

Digital Transformation and Corporate Environmental, Social and Governance Greenwashing: Promotion or Inhibition?

Chengyu Sun*, Chenxi Li, and Huiran Yang

International Business College, Dongbei University of Finance and Economics, Dalian 116025,
PR China

*Corresponding Author

Abstract

With the accelerated advancement of digital transformation and the global popularization of Environmental, Social, and Governance (ESG) standards, companies are facing challenges in environmental protection and social responsibility while pursuing economic benefits. However, the emergence of ESG greenwashing phenomena, which refers to false publicity and non-transparent disclosure in ESG performance, poses a challenge to the credibility of the ESG system. This paper aims to explore how digital transformation affects corporate ESG greenwashing behavior and analyzes its mechanism of action. By selecting listed companies on the Shanghai and Shenzhen A-shares market from 2012 to 2022 as samples, this paper uses a multiple linear regression model to empirically test the impact of digital transformation on corporate ESG greenwashing behavior. The results show that digital transformation can significantly inhibit corporate ESG greenwashing behavior. Further analysis reveals that this inhibitory effect is mainly achieved by improving enterprise total factor productivity, strengthening external supervision pressure, and enhancing corporate green innovation capabilities. In addition, heterogeneous tests show that the inhibitory effect of digital transformation on corporate ESG greenwashing is more significant in non-state-owned property, non-high-tech, and heavily polluting enterprises. This study not only enriches the research perspective of the impact of digital transformation on corporate non-financial performance but also provides specific guidance for companies on how to balance economic benefits and social responsibility during the process of digital transformation, which is of great theoretical and practical significance for achieving high-quality sustainable development.

Keywords

Digital Transformation; ESG Greenwashing; Total Factor Productivity; External Supervision; Green Innovation.

1. Introduction

China has clearly pointed out the necessity to "adhere to sustainable development". This guideline aims to promote the harmonious coexistence of economy, society, and the relationship between humans and nature, providing basic principles for corporate restructuring and industrial upgrading. With the evolution of the global business landscape, ESG standards have become an important measure to assess corporate sustainability and social responsibility. Against the backdrop of China's green development and the advancement of "dual carbon" goals, ESG practices have become an integral part of national strategy and have attracted unprecedented attention to corporate ESG performance.

Environmental information disclosure, as an important way for local governments, investors, and the public to understand a company's ecological protection and responsibility fulfillment

(Zhu et al., 2019), is a crucial channel for stakeholders to understand corporate environmental behavior and responsibility. greenwashing behavior refers to the misleading actions made by companies in environmental information disclosure (Li, 2018), which means that companies, through misleading information disclosure, create a green image to gain related benefits and enhance corporate image and market competitiveness (Bowen et al, 2014). Essentially, this behavior is a form of impression management by companies to gain social recognition (i.e., "legitimacy") for non-financial information (Li, Xin, 2024). It has many negative impacts at both the micro and macro levels. At the micro level, greenwashing can reduce consumer trust in the brand (Isac, 2024), affect corporate reputation (Wu, 2023), and reduce investor willingness to invest; at the macro level, greenwashing behavior can lead to market failure, weaken the effectiveness of environmental regulation (Wu, 2023), hinder the achievement of sustainable development goals, and even bring challenges to government regulation (Wu, 2023). Therefore, it is necessary to study the influencing mechanisms of corporate ESG performance in depth, to guard against the risks brought by greenwashing behavior, to effectively improve corporate ESG performance, and to provide a solid foundation for achieving high-quality sustainable development.

Digital transformation refers to the process of changing traditional work methods, business processes, and business models using digital technologies such as cloud computing, big data, and artificial intelligence to improve efficiency, create new value points, or improve customer experience. It can not only cause fundamental changes in corporate culture and organizational models through technology but is also a key support for building a new competitive advantage for the country, promoting high-quality development, and building a new development pattern. Current research on digital transformation mainly focuses on the impact of digital transformation on corporate economic value, such as the impact of digital transformation on corporate sustainable development performance (Liu et al., 2024), and the impact of digital transformation on the performance of intelligent manufacturing enterprises (Zhang, 2024). There is still a lack of research on non-economic value impacts, especially literature that directly establishes the relationship between digital transformation and ESG greenwashing.

While digital transformation enhances corporate operational efficiency and innovation capabilities, it may also bring some challenges and risks. On the one hand, as a strategic investment with excessive costs, digital transformation increases the pressure and uncertainty of corporate operations. While companies increase investment in digital transformation, they may reduce investment in non-economic areas such as green, environmental, and social responsibility in pursuit of short-term economic benefits (Harjoto & Wang, 2020), creating a crowding-out effect. To comply with policy requirements and meet the expectations of stakeholders, especially to attract ESG investment, some companies may adopt superficial ESG performance optimization strategies, aiming to create a positive ESG image, that is, to wash (Zhang, 2024), to obtain positive value; on the other hand, digital transformation brings significant economic benefits to companies through improving technical efficiency (Huang et al., 2023), reducing costs, and enhancing innovation capabilities. While promoting business growth and financial growth, digital transformation can also improve the social and environmental benefits of companies, that is, promoting the coordination of high-quality development and high-speed growth (Li & Li, 2024). These advantages not only alleviate the cash pressure on companies but may also enhance their willingness and ability to engage in ESG behavior. In addition, digital transformation has also improved the transparency of internal corporate information (Zhang et al., 2022), strengthening internal and external supervision, thus inhibiting the occurrence of ESG greenwashing behavior.

This paper delves into the above issues, studying the relationship between digital transformation and corporate ESG greenwashing behavior, aiming to answer three core questions: First, this paper explores how digital transformation affects corporate ESG

greenwashing. The empirical analysis found that digital transformation has an inhibitory effect on corporate ESG greenwashing; second, this paper analyzes the mechanism by which digital transformation inhibits corporate ESG greenwashing. The study found that digital transformation can improve corporate total factor productivity, strengthen external supervision pressure, and enhance corporate green innovation capabilities, thereby inhibiting corporate ESG greenwashing behavior; finally, this paper examines the heterogeneity characteristics of the impact of digital transformation on corporate ESG greenwashing. The results show that the inhibitory effect of digital transformation on corporate ESG greenwashing is more significant in non-state-owned property, non-high-tech, and heavily polluting enterprises. This may be because these enterprises face higher market and regulatory pressures, so the benefits brought by digital transformation are more obvious. Through the study of A-share listed companies from 2012 to 2022, this paper confirms that digital transformation has a significant inhibitory effect on corporate ESG greenwashing behavior, and this conclusion remains robust after the test of endogeneity and robustness. These findings provide valuable insights for policymakers and corporate managers to better balance economic benefits and social responsibility during the process of digital transformation and promote the sustainable development of enterprises.

The research contribution of this paper lies in: theoretically, this study expands the research perspective of the impact of digital transformation on corporate non-financial performance. By constructing the "digital transformation - corporate social responsibility fulfillment" research framework, it extends the research on the non-economic effects of digital transformation and supplements the study of corporate greenwashing, in-depth analyzing how digital transformation promotes the fulfillment of corporate social responsibility through improving corporate green innovation levels and internal control information disclosure. Practically, this study clarifies the impact path of digital transformation and greenwashing, helping to open the black box of corporate greenwashing, providing specific guidance for companies on how to balance economic benefits and social responsibility during the process of digital transformation, providing empirical support for companies when implementing digital strategies, emphasizing that companies should pay attention to the fulfillment of social responsibility while pursuing economic benefits to achieve their own sustainable development.

