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Research on the Impact of Digital Investment on Green Performance of Listed Enterprises

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Abstract. Based on the data of Chinese listed enterprises from 2017 to 2022, this paper examines the impact of digital investment on the green performance of listed enterprises. The study found that digital investment is negatively correlated with the green performance of listed enterprises, which is still valid after the robustness test. According to the heterogeneity analysis, digital investment has a more significant negative effect on the green performance of state-owned enterprises. The research conclusions not only reveal environmental effects of digital investment, but also broaden the research perspective of digital investment and corporate green performance, which has vital enlightening significance for the government to promote the construction of the ecological civilization and enterprises to improve green performance.

Keywords: Digital Investment; Listed Enterprises; Green Performance.

1. Introduction

At present, there is no unified definition of the green performance at home and abroad, and scholars have clarified the green performance from different perspectives. Taking the perspective of corporate green human resources, Tang Guiyao et al. [1] proposed that green performance is to encourage employees to use clean energy, improve resource utilization, reduce waste discharge and promote the healthy development of enterprises by implementing specific behaviors such as green recruitment, green salary and employee environmental protection. According to Suganthi L. [2] who clarified from the perspective of green results, green performance means that enterprises meet the needs of enterprise development through green operations and achieve the expected effects of organizations or institutions. Besides, green performance not only enhances the competitive advantage of enterprises, but also improves the relationship between enterprises and stakeholders such as the government, communities, and the public.Green performance also boosts the environmental performance and financial performance of enterprises. From the perspective of green characteristics, Jiang Xu and Tang Guiyao [3, 4] believed that the management team that pays attention to enterprises' green performance should have three characteristics, including the ability to perceive, innovative thinking and risk-taking features. Thus, they can timely perceive and accurately grasp the external environment, and invest resources and capabilities to implement environmental protection strategies to improve environmental protection performance and financial performance. Kong Lingying [5] synthesized the above views and held that green performance is to evaluate the economic and environmental benefits obtained by enterprises during the green development and their impact on a country or region based on considering resource input and environmental costs.

So which factors have an important impact on the green performance of listed enterprises? The macro factors that affect the green performance of listed enterprises include green policies and economic environment [5]. For example, Wang Lixia and Chen Yutao [6, 7] found an inverted U-shaped relationship between environmental policy and green performance with the intensity of 0.00015 as the boundary. Meanwhile, this effect will be affected by enterprise heterogeneity, such as enterprise scale, industry status, ownership nature, etc. Wang Xiaoling et al. [8] proposed that the driving force for green transformation in developing countries such as China and Russia mainly comes from the improvement of resource allocation efficiency, followed by technological progress. The micro-factors that affect the green performance of listed enterprises include corporate management behavior and

social public needs [5]. According to Guan Yamei et al. [9], business leaders are promoters of positive environmental behavior, and their decisions will affect employees' environmental behavior and environmental values. Wang Jianxiu et al. [10] held that the public can put forward opinions and appeals to the government through petitions, complaints, information disclosure, etc. Then, the government will put pressure on enterprises that do not meet green standards by strengthening the environmental regulation, so as to encourage enterprises to take more active participation and social responsibility. In this way, the production of enterprises can be standardized and the green transformation of enterprises can be promoted to reduce environmental compensation and enhance market legitimacy. At present, the literature on the impact of digital investment on green performance is relatively limited in the field of accounting research. It is necessary to study the impact of digital investment on green performance of listed enterprises.

Based on the natural logarithmic data and environmental performance data of the digitalization-related word frequencies in the annual reports of Chinese listed enterprises from 2017 to 2022, this paper explores the impact of digital investment on the green performance of listed enterprises. The research results prove that enterprises with more digital investment get worse green performance effects, which is more apparent in state-owned enterprises.

