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The Influence of Digital Transformation on Corporate "Greenwashing" Behavior

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Abstract. As China's economic development transitions from rapid growth to high-quality development, reducing environmental pollution has become an unavoidable proposition for enterprise sustainability. With the accelerated growth of China's digital economy in recent years, the impact of enterprises' digital transformation on "greenwashing" behavior needs to be studied in depth. This paper analyzes all A-share listed firms during the 2012-2022 period to investigate the association between digital transformation and corporate "greenwashing" behavior through empirical testing. The study finds that digital transformation exerts an inhibitory effect on corporate "greenwashing" behavior, with strategic green innovation weakens the effect. Heterogeneity analysis reveals that the inhibitory effect of digital transformation is particularly pronounced among enterprises in heavily polluted industries or non-state-owned enterprises. These findings offer theoretical support and policy inspiration for governmental initiatives to encourage the corporate digital transformation, ultimately promoting sustainable and high-quality economic growth.

Keywords: digital transformation, "greenwashing", strategic green innovation

1. Introduction

Recent years have witnessed China's economic paradigm has gradually transitioning from rapid expansion to quality-driven growth, with the problems of environmental challenges such as air pollution and global warming have attracted increasing attention. At the 2020 UN General Assembly, China committed to carbon peaking by 2030, and neutrality by 2060, highlighting its determination to achieve sustainable economic development. From advancing the green Belt and Road construction to establishing carbon accounting systems, the government policies are all focused on fostering environmentally responsible and low-carbon business practices. Enterprises need to actively respond to government policies and improve production efficiency. However, weak regulatory mechanisms may lead to corporate "greenwashing" behavior, which means spreading false green information in order to obtain an eco-friendly image [1]. The corporate "greenwashing" behavior will greatly affect the trust of consumers and investors, and affect the economic development.

According to the Research Report on China's Digital Economy Development(2024) published by the China Academy of Information and Communication Research, the scale of China's digital economy has grown from 11.2 trillion yuan in 2012 to 53.9 trillion yuan in 2023, marking a 3.8-fold

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growth. As a key driver of future enterprise development, digital transformation can substantially boost operational efficiency, enhance process transparency and reduce information asymmetry. On the other side, data-driven solutions are accelerating green energy optimization. This study investigates the impact of digital transformation on corporate "greenwashing" behavior, clarifying the relationship between the two will help prevent and manage "greenwashing" behavior and improve the authenticity of information disclosure.

Studies on "greenwashing" motivations identify three key drivers: external market, internal organization and individual, pointing out that a lax regulatory environment can strengthen the motivation [2]. Some studies demonstrate that corporate "greenwashing" exposure will decrease its cumulative excess return(CAR) in Chinese stock market [3], and perceived "greenwashing" will lower consumers' purchase intentions [4]. These findings demonstrate that "greenwashing" can not only affect enterprises' performance, but also consumers' evaluation of enterprises. Therefore, it is important to study how to mitigate corporate greenwashing practices and foster sustainable economic growth.

The current body of research studies the influence of digital transformation on corporate operations from multiple angles. Micro-level studies demonstrate that digital transformation improves the total factor productivity through innovation, human capital optimization, industry integration and cost reduction [5]. Macro-level studies find that digital technology adoption in the real industrial sector is able to transform shocks, alleviate financing constraints, contribute to sustained macroeconomic expansion [6]. In conclusion, digital transformation acts as a driving force for quality-oriented economic growth across at both micro and macro level. Therefore, investigating digital transformation's influence on sustainable economic growth can provide a theoretical insight for policy formulation.

2. Theoretical mechanisms and hypothesis

2.1. Digital transformation and "greenwashing"

The impact of digital transformation on "greenwashing" can be analyzed from the drivers of "greenwashing": external factors, organizational factors and individual factors [2].

External factors driving "greenwashing" include pressure from non-market participants(regulators and NGOs) and market participants (consumers, investors, and competitors), while inadequate regulatory environments and regulatory regimes can further drive firms to "greenwashing". Digital transformation can shape a more stringent regulatory environment, increase the cost of "greenwashing". Specifically, big data and digital technology can expands market governance by connecting institutional investors and social media for enhanced monitoring [7]. The internal digital transformation tools like blockchain can improve information transparency and operational traceability. Consequently, the digital transformation of enterprises will deepen the connection with the outside world, diminish informational disparities between the enterprises and shareholders, and intensify supervision, prompting enterprises to reduce "greenwashing".