2. Literature Review and Research Hypotheses

2.1. Literature Review

2.1.1. Digital Transformation

Digital transformation refers to the process of changing the operating model of physical enterprises by comprehensively using data, computing, communication, and connection technologies (Gregory, 2019). With the continuous deepening of digital transformation, its technological innovation, regional adaptability, systemic changes, and overall synergy effects (Ander et al., 2021) have had a profound impact on the sustainable development capabilities of enterprises. This impact is not limited to individual companies but may also be transmitted to their upstream and downstream partners through the supply chain (Song Hua, et al., 2023). Existing literature mainly discusses the impact of digital transformation on heavy industry enterprises in terms of carbon emissions by avoiding information asymmetry and improving resource allocation capabilities, and concludes that digital transformation has become a driving factor in improving environmental performance (Zheng, et al., 2023); some scholars have also focused on digital transformation based on green technology innovation, which has improved the total factor productivity of heavily polluting enterprises (Su, et al., 2023). In addition, Zhong et al. (2024) conducted research from the perspective of managers and found that corporate digital transformation can improve ESG performance by enhancing the perception and

decision-making capabilities of managers, and some scholars have found that digital transformation can promote corporate ESG performance by improving the transparency of internal corporate information (Hu, et al., 2023), and can also drive corporate ESG performance by alleviating the agency conflict between shareholders and management (Song, et al., 2024).

At the same time, some studies have shown that digital transformation can also bring some negative impacts on companies (He et al., 2023), the "timeliness" and "high efficiency" advantages brought by digital transformation make it possible for companies to borrow outside the banking supervision system (Cao et al., 2023). In addition, the application of digital technology and business model innovation have increased the complexity of corporate operations and organizational structure. Subsequently, multiple factors also lead to a double-edged sword effect of digital transformation on employee engagement, bringing positive experiences to employees while also causing negative effects on employee engagement due to potential risks of job displacement and unemployment (Yi, et al., 2024).

In summary, existing literature on corporate digital transformation mainly focuses on the macro impact of digital transformation on the outside world and has achieved certain results, but there are still deficiencies: although it has been found that digital transformation can improve corporate ESG performance through mechanisms such as alleviating information asymmetry and improving the perception capabilities of corporate managers, there are fewer research results that go deep into the level of ESG greenwashing. There is a lack of in-depth discussion on the specific mechanisms by which digital transformation affects ESG greenwashing, and further research is needed.

2.1.2. ESG Greenwashing

The term greenwashing was first proposed by environmentalist Jay Westervelt in 1986 (de Freitas Netto et al., 2020), generally referring to companies that, under the circumstances of poor environmental performance, actively communicate to the outside world to convey a positive environmental image. In the study of ESG, since ESG uses the three dimensions of environment, society, and governance to evaluate the situation of corporate social responsibility, the scope of corporate greenwashing is no longer limited to the environmental level but has been generalized. ESG greenwashing generally refers to the behavior of companies or financial institutions that, in order to obtain market or policy benefits, make false and exaggerated ESG statements to mislead stakeholders into believing that their products or activities meet ESG standards. For example, Walker and Wan define greenwashing as companies using symbolic social activities and corporate substantive social activities (2012). Shen et al. (2023) believe that greenwashing behavior is when companies issue ESG reports that are better than their actual environmental behavior. Similarly, Wang et al. (2023) collectively refer to ESG "greening" and ESG greenwashing as strategic ESG behaviors and vividly call it "inconsistent words and deeds", pointing out that ESG greenwashing is an "exaggeration", that is, the ESG information disclosed by companies has exaggerated its actual ESG performance level.

According to existing research, there are three main forms of ESG greenwashing: the first is exaggerated disclosure, that is, covering up their own ESG performance shortcomings by disclosing a large amount of ESG information (Topal, et al., 2019; Yu, et al., 2020); the second is selective disclosure, that is, only disclosing positive information and not disclosing negative information (Walke & Wan, 2012; Xi et al., 2024; Marquis et al., 2016); the third is vague disclosure, which means that companies provide ESG information with poor authenticity and credibility through wordplay (Sun et al., 2024). Corporate ESG greenwashing is a form of image management by companies using information asymmetry (Zhang, 2022). Better ESG performance often means fewer financing constraints, higher social reputation (Yu et al., 2020), more abundant talent resources, and higher customer loyalty (de Souza Barbosa et al., 2023),

so when external regulatory efforts are insufficient, or companies are not motivated to invest in ESG, companies are likely to engage in ESG greenwashing for their own interests.

Existing research has achieved considerable results on what factors influence ESG greenwashing and its mechanisms of action. Yu, et al. (2020) found from the perspective of corporate governance that the proportion of independent directors and institutional investors can inhibit greenwashing behavior, and Zhu, et al. (2024) also found the inhibitory effect of institutional investors on greenwashing, but Wang and Zhang (2024) pointed out that common institutional holdings increase corporate ESG greenwashing through strategic alliances and short-term dominance; Li and Xin (2024) found that companies with insufficient investment are more inclined to engage in ESG greenwashing, and the company's profitability, total factor productivity, ESG fund holding ratio, and analyst focus can alleviate this incentive, Marquis, et al. (2016) found that external supervision pressure can inhibit corporate greenwashing behavior, and Bai, et al. (2024) further found that regulatory legitimacy is negatively correlated with corporate ESG greenwashing, while normative and mimetic legitimacy pressures are positively correlated with ESG greenwashing; Xu and Wang found that green finance can curb ESG greenwashing (2024); in addition, Hu et al. (2023) found that ESG rating divergence can exacerbate corporate ESG greenwashing behavior; Huang et al. (2020) also found that corporate ESG greenwashing has regional isomorphism effects, and Li and Cai (2024) found that ESG greenwashing has peer pressure effects.

However, there is less literature focusing on the relationship between corporate digital transformation and ESG greenwashing. Existing research has found that corporate digital transformation can inhibit corporate ESG greenwashing through reducing information asymmetry between internal and external parties of the company (Li & Tian, 2024; Yang et al., 2024), improving corporate internal control quality, alleviating financing constraints (Li & Tian, 2024; Wang & Cao, 2024), driving green transformation (Li & Tian, 2024), improving accounting information quality (Wang & Cao, 2024), and alleviating agency problems (Song et al., 2024). In addition, Yang et al. (2024) found that supply chain digitalization can inhibit corporate greenwashing behavior by improving total factor productivity and alleviating information asymmetry between stakeholders and companies. Existing literature has explored the impact path of corporate digital transformation on corporate ESG greenwashing, but the results are relatively limited, and these mechanism perspectives are mostly traditional and single, which are not enough to fully summarize the path of digital transformation affecting corporate ESG greenwashing. Based on the existing research results, this paper further expands the mechanism by which digital transformation affects corporate ESG greenwashing to obtain more novel and in-depth research results.

2.2. Research Hypotheses

Corporate digital transformation is a high-cost investment at the strategic level of enterprises, usually involving a series of investment behaviors such as enterprise transformation plan design, digital equipment updates, digital system development and maintenance, employee digital literacy training, and the construction of professional digital teams, which will bring additional cost burdens to enterprises, such as learning costs and derived management costs (Li & Jia, 2018; Usai, 2021). For companies that started digitalization late and have a weak digital foundation, the early investment in the digital transformation process is high, the development cycle is long, and the effect is slow, which undoubtedly increases the uncertainty in corporate operations. Under this background, the high cost of digital transformation brings greater pressure on corporate cash flow, so it is likely to have a crowding-out effect on non-economic investment activities that do not have direct and short-term economic returns, especially for green innovation investment (Dong et al., 2024). However, driven by multiple factors such as policy orientation and public opinion, stakeholders are paying more attention

to corporate ESG performance, and corporate ESG performance is increasingly becoming a factor in investors' investment decisions. This may prompt companies to adopt washing strategies for ESG investment to obtain positive external evaluations in a "better than words" manner to obtain related benefits, rather than actually improving corporate ESG levels through ESG investment.

