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Digital Transformation, Investor Attention, and Green Innovation Technology

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Abstract

This paper empirically analyzes the impact of digital transformation on green innovation using a sample of China's A-share listed companies from 2010 to 2022. The empirical analysis shows that digital transformation has a significant impact on green innovation technology. Further mechanism analysis concludes that digital transformation significantly increases investor attention, thereby strongly promoting the development of green innovation technology. This study indicates that in the context of digital transformation, enterprises should adopt green innovation technology as a driving development strategy to enhance corporate value and provide.

Keywords: Digital transformation; Green innovation; Investor attention; Corporate governance

1. Introduction

While China's economy continues to grow rapidly, issues related to ecological resource constraints and environmental pollution are becoming increasingly prominent. Accelerating the transformation of the economic development model is imperative. The Central Committee of the Communist Party of China and the State Council have issued the "Overall Layout Plan for Digital China Construction," which sets the goal of achieving significant progress in "digital ecological civilization construction" by 2025 as a key target for building a Digital China. This plan outlines the goal of constructing a green and intelligent digital ecological civilization, setting new requirements for the application of new-generation digital technologies in ecological governance.

Continuous technological innovation and the expansion of digital applications are necessary to inject new momentum into the ongoing improvement of the ecological environment and to drive high-quality development. President Xi Jinping emphasized at the National Conference on Ecological and Environmental Protection the need to "deepen the application of digital technologies such as artificial intelligence, build a digital governance system for Beautiful China, and construct a green and intelligent digital ecological civilization." Against this backdrop, enterprises should actively respond to national policies and achieve the integration of digitalization and greening.

Currently, with the deep evolution of a new round of technological revolution, the development of green innovation technology has become a crucial means for enterprises to enhance competitiveness and achieve sustainable development. The application of technologies such as big data, cloud computing, and blockchain necessitates that enterprises promote the deep integration of digital transformation and green innovation technologies to foster sustainable development amidst digital transformation. The "14th Five-Year Plan for National Informatization" further emphasizes the need to "deeply advance the construction of a green and intelligent ecological civilization and promote the coordinated development of digital and green transformations." The 20th National Congress of the Communist Party of China has highlighted the acceleration of building a strong cyber nation and Digital China. The Party and the state prioritize the integrated development strategy of digital and green transformations, actively encouraging enterprises to implement green innovation strategies in the context of digital transformation to promote economic structural optimization, upgrade to an environmentally friendly society, and achieve continuous national economic growth. Therefore, can digital transformation effectively enhance green innovation technology levels? What are the mechanisms involved? Can digital transformation effectively increase investor attention and thus promote the development of green innovation technologies in enterprises?

By reviewing literature related to digital transformation, it is found that existing studies primarily focus on the impact of digital transformation on corporate value, corporate performance, market efficiency, and corporate investment. However, there is limited research analyzing the impact of digital transformation on corporate green innovation technologies from the perspective of investor attention. To enrich this body of research, this paper uses investor attention as a mediating variable to study the impact of digital transformation on corporate green innovation technologies.

Based on the above analysis, this paper takes A-share listed companies from 2010 to 2022 as samples to explore the impact of digital transformation on corporate green innovation, investigating the mediating effect of investor attention. Compared to existing research, the marginal contributions of this paper are mainly reflected in three areas: first, it explores the mechanisms through which digital transformation influences green innovation technology, enriching the discussion on the impact mechanisms of digital transformation on green innovation technologies. Second, it uses investor attention as a mediating variable to elucidate the pathways through which digital transformation affects corporate technological innovation. Third, it considers the heterogeneity of the relationship between digital transformation and green technological innovation from the perspective of whether the enterprises are state-owned.

2. Theoretical Analysis and Research Hypotheses

2.1 Digital Transformation and Green Innovation Technology

By reviewing existing literature, it is found that research on corporate green innovation technology mainly revolves around research progress and future prospects, as well as influencing mechanisms. In terms of research progress and future prospects, some scholars have studied the integrated research framework and future outlook for corporate green innovation, the classification and measurement of corporate green innovation technologies, and the research framework. In terms of influencing mechanisms, some scholars have studied that higher levels of green finance development help promote corporate green innovation technology levels, green innovation technology significantly impacts economic resilience, and green innovation technology can facilitate carbon emission reduction. From the above literature, it can be seen that scholars have conducted detailed research on corporate green innovation technology, laying a research foundation for further examining the impact of digital transformation on green innovation technologies.

