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The Impact and Mechanisms of Digital Transformation on Corporate Green Innovation

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Abstract. Given the deep integration of digital transformation with green development, understanding its effect on corporate green innovation has become a critical research focus. Employing panel data from Shanghai and Shenzhen A-share listed companies (2005-2024), this study empirically investigates three core issues: the direct relationship, the underlying mediating mechanisms, and the effect heterogeneity across firm types. The results delineate that: (1) digital transformation significantly promotes corporate green innovation; (2) the mediation pathway is partially explained by enhanced financial resource allocation for innovation; and (3) the effect is heterogeneous, being more substantial in high-tech and heavily polluting firms compared to their peers.

Keywords: digital transformation, corporate green innovation, innovation financial resources allocation

1. Introduction

As China's economy maintains steady rapid growth and industrialization advances further, the challenges of resource exhaustion and environmental deterioration have grown ever more salient. Within the national strategy of "carbon peaking and carbon neutrality," promoting green development has risen to the forefront of policy agendas. A key focus of the 20th National Congress of the Communist Party of China lay in stressing the necessity to "accelerate the green transition," thereby setting a clear trajectory for enterprises to pursue environmentally oriented technological advancement. Within this framework, green innovation centers on the systematic incorporation of energy efficiency, emission abatement, pollution management, and resource recycling into products and production processes. By means of technological progress and managerial reform, such innovation seeks to achieve a dual improvement in both ecological and economic performance [1].

Propelled by the development of digital economy, new technologies spread rapidly and reshape firms' organizations and management practices and even innovation models. Digital transformation, an integrated process of technological upgrading and organizational change, has reshaped firms' approaches to value creation and injected new momentum into enhancing innovation capacity and competitive advantage [2]. In the environmental field, it is projected that by 2030, digital technologies could reduce the overall societal carbon emissions by 12%–22%, and the emissions from the industrial sector could be reduced by 13%–22% [3]. These scenarios indicate that digital transformation can give birth to new momentum to drive corporate green innovation..

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However, most of the previous studies have linked digital transformation to general corporate performance and traditional innovation, while the relationship between digital transformation and green innovation remains weakly explored. This paper aims to fill the gap by empirically exploring the effect of digital transformation on corporate green innovation based on panel data of Chinese A-share listed firms (2005-2024). Furthermore, this paper explores the mediating mechanisms and effect heterogeneity of firm types, which is a significant omission in the existing studies.

2. Theoretical analysis and research hypotheses

2.1. Digital transformation and green innovation technologies

The RBV holds that a firm's sustainable competitive advantage lies in its ability to acquire and orchestrate resources—specifically those that are of value, scarce, hard to imitate, and non-substitutable [4]. According to this theoretical perspective, achieving green innovation requires more than merely holding these resources; firms must also possess the dynamic capability to orchestrate knowledge, technologies, financial capital, and human talent [5]. In this regard, digital transformation offers a critical means of cultivating this integrative capability.

Enterprise digital transformation is a comprehensive process of resource reconfiguration and organizational change in how firms use resources and organize work, driven by the extensive use of leading-edge technologies. The goal is to enhance efficiency, promote innovation, and optimize business models [6]. First, digital technologies alleviate the limitations of space and time for information flow, and enable enterprises to more efficiently acquire and integrate the key resources required for green innovation. By establishing data infrastructures and real-time sensing networks, enterprises can proactively allocate resources and greatly expand the range and depth of resource acquisition [7]. Second, digitalization also transforms how enterprises recognize the value of resources. In traditional settings, identifying and allocating resources typically relies on experiential judgment and limited indicators, making it difficult to maximize long-term synergy. By contrast, analytics and intelligent decision-support systems enable enterprises to more accurately assess the contribution of resources to green innovation, thereby optimizing allocation strategies and enhancing utilization efficiency [2]. Overall, these improvements facilitate better integration of green innovation elements and provide a solid basis for organizational capabilities.

The KBV identifies knowledge as the most important strategic resource and proposes to regard the capabilities to acquire, integrate, and diffuse knowledge as the key to achieving innovation performance [16]. Digital transformation enhances the process of knowledge integration. One aspect is that enterprises use digital means and information systems to break through information isolation and find and absorb external green knowledge and reconfigure scattered knowledge assets on the basis of green innovation [8]. Another aspect is that digital platforms foster collaborative mechanisms among innovation networks. By cooperating with research institutes, suppliers, and other partners through data-enabled collaboration on the digital platform, enterprises can build effective collaborative systems and rapidly upgrade green technology by accelerating joint development and continuous improvement of green technology [9].