Based on the above reasoning, this paper proposes the following hypothesis:

H1: Corporate digital transformation will stimulate corporate ESG greenwashing behavior.

However, more research indicates that corporate digital transformation can have beneficial effects on enterprises. First, corporate digital transformation reduces the operating costs of enterprises. Digital transformation reduces labor costs through automation, reduces inventory costs through market data analysis, and reduces idle production capacity by adjusting production plans in time through real-time monitoring and data analysis (Li et al., 2024); at the same time, automated and intelligent business processes also reduce errors brought by humans (Karttunen et al., 2023), reduce the misallocation and waste of resources, and improve the resource utilization rate of enterprises. Second, corporate digital transformation enhances corporate governance capabilities. On the one hand, digital transformation makes the organizational structure of enterprises tend to be flat (Zhao, 2001), which to some extent avoids the distortion of information transmission in a multi-level structure and alleviates information asymmetry within the enterprise; on the other hand, digital transformation provides technical support for responsibility traceability, such as blockchain technology, which has immutability and traceability (Zheng et al., 2018), can make corporate activities leave traces in an irreversible form, and facilitate the division of corporate responsibility bearers more accurately, which is conducive to forming a clear corporate governance pattern of rights and responsibilities. In addition, the digital process of information collection, integration, processing, analysis, and release not only improves the utilization rate of data resources for enterprises but also increases the transparency of corporate information, alleviating the information asymmetry between enterprises and stakeholders, and strengthening external supervision pressure on enterprises. Corporate ESG greenwashing will face greater risks and stronger supervision.

Based on the above reasoning, this paper proposes the following hypothesis:

H2: Corporate digital transformation will inhibit corporate ESG greenwashing behavior.

3. Research Design

3.1. Sample Selection and Data Sources

This paper selects listed companies on the Shanghai and Shenzhen A-shares market from 2012 to 2022 with Bloomberg and Huazheng ESG rating data as the initial research sample. According to the current common practice, the initial sample has been processed as follows: (1) excluding samples from the monetary financial service industry, insurance industry, and capital market service industry; (2) excluding samples of ST, *ST, PT companies; (3) excluding samples with serious missing key data and information; (4) performing a 1% Winsorizing on continuous variables to avoid the impact of extreme values on the results. After the above processing, a total of 6,851 valid observations were obtained. ESG data comes from Bloomberg and Huazheng databases, and corporate digital transformation and other corporate characteristic data all come from the CSMAR database.

3.2. Variable Definition and Measurement

3.2.1. Dependent Variable

This paper refers to the calculation methods of Sun et al (2024) for ESG greenwashing as follows:

$$GW = \frac{ESG_{dis} - \overline{ESG_{dis}}}{\sigma_{dis}} - \frac{ESG_{per} - \overline{ESG_{per}}}{\sigma_{per}}$$

The paper employs Bloomberg’s ESG score to measure corporate ESG disclosure score and employs Huazheng’s ESG score to measure corporate ESG performance score. Because Bloomberg’s ESG score is calculated based on the voluntary disclosure of ESG information by companies to the public. In contrast, Huazheng’s ESG score is calculated by multiple methods and the ESG information is collected from both internal and external sources, which is more objective. The paper standardizes the both with the Z-score method and subtract the ESG performance score from ESG disclosure score. When GW is positive, it indicates that the company has “greenwashing” behavior; when negative, it is “brownwashing”.

3.2.2. Independent Variable

There are currently two main methods to measure corporate digital transformation: one is represented by the methods of Wu et al. (2021) and Zhao et al. (2021), that is, using text analysis to count the frequency of keywords in the annual financial reports of listed companies to measure the level of corporate digital transformation; the other is to use the digital transformation data in the relevant database companies (Zhen et al., 2023). This paper chooses the second method, selecting the digital transformation index in the CSMAR database’s corporate digital transformation database. The value of this index is between 20 and 81 before tail trimming, and the GW value is between -6 and 6 before tail trimming, with a large difference, so the natural logarithm of the digital transformation index is taken as the proxy variable for digital transformation, Dig.

3.2.3. Control Variables

Table 1. Variable Definition

Variable Type	Variable	Variable Description	Definition
Dependent Variable	GW	ESG Greenwashing	Calculated based on the Bloomberg ESG rating and Huazheng ESG rating
Independent Variable	Dig	Digital Transformation	Natural logarithm of the enterprise digital transformation index from CSMAR database
Control Variable	Size	Firm Size	Natural logarithm of total assets at the end of the period
	Lev	Financial Leverage	Total liabilities at the end of the period / Total assets
	ROA	Return on Assets	Net profit / Total assets
	Tobin Q	Tobin Q	Market value of equity / Total assets
	Firm Age	Firm Age	Logarithm of the firm's age
	Liquid	Liquidity	Current assets at the end of the year / Total assets
	Growth	Revenue Growth Rate	Revenue growth rate
	Cashflow	Cash Flow	Net cash flow from operations / Total assets
	Dual	Duality of COB and CEO	1 if the chairman and general manager are the same person, otherwise 0
	Mshare	Management Equity Stake	Number of shares held by management / Total number of shares
	Top1	Largest Shareholder's Stake	Number of shares held by the largest shareholder at the end of the period / Total number of shares
Indep	Proportion of Independent Directors	Number of independent directors / Total number of directors in the company	

Referring to the practice of Wang et al. (2024), the following variables are introduced as control variables: company size (Size), corporate financial leverage (Lev), return on total assets (ROA), Tobin's Q index (Tobin Q), company age (Firm Age), liquidity (Liquid), revenue growth rate (Growth), cash flow (Cashflow), dual positions (Dual), management shareholding ratio (Mshare), the largest shareholder's shareholding ratio (Top1), and the proportion of independent directors (Indep). The specific definition of each variable is shown in Table 1.

3.3. Model Setting

Refer to existing literature (Li & Tian, 2024; Wang & Cao, 2024) to set up the following multiple linear regression model:

$$GW_{i,t} = \beta_0 + \beta_1 Dig_{i,t} + year + industry + \sum \gamma control + \epsilon$$

Where GW represents the dependent variable ESG Greenwash, that is, ESG greenwashing; Dig represents the independent variable corporate digitalization level; year represents fixed year effects; industry represents industry fixed effects; represents control variables, ϵ represents.... And when $\beta_1 > 0$, it means that corporate digital transformation will stimulate corporate ESG greenwashing behavior; when $\beta_1 < 0$, it means that corporate digital transformation will inhibit corporate ESG greenwashing behavior.

4. Empirical Results and Analysis

4.1. Descriptive Statistics

The descriptive statistical results of the variables are shown in Table 2. Table 2 shows that the mean of corporate ESG greenwashing GW is -0.491, and the standard deviation is 1.250, indicating that ESG greenwashing behavior varies greatly among different companies, with a maximum value of 2.950 and a minimum value of -3.362; at the same time, the mean of corporate digital transformation Dig is 3.590, and the standard deviation is 0.273, indicating that there is a certain difference in the level of digital transformation among different companies. The descriptive statistical results of each variable are basically consistent with existing research and are within the normal range.