Under the background of digital transformation and the "dual carbon" goals, the continuous development of new technologies such as big data is integrated into the real economy, and the development of the digital economy is advancing by leaps and bounds. Digital transformation has gradually evolved into a core driver for promoting green innovation technology. Digital transformation, as a technological resource, aids in the internal operational management of enterprises, boosting their green innovation technologies and enhancing their innovation capabilities. The pathways through which digital transformation influences corporate green innovation are as follows:

On one hand, digital transformation provides enterprises with a large amount of supportive data, facilitating the processing, analysis, and integration of internal and external resources, helping enterprises break down information barriers and silos, thus improving their green innovation technologies. Simultaneously, by analyzing consumer needs and preferences based on data, enterprises not only reduce the costs and workload of data collection but also determine the development direction and existing problems of green innovation technologies, aiding in enhancing green innovation capabilities. On the other hand, digital transformation offers enterprises more tools, platforms, and environments for green innovation technology. Enterprises utilize digital tools and platforms to develop and operate green innovation products, improving resource utilization efficiency, saving significant human resources, and achieving optimal resource allocation, thus providing resource support for corporate green innovation technologies.

Based on the above analysis, this paper proposes Hypothesis H1: Digital transformation can enhance the efficiency of corporate green innovation.

2.2 Mediating Effect of Investor Attention

Organizational legitimacy theory posits that there is a close contractual relationship between organizations and investors. Corporate operational decisions are closely linked with stakeholders, including investors who pay attention to the information regarding corporate innovation activities and operational status.

In the context of the application of big data, artificial intelligence, blockchain, and other technologies, enterprises that focus on green innovation technologies can achieve sustainable development in the foreseeable future, ultimately realizing the unity of environmental and economic benefits. With the transformation driven by big data, investors not only pay attention to the operational status of enterprises but also increasingly obtain detailed information on corporate green innovation activities through exchanges, playing a positive supervisory role in corporate green innovation technologies.

Investor attention may influence the promoting effect of digital transformation on corporate green innovation technologies. The 20th National Congress emphasized the need to promote green development in economic and social progress. Green development has become a strategic policy for the country's sustainable development. Investors, while focusing on the economic status of enterprises, also continuously pay attention to enterprises developing green innovations.

Corporate green innovation technology is a crucial strategic decision for enterprise development, and investor attention can influence the formulation of green innovation strategies. On one hand, digital transformation makes it easier for investors to obtain information related to the innovation capabilities of enterprises. Investors maintain high attention to the digital transformation and green innovation technology development of enterprises, enabling enterprises to gain more capital support and become more competitive in the digital era. On the other hand, based on the information asymmetry theory, there exists an information asymmetry problem between investors and internal corporate managers. Although investors acquire information, digital transformation allows enterprises to gain more information about their green innovation activities, enhancing information supervisability, attracting external investment, and promoting the development of corporate green innovation technologies.

Based on the above analysis, this paper further proposes Hypothesis H2: Digital transformation can enhance the efficiency of corporate green innovation by increasing investor attention.

3. Research Design

3.1 Research Subjects and Data Sources

This study uses A-share listed companies from 2010 to 2022 as research subjects. To ensure the credibility and validity of the data, companies with the following characteristics were processed: first, samples marked as ST were excluded; second, financial companies were excluded; third, companies with missing data were excluded; fourth, to eliminate the impact of outliers on the results, all variables were winsorized at the 1% level. After corresponding elimination and screening of the initial research sample data, the final sample includes a total of 10,883 observations. The data in this paper are sourced from the CSMAR database, the CNRDS database, and manually compiled using Python tools.

3.2 Variable Definitions

3.2.1 Dependent Variable: Green Innovation Technology

The dependent variable in this paper is corporate green innovation technology (GI). Corporate green innovation technology is an important indicator of the sustainable development capability of enterprises. Referring to the studies by Xu Jia and Han Jing, this paper uses the number of green invention patents applied for during the corporate fiscal year to measure the level of corporate green innovation technology, specifically: GI is equal to the natural logarithm of the total number of green invention patents applied for by listed companies plus one.