The possible innovations of this paper are as follows. Firstly, from the perspective of green performance, it expands the research on the green effect of digital investment. Existing studies focus on economic effects of digital investment, ignoring its green effects. This paper enriches the research of digital investment by discussing the impact of digital investment on the green performance of listed enterprises. Secondly, from the perspective of digital investment, the research on the influencing factors of corporate green performance has been expanded. Existing studies lay more emphasis on macro factors such as green policy and economic environment as well as micro factors such as corporate management behavior and social public demand, lacking in-depth discussion on factors affecting green performance. Thus, this paper broadens the research perspective of corporate green performance by examining how digital investment affects the green performance of listed enterprises. Thirdly, from the perspective of negative effects, the negative impact of digital investment on green performance is discussed. There has been numerous literature on the positive effect of digital investment on green performance. This paper proves the significant negative correlation between digital investment and green performance by abundant sample data of Chinese listed enterprises.

2. Theoretical Analysis and Research Hypotheses

(1) Digital Investment

Digital investment refers to the investment in digital hardware and software during the enterprise digitalization [11]. The advent of the digital economy era has enabled enterprises to increase investment in digitalization such as information technology, providing more support for their production, R&D and sales [12]. With the continuous improvement of the digitalization, enterprises can more accurately grasp customer information and knowledge and understand various needs of customers, so as to explore and develop new products and services, open up new markets for enterprises, and greatly enhance enterprise competitiveness [13].

(2) Impact of Digital Investment on the Green Performance of Listed Enterprises

On the one hand, digital investment may have a positive effect on the green performance of Chinese listed enterprises.

Digital investment can optimize energy management, realize real-time monitoring and optimal scheduling of energy consumption through intelligent systems, reduce energy waste, and improve energy efficiency. At the same time, digital investment helps to build a green supply chain, achieve information sharing between the upstream and downstream of the supply chain through information technology, and promote resource recycling and waste reduction. Digital investment can also be used to strengthen employees' environmental education and training, improve their environmental

awareness and skills, and lay a solid foundation for the sustainable development of enterprises and environmental performance. Qi Huaijin et al. [14] found that digital transformation has an internal information transmission function, which can help enterprises strengthen internal environmental communication and improve environmental management efficiency.According to Li Xianjiang [15], digital infrastructure equipment can effectively collect useful information in the production, which can reflect production data more comprehensively, directly and accurately, paving the way for information collection for green innovation. Liu Yang et al. [16] believed that digital transformation continues to empower the innovation of enterprises, redefines the transformation of organizational structure, and improves the operational efficiency and performance of organizations. Li Jixue and Gao Zhaojun [17] proposed that information technology can reduce the communication and coordination costs of enterprises, which play an important role in promoting the innovation of enterprise management methods, thereby promoting organizational performance. The direction of enterprise informatization investment can be divided into investment in various basic equipment, human capital and other intangible capital related to informatization, which can effectively improve organizational performance [18, 19].

On the other hand, digital investment may have a negative effect on the green performance of Chinese listed enterprises.

In most cases, one of the crucial reasons why digital investment fails to achieve good returns is that enterprises continue to use old processes that do not meet the requirements of informatization, resulting in expensive informatization software and hardware failing to play their due role. In addition, excessive reliance on information technology may lead enterprises to ignore traditional environmental protection practices and green innovations, thus affecting the improvement of green performance. Meanwhile, with the deepening of enterprise digitalization, data security and privacy protection have become important issues. Enterprises may face the risk of data leakage and abuse because of improper handling during the digital transformation. Many scholars have found that information technology investment will have a significant negative effect on performance, and Loveman had no strong evidence for the relationship between information technology investment and corporate performance [20]. Tou Zhibin found that the increase in the proportion of intangible assets in the automotive industry has a negative effect on business performance [21]. Guo Min confirmed that technology intangible assets have a negative effect on the main business profits of enterprises [22]. According to Zhao Quanwu and Liu Tingting, the implementation of ERP cannot significantly improve the financial status and operational performance of enterprises [23]. Liu Fei believed that information technology investment did not bring efficiency improvement to industrial listed enterprises by going beyond the logarithmic production function [24]. Sun Xiaolin, Xing Yiting, and Wang Zhangliang held that the impact of new information technology investment on organizational performance was not significant [25].