Table 2. Variable Descriptive Statistics

Variable	N	Mean	SD	Min	Max
GW	6,851	-0.491	1.250	-3.362	2.950
Dig	6,851	3.590	0.273	3.155	4.224
Size	6,851	23.40	1.271	20.12	26.45
Lev	6,851	0.471	0.188	0.0349	0.908
ROA	6,851	0.0538	0.0590	-0.373	0.247
Tobin Q	6,851	1.954	1.405	0.802	15.61
Firm Age	6,851	2.961	0.319	1.609	3.611
Liquid	6,851	1.936	1.934	0.268	25.08
Growth	6,851	0.157	0.342	-0.658	4.024
Cashflow	6,851	0.0649	0.0644	-0.196	0.267
Dual	6,851	0.206	0.404	0	1
Mshare	6,851	7.038	14.70	0	70.17
Top1	6,851	37.10	16.00	8.020	75.78
Indep	6851	37.592	5.558	28.57	60

4.2. Benchmark Regression

The multiple linear regression results of corporate digital transformation on corporate ESG greenwashing are shown in Table 3. Table 3 (1) shows that without considering control variables, year fixed effects, and industry fixed effects, the regression coefficient of Dig on GW is -0.259, which is significantly negative at the 1% level; when control variables are introduced but year and industry fixed effects are not considered, the regression coefficient of Dig on GW is -0.398, which is significantly negative at the 1% level; when control variables are introduced and year and industry fixed effects are considered, the regression coefficient of Dig on GW is -0.393, which is significantly negative at the 1% level. The results of the benchmark regression show that corporate digital transformation has a significant inhibitory effect on corporate ESG greenwashing behavior. Therefore, Hypothesis H2 is established, that is, corporate digital transformation will inhibit corporate ESG greenwashing behavior.

Table 3. Corporate Digital Transformation and ESG Greenwashing

VARIABLE	(1)	(2)	(3)
	Gws	Gws	Gws
DIG	-0.259*** (-4.70)	-0.398*** (-7.06)	-0.393*** (-4.61)
SIZE		0.178*** (11.62)	0.161*** (9.16)
LEV		-0.517*** (-4.22)	-0.443*** (-3.20)
ROA1		-1.032*** (-2.90)	-0.622* (-1.66)
TOBINQ		0.0602*** (4.61)	0.0541*** (3.80)
FIRMAGE		-0.0290 (-0.59)	-0.150*** (-2.60)
LIQUID		0.0104 (1.05)	0.0254** (2.43)
GROWTH		0.192*** (4.15)	0.184*** (3.90)
CASHFLOW		0.218 (0.79)	-0.106 (-0.37)
DUAL		0.176*** (4.59)	0.171*** (4.39)
MSHARE		0.00829*** (7.28)	0.00771*** (6.53)
TOP1		0.000874 (0.87)	-0.000796 (-0.74)
INDEP		-0.000839 (-0.31)	0.000395 (0.14)
YEAR			Yes
INDUSTRY			Yes
_CONS	0.439** (2.21)	-3.125*** (-8.02)	-2.069*** (-4.16)
N	6851	6851	6851
R ²	0.0032	0.0389	0.0651

Note: ***, ** and * represent significance at the 1%, 5%, and 10% levels, respectively. The same applies below.

4.3. Endogeneity Test

Table 4. Corporate Digital Transformation and ESG greenwashing Endogeneity Test

Variable	(1)	(2)
	Gws	Gws
Dig/Dig_Binary	-0.482*** (0.111)	-0.150** (0.0660)
Size	0.203*** (0.020)	0.0722** (0.0318)
Lev	-0.531*** (0.155)	0.448* (0.255)
Roa1	-0.981** (0.420)	0.647 (0.687)
Tobinq	0.065*** (0.016)	0.0673*** (0.0258)
Firmage	-0.084 (0.068)	-0.159 (0.0986)
Liquid	0.012 (0.013)	0.0492*** (0.0168)
Growth	0.179*** (0.056)	0.320*** (0.0783)
Cashflow	0.040 (0.319)	-1.792*** (0.486)
Dual	0.167*** (0.043)	0.0899 (0.0705)
Mshare	0.007*** (0.001)	0.00841*** (0.00202)
Top1	-0.001 (0.001)	0.00189 (0.00202)
Indep	0.001 (0.003)	-0.000168 (0.00509)
_Cons	-2.696*** (0.596)	-2.279*** (0.810)
N	5538	2049
R ²	0.072	NA

The improvement of digital transformation level can inhibit corporate ESG greenwashing behavior, and the improvement of corporate greenwashing behavior can also promote corporate digital transformation, and there may be a reciprocal relationship between the explanatory variable and the explained variable. Therefore, this paper uses lagged regression and propensity score matching (PSM) to conduct endogeneity tests.

4.3.1. Lagged Regression

The lagged period considers the time relationship between the explanatory variable and the explained variable, which can weaken the bidirectional relationship between digital transformation and ESG greenwashing. Therefore, this paper selects the lagged digital transformation data for regression. As shown in Table 4, Column 1, the regression coefficient of lagged digital transformation on corporate greenwashing is -0.482, which is significantly negative at the 1% level. This indicates that after considering the endogeneity issue, the previous research conclusion remains unaffected.

4.3.2. Propensity Score Matching (PSM) Method

The relationship between digital transformation and corporate greenwashing may have a self-selection issue. The PSM method can alleviate the estimation bias caused by self-selection issues. First, a logistic regression model is used to perform propensity score matching, dividing the data into treatment and control groups, using financial and market indicators such as company size as explanatory variables, and then generating predicted probabilities. The two groups of samples meet the support hypothesis and pass the matching quality check, treatment effect estimation, and balance check. Finally, a weighted regression is conducted to examine the impact of the treatment variable on the outcome variable. The regression results of the matched sample are shown in Table 4, Column 2, where the regression coefficient of digital transformation is significantly negative at the 5% level. In summary, after overcoming the self-selection bias issue, the previous research conclusion remains reliable.

4.4. Robustness Test

Table 5. Corporate Digital Transformation and ESG greenwashing Robustness Test

Variable	Tobit	Dig Replaced	5% Winsorizing
	GWS	GWS	GWS_C
Dig/Dig_C	-0.393*** (-4.64)	-1.820* (-2.34)	-0.358*** (-4.40)
Controls	YES	YES	YES
Year	YES	YES	YES
Industry	YES	YES	YES
_Cons	-2.069*** (-4.19)	-3.074*** (-6.70)	-2.263*** (-4.56)
Var(E.Gws)	1.461*** (58.53)		
N	6851	6851	6851

4.4.1. Changing Measurement Models.

To reduce the error caused by data interference, this paper uses the Tobit model for robustness testing. The regression results after changing the measurement model are shown in Table 5, Column 1. The coefficient of digital transformation (Dig) on corporate ESG greenwashing (GW) is -0.393, which is significant at the 1% level. This indicates that even after changing the model, digital transformation still has an inhibitory effect on corporate ESG greenwashing, verifying the robustness of the research results.

4.4.2. Replacing Digital Transformation Variables

This paper borrows the research method of Zhao et al. (2021) to replace the measurement indicators of digital transformation and quantifies the evaluation of corporate digital transformation by processing the frequency of relevant keywords. The empirical analysis results in Table 5, Column 2 show that the coefficient of corporate digital transformation (Dig) is -1.820, which is significant at the 5% level. This indicates that even after replacing the measurement method of the independent variable, the deepening of corporate digital transformation still significantly negatively affects corporate ESG greenwashing behavior, verifying the robustness of the research results.

