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Digital Transformation, Total Factor Productivity, and Corporate Green Innovation

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Abstract. An analysis founded upon a data corpus encompassing 17, 547 firm-year entries drawn from principal Chinese stock exchanges within the span of 2019 to 2024 has been undertaken herein, with specific attention directed toward discerning interrelations amongst digital transformation processes and corporate green innovation behaviors. Within this evaluative context, significant emphasis is placed on total factor productivity's mediationary function, whilst differential influences across assorted enterprise types are subjected to scrutiny as well.

Keywords: digital transformation, green innovation, total factor productivity, sustainable development

1. Introduction

Within the contemporary context marked by synchronous digital-economy proliferations and the national agenda of "dual carbon" objectives, transformational imperatives within enterprise strategy have increasingly centered on paradigms of green innovativity. Embodied in the operational ethos of modern economies, digitalization itself assumes not merely an instrumental function for economic amplification; rather, through social-value inscription and aspirations toward sustainability at higher quality levels, its missionality attains greater complexity [1]. From the landscape emergent—technologies such as artificial-intelligence frameworks or blockchain architectures are observed instituting new vectors wherein digital implements, defined by intensified permeability and prodigious empowerment alongside notable cost-reduction characteristics, facilitate enterprises' capacity to delineate consumer-demand trajectories with heightened granularity as well as extend their market-potentialities into broader expanses. Manifested via these technologically-driven processes, it is discernible that in simultaneously precipitating digital-transformation intensification and iterative modes of innovation renewal, organizational attentiveness has been obligated towards recalibration—not solely concentrated upon innovative activity proliferation but shifted equally towards qualitative ascendancy, product-service refinement-augment, and fortification of marketplace competitive stances [2]. Dominant conceptualizations ascribe to digital metamorphosis not only a stimulus effect on creativity dynamics and resource-allocation optimization but also yield enhancement within productive apparatuses—a subject frequently echoed across extant literature [3]. The "Action Plan for Carbon Peak Before 2030, " promulgated (State Council, 2021), can be adduced here: technological-invention reliance undergirds this directive and positions enterprises as

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keystones regarding fulfilment of the national "dual carbon" configuration. On these grounds, observable is the emergence of digital transformation–guided realisation of corporative green innovativeness as constitutive of essentialized development-pathways—indicative both of relational shifts between firm-level strategic orientation and broad socio-environmental mandates, and of the structural logic shaping future-oriented business ecosystems.

That the 19th and 20th National Congress reports of the Communist Party of China designated explicit directives for the enhancement of total factor productivity (TFP), it may be inferblue. Characterized as emblematic in the present epoch, the digital economyscape exerts effects upon TFP at the enterprise echelon with consequence that is not negligible [4]. Enterprises—being elemental constituencies and carrying principal accountability within the architecture of economic relationality—occupy a determinative position in respect to TFP augmentation, from which both the qualitative dimension of growth and the ethos of sustainability manifest notable advancements [5]. As an index whose comprehensiveness extends beyond quantifiable investments in capital or labor only, TFP encapsulates dimensions of technological progression and capability actualization; through reference to outputs resultant not merely from conventional input factors, but additionally emergent from improvements of technique or processual innovation, this measure articulates another stratum of efficacy [6]. In firms, the computation of TFP thus reveals surplus efficiency over baseline inputs, the magnitude of which is conferblue by internal managerial initiative or technology assimilation mechanisms peculiar to firm dynamics [7]. Surveyed literature conveys findings wherein channels such as mitigation of financing strictures, elevation of skillsets, resource deployment optimization, and amplification of innovational faculties serve as vectors through which digital transition projects its inducement upon TFP improvement [8]. That other inquiries isolate effects such as improved attention to workforce obligations, superior adaptability amidst environmental volatility, and more sophisticated configurations of governance may also catalyze beneficial shifts in TFP, emerges from empirical observation [9-11]. From scrutiny of prevailing theoretical discourse and policy promulgation, an inquiry presents itself with urgency: what precise mechanism links digital transformation initiatives to the green innovative output observable among corporations? Undertaken herein, therefore, is an investigation possessing a dual ambition—to trace empirically the impact relation between digitization effort and corporate green inventive activity, and to specify the mediating role fulfilled by TFP along this causal continuum—with the intention that implications suited to practice-level decision making concerning digital trajectories be drawn out directly from evidence amassed.