Organizational factors include organizational inertia. First, organizational inertia means that some companies exaggerate their environmental performance for short-term gains without substantive action. Digital transformation solves this by restructuring and updating organizational structure that enhances resource integration and dynamic capabilities [8]. Therefore, digital transformation can promote organizational change and overcome organizational inertia. Secondly, due to inadequate or absent coordination with the product development department, packaging department, or suppliers, the marketing or public relations department may exaggerate the greenness of the product. Digital

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transformation will change the communication and information transfer from traditional to digital, break down the communication barriers, and improve the level of collaboration, thus reducing "greenwashing".

Individual factors include optimism bias. Optimism bias means that decision makers underestimate the negative impact of "greenwashing". With digital transformation, the company's products are digitized into specific metrics, and the data-driven production system can avoid errors caused by human subjectivity [9]. Furthermore, digital transformation enables firms to leverage cloud computing, big data and other technologies to internal controls, reducing operational risks [10]. Therefore, through digital transformation, enterprises can digitize and visualize the production process, reduce irrational decisions that may be made by managers due to personal factors, and reduce the occurrence of "greenwashing".

Summarizing the preceding analysis, this paper formulates the following hypothesis:

H1: Digital transformation can inhibit the "greenwashing" behavior of enterprises.

3. Model setting

3.1. Sample selection and data sources

This paper utilizes all A-share listed companies during 2012-2022 period as samples with following treatments: (1) removal of financial sector enterprises; (2) elimination of ST and *ST companies during the sample period; (3) exclusion of observations with incomplete data records. Finally, 8577 firm-year observations containing 1335 listed firms are obtained. The data sources for this research comprise the following: (1) "greenwashing" index is obtained from Bloomberg database and wind database; (2) digital transformation is obtained from corporate annual reports; (3) financial data and company characteristics data from CSMAR database. To mitigate outlier effects, all continuous variables undergo winsorization at both the 1% and 99% levels.

3.2. Variable definition

3.2.1. Explained variable: degree of "greenwashing" (GWS)

Referring to the existing research [11], we use Bloomberg ESG scores(0-100 scale) as a measure of corporate disclosure environmental behavior, while utilizing CSI ESG scores(0-100 scale) to asses substantive environmental behavior due to their close proximity to the Chinese market and extensive coverage. In order to eliminate the difference between the two on the scale, a standardization process is carried out. The subtraction of the two standardized value is the degree of "greenwashing". The larger the value, the more serious the degree of "greenwashing". The formula is shown in equation (1), where $ESG_{disclosure_{i,t}}$ represents ESG disclosure score, and $ESG_{rating_{i,t}}$ represents ESG substance score.

$$GWS_{i,t} = \frac{ESG_{disclosure_{i,t}} - \overline{ESG_{disclosure}}}{\sigma(ESG_{disclosure})} - \frac{ESG_{rating_{i,t}} - \overline{ESG_{rating}}}{\sigma(ESG_{rating})} \quad (1)$$

3.2.2. Explanatory variable: digital transformation (DIG)

This study quantifies digital transformation by extracting key terms related to five technological domains(artificial intelligence, blockchain, cloud computing, big data, and digital technology applications) from corporate annual reports [12]. The methodology employs Python programming to

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aggregate the occurrence frequency of these terms. The digital transformation index is calculated by normalizing the keyword frequency against the report segment length and scaling by a factor of 100 [13].

3.2.3. Control variables

Referring to the existing studies, this paper selects variables such as enterprise size (Size) as control variables, and each variable and its definition are specified in Table 1.