4.4.3. 5% Winsorizing

In addition, this paper refers to the method of Li (2024) and conducts a 5% tail trimming on the original sample, and then re-conducts the regression test. The regression results in Table 5, Column 3 show that the coefficient of digital transformation (Dig_C) is -0.358, which is significant at the 1% level. This indicates that after conducting 5% tail trimming, digital

transformation inhibits corporate ESG greenwashing behavior, verifying the robustness of the research results.

5. Further Testing

5.1. Mechanism of Action

Combining the theoretical analysis in the previous sections, digital transformation can play a role in improving operational efficiency, enhancing information disclosure transparency, and promoting corporate innovation capabilities. Therefore, this paper examines the mechanism by which digital transformation inhibits corporate ESG greenwashing from three aspects: total factor productivity, external supervision pressure, and green innovation capabilities.

5.1.1. Total Factor Productivity

Digital transformation has a positive impact on enhancing total factor productivity in enterprises. Existing research shows that digital transformation can improve total factor productivity through enhancing innovation capabilities, optimizing human capital structure, promoting the integration of advanced manufacturing, reducing costs (Zhao, et al., 2021), driving organizational structure changes (Li, et al., 2024), optimizing production decisions, and enhancing corporate market perception (Qi, Xiao, 2020). This paper uses the Levinsohn-Petrin (LP) method to calculate the total factor productivity of enterprises. As shown in Column 2 of Table 6, the regression coefficient of digital transformation (Dig) on total factor productivity (TFP_LP) is 0.312, which is significant at the 1% level. This result indicates that corporate digital transformation has a significant positive impact on total factor productivity, consistent with expectations, suggesting that digital transformation can inhibit corporate ESG greenwashing by enhancing total factor productivity. Total factor productivity implies that enterprises have stronger profitability, enabling them to strengthen competitive advantages and financing capabilities, optimize operational conditions, and reduce the need to embellish financial information to avoid penalties, thereby improving the quality of information disclosure and inhibiting ESG greenwashing (Sun, 2019; Yang et al., 2024).

5.1.2. External Supervision Pressure

Corporate digital transformation can enhance information transparency, thereby increasing external supervision pressure on enterprises. Information asymmetry is one of the foundations that enable companies to engage in ESG greenwashing (Xie, Zhang, 2023). The application of digital technology not only enhances the data processing capabilities of enterprises (Li, 2023) but also improves external stakeholders' ability to access corporate information (Niu, Y. et al., 2023), enhancing the transparency of corporate information. The increase in information transparency brings a "spotlight" effect to enterprises, amplifying inappropriate behaviors and increasing external supervision pressure on enterprises (Wang, Cao, 2024). Analysts convey corporate information to the market in the form of analysis reports, and the number of such reports can reflect the strength of external supervision pressure on enterprises. Therefore, this paper uses the number of analysts as a proxy variable for external supervision pressure. As shown in Column 2 of Table 6, the regression coefficient of digital transformation (Dig) on the number of analysts (analyst) is 0.153, which is significant at the 5% level. When using the number of research reports (report) to measure external supervision pressure, similar results are obtained in Column 3. This indicates that corporate digital transformation leads to an increase in external supervision pressure, consistent with expectations, suggesting that digital transformation can inhibit corporate ESG greenwashing by enhancing external supervision pressure. The increase in external supervision pressure raises the risks and costs of corporate ESG greenwashing, while also urging companies to fulfill their social responsibilities (Wang Xue, 2024), thereby inhibiting corporate ESG greenwashing behavior.

5.1.3. Green Innovation

Table 6. Mechanism Test of Corporate Digital Transformation Inhibiting ESG Greenwashing

Variable	(1)	(2)	(3)	(4)
	Analyst	TFP_LP	Report	GI
Dig	0.153** (2.57)	0.312*** (9.46)	0.216*** (2.91)	0.474*** (7.78)
Size	0.543*** (44.38)	0.567*** (83.42)	0.671*** (43.86)	0.183*** (14.53)
Lev	-0.460*** (-4.78)	0.919*** (17.16)	-0.519*** (-4.31)	0.178* (1.80)
Roa1	5.379*** (20.67)	2.694*** (18.64)	6.801*** (20.90)	0.219 (0.82)
Tobinq	0.240*** (24.17)	-0.0170*** (-3.10)	0.290*** (23.39)	0.0256** (2.52)
Firmage	-0.321*** (-7.98)	-0.0203 (-0.91)	-0.363*** (-7.22)	0.0334 (0.81)
Liquid	-0.0243*** (-3.34)	0.00714* (1.77)	-0.0282*** (-3.10)	0.000151 (0.02)
Growth	0.00562 (0.17)	0.0802*** (4.40)	0.0418 (1.02)	-0.124*** (-3.67)
Cashflow	0.423** (2.12)	0.779*** (7.02)	0.674*** (2.70)	0.623*** (3.04)
Dual	0.0913*** (3.38)	-0.0591*** (-3.94)	0.114*** (3.37)	0.0444 (1.60)
Mshare	0.00991*** (12.07)	-0.00134*** (-2.93)	0.0129*** (12.56)	0.00149* (1.77)
Top1	-0.00240*** (-3.21)	0.00242*** (5.83)	-0.00260*** (-2.78)	0.000794 (1.03)
Indep	-0.00845*** (-4.32)	-0.00134 (-1.23)	-0.00975*** (-3.99)	0.00126 (0.63)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
_Cons	-10.09*** (-29.14)	-5.890*** (-30.63)	-12.79*** (-29.55)	-5.919*** (-16.66)
N	6851	6851	6851	6851

Digital transformation can promote corporate green innovation. First, from an internal perspective, digital transformation optimizes the allocation of internal innovation resources by reducing information asymmetry within enterprises and improving internal decision-making efficiency (Wang, Sheng, 2024), thereby enhancing green innovation capabilities (Ma, Fu, 2024) and stimulating green innovation vitality. Second, from an external relationship perspective, the popularization of green concepts makes customers prefer environmentally friendly products (Peattie, K., 2010), and digital technology helps enterprises gain insights into these preferences (Zhao et al., 2021), enhancing the motivation for green innovation. This paper

refers to the method of Xu and Cui (2020) and uses the sum of the number of green invention patents and green utility model patents plus one, taking the natural logarithm of the result as a proxy variable for measuring corporate green innovation. The regression results show that the regression coefficient of digital transformation (Dig) on green innovation (GI) is 0.474, which is significant at the 1% level, proving that digital transformation enhances corporate green innovation capabilities, consistent with expectations, indicating that digital transformation can inhibit ESG greenwashing by promoting corporate green innovation. The creation and application of green innovation results enable enterprises to reduce resource consumption while also decreasing pollutant emissions (Shi, B., 2024; Zhang, D., 2023), allowing enterprises to fulfill their environmental responsibilities and thus inhibit ESG greenwashing.

5.2. Heterogeneity Test

5.2.1. State-Owned Enterprises vs. Non-State-Owned Enterprises

When exploring the relationship between digital transformation and ESG greenwashing, the inhibitory effect of digital transformation on corporate ESG greenwashing may vary between enterprises of different ownership types. The results of the grouped regression show that the inhibitory effect of corporate digital transformation on ESG greenwashing behavior is significantly different among enterprises of different ownership types. As shown in Columns 1 and 2 of Table 7, for non-state-owned enterprises, the coefficient of digital transformation on ESG greenwashing is -0.683, which is significant at the 1% level; for state-owned enterprises, this coefficient is -0.180, which is not significant. The regression results indicate that digital transformation is more effective in inhibiting ESG greenwashing behavior in non-state-owned enterprises compared to state-owned enterprises. This may be due to the fact that state-owned enterprises, with their state-owned background and political connections, face weaker financing constraints than non-state-owned enterprises (Yu et al., 2012; Zheng, 2017). Therefore, their motivation to engage in ESG greenwashing is relatively weaker. Additionally, for listed state-owned enterprises, they are subject not only to audits by registered accountants but also to government audits, which increases their regulatory pressure compared to non-state-owned enterprises, thereby reducing the likelihood of engaging in ESG greenwashing.