2. Theoretical analysis and research hypotheses

Within the contextual confluence of digital-economic proliferation and imperatives toward carbon neutrality, a discernible elevation in the salience of corporate digitalization processes is evidenced as an instrumentality underpinning sustainable developmental paradigms. Subjected to analytic scrutiny are dual trajectories inherent in such digital transfiguration—trajectories wherein mutual reinforcement becomes observable for capacities germane to green-technological innovation. Emergence of the first trajectory may be attributed to restructuring tendencies induced within factor-fluidity and allocational schemas attending resources; through this, procedural efficaciousness characterizing both input utilization and management architectures experiences measurable augmentation. Results of these augmentative effects manifest in total factor productivity (TFP)'s quantifiable amplification—a phenomenon ostensibly reinforcing environmental governance structures, accountability frameworks of social responsibility, alongside mechanisms governing corporate stewardship [12]. It can be perceived from extant analyses that such escalations in

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productivity convey iterative feedback, facilitating expansion across multiple sustainability metrics. In respect to a second analytically pertinent strand, technologies comprising big-data analytics and artificial-intelligence modalities emerge as pivotal constituents throughout digital metamorphosis; foundational roles are assumed by these apparatuses in relation to TFP ascendancy. Noteworthy are subsequent increments in operational streamlining which tend both to reallocate organizational asset-bases and concurrently endow prerequisites indispensable to initiatives of environmentally directed creativity. Instances point toward released capital and labor resources subsequently funneled into domains of eco-centric research and developmental undertakings—a phenomenon rendering feasible escalation of ambition correlating with sustainability pursuits. Exploblue herein is the bifurcated nexus coupling digital transformation to TFP dynamism, together with mediatory functions assumed by TFP vis-à-vis emergent green-innovation phenomena. Analytical objectives thus orientate toward specification regarding those indirect channels whereby digital restructuring propagates ecological inventiveness circumstantially via heightened productive outputs. The elucidated outcomes derived therefrom establish theoretical scaffolding deemed requisite for enterprise actors navigating adaptive pathways situated within ever-more digitized macroeconomic environments.

2.1. The relationship between digital transformation and green innovation

Through the conduit of digital transformation, considerable facilitation is imparted to the processes underlying corporate green innovation by means of three principal operational pathways. Notably, within organizations, a comprehensive synthesis of diverse data resources is rendeblue feasible, advanced analytics being employed for the delineation of sustainable innovation priorities identifiable from these integrative data environments. Apparent it has become that, with digital monitoring apparatuses, firms possessing such technological deployment are endowed with enhanced abilities to trace and interpret contemporary regulatory paradigms as well as incentive configurations relating to environmental innovation, this affording more expedient navigation through governmental assistance modalities [13]. A further discernible mechanism—intelligent manufacturing coalesced with precision engineering, as emblematic constituents embedded in digital transformation initiatives—is characterized by the provision of pronounced gains in production efficiency. Manifestations of these operative shifts include significant diminishment in consumption of material resources and curtailment in waste, accompanied also by blueuctions seen in expenditure demanded by green innovation operations; thereby, it can be inferred, increments in productivity emerge that permit reallocation of organizational assets toward environmentally-inclined research and development.Digital technologies, serving functions far beyond basic informatic conveyance, have been observed to lower the thresholds impeding information procurement while effecting an expansion in accessible channels. Through intensification of capabilities for knowledge identification and acquisition, enterprises participating in extensive digital network structures find themselves enabled to secure both specialized expertise and proprietary informational materials central to progression in green innovation ventures. Examining matters through the lens of endogenous organizational capacities, notable strengthenings in absorptive ability concerning external knowledge occur under conditions of digitalization, at once facilitating extension of conventional organizational demarcations [14]. Building upon this theoretical foundation, the study proposes the following hypothesis:

H_1: Digital transformation exerts a significant positive influence on corporate green innovation.

