

# Digital Investment and Corporate Greenwashing Behaviour

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**Abstract.** In the current wave of digital economy and the increasingly serious international pollution problem, how to achieve a balance between digital investment and environmental governance is a very practical issue. Based on the data of A-share listed companies from 2010 to 2023, the article analyzes the impact of digital investment on corporate greenwashing behavior. The study finds that digital investment promotes the greenwashing behavior of enterprises, and there is heterogeneity in the nature of property rights, the degree of pollution in the industry and the degree of regional marketization. The moderating effect analysis shows that environmental regulation and environmental certification can strengthen the facilitating effect of digital investment on the greenwashing behavior of enterprises. The findings of this study not only deepen the understanding of the factors influencing the digitalization and greenwashing behavior of enterprises, but also provide corresponding suggestions for enterprises, governments and the public.

**Keywords:** digital investment ; corporate greenwashing behavior ; fixed effects analysis ; moderating effects analysis.

## 1. Introduction

At present, global environmental problems are becoming increasingly serious, and countries are vigorously promoting environmental governance. The report of the 20th Party Congress points out that it is necessary to effectively promote the construction of a beautiful China, deeply promote the prevention and control of environmental pollution, and vigorously promote the construction of ecological civilization. Enterprises, as the lifeblood of national economic development, are also the main source of pollutant emissions. In China's environmental governance work, enterprise pollution prevention and control occupies a core position. Meanwhile, with the continuous improvement of public environmental awareness, Environmental, Social, and Governance (hereinafter referred to as ESG) has become a focal topic in the current society. The Code of Governance for Listed Companies (Revised 2018) stipulates that listed companies shall disclose environmental information (E), fulfilment of social responsibilities such as poverty alleviation (S) and corporate governance-related information (G) in annual reports, social responsibility reports and other public reports in accordance with laws, regulations and requirements of relevant authorities. Among them, environmental information disclosure, as a core component of the "environment" dimension in the ESG framework, is an important link for enterprises to disclose the performance of their environmental responsibilities to the public and the government and other regulatory bodies, which can alleviate the problem of information asymmetry to a certain extent, and help stakeholders to understand the environmental behaviours of enterprises. Ideally, in order to maintain a good public image, enterprises will take the initiative to strengthen their pollution control work. However, under the premise of responding to national policy requirements and public concern, some enterprises will, in order to achieve the goal of profit maximisation, manipulate the disclosure of public environmental information not by strengthening pollution control, but by "filtering information" to hide substantive environmental problems, which is known as "Greenwashing".

Under the wave of digital economy, digital transformation has become a key factor for enterprises to continue to grow and maintain competitiveness, as well as one of the main engines of national economic growth in the future. As technologies such as big data, cloud computing, artificial intelligence (AI), the Internet of Things (IoT) and blockchain mature, more and more enterprises are seeking to optimise their business processes, innovate their service models, enhance their customer experience and develop new sources of revenue through digital investments. Global enterprise digital

transformation spending is expected to reach US\$2.8 trillion by 2025, accounting for approximately 50 per cent of overall enterprise spending. By 2026, 40% of the revenue of Global 2000 companies will come from digital-related products and services.

As the new technological revolution continues to evolve, digital transformation and a series of concepts developed by digitalisation have become hot research topics in the academic world. However, there have been two perspectives on the theory of digitalisation: the information value-added theory and the productivity paradox. Undoubtedly, digital technology can play an important role in business operation and production, government governance and residents' life [1]. As for enterprises, digitalisation can increase their own economic value[2]. Digital transformation, on the other hand, can improve enterprises' external information transparency and internal control[3]. The root cause of enterprises' greenwashing behaviour is to create more economic value, while the external causes are external diseconomies and information asymmetry[4]. Thus, digitalisation is closely related to the greenwashing behaviour of enterprises. In the context of the digital economy, it is particularly important to study how digital investment affects corporate greenwashing behaviour.

To this end, based on the perspective of environmental information disclosure, this paper takes A-share listed companies from 2010 to 2023 as the research sample, takes digital investment as the digital entry point, explores its impact on corporate greenwashing behaviours, and conducts the analysis of heterogeneity of enterprises, industries and regions, and then conducts the analysis of moderating effects from four aspects, namely, governmental environmental regulation, corporate environmental cognition, media attention and executive cognition, and draws conclusions and puts forward corresponding recommendations based on the results. We then analyse the moderating effects of government environmental regulation, corporate environmental awareness, media attention and executive perception, and draw conclusions and make recommendations based on the results.

The contribution of this paper is reflected in the following: first, the concept of digitalisation itself is relatively broad, the scope of research is wider, this paper takes digital investment as the entry point of enterprise digitalisation, which increases the research angle of enterprise digitalisation from the investment side; second, the current research on enterprise digitalisation is mainly centred on the economic factors, and this paper takes ESG disclosure as the perspective, which enriches the research of digitalisation in the aspect of non-economic factors of the enterprise to a certain degree; third, in the wave of digital economy, the research of digitalisation is mainly focused on the economic factors. Third, in the wave of digital economy and the increasing international pollution problem, this paper takes into account the two sides of the digital theory and the progress of enterprise digitalisation, and puts forward and verifies the hypothesis that digital investment has a facilitating effect on the greenwashing behaviour of enterprises, which will provide a basis for the later in-depth research on the digital technology, digital transformation, and enterprise environmental information disclosure, and so on. It provides new content for later in-depth research on digital technology, digital transformation, and corporate environmental information disclosure. Fourthly, the conclusions of this paper can also provide reference suggestions for enterprises, the public and government regulators on digital investment and corporate greenwashing, and further promote the coordinated development of corporate digital transformation and ESG information disclosure.