3.2.2 Independent Variable: Digital Transformation

The independent variable in this paper is digital transformation (Digit). Referring to the study by Wu Fei et al., this paper uses the frequency of digital characteristic words in the annual reports of listed companies, specifically: Digit is equal to the natural logarithm of the frequency of digital characteristic words in the annual reports of listed companies plus one.

3.2.3 Mediating Variable: Investor Attention

The mediating variable in this paper is investor attention. Referring to the study by Li Bin, Yao Yao, and Li Haixia, this paper uses the number of investment analysts tracking listed companies, specifically: AT is equal to the natural logarithm of the number of investment analysts tracking listed companies.

3.2.4 Control Variables

To control for other variables that may affect the level of corporate green innovation technology, this paper selects the following control variables based on previous research: company size (Size), ownership concentration (OC), enterprise growth (Growth), profitability (ROA), Tobin's Q (Q), property rights nature (SOE), and controls for the time effect (Year) and industry effect (Industry). The specific definitions of the control variables are shown in Table 1.

Variable Type	Variable Name Variable Symbol		Variable Definition
			ln (Number of green
	Corporate Green	CI	invention patents
Dependent variable	Innovation Technology	61	applied by listed
			companies + 1)
	Corporate Digital Transformation		ln (Frequency of digital
Indonondont Variable		Digit	feature words in the
Independent Variable			annual reports of listed
			companies + 1)
Mediating Variable	Investor Attention	АТ	ln (Number of analysts
			tracking the listed
			company)
Control Variables	Firm Size	Site	Natural logarithm of
		5126	total assets
Control Variables	Ownership	ip OC	Shareholding ratio of
	Concentration		the largest shareholder

			(Ending total assets -
Control Variables	Growth	Growth	Beginning total assets)
			/ Beginning total assets
Control Variables	Drofitability	POA	Net profit / Average
Control variables	Promability	KOA	total assets
Control Variables	Tobin Q	Q	Firm's current Tobin Q
			According to the
	Property Rights Nature		nature of equity
		SOE	control, if the
Control variables		50E	company is
			state-owned, the value
			is 1, otherwise, it is 0
Control Variables	Year	Year	Control for year effects
Control Workship	To 1 sta	To J	Control for industry
Control variables	maustry	muustry	effects

3.3 Model Construction

To test the aforementioned hypotheses, this paper designs a multiple linear regression model for empirical analysis. The digital transformation is taken as the dependent variable and the green innovation technology of enterprises as the independent variable. After controlling for company characteristics and further considering industry and year fixed effects, a fixed effect logistic regression model is constructed as follows:

$$GI_{i't} = \alpha_0 + \alpha_1 Digit_{i't} + \alpha_2 \sum control_{i't} + Year + Industry + \epsilon_{i't}$$
(1)

The specific mediation effect test models in this paper are as follows:

$$AT_{i,t} = \beta_0 + \beta_1 Digit_{i,t} + \beta_2 \sum control + Year + Industry + \epsilon_{i,t}$$
(2)
$$AT_{i,t} = \gamma_0 + \gamma_1 Digit_{i,t} + \gamma_2 AT_{i,t} + \gamma_3 \sum control + Year + Industry + \epsilon_{i,t}$$
(3)

In model (1), $GI_{i\nu t}$ is the dependent variable representing the green innovation technology of enterprise i in year t; $Digit_{i\nu t}$ is the independent variable representing the digital transformation of enterprise i in year t; $control_{i\nu t}$ are the control variables. Models (2) and (3) are used to test hypothesis H3. In model (2), digital transformation is the independent variable, and investor attention is the dependent variable. In model (3), the independent and dependent variables are the same as in model (1), but investor attention is introduced as a mediating variable to explore the mediating effect of investor attention in the relationship between digital transformation and green innovation technology. Year and Industry represent year and industry fixed effects, respectively, and ϵ_{int} is the residual term.

