the results show that sustainability strategies have a positive impact on ESG performance. When firms develop and implement sustainability strategies, they not only help improve their ESG performance but also build a better reputation and competitive advantage in the market.

Third, sustainability strategies strengthen the positive correlation between green innovation and ESG performance. This could have something to do with the level of integration of the leadership team with ESG values. For the successful implementation of sustainability strategies and the pursuit of green innovations, the approval and support of top management is essential.

These results confirm the importance of the RBV and upper-echelon theory in explaining organisational sustainability and performance improvement. The RBV theory emphasises the importance of the firm's resources and capabilities (Barney, 2001; Ferreira et al., 2023; Galbreath, 2005), while the upper-echelon theory states that the values and perceptions of top managers have a significant impact on strategic choices and firm performance (Hambrick, 2007; Jahanshahi & Brem, 2017). The combination of these two theories provides a more comprehensive understanding of how firms can achieve sustainable development and long-term success through green innovation and sustainability strategies.

When formulating corporate strategies and business decisions, firms should pay attention to green innovations and integrate them into their long-term development plans. Green innovation can improve firms' ESG performance and help them gain long-term competitive

advantages in the highly competitive market (Li et al., 2023). The crucial role of top management in promoting corporate sustainability was also highlighted. Their recognition and support are essential for the successful implementation of sustainability strategies and the realisation of green innovations.

The study not only confirms the positive moderating effect of sustainability strategy on the relationship between green innovation and ESG performance but also highlights the crucial role of top management in promoting sustainable corporate development. Firms should focus on the synergy of green innovation and sustainability strategies to achieve higher ESG performance and long-term competitive advantage. Specifically, top management needs to drive a sustainability strategy, provide the necessary resources and support, and see green innovation as a core component of the firm's long-term growth.

6.0 SUGGESTION FOR FUTURE RESEARCH

There are still some limitations to this study. First, the research sample is limited to new-generation information technology listed firms in China's strategic emerging industries and can be further expanded to other industries or regions. Secondly, this study mainly focuses on the moderating effect of sustainability strategy on green innovation and ESG performance, and the impact of other influencing factors, such as industry characteristics of this moderating effect, can be further studied in the future.

In addition, with the continuous improvement of ESG disclosure standards and evaluation systems, future research can further focus on the impact of changes in these standards and systems on ESG performance. By expanding the scope of research and paying attention to the latest ESG standards, future research will be able to more comprehensively reveal the mechanism and impact of green innovation and sustainability strategies in different contexts and provide more in-depth theoretical and practical guidance for firms to achieve sustainable development.

CO-AUTHOR CONTRIBUTION

The authors affirmed that there is no conflict of interest in this article. Author1 carried out the fieldwork, prepared the literature review and overlooked the write-up of the whole article. Author 2 wrote the research methodology and did the data entry. Author3 carried out the statistical analysis and interpretation of the results. Author 4 carried out the conclusion and guided the write-up.

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