## **2. Literature Review and Research Hypotheses**

### **2.1 Literature Review**

#### **2.1.1 Literature review of corporate greenwash**

The concept of greenwashing was first proposed in 1986 by Jay Westerveld, an American environmentalist, to accuse some hotels of not adopting substantive environmental protection measures, even though they ostensibly advertised greenness in order to reduce their operating costs<sup>[5]</sup>. Currently, related literature mainly focuses on the identification, motivation and economic consequences of corporate greenwashing behaviour. So far, there is no uniform definition and

measurement standard for this concept at home and abroad, and it can be mainly divided into three categories: false disclosure, selective disclosure, and decoupling between symbolic and substantive behaviours [6]. From the viewpoint of corporate greenwashing motivation, it can be divided into the external factors of institutional and market environments and the internal factors of organisational culture and managerial preferences [7]. Among them, the information asymmetry in the market environment, on the one hand, comes from the objective difference of consumers' green demand and green cognition, on the other hand, with the increasing popularity of ESG investment, investors not only pay attention to financial information, but also pay more attention to the enterprise's environmental information, and the enterprises tend to attract more investment by establishing a better image of responsibility and obtaining higher ESG scores through greenwashing behaviours [8]. In terms of economic consequences, the exposure of greenwashing behaviour can seriously damage corporate value and responsibility image [9], interfere with the operation of the capital market [10], and exacerbate the problem of asymmetric information and "adverse selection" problems [11], and hindering environmental regulation and related policies [12].

### 2.1.2 Literature review on digital investment

There have always been opposing theories of digitisation. The information value-added theory suggests that digitalisation can have a positive value-added effect on enterprises; the productivity paradox suggests that although digital technology may seem to bring significant efficiency gains, the actual measurable productivity growth is not significant, or even has a negative impact [13]. With the advent of the digital economy, related research has gradually gone from "what is digital" to "what economic impact will digital technology bring". At the macro level, the digital economy, as an emerging mode of economic development, can not only stimulate a new round of consumption and investment growth through the creation of new industrial forms, but also empower traditional industries and achieve the multiplier effect of industrial total factor productivity [14], which has become a value tool to drive economic and social transformation. At the micro level, traditional industries represented by the manufacturing industry and emerging industries created by the digital economy are grasping the windfall of digital technology, deeply embedding and integrating digital technology into the entire industrial chain [15], realising the digital transformation of enterprises, and ultimately reducing the operating costs of enterprises and creating more added value. The impact of digital transformation is multidimensional, and in the production and operation of enterprises, it is mainly manifested in the production and operation of intelligence and efficient resource allocation [16]. From the enterprise side, digital transformation has reconfigured the enterprise's organisational methods, production methods, business models and organisational boundaries, and has had a significant impact on the enterprise's activities in production, distribution, exchange and consumption [17], which in turn changes the enterprise's relationship with investors, suppliers and other stakeholders. In addition, digital transformation can improve social responsibility fulfilment by increasing the transparency of external information and strengthening internal controls [18].

### 2.1.3 Literature review

At present, the academic community's elaboration of the content of corporate greenwashing is multi-faceted and diversified, but there is no clear conceptual definition and identification criteria for corporate greenwashing behaviour, and the existing literature is only limited to analyses of its motivation and economic research. In terms of digital investment, the relevant literature on the digital economy and the impact of digitalisation has been relatively rich, but there are still the following shortcomings: firstly, the existing research on digital technology and digital transformation is too generalised and forward-looking, which is not in line with the background of the current initial exploration of digitalisation, and lacks the current research at the enterprise level; secondly, the concept of digitalisation is too broad, and lacks the appropriate research angle and suitable measurement method, which can be compared with the concept of digitalisation. measurement method to quantitatively study it with other subjects; Third, current research on enterprise digitisation

mostly focuses on economic value and lacks research on non-economic areas at the enterprise end. This paper makes up for the above shortcomings.

## **2.2 Research hypotheses**

### **2.2.1 Digital investment and corporate greenwashing behaviour**

According to resource allocation theory, in corporate investment decision-making, as corporate resources are limited, as a company's investment in one area increases, it often must reduce its investment in other areas. The logic behind such decisions is based on an assessment of the return on various possible investment outputs, i.e., firms attempt to allocate their limited resources to uses that maximise expected returns [19]. Specifically, if a firm increases its digitalisation investment, it needs to sacrifice or reduce its investment in other areas. This means that firms may be reducing their environmental governance investments and shifting more resource allocation to digital investments in order to achieve the profit maximisation principle by obtaining greater production benefits. Although, the exposure of greenwashing behaviour can have serious economic consequences, firms have an innate preference for opportunism and inertia in environmental governance, and if external regulation is unfavourable, it can provide an opportunity for firms to greenwash[20]. According to the risk-benefit theory, digital investment increases the additional economic benefits of greenwashing, which is much greater than the risk of exposure of greenwashing, and firms are more likely to respond to environmental disclosure through greenwashing[21]. This makes it more likely that companies will respond to environmental disclosure requirements through greenwashing behaviour.