To sum up, digital investment may affect the green performance of Chinese listed enterprises from both positive and negative aspects. On this basis, this paper proposes the following competitive hypotheses:

H1a: Digital investment is positively correlated with the green performance of Chinese listed enterprises;

H1b: Digital investment is negatively correlated with the green performance of Chinese listed enterprises.

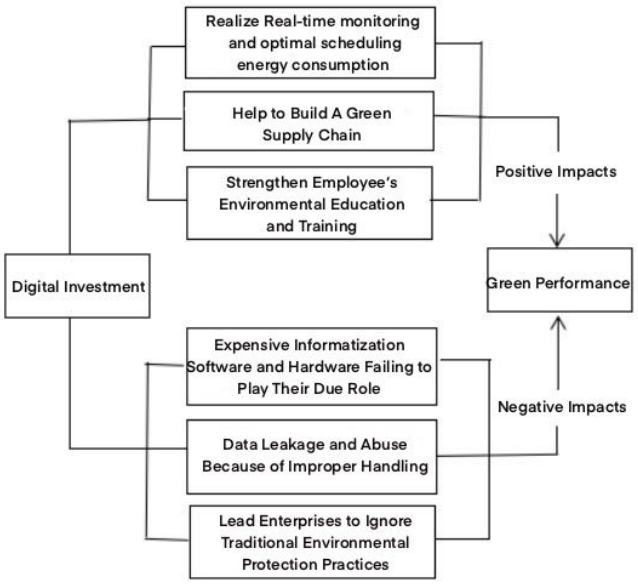

Figure 1. Theoretical Analysis Framework of How Digital Investment Affects Green Performance of Listed Enterprises

3. Research Design

(1) Data Sources and Sample Selection

Taking Chinese listed enterprises from 2017 to 2022 as the original sample, this paper processes according to the following criteria. (1) Exclude financial listed enterprises; (2) Exclude ST listed enterprises; (5) Eliminate the samples with missing data in the rest of the data. There are 20,464 valid annual sample observations finally retained, with Table 1 for specific sample screening. In this paper, the environmental research database (ENV) of CSMAR is used to compile and calculate the originally environmental performance data of listed enterprises with Stata. Digital investment data comes from the digitalization-related word frequencies in the annual reports of listed enterprises [27]. To alleviate the influence of sample outliers, the continuous variables are tailed in 1% percentile and 99% percentile.

Table 1. Sample Screening

Sample Screening Process	Sample Size
2017-2022 A-share Listed Enterprises	34302
Exclude Financial Enterprises	798
Exclude ST Enterprises	1548
Eliminate Enterprises with Missing Data	11492
Final Sample Size	20464

(2) Variable Measurement

1. Dependent Variable: Environmental Performance Index (EPI)

According to the existing research [26], this paper uses the ENV database of CSMAR and adopts the comprehensive scoring method to construct EPI of listed enterprises. EPI are composed of the following parts. (1) whether the enterprise has the concept of environmental protection. (2) whether there are environmental protection goals. (3) whether the environmental protection management system has been adopted. (4) Whether they have conducted environmental protection education and training. (5) Whether there is a special act of environmental protection. (6) whether the emergency response mechanism for environmental incidents is adopted. (7) Whether the enterprise has a "three simultaneous" system. (8) whether it has received honors or awards in environmental protection. (9) Whether the enterprise has passed the ISO14001 certification. For every enterprise that meets the above items, it scores 1. If not, it scores 0. This paper takes the total score of these nine items of listed enterprises as the explained variable, which is expressed as EPI in the model.

In the robustness test, the comprehensive score of environmental protection and governance is used to measure EPI, which specifically includes six aspect: exhaust gas emission reduction, wastewater emission reduction, dust reduction, solid waste utilization and disposal, noise and light control, and implementation of clean production. Meanwhile, 0, 1 or 2 points are given based on their disclosure degree (whether to disclose; qualitative or quantitative disclosure). This paper takes the total score of above-mentioned six items of listed enterprises as the explained variable, which is expressed as RT in the model.