In sum, digital transformation helps firms improve their efficiency in acquiring and evaluating resources, and enhances their ability to identify, integrate, and disseminate knowledge. These improvements facilitate better coordinated configuration and collective application of key elements in the green innovation process, and enhance firms' green innovation. On this basis, we posit the following research hypothesis.

H1: Digital transformation enhances the green innovation capabilities of firms.

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2.2. The mediating role of financial resources for innovation

Digital transformation promotes the increase of firms' financial strength for green innovation through the following mechanisms: Firstly, digital transformation can improve the efficiency of resource allocation and the accuracy of decision making, so that firms can make more accurate judgments on the value of R&D investment and the direct flow of finance into innovation-linked activities [10]. Secondly, digital transformation can improve the transparency of information, improve the financing environment and increase the supply of capital [11]. In addition, digital finance platform improves the credibility of financial institutions through data-driven credit assessment and real-time information exchange, alleviates financing constraints and expands the supply of green innovation investment funds [12].

With the increase in financial strength, enterprises can further invest in green technology research and development, providing adequate financial support for green innovation. One is that more financial input greatly improves innovation efficiency; in the field of green technology, more financial input can make technological exploration more effective, and green innovation will be realized more quickly [13]. The other is that more financial input can enhance the innovation ability of enterprises in terms of technology development, talent aggregation and intellectual property, providing a solid basis for green innovation [14].

In summary, digital transformation improves the financial strength of enterprises in green technology research by improving the allocation efficiency of resources, reducing innovation costs and expanding financing channels, thereby promoting green innovation. Based on the above research findings, the following preliminary hypothesis is proposed on this basis:

H2: The influence of digital transformation on corporate green innovation manifests primarily via an increase in the financial resources dedicated to innovation.

3. Model construction

3.1. Research sample and data sources

The initial data universe encompassed all A-share between 2005 and 2024. This universe was subsequently subjected to a screening procedure that involved: (1) the removal of ST, *ST, and PT firms; (2) the exclusion of financial companies based on the CSRC's 2021 industry codes; and (3) the elimination of records with missing information. A winsorization at the top and bottom 1% was also performed on all continuous variable.

Data were compiled from multiple sources: corporate digital transformation metrics were constructed via Python-based text mining of annual reports, green patent information was sourced from CNRDS, and financial and corporate governance data were retrieved from CSMAR.

3.2. Variable definitions

3.2.1. Explanatory variable (DT)

Firm-level digital transformation is operationalized via a text-based index, developed in line with prior research [15]. Using Python for text mining, digitalization-related terms were extracted and analyzed for frequency. The final composite scores are derived from the prevalence of keywords linked to the adoption of digital technologies, internet-enabled business models, smart production, and modern information infrastructure.

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3.2.2. Explained variable (GI)

Green innovation is measured at the firm level by the total number of green patent applications, which is a measurement method used in previous studies [16]. Its definition is intended to reflect all these patents which a firm applied for either independently or jointly in one year, which is similar to its innovative performance in the environmental field.

3.2.3. Mediating variable (FI)

R&D investment is the basis of innovation development. Following the definition in previous studies [17], we evaluate the amount of financial input used in R&D by using R&D intensity, which is the ratio of R&D expenditure to total operating revenue.

3.2.4. Control variables

The empirical model accounts for a range of firm-level control variables to alleviate concerns of omitted variable bias. Variable definitions and corresponding descriptive statistics are elucidated in Table 1..

3.3. Model specification

The study has dual objectives: to gauge the immediate impact of digital transformation on green innovation and to uncover the transmission pathway of this effect.

$$GI_{i,t} = a_0 + a_1 DT_{i,t} + \beta CON_{i,t} + Ind_i + Year_t + \varepsilon_{i,t} \quad (1)$$

$$FI_{i,t} = b_0 + b_1 DT_{i,t} + \beta CON_{i,t} + Ind_i + Year_t + \varepsilon_{i,t} \quad (2)$$

$$GI_{i,t} = c_0 + c_1 DT_{i,t} + \beta CON_{i,t} + Ind_i + Year_t + \varepsilon_{i,t} \quad (3)$$

In the model, FI denotes the mediating variable, and CON comprises all control variables. Subscripts i and j correspond to industry and year, respectively. To account for unobservable heterogeneity, the model incorporates both industry fixed effects Ind_i and year fixed effects $Year_t$. The term ε represents the disturbance term component.