Digital investment has led to a wave of increased digitisation and digital transformation, but the impact of increased digitisation has both positive and negative aspects. Positively, enterprises can rely on digital transformation to integrate various types of information resources, improve external information transparency and internal control, reduce the low marginal cost of enterprises, form economies of scale and thus increase enterprise output and productivity[22], improve the enforceability and monitoring mechanism of environmental information disclosure, and increase the enterprise greenwashing behaviour is difficult. Negatively, enterprises can apply more means and resources through digital technology to expand their own environmental image promotion and display, better reputation and competitive advantage in the market, increasing the benefits of greenwashing behaviour; in addition, digital technology makes the dissemination and reception of information more rapid and convenient, but at the same time, it is easier for enterprises to manipulate and tamper with data. In addition, digital technology makes the dissemination and reception of information more rapid and convenient, but at the same time, it is also easier for enterprises to manipulate and tamper with data, which reduces the cost of greenwashing behaviour. Digital technology can be a tool for corporate greenwashing.

Today, while digital investment is rising steadily, companies are still in the early stages of exploring digital technologies. The road to digital transformation is long and arduous, and most enterprises have not reached the ideal stage of using digital technology to obtain more economic value and empower corporate disclosure. And in the current competitive market environment, enterprises often need to enhance their own image and competitiveness through a variety of means, out of interest maximisation considerations, greenwashing as a relatively low-cost, high-return strategy, compared to investing in a large number of environmental governance costs are more favourable to enterprises.

In summary, this paper puts forward Hypothesis 1:

H1: The impact of digital investment on corporate greenwashing behaviour is a facilitating effect.

### **2.2.2 The moderating effect of digital investment on corporate greenwashing behaviour**

Due to the differences in government regulation, environmental certification, media attention and executive perception, the impact of digital investment on corporate greenwashing behaviour varies.

#### **(1) Moderating effect of environmental regulation**

Environmental regulation refers to the government's constraints and regulations on greenwashing behaviour, which can regulate the extent to which economic policy uncertainty affects companies'

greenwashing behaviour. A stronger environmental regime in a region means that the government is likely to formulate more explicit policy guidelines to regulate firms' environmental behaviour, and to monitor firms' disclosure of environmental information through stricter standards and measures[23]. In order to cope with stronger environmental regulation, enterprises often need to pay more economic costs, and the cost gap between "real green" and "fake green" becomes wider. Digital investment can put the extra cost into digital transformation and obtain more additional economic benefits; at the same time, digital technology also provides a technological basis for enterprises to falsely disclose environmental information, which reduces the cost of greenwashing. Therefore, in regions with higher environmental regulation intensity, digital transformation has a stronger effect on enterprises' greenwashing. In other words, in regions with lower environmental regulations, the constraints and regulations on corporate environmental information disclosure become smaller, and the pressure on compliance costs becomes smaller, so that enterprises can establish their brand image and gain competitive advantages among consumers and investors through lower environmental input costs rather than risking the exposure of greenwashing behaviours. In summary, this paper proposes Hypothesis 2a:

H2a: environmental regulation will strengthen the digital investment on the promotion of corporate greenwashing behaviour, i.e., a positive regulatory effect.

(2) The moderating effect of environmental certification

Environmental certification is a kind of recognition of the environmental behaviour of enterprises, and is also the starting point for enterprises to carry out environmental governance [20]. Enterprises with environmental certification have greater market recognition and competitive advantages in the market, are better able to gain the trust of consumers and investors, and avoid the risk of non-compliance. For companies with environmental certification, they already have the above advantages, and the benefits of "real green" behaviours are reduced, so they are often reluctant to continue to invest large amounts of environmental costs, and tend to choose low-cost, high-return greenwashing behaviours to cope with the disclosure requirements, coupled with the reduction of digital technology, which can reduce the risk of non-compliance. Instead, they tend to choose low-cost and high-return greenwashing behaviour to meet the disclosure requirements, and digital technology has lowered the cost and technological threshold of greenwashing behaviour, deepening the tendency of enterprises to choose greenwashing behaviour. For enterprises that do not have environmental certification, they need to obtain environmental certification through "real green" behaviour to improve their competitive advantage in the market, expand market recognition and avoid the risk of non-compliance. to obtain this kind of benefit. In summary, this paper puts forward Hypothesis 2b:

H2b: Environmental certification will strengthen the promotion effect of digital investment on the enterprise's greenwashing behaviour, i.e., positive moderating effect.