Table 1. Definition of variables

Variable type	Variable name	Variable symbol	Description
Explained variable	Greenwashing	GWS	Calculated according to the formula, as shown in equation (1)
Explanatory variable	Digital transformation	DIG	Frequency of the keyword "digitization"/length of the annual report*100
Control variables	Enterprise size	Size	Log-transformed total asset value
	Asset-liability ratio	Lev	Ratio of Total liabilities to total assets
	Shareholding concentration	Top	The shareholding proportion of top ten major shareholders
	Age of enterprise	Age	(Year of observation of enterprise - year of registration + 1) in natural logarithms
	Growth potential	Tobinq	
	Return on assets	ROA	Ratio of net profit to average total assets
	Cash flow ratio	CashF	Operating cash flow to total assets ratio

3.3. Model building

This study sets up model (2) as the baseline specification to examine how digital transformation affects corporate "greenwashing" intensity. The subscripts i and t correspond to the firm and year respectively. $GWS_{i,t}$ represents firm i's "greenwashing" intensity in year t, $DIG_{i,t}$ captures its digital transformation extent, and $CV_{i,t}$ is a series of control variables. The paper controls for firm fixed effects $Firm_i$ and year fixed effects $Year_t$, and $\varepsilon_{i,t}$ is a random disturbance term.

$$GWS_{i,t} = \beta_0 + \beta_1 DIG_{i,t} + \beta_2 CV_{i,t} + Firm_i + Year_t + \varepsilon_{i,t} \quad (2)$$

4. Empirical analysis

4.1. Baseline regression

Table 2 presents the baseline regression outcomes investigating digital transformation's association with corporate "greenwashing". The empirical specification progresses sequentially: column (1) presents baseline estimates without controls or fixed effects, column (2) introduces control variables, while column (3) augments the model with temporal and enterprise fixed effects. The analysis reveals that the coefficient on digital transformation is -3.010 and the negative significance of the

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coefficient remains unchanged. These findings confirm the hypothesized negative correlation(H1) between digital transformation and “greenwashing” behavior.

Table 2. Baseline regression

	(1)	(2)	(3)
	GWS	GWS	GWS
DIG	-2.712***	-2.851***	-3.010**
	(-4.112)	(-4.451)	(-2.415)
Age		-0.155***	-0.216***
		(-7.529)	(-2.949)
ROA		-0.448	0.690**
		(-1.486)	(2.270)
Top		0.694***	0.546***
		(7.371)	(2.751)
TobinQ		0.064***	0.035**
		(6.047)	(2.452)
CashF		0.231	-0.296
		(1.085)	(-1.430)
Lev		-0.416***	0.243
		(-4.689)	(1.490)
Size		0.126***	-0.011
		(9.781)	(-0.282)
Constant	-0.424***	-3.318***	-0.149
	(-28.778)	(-12.138)	(-0.169)
Firm	No	No	Yes
Year	No	No	Yes
N	8,577	8,577	8,477
Adj. R^2	0.002	0.042	0.471

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively, with t-statistics in parentheses (the same applies hereafter).

4.2. Robustness test

4.2.1. Replace fixed effects

In the baseline regression, the analysis incorporates both year and firm fixed effects to account for unobserved variables. For robustness testing, a double fixed effects model of year (Year) + industry (Industry) [14] is adopted and the results are shown in the first column of Table 3. The coefficient of digital transformation remains negative and significant at the 1% level.

DOI: 10.54254/2754-1169/2025.LD25057

Table 3. Robustness test

	(1)	(2)	(3)	(4)
	GWS	DIG	GWS	GWS
DIG	-2.658***		-8.824*	-0.035*
	(-2.962)		(-1.801)	(-1.895)
PAM		0.462***		
		(8.368)		
Controls	Yes	Yes	Yes	Yes
Firm	No	Yes	Yes	Yes
Industry	Yes	No	No	No
Year	Yes	Yes	Yes	Yes
N	8,577	8470	8470	8,477
Adj. R^2	0.055			0.471
F		70.029	4.840	
Kleibergen-Paap Wald rk F		70.029		
		{16.38}		
Kleibergen-Paap rk LM		65.122***		
		[0.000]		
SW S stat.		3.659		

Note: p-values are reported in [ ]; { } contains critical values for the Stock-Yogo weak identification test at the 10% significance level.