2. Independent Variable: Digital Investment (EI)

Based on the existing research [27], this paper measures digital investment by analyzing the natural logarithmic number of digitalization-related word frequencies in annual reports of listed enterprises, which is expressed as EI in the model.

3. Control Variables

Based on the existing research [26], this paper controls the enterprise scale (Size), that is, the natural logarithm of the total number of employees; enterprise age (Age), that is, the natural logarithm of the difference between the observation year and the establishment year; the property rights (Soe) of enterprises is set as 1 for state-owned enterprises and 0 for non-state-owned enterprises; shareholding ratio of the largest shareholder (Top1), that is, the ratio of the number of shares held by the largest shareholder to the total share capital; board size (Board), that is, the total number of board members; R&D intensity (RD), that is, the ratio of R&D investment to operating income; enterprise growth (Grow), expressed by the growth rate of total assets; audit quality (Big4), that is, whether the enterprise is audited by the international "big four" accounting firms, if so, it is 1, otherwise it is 0. To reduce the impact of outliers, continuous variables are tailed at 1% and 99% quantiles in this paper, with the specific definitions of variables shown in Table 2.

Table 2. Variable Definitions and Descriptions

Category	Name	Symbol	Measurement
Explained Variable	Environmental Performance	EPI	See the Description in the Paper for Details
Explanatory Variable	Digital Investment	EI	Analyze the natural logarithm of the number of digitized-related word frequencies in annual reports
Control Variable	Shareholding Ratio of the Largest Shareholder	LHR	Ratio of the number of shares held by the largest shareholder to the total share capital
	Enterprise Growth	Grow	Growth rate of total assets
	R&D Intensity	RD	Ratio of R&D investment to operating income
	Property Rights of Enterprises	soe	1 for state-owned enterprises and 0 for non-state-owned enterprises
	Board Size	Board	Total number of board members
	Enterprise Age	Age	The difference between the observation year and the establishment year
	Audit Quality	Big4	Whether the enterprise is audited by the international "big four" accounting firms. If so, it is 1, otherwise it is 0
	Enterprise Scale	Size	Natural logarithm of the total number of employees

(3) Model Design

To test the impact of digital investment on the green performance of listed enterprises, this paper constructs model (1) as shown in formula (2).

$$EPI=\beta_0+\beta_1 EI+\beta_2 LHR+\beta_3 Grow+\beta_4 RD+\beta_5 soe+\beta_6 Board+\beta_7 Age+\beta_8 Big4+\beta_9 size+\varepsilon \quad (1)$$

4. Analysis of Empirical Results

(1) Descriptive Statistics

According to Table 3 that shows the descriptive statistics for the main variables, the average value of EPI is 2.150, the minimum is 0, and the maximum is 9, indicating large differences in EPI scores between different enterprises. The average of EI is 1.840, the minimum is 0, and the maximum is 6.380, indicating a significant gap between the minimum and maximum of different enterprises' EI, indicating that different enterprises' EI vary.

Table 3. Descriptive Statistics

Variable	Sample Size	Average	Standard Deviation	Minimum	Median	Maximum
EPI	20464	2.150	2.100	0	2	9
LHR	20464	32.800	14.550	1.840	30.410	89.990
Grow	20464	0.220	0.780	-0.860	0.080	46.930
Soe	20464	0.270	0.440	0	0	1
Board	20464	8.300	1.610	0	9	18
Age	20464	9.460	8.050	0	7	32
Big4	20464	0.060	0.240	0	0	1
RD	20464	8.970	261.600	0	3.990	31729
Size	20464	7.660	1.240	0	7.540	13.250
EI	20464	1.840	1.460	0	1.610	6.380

(2) Regression Results Between Digital Investment and Green Performance of Listed Enterprises