(3) The moderating effect of media attention

The media, as one of the information dissemination channels, can not only capture the response of public opinion, but also effectively monitor corporate behaviour[15]. The media's supervision of corporate green behaviour not only increases the sense of corporate social responsibility, but also increases the risk of exposure of corporate greenwashing behaviour[6]. In addition to the purpose of profit maximisation, enterprises with higher media attention tend to have a stronger sense of corporate responsibility, pay more attention to the substantive behaviour of corporate environmental governance, and invest a large amount of environmental costs to take more practical actions to fulfil their environmental responsibilities and disclose environmental information. At the same time, higher media attention means stronger social supervision and greater risk of exposure of greenwashing behaviour, which reduces the likelihood of enterprises investing more costs in digital technology and responding to environmental information disclosure through greenwashing behaviour. Comparatively speaking, enterprises with lower media attention may lack sufficient social supervision, have more opportunities and room for greenwashing behaviour and greater sense of social responsibility, and are more likely to make use of greenwashing behaviour to obtain short-term benefits and a good reputation. In summary, this paper puts forward Hypothesis 2c:

H2c: Media attention will weaken the promotion effect of digital investment on corporate greenwashing behaviour, i.e., negative moderating effect.

#### (4) Moderating effect of executive cognition

Executive environmental cognition refers to the level of executive cognition of environmental issues and the degree of environmental awareness, which is an important foundation and prerequisite for the implementation of environmental decision-making by enterprises[21], and has an important impact on the quality of corporate environmental information disclosure. Enterprises with higher executive environmental cognition have stronger willingness and self-consciousness in green management, in addition to the purpose of profit maximisation, and are more inclined to take substantial environmental protection actions and integrate them into their corporate values and business models. For long-term considerations, they are often unwilling to risk exposure of their greenwashing behaviour just to gain a false social image and competitive advantage. Therefore, the impact of digital technology on greenwashing is not obvious in companies with high executive awareness of environmental protection. Comparatively speaking, enterprises with lower executive environmental awareness do not pay enough attention to environmental protection and lack sustainable development strategies and long-term planning, so they are more likely to invest excess environmental costs digitally for the purpose of maximising economic benefits. In summary, this paper proposes Hypothesis 2d:

H2d: Executive cognition will weaken the promotion effect of digital investment on corporate greenwashing behaviour, i.e., a negative moderating effect.

### 3. Research design

#### 3.1 Sample Selection and Data Source

This paper selects the sample data of China's A-share listed companies from 2010 to 2023 as the research object. In view of the universality of the industry of the enterprise's greenwashing behaviour, the sample data selection is not limited to highly polluting industries. Sample data screening and processing are as follows: ① In order to avoid the impact of financial anomalies on the empirical results of enterprise data, excluding ST, \*ST and PT data; ② the financial industry to convey corporate profitability model and greenwashing behaviour with other industries there is a clear difference between the data of enterprises in the financial industry; ③ the regression model in this paper has its own industry and time fixed effects, and the data of the regression model. The regression model in this paper itself has industry and time fixed effects, and the missing samples will affect the accuracy of the empirical results, excluding the data of enterprises with missing values; ④ Due to the missing data of greenwashing in some enterprises in 2023, the interpolation algorithm is used to fill them. ⑤ Winsorize the continuous data by 1% up and down. The data of enterprise characteristics in this paper are obtained from the database of Cathay Pacific. The ESG disclosure data of enterprises measuring the level of greenwashing comes from Bloomberg Terminal, and the ESG rating data comes from CSI database.

#### 3.2 Model Setting

In order to investigate the impact of digital investment on corporate greenwashing behaviour, this paper establishes the following regression model:

$$GW_{it} = \beta_0 + \beta_1 DGI_{it} + \alpha Controls_{it} + Ind + Year + \varepsilon_{it} \quad (1)$$

where: *i* and *t* denote listed firms and year, respectively; *GW* denotes firms' greenwashing behaviour; *DGI* denotes digitised investment;  $\beta$  is the estimated coefficient of interest in this paper; *Controls* is a set of control variables indicating factors affecting firms' greenwashing behaviour; *Ind* denotes industry fixed effects; *Year* denotes time fixed effects; and  $\varepsilon$  denotes a random error term. behaviour; *Ind* denotes industry fixed effects; *Year* denotes time fixed effects; and  $\varepsilon$  denotes a random error term.

In order to further test the moderating roles of environmental regulation, environmental certification, media attention and executives' environmental awareness in the process of digital transformation affecting firms' greenwashing behaviour, this paper establishes the following regression model:

$$GW_{it} = \beta_0 + \beta_1 DGI_{it} + \beta_2 M_{it} + \beta_3 DI_{it} \times M_{it} + \alpha Controls_{it} + Ind + Year + \varepsilon_{it} \quad (2)$$

Where M is the moderating variable, including environmental regulation (ER), environmental certification (ISO), media attention (Media), and executive environmental awareness (EA).

### 3.3 Selection of variables

#### 3.3.1 Explanatory variable: corporate greenwashing behaviour (GW)

Referring to Zhang (2022), this paper uses the gap between firms' ESG disclosure and ESG ratings to measure the level of corporate greenwashing:

$$GW_{i,t} = \left[ \left( ESG_{Disclosure\ i,t} - \overline{ESG_{Disclosure\ i,t}} \right) / \sigma_{ESG_{Disclosure}} \right] - \left[ \left( ESG_{Rating\ i,t} - \overline{ESG_{Rating\ i,t}} \right) / \sigma_{ESG_{Rating}} \right] \quad (3)$$

The standardised difference between ESGDisclosure, which represents the ESG disclosure data, and ESGRating, which represents the level of ESG rating, is the level of greenwashing.