4.2.2. Instrumental variable method

This paper utilizes an instrumental variable methodology to address endogeneity concerns and conduct robustness tests. Referring to former study [15], The industry/region, as aggregate sample characteristics remain unaffected by individual firm behavior while maintaining correlation with the explanatory variables. Columns (2)-(3) of Table 3 present the first-stage and second-stage regression results, respectively. The first stage results demonstrate a statistically significant positive coefficient (at 1% level), suggesting a statistically positive association between peer firms' industry-average characteristics and corporate digital transformation levels. Building upon these findings, the study undertakes the subsequent analyses: firstly, the values of Cragg-Donald Wald F statistic and Kleibergen-Paap Wald rk F statistic for the first-stage regression are 519.178 and 70.029, respectively, which are significantly larger than the Stock-Yogo weak ID test critical value of 16.38 for the critical value of 10% bias in the values, demonstrating that the chosen instrumental variables effectively avoid weak instrument issues; secondly, the Kleibergen-Paap rk LM test results decisively reject (at 1% level) the null hypothesis of instrumental variable under-identification in the specified regression model. The estimated coefficients of the second-stage regression results are also significantly negative, demonstrating that corporate digital transformation exerts a statistically significant restraining effect on "greenwashing" practices among firms.

DOI: 10.54254/2754-1169/2025.LD25057

4.2.3. Replacement of digital transformation metrics

Consistent with prior literature [12], we reconstruct the digital transformation metric through logarithmic conversion of keyword frequencies. As evidenced in Table 3's column (4) regression outputs, the digital transformation variable maintains a statistically significant inverse relationship at the 10% level, confirming the robustness of our findings.

4.3. Heterogeneity test

4.3.1. Heterogeneity test: industry

In alignment with the Listed Company Industry Categorization Standards (CSRC, 2012) promulgated by China's securities regulatory authority, 16 industries can be defined as heavily polluting industries(coded as 1, others as 0). Given the subsample regression approach employed, we conduct between-group coefficient difference test to assess between-group differences. As shown in Table 5 columns (1)-(2), heavily polluting industries exhibit a significantly negative coefficient at the 5% level, while less polluting industries show significance at 10%, with these differences statistically confirmed by the difference tests. While some scholars point out that polluting industries need to cater to the increasing attention of society to environmental issues, they have a stronger incentive to "greenwashing", so digital transformation has a greater impact on them relatively [16]; others find that heavily polluting enterprises have less room for "greenwashing" due to the high supervision from investors and government, so the inhibitory effect is smaller [14]. Our results support the former view, positing that firms in heavily polluted industries exhibit stronger "greenwashing" incentives, while simultaneously demonstrating digital transformation's enhanced mitigating effect in such contexts..

Table 4. Heterogeneity test

	(1)	(2)	(3)	(4)
	heavily polluted industries	non-heavily polluted industries	state-owned enterprises	non-state-owned enterprises
DIG	-11.990**	-2.325*	-0.379	-5.706***
	(-2.478)	(-1.784)	(-0.191)	(-3.328)
Constant	-1.727	-0.169	-0.107	-0.186
	(-1.178)	(-0.150)	(-0.079)	(-0.153)
Controls	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	2,985	5,476	4,191	4,267
Adj. R^2	0.437	0.490	0.467	0.480

4.3.2. Heterogeneity test: property

The empirical analysis reveals a statistically significant association between digital transformation and non-state-owned(non-SOEs) at the 1% significance level, whereas no such significant

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relationship is observed for SOEs. These findings are corroborated by the between-group coefficient difference test. SOEs possess stronger social attributes and are required to prioritize social benefits [16]. Operating under stricter regulatory environments, SOEs have less space for "greenwashing". In contrast, non-SOEs typically face greater market competition pressures. Digital transformation enables them to enhance information transparency and external oversight efficiency, thereby curbing opportunistic behavior. Furthermore, environmental decision-making in non-SOEs tends to be more market-driven. The economic benefits derived from "greenwashing" amplify their incentives to engage in such practices. Additionally, non-SOEs often exhibit more flexible organizational structures, allowing them to integrate digital technologies more swiftly into internal monitoring systems and supply chain management. Consequently, digital transformation exerts a stronger restraining influence on corporate misconduct specifically within non-state-owned enterprises.

5. Mechanism analysis

The Ministry of Science and Technology's Guidance on Establishing a Market-Driven Green Technology Innovation Framework, as endorsed by the National Development and Reform Commission (NDRC), emphasizing green innovation's growing centrality as both a catalyst for sustainable growth and an essential foundation for environmental protection, ecological advancement, and quality-focused economic progress. Prior studies consistently demonstrate digital transformation's capacity to accelerate enterprise's eco-innovation initiatives through mechanisms such as the "governance effect" and "multiplier effect" [17]. Consequently, green innovation plays a pivotal role in corporate environmental governance.