5.2.2. High-Tech vs. Non-High-Tech Enterprises

The differences between high-tech and non-high-tech enterprises may also lead to significant differences in the ability of digital transformation to inhibit ESG greenwashing behavior. To explore the inhibitory effect of digital transformation on ESG greenwashing behavior between high-tech and non-high-tech enterprises, this paper adopts the definition of high-tech enterprises from Peng and Mao (2017) and conducts grouped regression analysis. As shown in Columns 3 and 4 of Table 7, for non-high-tech enterprises, the coefficient of digital transformation on ESG greenwashing is -0.422, which is significant at the 1% level; for high-tech enterprises, the coefficient is -0.352, which is also significant at the 1% level. This indicates that digital transformation has a stronger inhibitory effect on ESG greenwashing behavior in non-high-tech enterprises. This may be because, compared to high-tech enterprises, non-high-tech enterprises have a weaker digital foundation, and the increase in information transparency and operational efficiency brought about by digital transformation has a stronger marginal effect on inhibiting ESG greenwashing behavior.

5.2.3. Heavy Polluting vs. Non-Heavy Polluting Enterprises

There are also significant differences in the inhibitory effect of digital transformation on ESG greenwashing behavior between heavy polluting and non-heavy polluting enterprises. To explore the inhibitory effect of digital transformation on ESG greenwashing behavior between heavy polluting and non-heavy polluting enterprises, this paper adopts the standards defined by Wang and He (2021) and Pan et al. (2019) to categorize heavy polluting enterprises. The

results of the grouped regression analysis are shown in Columns 5 and 6 of Table 7. The regression coefficient of digital transformation on ESG greenwashing for non-heavy polluting enterprises is -0.341, while for heavy polluting enterprises, the coefficient is -0.492, both significant at the 1% level. This indicates that digital transformation has a stronger inhibitory effect on ESG greenwashing behavior in heavy polluting enterprises compared to non-heavy polluting enterprises. The reason may be that heavy polluting enterprises, due to their potential negative environmental impacts, face greater external scrutiny and public pressure. This pressure may lead heavy polluting enterprises to be more inclined to engage in greenwashing to improve their public image and reduce reputational risks, thus making the effect of digital transformation on inhibiting ESG greenwashing more pronounced.

Table 7. Heterogeneity Test of Corporate Digital Transformation Inhibiting ESG Greenwashing

Variable	(1)	(2)	(1)	(2)	(1)	(2)
	Non-state-owned	State-owned	Non-high-tech	High-tech	Non-heavy polluting	Non-heavy polluting
	Gws	Gws	Gws	Gws	Gws	Gws
Dig	-0.683*** (0.122)	-0.180 (0.126)	-0.422*** (0.130)	-0.352*** (0.114)	-0.341*** (0.0972)	-0.492*** (0.185)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-1.216* (0.739)	-3.594*** (0.743)	-2.666*** (0.702)	-1.671** (0.679)	-1.979*** (0.563)	-2.763*** (0.973)
N	3,153	3,558	3,079	3,772	4,976	1,875
R-Squared	0.090	0.098	0.064	0.072	0.069	0.054

6. Research Conclusion and Implications

6.1. Research Conclusion

With the increasing challenges of population growth, environmental degradation, energy depletion, and climate anomalies, sustainable development has become a common issue faced by all humanity, and ESG has thus become the focus of global attention. At the same time, digital transformation, with its advantages in cost savings, governance optimization, and innovation promotion, has become an essential path for enterprises to achieve sustainable development and plays a crucial role in shaping corporate ESG performance. This paper takes A-share listed companies from 2012 to 2022 as the research object and further clarifies the impact of corporate digital transformation on corporate ESG greenwashing and its mechanisms through empirical analysis. The research results show that: first, corporate digital transformation can inhibit corporate ESG greenwashing behavior; second, total factor productivity, external supervision pressure, and green innovation play a mediating role in the impact of corporate digital transformation on corporate ESG greenwashing. Specifically, digital transformation inhibits corporate ESG greenwashing behavior by improving corporate total factor productivity, strengthening external supervision, and promoting corporate green innovation; finally, when considering the heterogeneity of samples, this paper finds that the inhibitory effect of digital transformation on ESG greenwashing behavior is more pronounced in non-state-owned enterprises, non-high-tech enterprises, and heavy polluting enterprises.

6.2. Practical Implications

Based on the above research conclusions, this paper provides the following practical implications for policymakers, corporate managers, and investors in promoting corporate social responsibility and achieving sustainable development:

First, corporate digital transformation, as an important driving force for economic development, plays a significant role in improving corporate total factor productivity and inhibiting corporate ESG greenwashing. Therefore, policymakers should strengthen relevant incentive measures to encourage enterprises to engage in digital transformation, especially providing support in terms of policies, technology, and funding for small and medium-sized enterprises with relatively weak digital foundations to alleviate the cost pressures they encounter during digital transformation. At the same time, enterprises themselves should fully adapt to the trend of digital development, formulate feasible digital transformation plans, leverage digital technologies to empower enterprise development, and create social benefits while achieving their economic benefits.

Second, strengthening external supervision is an effective means to inhibit corporate ESG greenwashing. Therefore, investors should fully play the role of external supervision to prevent inappropriate corporate ESG greenwashing behaviors and assist in the long-term development of enterprises. Social media should actively assume social responsibility, publicizing typical and positive cases of corporate digital transformation and ESG investment while daring to expose false disclosures of corporate ESG information, thereby enhancing the supervisory role of social public opinion. Policymakers should introduce specific policies to regulate ESG information disclosure and strengthen ESG audits to curb short-sighted and opportunistic behaviors of corporate governance, achieving external governance effects.

Third, enhancing green innovation capabilities is an important lever for improving corporate ESG performance. Green innovation can support corporate sustainable development by reducing pollution and improving resource efficiency; it can also help enterprises explore new markets and enhance competitiveness while lowering operational costs. Therefore, enterprises should adopt a green-oriented approach and lead with innovation, vigorously carry out green innovation research and development, enhance their competitiveness, achieve energy conservation and emission reduction, lower costs, and fulfill environmental responsibilities, thereby establishing a green and environmentally friendly corporate image. Policymakers should fully recognize the important value of green innovation for green low-carbon and sustainable development and provide moderate economic rewards and tax incentives for enterprises that achieve green innovation results such as green invention patents and green utility model patents.

Fourth, policymakers should consider the differences among enterprises, taking into account factors such as ownership type and industry characteristics, and adopt tailored policies to strengthen government-enterprise cooperation, formulating differentiated ESG investment and disclosure policies, as well as digital transformation and green innovation incentive policies, encouraging enterprises to fulfill their environmental responsibilities and effectively stimulating the vitality of corporate sustainable development.

References

- [1] Zhu, W., Sun, Y., & Tang, Q. (2019). Substantive Disclosure or Selective Disclosure: The Impact of Corporate Environmental Performance on the Quality of Environmental Information Disclosure. *Accounting Research*, 2019(03), 10-17.
- [2] Li, Z. (2018). Will Cheap Talk on Environmental Responsibility Get Punished? *The Journal of World Economy*, 41(12), 167-188.