#### 3.3.2 Explanatory variable: digitalisation investment (DGI)

Enterprise digital investment can be divided into digital hardware investment and digital software investment, digital hardware investment is mainly the enterprise fixed assets related to electronic equipment and computer office equipment and other inputs, digital software investment mainly includes the enterprise intangible assets related to information systems and software and other inputs. In this paper, the digital hardware input and digital software input for summing, and then take the natural logarithm of the digital investment.

#### 3.3.3 Control variables and adjustment variables

Referring to the study of Huang et al. (2019), in order to control other factors that may affect the enterprise's greenwashing behaviour, this paper selects a series of variables related to the enterprise's greenwashing behaviour as control variables: enterprise size, financial leverage, profitability, maturity, cash flow, fixed asset ratio, equity concentration, and nature of ownership. The definitions of control variables and moderating variables are shown in the Table 1:

Table 1 The definitions of control variables and moderating variables

Variable Name	Variable Symbol	Variable Definition
Firm Size	Size	Natural logarithm of year-end total assets
Financial Leverage	Lev	Lev Ratio of Total Debt to Total Assets
Profitability	ROA	Ratio of net profit to total assets
Maturity	Age	Natural logarithm of number of years on the market plus one
Cash Flow	Flow	Net cash flow from operating activities to total assets
Fixed Assets	Fixed	Net Fixed Assets to Total Assets
Shareholding Concentration	Top1	Ratio of the number of shares held by the largest shareholder to the total number of shares
Nature of ownership	SOE	State-owned enterprises take the value of 1, otherwise 0

Environmental Regulation	ER	The number of environmental regulations in each province divided by 100
Environmental Certification	ISO	ISO14001 certified companies take 1, otherwise 0
Media	Media	The natural logarithm of the total number of corporate news stories for the year plus one
Executive Awareness	EA	Natural logarithm of the total number of keywords related to environmental protection of the enterprise plus one

## 4. Empirical results and analyses

### 4.1 Descriptive statistics

The descriptive statistics of the main variables are shown in Table 2. It can be seen that the mean value of GW is -0.0946 and the standard error is 1.5172, indicating that there are different levels of greenwashing behaviours in the sample enterprises as a whole, and there are significant differences between different enterprises; the maximum value of DGI is 26.9991, the minimum value is 0.9359 and the standard error is 2.2495, indicating that there are significant differences in the digital level of the sample enterprises. The maximum value of DGI is 26.9991, the minimum value is 0.9359, and the standard error is 2.2495, which indicates that there is a significant difference in the digitalisation level of the sample enterprises, and it provides a good data basis for this paper to study the impact of greenwashing behaviour of enterprises; the results of the control variables are basically the same as those of existing literature.

Table 2 Descriptive Statistics

Indicator	Sample Size	Mean	Standard Error	Maximum	Minimum
GW	6618	-0.0946	1.5172	11.1266	-13.8598
DGI	6618	16.9136	2.2495	26.9991	0.9359
Size	6618	23.2368	1.2831	28.6067	18.3172
Lev	6618	0.4728	0.1893	0.9789	0.0075
ROA	6618	0.0515	0.0588	0.4854	-0.9652
Age	6618	2.5445	0.6268	3.4965	0.0000
Flow	6618	0.1552	0.1176	0.8574	0.0023
Fixed	6618	0.2357	0.1800	0.9542	0.0002
Top1	6618	38.5354	16.4000	113.8400	5.0400
SOE	6618	0.5882	0.4922	1.0000	0.0000

The results of the correlation analysis between the main variables are shown in Table 3. From the figure, it can be seen that digital investment and enterprise greenwashing behaviour are significantly positively correlated ( $\beta = 0.498$ ,  $p < 0.01$ ), i.e., the greater the intensity of digital investment, the stronger the enterprise greenwashing behaviour, which preliminarily proves Hypothesis 1. Meanwhile, the correlation coefficients of the variables are less than 0.6. Meanwhile, the correlation coefficients between the variables are less than 0.6, and there is no obvious multicollinearity problem. In addition, we further tested the variance inflation factor (VIF) of all variables, and the maximum value of VIF is 1.87, the minimum value is 1.18, and the mean value is 1.42, which is much lower than the critical value of 10, so there is no substantial multicollinearity problem.

Table 3 Correlation Analysis

	GW	DGI	Size	Lev	ROA	Age	Flow	Fixed	Top1	SOE
GW	1									
DGI	0.498***	1								
Size	0.411***	0.598***	1							
Lev	-0.159	0.307***	0.403***	1						



ROA	-0.21**	-0.483***	-0.27***	-0.321***	1					
Age	0.06	0.009	0.242**	-0.063	0.033	1				
Flow	-0.232**	-0.21**	-0.158	0.067	0.146	-0.028	1			
Fixed	0.365***	0.179*	-0.082	-0.406***	-0.095	-0.231**	-0.412***	1		
Top1	0.121	0.411***	0.426***	0.361***	-0.169*	-0.1	-0.311***	0.087	1	
SOE	-0.108	-0.138	-0.073	-0.252**	0.132	0.132	-0.218**	0.214**	0.374***	1

Note: \*\*\*, \*\*, and \* denote  $p < 0.01$ ,  $p < 0.05$ , and  $p < 0.1$ , respectively; standard errors for firm-level clustering adjustment are in parentheses. Same as below.