3.4 Empirical Analysis

3.4.1 Descriptive Statistics

Table 2 shows the descriptive statistics of the sample used in this paper. From the statistical results, the mean value of the dependent variable green innovation technology is 0.280, the minimum value is 0, and the maximum value is 6.160. This indicates that there is a large gap in the level of green innovation technology among different enterprises, with some enterprises having green innovation technology and others not, generally at a low level. The mean value of the independent variable digital transformation is 1.530, with a minimum value of 0 and a maximum value of 6.270. This indicates that there is a significant difference in the level of digital implementation among different enterprises, and the overall level is relatively low.

From the statistical results, other variables are consistent with existing literature. The descriptive statistics are within a reasonable range, and the data are sufficiently dispersed, indicating high empirical research reliability.

	Sample size	Mean	Std. Dev.	Minimum	Median	Maximum
GI	10883	0.280	0.700	0.000	0.000	6.160
Digit	10883	1.530	1.470	0.000	1.390	6.270
Size	10883	22.400	1.320	15.720	22.220	28.640
OC	10883	35.320	15.030	2.600	33.400	89.990
Growth	10883	0.240	0.710	-0.830	0.120	37.030
Q	10883	2.380	7.620	0.640	1.750	729.600
ROA	10883	0.140	0.080	0.000	0.170	0.260

Table 2 Descriptive Statistics

3.4.2 Model Regression Analysis

Table 3 presents the baseline regression results of digital transformation on green innovation technology. Column (1) shows the regression results without control variables, with a regression coefficient of 0.0538 for digital transformation, which is significantly positive at the 1% level. Column (2) includes control variables, and the regression coefficient for digital transformation is 0.0396, also significantly positive at the 1% level. The regression coefficients of the explanatory variables are all significantly positive, indicating that digital transformation promotes the level of green innovation technology in enterprises, confirming hypothesis H1.

Technology

	0.	
	(1)	(2)
	GI	GI
Digit	0.054***	0.040^{***}
	(0.006)	(0.006)
Size		0.117***
		(0.006)
OC		0.000
		(0.001)
Growth		-0.015
		(0.009)
Q		0.002^{*}
		(0.001)
ROA		-0.050
		(0.179)
Year	Yes	Yes
Industry	Yes	Yes
_cons	-0.234	-2.684***
	(0.397)	(0.412)
N	10883.000	10883.000
\mathbb{R}^2	0.270	0.297
adj. R ²	0.178	0.208

Table 3. Baseline Regression Results of Digital Transformation on Green Innovation

3.4.3 Mediation Effect of Investor Attention

Table 4 displays the test results of the mediation effect of investor attention on the relationship between digital transformation and green innovation technology. Column (1) shows that the coefficient between digital transformation and investor attention is 0.0670, significant at the 1% level. Column (2) shows that the coefficient between digital transformation and green innovation technology is 0.0367, significant at the 1% level, while the coefficient between investor attention and green innovation technology is 0.0367, significant at the 1% level, while the coefficient between the transformation at the 1% level. This indicates that digital transformation has a significant positive impact on both investor.

attention and green innovation technology, with investor attention partially mediating the effect. Therefore, hypothesis H2 is confirmed.

Technology			
	(1)	(2)	
	АТ	GI	
Digit	0.067^{***}	0.037***	
	(0.010)	(0.006)	
Size	0.367***	0.101***	
	(0.010)	(0.007)	
OC	0.000	0.000	
	(0.001)	(0.001)	
Growth	0.108^{***}	-0.020**	
	(0.014)	(0.009)	
Q	0.007^{***}	0.001	
	(0.001)	(0.001)	
ROA	0.536^{*}	-0.073	
	(0.276)	(0.179)	
AT		0.043***	
		(0.007)	
Year	Yes	Yes	
Industry	Yes	Yes	
_cons	-7.298***	-2.372***	
	(0.636)	(0.414)	
N	10883.000	10883.000	
\mathbb{R}^2	0.316	0.300	
adj. R ²	0.229	0.211	

Table 4. Mediation Test Results of Digital Transformation's Impact on Green Innovation

3.4.4 Robustness Analysis

To verify robustness, we conducted a test of digital transformation lagged by one period while keeping the mediator and control variables unchanged. The results are shown in Table 5. The coefficient of digital transformation and green innovation technology is 0.0329, significant at the 1% level. The regression results remain consistent with those described above.