However, not all forms of green innovation necessarily yield positive outcomes. Due to information asymmetry between firms and regulators, firms may strategically manipulate green innovation-referred to as strategic green innovation-by pursuing low-cost, short-term initiatives to comply with policy requirements and gain benefits. In the absence of stringent oversight, firms might combine superficial innovations with exaggerated or false advertising, thereby intensifying "greenwashing". Specifically, firms may prioritize visible, "display-oriented" innovations over substantive green improvements in core production processes. Such illusory "green progress" could further incentivize firms to amplify their promotional claims through "greenwashing".

Strategic green innovation may potentially diminish digital transformation's capacity to curb "greenwashing" practices. While digital transformation improves informational disclosure and thereby increases the risk of "greenwashing", strategic green innovation provides firms with alternative profit channels. The financial gains from strategic green innovation may outweigh the potential penalties associated with higher regulatory scrutiny driven by improved digital capabilities, thereby diminishing the inhibitory effect of digital transformation. Moreover, the presence of strategic green innovation enables firms to disguise low-quality green initiatives as certified innovations, further obscuring "greenwashing" practices.

Following existing literature [18], utility model patents are adopted as a proxy for strategic green innovation. For comparative purposes, green innovation patents are also utilized as a measure of substantive green innovation. Building upon this analytical structure, regression specifications (3) and (4) are formulated to respectively assess how strategic versus substantive green innovation moderate the digital transformation-"greenwashing" relationship

$$GWS_{i,t} = \beta_0 + \beta_1 DIG_{i,t} + \beta_2 GI1_{i,t} + \beta_3 GI1_{i,t} \times DIG_{i,t} + \beta_4 CV_{i,t} + Firm_i + Year_t + \varepsilon_{i,j,t} \quad (3)$$

$$GWS_{i,t} = \beta_0 + \beta_1 DIG_{i,t} + \beta_2 GI2_{i,t} + \beta_3 GI2_{i,t} \times DIG_{i,t} + \beta_4 CV_{i,t} + Firm_i + Year_t + \varepsilon_{i,j,t} \quad (4)$$

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Where $GI1_{i,t}$ represents strategic green innovation and $GI2_{i,t}$ represents substantive green innovation.

Table 5. Mechanism analysis

	(1)	(2)
	GWS	GWS
GI1	0.045**	
	(2.300)	
GI2		0.040**
		(2.077)
DIG	-4.288***	-3.524***
	(-2.998)	(-2.638)
GI1×DIG	1.115*	
	(1.676)	
GI2×DIG		0.299
		(0.597)
Constant	0.051	0.108
	(0.057)	(0.121)
Controls	Yes	Yes
N	8,477	8,477
Adj. R^2	0.472	0.471

The moderating role of strategic versus substantive green innovation is empirically tested in Table 5's columns (1) and (2) through separate regression analyses. Regression outputs reveal a statistically significant positive coefficient (at 10% level) for the GI1×DIG interaction term in column (1), contrasting with the non-significant GI2×DIG coefficient in column (2). These findings indicate that strategic green innovation weakens the inhibitory effect of digital transformation on greenwashing, whereas substantive green innovation does not affect this inhibitory effect.

6. Conclusion

This study examinates A-share listed companies(2012-2022), finding that digital transformation effectively curbs corporate "greenwashing". Heterogeneity analysis reveals a stronger inhibition effect on firms operating in heavily polluted industries and non-state-owned entities. Mechanism analysis reveals that strategic green innovation attenuates the inhibitory effect of digital transformation on "greenwashing". Building on the evidenced results, this study proposes the subsequent policy implications.

Firstly, enterprises should pursue digital transformation by capitalizing on digital economy opportunities. They must realize that "greenwashing" will greatly affect enterprises' long-term growth. Specifically, enterprises can use IoT, big data and other technologies for real-time monitoring; use blockchain technology to strengthen supply chain collaboration. Secondly, the government should promote digital transformation through policy incentives like targeted funding and tax benefits. Besides, the government should strengthen supervision by technology and release strict regulations, establish evaluation criteria for green innovation quality to identify whether firms

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engage in strategic green innovation while strengthening penalties for firms that exploit strategic innovation practices to obtain policy incentives. Finally, facilitating industry-university-research collaboration to accelerate green technologies development.

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