## 4.2 Benchmark regression results

The results of the benchmark regressions are shown in the Table 4. Column (1) and (2) report the regression results before and after the addition of control variables. It can be seen that the DGI coefficient in Column (1) is significantly negative, considering the differences in enterprise greenwashing behaviour among different enterprises, and the DGI coefficient is still significantly negative after adding control variables in Column (2), indicating that digital investment plays a facilitating role in enterprise greenwashing behaviour, further verifying Hypothesis 1. The DGI coefficient is still significantly negative after adding the control variable in Column (2), indicating that digital investment plays a facilitating role in enterprises' greenwashing behaviour, further verifying Hypothesis 1.

Table 4 Benchmark Regressions

Variable	GW	
	(1)	(2)
DGI	0.0401*** (0.0085)	0.0415*** (0.0100)
Size		-0.0093 (0.0206)
Lev		0.4716*** (0.1385)
ROA		-2.0366*** (0.3540)
Age		-0.1258*** (0.0381)
Flow		-0.2444 (0.1840)
Fixed		-0.4260*** (0.1488)
Top1		0.0018 (0.0012)
SOE		-0.3507*** (0.0438)
Con	-0.7732*** (0.1445)	-0.1062 (0.4041)
Industry fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Observations	6618	6618
R <sup>2</sup>	0.2408	0.2600
adj R <sup>2</sup>	0.2312	0.2496

## 4.3 Endogeneity test

Table 5 Endogeneity test and Robustness test

Variable	GW			
	Explanatory variable lagged one period	Explanatory variable lagged two periods	Replacement of explanatory variables	Removal of IT industry
	(1)	(2)	(3)	(4)
DGI	0.0348*** (0.0099)	0.0310*** (0.0100)	0.0251** (0.0112)	0.0374*** (0.0102)
Con	-0.3543 (0.4148)	-0.6542 (0.4324)	-1.1341** (0.4565)	-0.3896*** (0.4189)
Control Variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	6618	6618	6618	5620
R <sup>2</sup>	0.2722	0.2725	0.1117	0.2721
adj R <sup>2</sup>	0.2615	0.2611	0.0959	0.2608

The lag period takes into account the temporal relationship between the explanatory variables and the explained variables and is able to weaken the bi-directional relationship between the two. Therefore, the data of digital investment with one and two periods lag is selected for regression. From Columns (1) and (2) of Table 5, the regression coefficients of one-period and two-period lagged digital investment on firms' drifting green are 0.0348 and 0.0310, respectively, which are both significantly negative at the 1% level. This indicates that the findings of the previous study are not affected after considering the endogeneity issue.

#### 4.4 Robustness test

##### 4.4.1 Replacement of explanatory variables

In view of the diversity of measurement methods of corporate greenwashing behaviour, in order to obtain more robust regression results, this paper refers to the research method of Huang et al. (2020). Corporate greenwashing is the behaviour of enterprises whose symbolic environmental commitments are inconsistent with their substantive environmental practices, and is specifically divided into two types: selective disclosure and expressive manipulation. Among them, selective disclosure refers to enterprises' selective disclosure of environmental information, and expressive manipulation refers to enterprises' strategic whitewashing of their environmental performance. In this paper, we use the ratio of undisclosed matters to all disclosed matters to measure the degree of selective disclosure (GWLS); and the ratio of symbolic disclosure to all disclosed matters to measure the degree of expressive manipulation (GWLE). Finally, the geometric mean is used to calculate the degree of greenwash for each firm. The specific formula is as follows:

$$GWLS = 100 \times (1 - \text{Number of matters disclosed} / \text{Number of matters subject to disclosure}) \quad (4)$$

$$GWLE = 100 \times (1 - \text{Number of symbolic disclosures} / \text{Number of matters disclosed}) \quad (5)$$

$$GWL = \sqrt{GWLS \times GWLE} \quad (6)$$

The results of the regression with replacement of the explanatory variables are shown in Column (3) of Table 5. It can be seen that the regression coefficient of digital investment on corporate greenwash after replacing the measure of corporate greenwash behaviour is 0.0251, which is significantly negative at the 5 per cent level. It can be seen that the results of this study are still robust even after changing the measure of firms' greenwashing behaviour.

#### 4.4.2 Excluding the information technology industry

Considering that the information technology industry has a natural advantage in digital transformation relative to traditional industries, there are large differences in the degree of transformation in the industry itself. Therefore, this paper excludes the information technology industry from the sample, and re-runs the regression. The results, as shown in Column (4) above, show that the regression coefficient of digital investment on firms drifting green is 0.0374, which is significantly negative at the 1% level, further verifying the robustness of the previous conclusion.