4. Empirical analysis

4.1. Descriptive statistics

Table 1 summarizes the descriptive statistics for the primary variables. As reported, corporate green innovation (GI) demonstrates a mean of 0.880 and spans from 0 to 21. The core explanatory variable, digital transformation (DT), exhibits a considerably lower average of 0.0200 within a narrow range of 0 to 0.140. The concentration of DT values at this low magnitude implies that the

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adoption of digital practices is still at a relatively limited and early phase for the majority of sampled firms.

Table 1. Descriptive statistics of main variables

Variable	N	Mean	SD	Min	Max
GI	26655	0.880	2.730	0	21
DT	26655	0.0200	0.0200	0	0.140
lnDT	26655	1.810	1.430	0	5.330
Size	26655	22.34	1.250	20.18	26.33
Age	26655	1.950	0.970	0	3.370
ROA	25968	0.0400	0.0600	-0.250	0.200
Lev	26655	0.410	0.190	0.0600	0.880
Ind	24071	37.85	5.360	33.33	57.14
TobinQ	26655	2.070	1.280	0.830	8.130
Bal	26655	0.790	0.610	0.0400	2.830
Liq	26655	2.520	2.300	0.400	14.29

4.2. Baseline regression

This finding is evident in the simple fixed-effects model (column (1)) and remains robust at the 1% significance level after incorporating all control variables in column (2). Moreover, the coefficient undergoes no substantial change and is estimated with greater precision in the full model.

Demonstrating remarkable consistency, the coefficient for digital transformation is estimated at 2.39 and maintains its statistical significance across different model setups. This suggests that a 1% increase in digital transformation corresponds to a 2.39% gain in green innovation performance. These robust findings substantiate the premise that digital transformation significantly promotes green innovation, thereby providing firm empirical grounding for Hypothesis H1.

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Table 2. Baseline regression, robustness checks, and mechanism test results

	GI		FI	GI	GI	
	(1)	(2)	(3)	(4)	(5)	(6)
DT	6.251***	2.390***	18.27***	2.259***		2.082**
	(0.871)	(0.873)	(1.510)	(0.876)		(0.872)
lnDT					0.0987***	
					(0.0150)	
FI				0.00737*		
				(0.00379)		
Size		0.581***	0.513***	0.577***	0.566***	0.489***
		(0.0189)	(0.0327)	(0.0190)	(0.0191)	(0.0215)
Age		-0.231***	-0.847***	-0.225***	-0.230***	-0.203***
		(0.0207)	(0.0358)	(0.0210)	(0.0207)	(0.0216)
ROA		0.558*	-17.97***	0.694**	0.625**	0.0876
		(0.285)	(0.493)	(0.293)	(0.285)	(0.290)
Lev		0.453***	-4.621***	0.488***	0.476***	0.530***
		(0.136)	(0.236)	(0.138)	(0.136)	(0.137)
Ind		0.00418	0.00338	0.00414	0.00406	0.00646**
		(0.00305)	(0.00529)	(0.00306)	(0.00305)	(0.00307)
TobinQ		0.0490***	0.729***	0.0436***	0.0450***	0.0371**
		(0.0151)	(0.0261)	(0.0154)	(0.0151)	(0.0151)
Bal		-0.121***	0.233***	-0.123***	-0.124***	-0.140***
		(0.0274)	(0.0475)	(0.0275)	(0.0274)	(0.0275)
Liq		-0.00564	0.304***	-0.00790	-0.00541	-0.00272
		(0.0103)	(0.0178)	(0.0103)	(0.0102)	(0.0103)
_cons	-0.494	-12.04***	-6.071*	-11.87***	-11.73***	-14.38***
	(1.978)	(1.901)	(3.297)	(1.906)	(1.901)	(1.914)
Dual /Cashflow/ Man	No	No	No	No	No	Yes
Ind	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Observation	26,655	23,418	23402	23402	23418	23418
Adj.R^2	0.094	0.154	0.445	0.154	0.155	0.157

4.3. Mechanism test

We test the mediating effect of innovation-oriented financial resources following [18]. The baseline relationship controlling for covariates and fixed effects is shown in Column (2) of Table 2. Subsequently, Column (3) regresses financial resources on digital transformation, which returns a significantly positive coefficient at the 1% level. It suggests that a one-percent increase in digital transformation is associated with a 18.27% increase in financial resources devoted to innovation, which is an important step in the mediation process. Then, in Column (4), in addition to the baseline

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model, we add the mediating variable innovation financial resources. Its coefficient is estimated as 0.00737, and is statistically significant at the 10% level. Compared with the baseline coefficient of 2.390, when the mediator is included, the point estimate of digital transformation decreases to 2.259, and it is still statistically significant at the 1% level.