- [3] Bowen, F., & Aragon-Correa, J. A. (2014). Greenwashing in Corporate Environmentalism Research and Practice: The Importance of What We Say and Do. *Organization & Environment*, 27(2), 107-112.
- [4] Li, C., & Xin, L. (2024). Greenwashing or Brownwashing: The Tendency of ESG-washing in the Context of Inefficient Investment. *Economic Management Journal*, 46(05), 168-189.
- [5] Isac, N., Javed, A., Radulescu, M., et al. (2024). Is Greenwashing Impacting on Green Brand Trust and Purchase Intentions? Mediating Role of Environmental Knowledge. *Environment, Development and Sustainability*, 1-18.
- [6] Wu, S. (2023). A Literature Review of Corporate Greenwashing Behavior. *Modern Management*, 13(12), 1609-1615.
- [7] Liu, J., & Guo, L. (2023). Research on the Impact of Digital Transformation on Corporate Sustainable Development Performance. *Financial Theory and Practice*, (12), 1-13.
- [8] Zhang, X. (2024). The Impact of Digital Transformation on the Performance of Intelligent Manufacturing Enterprises. *Market Modernization*, 2024(21), 117-119.
- [9] Harjoto, M. A., & Wang, Y. (2020). Board of Directors Network Centrality and Environmental, Social and Governance (ESG) Performance. *Corporate Governance: The International Journal of Business in Society*, 20(6), 965-985.
- [10] Zhang, S. (2024). ESG Information Disclosure Quality, Media Supervision, and Corporate Investment Efficiency [D]. Jilin University.
- [11] Huang, B., Li, H., Liu, J., et al. (2023). Digital Technology Innovation and High-Quality Development of Chinese Enterprises: Evidence from Enterprise's Digital Patents. *Economic Research Journal*, 58(03), 97-115.
- [12] Li, H., & Li, Z. (2024). The Impact of Digital Transformation on High Quality Development and High Speed Growth of Enterprises: From the Perspective of Quality, Efficiency, and Incentive Changes. *Chinese Rural Economy*, (04), 120-140.
- [13] Zhang, M., Zhang, Y., & Song, S. (2022). Enterprise Digital Transformation and Tax Avoidance: From the Perspective of Internal Control and Information Transparency. *Economic Survey*, 39(06), 118-127.
- [14] GREGORY, V. (2019). Understanding Digital Transformation: A Review and a Research Agenda. *The Journal of Strategic Information Systems*, 28(2), 118-144.
- [15] ANDRE, H., RENE, B., et al. (2021). A Systematic Review of the Literature on Digital Transformation: Insights and Implications for Strategy and Organizational Change. *Journal of Management Studies*, 58(5), 1159-1197.
- [16] Song, H., Han, M., & Hu, X. (2023). How Does Supply Chain Finance Boost the Low-carbon Development of Supply Chain? A Case Study Based on the Innovation Practice of State Grid Yingda. *Management World*, (5), 93-112.
- [17] Zheng, R., Wu, G., Cheng, Y., Liu, H., Wang, Y., & Wang, X. (2023). How Does Digitalization Drive Carbon Emissions? The Inverted U-Shaped Effect in China. *Environmental Impact Assessment Review*.
- [18] Su, J., Wei, Y., Wang, S., & Lei, Q. (2023). The Impact of Digital Transformation on the Total Factor Productivity of Heavily Polluting Enterprises. *Scientific Reports*.
- [19] Zhong, T., & Hu, J. (2024). Corporate Digital Transformation and ESG Performance—From the Perspective of Managerial Learning Theory. *Friends of Accounting*, 2024(11), 118-126.
- [20] Hu, J., Han, Y., & Zhong, Y. (2023). How Corporate Digital Transformation Affects Corporate ESG Performance. *Review of Industrial Economics*, (1), 105-123.
- [21] Song, J., Huang, H., & Jiang, Y. (2024). Research on the Impact of Digital Transformation on Corporate ESG Performance. *Soft Science*, 1-12.
- [22] He, C., Ding, Y., & Ma, Y. (2023). Corporate Digital Transformation and Capital Market Stability—Empirical Evidence of “Data Power” Intensifying Stock Price Synchronicity. *Journal of Finance and Economics*, 38(04), 74-91.

- [23] Cao, H. P., & Ma, Y. (2023). Will Digital Transformation Aggravate the Shadow Banking of Enterprises?--Empirical Evidence Based on Listed Non-financial Enterprises. *Journal of Harbin University of Commerce (Social Science Edition)*, (06), 3-19.
- [24] Yi, L., Yu, Z., & Chen, H. (2024). Boosting Morale or Creating Anxiety? The Double-Edged Sword Effect of Digital Transformation on Employee's Engagement. *Journal of Business Economics*, (02), 5-16.
- [25] de Freitas Netto, S. V., Sobral, M. F. F., Ribeiro, A. R. B., et al. (2020). Concepts and Forms of Greenwashing: A Systematic Review. *Environmental Sciences Europe*, 32, 1-12.
- [26] Walker, K., & Wan, F. (2012). The Harm of Symbolic Actions and Green-Washing: Corporate Actions and Communications on Environmental Performance and Their Financial Implications. *Journal of Business Ethics*, 109, 227-242.
- [27] Shen, Y., Qian, M., Lv, M., et al. (2023). Minority shareholder supervision and greenwashing governance: an analysis based on the word embedding model. *China Population, Resources and Environment*, 33(08), 116-129.
- [28] Wang, J., Liu, X., Yu, X., et al. (2024). Bank-Enterprise ESG Consistency and Post-Loan Corporate Strategic ESG Behavior. *Journal of Finance and Economics*, 50(4).
- [29] Topal, İ., Nart, S., Akar, C., et al. (2020). The Effect of Greenwashing on Online Consumer Engagement: A Comparative Study in France, Germany, Turkey, and the United Kingdom. *Business Strategy and the Environment*, 29(2), 465-480.
- [30] Yu, E. P., Van Luu, B., & Chen, C. H. (2020). Greenwashing in Environmental, Social and Governance Disclosures. *Research in International Business and Finance*, 52, 101192.
- [31] Xi, M., Liu, P., & Zhang, L. (2024). Corporate ESG Information Manipulation: Impact, Methods, and Motivations. *Finance & Economics*, (09), 16-29.
- [32] Marquis, C., Toffel, M. W., & Zhou, Y. (2016). Scrutiny, Norms, and Selective Disclosure: A Global Study of Greenwashing. *Organization Science*, 27(2), 483-504.
- [33] Sun, J., Zu, N., & Wang, H. R. (2024). Effects of Big Data Technologies on Enterprises' Greenwashing: Based on the Perspective of Greenwashing Behaviors. *Collected Essays on Finance and Economics*, (10), 92-102.
- [34] Zhang, D. (2022). Green Financial System Regulation Shock and Greenwashing Behaviors: Evidence from Chinese Firms. *Energy Economics*, 111, 106064.
- [35] de Souza Barbosa, A., da Silva, M. C. B. C., da Silva, L. B., et al. (2023). Integration of Environmental, Social, and Governance (ESG) Criteria: Their Impacts on Corporate Sustainability Performance. *Humanities and Social Sciences Communications*, 10(1), 1-18.
- [36] Zhu, F., Fan, H., & Wu, H. (2024). Do Holdings of Institutional Investors Spur Firms to "Greenwash"? —An Empirical Study Based on the Disclosure of Corporate Social Responsibility Reports of Heavily Polluting Enterprises. *Journal of Finance and Economics*, 39(02), 90-106.
- [37] Wang, N., Zhang, S. (2024). Inhibition or Exacerbation? The Impact of Common Institutional Ownership on Corporate ESG Greenwashing. *Review of Industrial Economics*, (04), 83-100.
- [38] Bai, J., Luo, C., & Gu, F. (2024). Systematic Legitimacy Pressure and Corporate ESG Greenwashing. *Systems Engineering —Theory & Practice*, 1-36.
- [39] Xu, W., & Wang, X. (2024). Research on the ESG Transformation and "Greenwashing" Issues of Heavily Polluting Enterprises Under the Influence of Green Finance. *The Theory and Practice of Finance and Economics*, 1-8.
- [40] Hu, X., Hua, R., Liu, Q., et al. (2023). The Green Fog: Environmental Rating Disagreement and Corporate Greenwashing. *Pacific-Basin Finance Journal*, 78, 101952.
- [41] Huang, R., Xie, X., & Zhou, H. (2020). 'Isomorphic' behavior of corporate greenwashing. *China Population, Resources and Environment*, 30(11), 139-150.
- [42] Li, X., & Cai, X. (2024). Does Corporate ESG Performance Exhibit Peer Pressure Effects? *Collected Essays on Finance and Economics*, (10), 70-80.