Table 4. Digital Investment and Green Performance of Listed Enterprises

	(1) EPI
EI	-0.225***
	(0.010)
LHR	0.005***
	(0.001)
Grow	0.018
	(0.035)
RD	0.002
	(0.003)
Size	0.568***
	(0.013)
Soe	0.339***
	(0.037)
Board	0.052***
	(0.009)
Age	0.004*
	(0.002)
Big4	0.941***
	(0.058)
_ cons	-2.557***
	(0.112)
N	20464
R^2	0.196
adj. R^2	0.196

Standard errors in parentheses

* p < 0.1, * * p < 0.05, * * * p < 0.01

Column (1) of Table 4 shows the regression results of model (1). As shown in Table 4, Column (1), the EI regression coefficient of digital investment is -0.225 and it is significant at the level of 1%, which proves that enterprises with more digital investment have worse green performance effects. The regression results show a significant negative correlation between digital investment and green performance. In addition, the regression results of control variables are basically consistent with existing studies.

(3) Robustness Test

Table 5. Replacement of Main Variables

	(1)
	RT
EI	-0.430***
	(0.013)
LHR	0.006***
	(0.001)
Grow	0.041
	(0.045)
RD	0.001
	(0.003)
Size	0.627***
	(0.017)
Soe	-0.005
	(0.048)
Board	0.073***
	(0.011)
Age	0.005*
	(0.003)
Big4	0.874***
	(0.075)
_ cons	-2.396***
	(0.146)
N	20464
R^2	0.161
adj. R^2	0.161

Regression was conducted again by replacing EPI and EI. According to Table 5 that shows the regression results of replacing the main variables, the higher the digital investment, the worse the green performance. All results were consistent with the baseline regression results.

(4) Heterogeneity Test

According to Columns (1) and (2) in Table 6 that show the heterogeneity test of different property rights, coefficients of state-owned enterprises and non-state-owned enterprises are significantly negative, but the coefficients of state-owned enterprises are smaller. This means that the more digital investment, the worse the green performance, which is more apparent in state-owned enterprises.

Table 6. Results of Heterogeneity Analysis

	(1)	(2)
	EPI	EPI
EI	-0.230***	-0.223***
	(0.023)	(0.011)
LHR	0.006***	0.004***
	(0.002)	(0.001)
Grow	-0.011	0.036
	(0.102)	(0.036)
RD	0.025***	-0.001
	(0.007)	(0.003)
Size	0.629***	0.534***
	(0.026)	(0.015)
Board	0.038**	0.059***
	(0.017)	(0.010)
Age	0	0.008***
	(0.004)	(0.003)
Big4	1.080***	0.809***
	(0.099)	(0.074)
_ cons	-2.679***	-2.357***
	(0.243)	(0.131)
N	5489	14975
R^2	0.188	0.143
adj. R^2	0.187	0.142

5. Conclusions and Suggestions

Based on the effective data of Chinese listed enterprises from 2017 to 2022, this paper examines the impact of digital investment on the green performance of Chinese listed enterprises. The research findings are as follows. (1) The impact of digital investment on the green performance of listed enterprises in China is significantly negative, which is still valid after a series of robustness tests. (2) The negative effect of digital investment on the green performance of state-owned enterprises is more significant than that of non-state-owned enterprises.

This study has some practical value. The above research conclusions provide a vital reference for the government to promote the digital economy to help the development of ecological civilization, and for enterprises to promote digital investment to achieve green development. For the government, its departments should establish an environmental performance evaluation mechanism for information investment, regularly evaluate environmental impacts of investment projects, and adjust relevant policies and measures according to evaluation results. In addition, government departments should formulate and implement emergency plans to deal with environmental risks and emergencies that may be caused by information investment. For enterprises,they should evaluate the impact of green investment on environmental performance, make reasonable plans according to their actual situation and needs, and adjust strategies when necessary to ensure that investment can improve environmental performance and avoid blind investment and waste of resources. Besides, enterprises should moderately pay attention to and use the new generation of information technology to avoid information overload caused by excessive attention, which will affect the quality of decision-making and environmental performance.

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