#### 4.5 Heterogeneity analysis

Table 6 Heterogeneity analysis

Variables	GW					
	Non-state-owned enterprises	State-owned enterprises	Non-heavily polluting industries	Heavily polluting industries	Low-marketised areas	High-marketised areas
	(1)	(2)	(3)	(4)	(5)	(6)
DGI	0.0981*** (0.0167)	0.0069 (0.0126)	0.0353*** (0.0131)	0.0522*** (0.0155)	0.0729*** (0.0154)	0.0167 (0.0143)
Con	-0.8602 (0.8109)	-0.1549 (0.4904)	-0.1353 (0.4748)	-1.2621 (0.7808)	-1.323** (0.6226)	-1.1649* (0.5998)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2725	3893	4440	2178	3204	3414
R <sup>2</sup>	0.2778	0.2806	0.2446	0.2887	0.2661	0.2881
adj R <sup>2</sup>	0.2569	0.2656	0.2318	0.2758	0.2426	0.2699

##### 4.5.1 Nature of property rights

There are big differences between state-owned enterprises and non-state-owned enterprises in terms of resources, goals and values. With more resource endowment and policy inclination, SOEs are more likely to achieve the optimisation and upgrading of their products and services through digital investment, and achieve the improvement of their economic and non-economic benefits in the process of applying digital technology. At the same time, different from non-state-owned enterprises (NSOEs) which take profitability and maximisation of shareholders' interests as their business objectives, SOEs, in addition to pursuing economic benefits, may also shoulder social responsibilities and macroeconomic objectives issued by the government, often have a stronger sense of social responsibility, and may need to consider social benefits and public interests in their business activities. Therefore, this paper divides the sample enterprises into non-state-owned enterprises and state-owned enterprises according to the nature of property rights to conduct regressions separately, and the results are shown in Column (1) and (2) of Table 6. The results show that the coefficient of digital investment for the non-state-owned enterprises subgroup is significantly positive at the 1% level, while it is not significant for the state-owned enterprises subgroup. The possible reason is that state-owned enterprises, due to their special characteristics, bear more environmental social responsibility, face more government and public supervision, information disclosure is more open and transparent, the level of corporate greenwashing is lower, and digital investment has less impact on them.

#### 4.5.2 Degree of industry pollution

The degree of pollution caused by different industries is different, and the corresponding level of greenwashing may also be different. This paper according to the 2008 release of the "Listed Companies Environmental Verification Industry Classification Management Directory" will be divided into non-heavily polluted industries and heavily polluted industries were regressed, the regression results as shown in Table 6. Column (3) and (4) The results show that the coefficients of digital investment for both non-heavily polluting and heavily polluting firms are significantly positive at the 1% level, with the coefficients for heavily polluting firms being significantly higher than those for non-heavily polluting firms. The possible reason for this is that heavily polluting firms engage in a greater degree of corporate greenwashing than non-heavily polluting firms in order to build up a good corporate image and to face investor and public pressure. Therefore, digital investment has a stronger effect on the promotion of corporate greenwashing.

#### 4.5.3 Degree of regional marketisation

To a certain extent, the operation of enterprises will be affected by the process of regional marketisation, and the greenwashing behaviour of enterprises will also vary accordingly. In order to further explore the impact of digital investment on enterprise greenwashing behaviour in regions with different degrees of marketization, this paper selects the Fanzang marketization index to measure the process of marketization and conducts regressions according to the average of the two groups of high and low marketization, with the results shown in Column (5) and (6) of Table 6. The results show that the coefficient on digital investment is significantly positive at the 1% level for the low marketisation group of firms, while it is not significant for the high marketisation group of firms. This may be due to the fact that high marketisation regions have better institutional environments, higher overall levels of digital investment, higher business efficiency, and correspondingly lower greenwashing behaviour. The promotion effect of digital investment on enterprises is weaker.

#### 4.6 Analysis of moderating effects

Table 7 Analysis of moderating effects

Variables	GW			
	(1)	(2)	(3)	(4)
DGI	0.0235* (0.0131)	0.0280** (0.0115)	-0.0683 (0.0442)	0.0415*** (0.0101)
ER	-149.7816** (66.4581)			
DGI×ER	8.3704** (3.9200)			
ISO		-0.7395** (0.2851)		
DGI×ISO		0.0381** (0.0166)		
Media			-0.2965** (0.1284)	
DGI×Media			0.0187** (0.0074)	
EA				0.0000 (0.0017)
DGI×EA				0.0000 (0.0001)
Con	0.1461 (0.4201)	0.0987 (0.4096)	2.0102 (0.8854)	-0.1093 (0.4050)
Control Variables	Yes	Yes	Yes	Yes

Industry fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	6618	6618	6618	6618
R <sup>2</sup>	0.2607	0.2613	0.2610	0.2600
adj R <sup>2</sup>	0.2501	0.2507	0.2504	0.2494

#### 4.6.1 Environmental regulation

The impact of digital investment on firms' greenwashing behaviour varies according to the intensity of environmental regulations. The moderated effects of environmental regulations are modelled as shown in Column (1) of Table 7. The results show that the coefficient of digital investment is significantly positive at the 10% level, and the coefficient of the cross term is also significantly positive at the 5% probability, which verifies Hypothesis 2a. The possible reasons are that firms in regions with higher environmental regulation intensity face greater pressure on compliance costs, and the cost gap between "real green" and "fake green" is larger, and the cost difference between "real green" and "fake green" is larger. The reason may be that in regions with higher environmental regulation intensity, enterprises face higher compliance cost pressure, and the cost gap between "real green" and "fake green" is larger, so enterprises tend to digitally invest the excess environmental costs, and adopt low-cost and high-yield greenwashing behaviour to cope with stronger environmental information disclosure requirements. Digital investment has a stronger effect on the promotion of greenwashing behaviour of enterprises.