Table 5. Regression Results with Lagged Treatment		
	(1)Lagged	(2)Two-period Lagged
	F.GI	F2.GI
Digit	0.033***	0.061***

Table 5. Regression Results with Lagged Treatment

	(0.012)	(0.016)
Size	0.115***	0.134***
	(0.013)	(0.017)
OC	0.001	0.001
	(0.001)	(0.001)
Growth	-0.011	-0.003
	(0.017)	(0.018)
Q	0.001	0.000
	(0.001)	(0.001)
ROA	-0.296	-1.323
	(0.417)	(0.832)
Year	Yes	Yes
Industry	Yes	Yes
_cons	-2.683*** -3.129***	
	(0.482)	(0.881)
N	3210.000	2404.000
\mathbb{R}^2	0.341	0.406
adj. R ²	0.139	0.201

3.4.5 Heterogeneity of Ownership

Table 6 demonstrates that state-owned enterprises have a greater advantage in digital transformation and green innovation technology compared to non-state-owned enterprises. Possible reasons include the ability of state-owned enterprises to obtain more favorable policies, thus being more willing to increase green R&D investment. Additionally, government intervention in state-owned enterprises in response to national policies is more effective in achieving sustainable development goals. This makes state-owned enterprises more competitive in developing green innovation technology under digital transformation. Our study examines whether there is heterogeneity in the impact of digital transformation on green innovation technology across different types of enterprises. Columns (1) and (2) in Table 6 show that digital transformation has a more significant impact on green innovation technology in state-owned enterprises.

	(1)State-owned enterprises	(2non-state-owned enterprises
	GI	GI
Digit	0.059***	0.038***

	(0.015)	(0.007)
Size	0.130***	0.092***
	(0.013)	(0.008)
OC	-0.001	0.001
	(0.001)	(0.001)
Growth	0.005	-0.014
	(0.044)	(0.009)
Q	0.017	0.001
	(0.012)	(0.001)
ROA	0.105	-0.196
	(0.266)	(0.291)
Year	Yes	Yes
Industry	Yes	Yes
_cons	-2.771***	-2.239***
	(0.841)	(0.467)
N	3576.000	7307.000
\mathbb{R}^2	0.461	0.308
adj. R ²	0.297	0.188

4. Research conclusions and suggestions

4.1 Research Conclusion

Based on the data of A-share listed companies from 2010 to 2022, this paper deeply analyzes the impact of digital transformation on the level of green innovation technology of enterprises and its action path. Through empirical analysis, the hypotheses proposed are all reasonable, and the research results are obtained: First, enterprise digital transformation can promote enterprise green innovation technology. By studying the impact of digital transformation on green innovation technology, this paper enriches relevant literature on the economic consequences of digital transformation, and provides different research perspectives for the study of green innovation technology; Second, digital transformation can increase the attention of investors, and thus improve the green innovation technology of enterprises. This analysis helps to clarify the role path of digital transformation for green innovation technology; Third, through further property rights heterogeneity analysis and verification, digital transformation has a more significant effect on the green innovation technology level of state-owned enterprises. Through this conclusion, the government can continuously adjust the policy according to the actual situation of local enterprises, and allow enterprises to continuously attract investors as much as possible, so as to enhance the green innovation technology ability of enterprises.

4.2 Suggestions

Enterprises should take the initiative to change their thinking and actively adopt digital and other technologies. Enterprises should adopt digital technology to promote the development of green innovation technology, and pay attention to the impact of digital transformation on the development of enterprises. Guide enterprises to optimize internal processes, improve operational efficiency, reduce operating costs, and enhance the level of green innovation technology and enhance competitiveness in the digital era.

Enterprises should attach importance to the role of external investors and use digital technology to improve the transparency of information. Enterprises should disclose financial information accurately and timely, reduce the asymmetry of information, enhance the trust of external investors, develop the green innovation technology of enterprises, and improve the value of enterprises.

The government should accelerate the optimization of measures to promote the digital transformation of enterprises, and build a market environment for the coordinated development of digital and green. Give full play to the regulatory role and supervise the positive guiding role of digital transformation of enterprises for the development of green innovative technologies.

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