Altogether, the results indicate that innovation financial resources play an important partially mediating role in the underlying mechanism between digital transformation and firms' green innovation. In particular, digital transformation promotes green innovation through enhancing firms' R&D investment, which provides strong empirical support for Hypothesis H2.

4.4. Robustness checks

To assess the robustness of the main results, this study conducts the following two complementary analyses.

4.4.1. Alternative measurement of the explanatory variable

Following the method of previous studies [6], another indicator of the digital transformation intensity of listed firms is constructed by extracting the keyword "digital transformation" from annual reports using text mining based on Python. Textual analysis methodology operationalizes "digital transformation" by aggregating keywords in five dimensions, including blockchain and cloud computing. Python-based frequency analysis was used to quantify the occurrence of the above three terms. Finally, the composite index was calculated using the natural logarithm of one plus the total count. As can be seen from Column (5) of Table 2, the coefficient of this indicator is 0.0987 and is significant at the 1% level. The finding reinforces our main conclusion.

4.4.2. Inclusion of additional control variables

To address the risk of bias from omitted variables, the following three additional control variables are included: CEO duality (Dual), free cash flow per share (Cashflow), and aggregate managerial compensation (Man). As can be seen from Column (6) of Table 2, the coefficient of digital transformation still remains positive and significant, which supports our baseline results.

In summary, the findings are robust to alternative model specifications and the inclusion of more control variables, which enhances the confidence in the robustness of the study's key results.

4.5. Heterogeneity analysis

4.5.1. By pollution intensity

Leveraging the official list of key pollutant-discharging enterprises as a benchmark, the research sample was bifurcated into heavily polluting firms and their counterparts. The subsample analysis discloses that for heavy polluters, the coefficient of digital transformation reaches 15.49 with 1% statistical significance (Table 5, Columns 1-2), thereby exerting a substantial positive impact on their green innovation performance. By contrast, the digital transformation coefficient for non-heavily polluting enterprises stands at 0.79 and is statistically not different from zero. The results reveal a distinctly heterogeneous pattern, where the beneficial effect of digital transformation is substantially stronger for enterprises facing greater regulatory scrutiny due to their high pollution levels. A plausible explanation is that such firms face tighter environmental regulations and stronger social scrutiny, thereby attaching greater importance to pursuing green innovation.

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4.5.2. By high-tech industry

The sample firms can be categorized into high-tech and non-high-tech groups. (3) and (4) in Table 3 reveal that, for high-tech firms, the value of digital transformation is 2.254 and it is significant at the 5% level, which indicates that digitalization has a significant impact on green innovation of high-tech firms. While the coefficient of non-high-tech firms is 1.817, it is positive but not significant, which indicates that digitalization exerts a relatively weaker impact on green innovation of non-high-tech firms. The above differences may originate from the fact that technological accumulation of high-tech enterprises is generally stronger, and they have greater R&D strength and higher degree of dependence on innovation-driven development. In addition, they generally have more mature mechanisms to allocate and allocate resources, and they can better absorb and apply digital technology, so as to obtain more green innovation achievements.

Table 3. Heterogeneity analysis

	(1)	(2)	(3)	(4)
	GI	GI	GI	GI
DIG	15.49***	0.790	2.254**	1.817
	(3.026)	(0.904)	(1.018)	(1.805)
Control Variables (CV)	Yes	Yes	Yes	Yes
Industry/Year FE	Yes	Yes	Yes	Yes
Observations (N)	7,835	15,583	15,987	7,431
Adj. R^2	0.171	0.148	0.150	0.193

5. Research conclusions and policy implications

5.1. Research conclusions

First, digital transformation is recognized as a critical driver in substantially boosting firms' green innovation performance. Quantitatively, a one-percent rise in digital transformation is associated with an estimated 2.39% gain in green innovation performance, indicating a high elasticity.

Second, the mechanism analysis finds that the financial support for innovation plays as a partially mediator. Specifically, the digital transformation will increase the additional investment in innovation-related financial resources, and then the effectiveness of green innovation is enhanced.

Third, the subsample analysis finds that the positive effect of digital transformation is considerably larger in heavily polluting firms and high-tech enterprises.