#### 4.6.2 Environmental certification

The impact of digital investment on corporate greenwashing behaviour varies according to the strength of environmental certification. The results of the moderating effect model on environmental certification are shown in column (2) of Table 7 above. The results show that the coefficient of digital investment is significantly positive at the 5% level, and the coefficient of the cross term is also significantly positive at the 5% probability, which verifies Hypothesis 2b. The probable reason is that firms that already have environmental certificates already have corresponding environmental benefits, and the risk of non-compliance is reduced, and the benefits of "real green" are reduced, and firms tend to invest the excess environmental costs in digital investment to obtain the benefits of "real green". Enterprises tend to invest the excess environmental costs in digital investment to obtain more revenue, and adopt low-cost, high-yield greenwashing behaviour to cope with the environmental information disclosure requirements, and digital investment on the greenwashing behaviour of enterprises to promote the role of the stronger.

#### 4.6.3 Media attention

The impact of digital investment on corporate greenwashing behaviour varies across media attention. The results of the moderated effect model for media attention are shown in column (3) of Table 7. The results show that the coefficient of digital investment is negative but not significant, while the coefficient of the cross term is significantly positive with a probability of 5%, which is not able to test Hypothesis 2c, suggesting that the media attention may play a certain negative moderating role, but the effect of digital investment on corporate greenwashing under media attention is not significant. The possible reason is that, in the network era, the media and the public information access and dissemination become more and wider, and the overall variability of media attention is smaller.

#### 4.6.4 Executive Cognition

The impact of digital investment on corporate greenwashing behaviour varies across different executive perceptions. The results of the moderated effects model on executive cognition are shown in column (4) of Table 7 above. The results show that the coefficient of digital investment is positive and significant at the 1% level, while the coefficient of the cross term is not significant, which is not able to test Hypothesis 2d, suggesting that the impact of digital investment on corporate greenwashing

behaviours under different executive perceptions is not significant. This may be due to the fact that the frequency of keywords about environmental protection in enterprises is small or the difference is not significant enough to verify the negative moderating effect of executives' perceptions.

## **5. Conclusions and Policy Recommendations**

### **5.1 Research Conclusion**

This paper takes A-share listed companies from 2010 to 2023 as a research sample, and takes digital investment as a digital entry point to explore its impact on corporate greenwashing behaviour. The results show that digital investment has a contributing effect on corporate greenwashing behaviour. Meanwhile, the results of heterogeneity analysis show that the promotion effect is stronger in non-state-owned enterprises, non-polluting industries and local marketised areas. The results of moderating effect analysis show that both environmental regulation and environmental awareness can strengthen the promotion effect of digital investment on enterprises' greenwashing behaviour.

### **5.2 Policy Recommendations**

Based on the above findings, this paper puts forward the following recommendations for enterprises, the government and the public:

(1) In addition to the fundamental purpose of profit maximisation, enterprises should actively respond to the demands of the government and the public, take the main responsibility of environmental governance, and improve their sense of social responsibility. While strengthening digital investment, enterprises should not reduce environmental costs at the expense of investment, through corporate greenwashing behaviour to respond to the requirements of environmental information disclosure, or even digital technology to make false statements, avoiding the disclosure of environmental information. Enterprises should take a long-term view of the problem, environmental governance and sustainable development into long-term planning and decision-making, to avoid the pursuit of short-term interests that lead to greenwashing behaviour as well as the exposure of the serious economic consequences of the behaviour; not to mention that because of the government's regulatory pressures are too strong or have already obtained the environmental certification will not be willing to invest in more environmental governance costs to continue the environmental governance work. Not to mention that because the government regulatory pressure is too great or the environmental certification has been obtained, they are not willing to invest more environmental governance costs to continue environmental governance.

(2) In addition to regulating the disclosure of environmental information, the government should also strengthen the verification of the authenticity and reliability of the disclosed environmental information, including the disclosure of false and symbolic environmental information, so as to reduce the space for enterprises to greenwash. As stronger government regulation will increase the cost of compliance, the government should also increase the subsidies for environmental protection to reduce the pressure on enterprises, increase the benefits of environmental management, and help enterprises achieve sustainable development. In addition, as environmental certification means that the enterprise has achieved the purpose of environmental governance, with the so-called competitive advantage and social recognition. The government should carry out regular verification of environmentally certified enterprises, and update environmentally certified enterprises in a timely manner, so that environmental certification becomes a continuous purpose of corporate environmental governance. In addition, the government should increase support for the digital transformation of enterprises to help them achieve the coordinated development of digital transformation and environmental governance.

(3) The public should raise environmental awareness and play the role of social supervision. As consumers, they should improve their green awareness and reduce the information asymmetry arising from the gap between them and green awareness; as investors, they should pay more attention to environmental information in the face of the growing demand for ESG investment. In addition, digital

technology provides more information access channels and accelerates the speed of information dissemination. Consumers and investors should make full use of the acquired information, learn to distinguish the authenticity of the information, and do a good job of social supervision, so as to help enterprises improve their social responsibility and achieve sustainable development.

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