- [43] Li, S., & Tian, Z. (2024). Can Digital Transformation Improve Corporate Greenwashing Behavior? *Finance and Economy*, (04), 39-50+65.
- [44] Yang, F., Zhang, H., & Sun, Q. (2024). Can Supply Chain Digitalization Inhibit Corporate Greenwashing Behavior? *Economic Development Studies*, (01), 87-102.
- [45] Wang, J., & Cao, Z. (2024). Can Digital Transformation Restrain "Greenwashing" Behavior of Enterprises. *Journal of Hunan University (Social Sciences)*, 38(02), 58-67.
- [46] Li, M., & Jia, S. (2018). Resource Orchestration for Innovation: The Dual Role of Information Technology. *Technology Analysis & Strategic Management*, 30(10), 1136-1147.
- [47] Usai, A., Fiano, F., Petruzzelli, A. M., et al. (2021). Unveiling the Impact of the Adoption of Digital Technologies on Firms' Innovation Performance. *Journal of Business Research*, 133, 327-336.
- [48] Dong, C., Dong, X., Jiang, Q., et al. (2024). Impact and mechanisms of ESG rating divergence on listed companies' green innovation. *China Population, Resources and Environment*, (08), 103-113.
- [49] Li, X., Chen, Z., & Chen, Y. (2024). Corporate Digital Transformation and Financial Performance—Evidence from Digital Patent Data of Listed Companies. *Technology Economy*, 43(01), 73-87.
- [50] Karttunen, E., Lintukangas, K., & Hallikas, J. (2023). Digital Transformation of the Purchasing and Supply Management Process. *International Journal of Physical Distribution & Logistics Management*, 53(5/6), 685-706.
- [51] Zhao, W. (2001). The Causes and Countermeasures of Enterprise Organizational Pattern Innovation in the Network Age. *Academia Bimestris*, (04), 71-75.
- [52] Zheng, Z., Xie, S., Dai, H. N., et al. (2018). Blockchain Challenges and Opportunities: A Survey. *International Journal of Web and Grid Services*, 14(4), 352-375.
- [53] Wu, F., Hu, H., Lin, H., et al. (2021). Enterprise Digital Transformation and Capital Market Performance: Empirical Evidence from Stock Liquidity. *Management World*, 37(07), 130-144+10.
- [54] Zhao, C., Wang, W., & Li, X. (2021). How Does Digital Transformation Affect Total Factor Productivity of Enterprises? *Finance and Trade Economics*, 42(07), 114-129.
- [55] Zhen, H., Wang, X., & Fang, H. (2023). Administrative Protection of Intellectual Property Rights and Corporate Digital Transformation. *Economic Research Journal*, 58(11), 62-79.
- [56] Lu, X., & Lian, Y. (2012). Estimation of Total Factor Productivity of Industrial Enterprises in China: 1999-2007. *China Economic Quarterly*, 11(02), 541-558.
- [57] Chiarini, A. (2021). Industry 4.0 Technologies in the Manufacturing Sector: Are We Sure They Are All Relevant for Environmental Performance? *Business Strategy and the Environment*, 30(7), 3194-3207.
- [58] Qi, Y., & Xiao, X. (2020). Transformation of Enterprise Management in the Era of Digital Economy. *Management World*, 36(06), 135-152+250.
- [59] Sun, J. (2019). Research on the Relationship between Listed Companies' Resource Allocation Efficiency and Information Disclosure Quality [D]. Jilin University.
- [60] Xie, T., & Zhang, Q. (2023). Does Fintech Inhibit Corporate "Greenwashing"? *Journal of Financial Development Research*, (05), 20-27.
- [61] Li, H. (2023). Does the Digital Transformation of Enterprises Mitigate Stock Price Crash Risk? *Collected Essays on Finance and Economics*, (07), 58-67.
- [62] Niu, Y., Wang, S., Wen, W., et al. (2023). Does Digital Transformation Speed Up Dynamic Capital Structure Adjustment? Evidence from China. *Pacific-Basin Finance Journal*, 79, 102016.
- [63] Wang, X., & Liu, Q. (2024). Does Analyst Attention Improve Corporate ESG Performance? *Modern Economic Discussion*, (02), 51-66.
- [64] Wang, J., & Sheng, N. (2024). Digital Transformation Drives Enterprise Green Innovation—Analysis Based on Information Effect, Resource Effect and Technology Effect. *Journal of Beijing University of Technology (Social Science Edition)*, 24(05), 113-130.
- [65] Ma, S., & Fu, S. (2024). The Impact of Corporate Digital Transformation on Green Innovation—Based on the Panel Data of Manufacturing Listed Companies from 2007 to 2020. *Journal of Guangxi Vocational and Technical College*, 17(03), 8-18.

- [66] Peattie, K. (2010). Green Consumption: Behavior and Norms. *Annual Review of Environment and Resources*, 35(1), 195-228.
- [67] Xu, J., & Cui, J. (2020). Low-Carbon Cities and Firms' Green Technological Innovation. *China Industrial Economics*, (12), 178-196.
- [68] Shi, B., Wang, X., Jiang, X., et al. (2024). Green Institutional Investors' Shareholding and Corporate Environmental Responsibility. *Finance Research Letters*, 62, 105232.
- [69] Zhang, D. (2023). Does Green Finance Really Inhibit Extreme Hypocritical ESG Risk? A Greenwashing Perspective Exploration. *Energy Economics*, 121, 106688.
- [70] Yu, W., Wang, M., & Jin, X. (2012). Political Connection and Financing Constraints: Information Effect and Resource Effect. *Economic Research Journal*, 47(09), 125-139.
- [71] Zheng, L. (2017). Financing Constraint, State-Owned and Non-State-Owned Controlled Companies' Cash Holding Value Difference—Based on the Analysis of Economic Cycle. *Industrial Economic Research*, (06), 1-13.
- [72] Peng, H., & Mao, X. (2017). Government Subsidies for Innovation, Company Executives Background and R&D Investment-Evidence from the High-tech Industry. *Finance & Trade Economics*, (03), 147-161.
- [73] Wang, Y., & He, Y. (2021). Environmental Regulations, Relocation of Heavy Polluting Enterprises and Collaborative Governance Effect: Evidence Based on the Establishment of Subsidiaries in Different Places. *Economic Science*, (05), 130-145.
- [74] Pan, A., Liu, X., Qiu, J., & Shen, Y. (2019). Can Green M&A of Heavy Polluting Enterprises Achieve Substantial Transformation under the Pressure of Media. *China Industrial Economics*, (02), 174-192.