5.2. Policy implications

The findings offer important insights for both corporate practice and public policy formulation:

First, Priority ought to be given to the digitalization of R&D, production, and supply chains, while building green-oriented data governance systems and collaborative mechanisms. Such practices can enhance information exchange, promote knowledge spillovers, thereby building robust capacities in green innovation and enduring sustainable competitiveness.

Second, the use of digital financial tools can improve management efficiency, facilitate dynamic input–output performance assessments, and ensure that financial resources are aligned with a firm's innovation capacity, thus achieving an optimal allocation of firm resources to green innovation.

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Third, the government should improve institutional arrangements and enhance policy support. An integrated mechanism to coordinate digitalization and green development should be established. Green credit, green tax policies, and R&D grants can facilitate green innovation by encouraging firms to turn digital innovation outputs into green innovation outputs. In contrast, environmental regulations and disclosure policies should be strengthened to place more stringent constraints on highly polluted firms. In addition, the government should promote the development of digital infrastructure and cross-industry standards to create an appropriate institutional environment for sustainable technological change.

References

[1] hen, Y.-S., Lai, S.-B. and Wen, C.-T. (2006) The Influence of Green Innovation Performance on Corporate Advantage in Taiwan. Journal of Business Ethics, 67, 331-339.
[2] Qi, Y.D. and Xiao, X. (2020) Transformation of Enterprise Management in the Era of Digital Economy. Management World, 6, 135-152.
[3] China Academy of Information and Communications Technology (CAICT). White Paper on Digital Carbon Neutrality [R]. 2021.
[4] Barney, J. B. Firm Resources and Sustained Competitive Advantage [J]. Journal of Management, 1991, 17(1): 99-120.
[5] Yang, D., & Chai, H. M. (2015). A Review of Driving Factors of Green Technology Innovation and Its Effect on Firm's Performance. China Population, Resources and Environment, 25(11S): 132-136.
[6] Wu, F., Hu, H. Z., Lin, H. Y., & Ren, X. Y. (2021). Enterprise Digital Transformation and Capital Market Performance: Empirical Evidence from Stock Liquidity. Management World, (7): 130-144.
[7] Xie, K., Xia, Z. H., & Xiao, J. H. (2020). The Enterprise Realization Mechanism of Big Data Becoming a Real Production Factor: From the Product Innovation Perspective. China Industrial Economics, (5): 42-60.
[8] Yu, F., Liu, M. X., Wang, L. F., & Li, L. (2019). Impact of Knowledge Couplings on Manufacturing Firms' Green Innovation: The Moderating Effect of Slack Resources. Nankai Business Review, 22(3): 54-65.
[9] Shen, G.B., & Yuan, Z.Y. (2020). The Effect of Enterprise Internetization on the Innovation and Export of Chinese Enterprises. Economic Research Journal, 1, 33-48.
[10] Vial, G. (2019). Understanding Digital Transformation: A Review and a Research Agenda. Journal of Strategic Information Systems, 28, 118-144.
[11] Jin, Y., Wen, W., & He, Y. (2022). Impact of Digital Transformation on Corporate Green Innovation: Evidence from China's Manufacturing Listed Companies. Finance and Trade Research, 7, 69-83.
[12] Lee, I., & Shin, Y. J. (2018). Fintech: Ecosystem, business models, investment decisions, and challenges. Business Horizons, 61(1), 35-46.
[13] Li, P., & Liu, L. L. (2017). Government R&D Funding, Enterprise R&D Inputs and Efficiency of Innovation in China. Science Research Management, 38(1), 21-31.
[14] Hottenrott, H., & Peters, B. (2012). Innovative Capability and Financing Constraints for Innovation: More Money, More Innovation? Review of Economics and Statistics, 94(4), 1126–1142.
[15] Popp, D. (2019). Environmental Policy and Innovation: A Decade of Research. International Review of Environmental and Resource Economics, 13(3–4), 265–337.
[16] Liu, J. K., & Xiao, Y. Y. (2022). China's Environmental Protection Tax and Green Innovation: Incentive Effect or Crowding-out Effect? Economic Research Journal, 1, 72-88.
[17] Liu, Y. H., Mou, S., & Yin, Y. G. (2021). Is Product Market Competition Risk Priced in the Cross-Section of Stock Returns? —Evidence and Interpretation from China's A-Share Market. China Economic Quarterly, 21(6), 2062-2082.
[18] Jiang, T. (2022). Mediating Effects and Moderating Effects in Causal Inference. China Industrial Economics, 5, 100-120.