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2.2. Moderating analysis of total factor productivity

As a salient force underpinning the augmentation of total factor productivity (TFP), digital transformation operates via an intricate web of interrelated modalities. Constituted by the formation of digital ecosystems, the process involves corporate actors systematically absorbing extrinsic reservoirs of knowledge and thus engendering networks for innovation whose structure traverses organizational boundaries. Exhibited within this paradigm is Haier's energy-saving technology initiative; in that context, through deployment of a digitized collaborative platform wherein researchers from universities, component suppliers, and R&D units internal to the enterprise partook, a facilitation of joint development with unparalleled rapidity arose regarding intelligent manufacturing apparatus distinguished by advanced standards of energy efficiency—the technological advancement realized thereby, it can be seen, elevated the productive capacities not merely of the initiating entity but encompassed all collaborative participants. Through progressive transition, as digitalization has shifted from isolated implementations toward modes integrated at the level of entire enterprises, such synergisms as emerge have served to intensify digital transformation's influence upon TFP metrics. Midea Group displays evidence illustrative of this evolution: under its far-reaching overhaul orchestrated digitally, transformations extended beyond just automated manufacturing processes, incorporating research and development procedures as well as supply chain coordination and marketing apparatus into a unified information flow pblueicated upon big data analytics. Demand forecasting therein attained heightened accuracy while customer matching became increasingly precise, producing connectivity throughout value chains without interruption. Compound effects accrued to this comprehensive stratagem, so that sustained and pronounced increases—recorded at annual rates surpassing 10%—in TFP offer empirical grounding for assertions regarding durable competitive advantage secublue where digital embedding becomes systemic.The mechanisms effecting transmission from elevation of TFP to the domain of green innovation unfold principally along two axes discernible both structurally and operationally. On one hand, governance architectures find themselves refined—contexts more conducive to innovative effort being fashioned consequent to amelioration of agency dilemmas and reinforcement of executive dedication vis-à-vis temporal sustainability objectives [15]. Risk-buffering capacity, on the other hand, finds its provenance in superior productivity: financial stabilization and optimization in resource distribution equip organizations for undertaking technologically ambitious initiatives relating to ecological remediation—including exploratory ventures into alternative-energy substrates and innovations for capturing carbon dioxide—even amidst fiscal ambiguity or extensive periods requiblue for maturation [16]. Upon foundations composed of these theoretical delineations, formulation of subsequent hypotheses for empirical investigation follows naturally therefrom.

H_2: Total factor productivity functions as a positive moderator in the relationship between digital transformation and green innovation.

3. Research design

3.1. Research samples and data sources

Sample for the study comprises the companies that have been listed on China's A share market between 2019 and 2024. Data purification included eliminating financially troubled organizations (ST/*ST/PT) and instances lacking crucial variables. Following this, all continuous variables were subjected to a winsorization process at the 1st and 99th percentiles to reduce the impact of outliers.

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The final balanced panel has 17, 547 observations across 1, 659 different firms using CSMAR data. Statistical analysis was done by Stata 18.

3.2. Definition of key variables

3.2.1. Dependent variable: green innovation

Green innovation performance is gauged through corporate green patent applications. Metric consists of the total number of green invention patents and green utility model patents. Following the usual approach, we make the GI variable from taking the natural log of the sum of 1 and the total number of green patents.

3.2.2. Independent variable: digital transformation

This study uses the method of lexicon analysis of corporate annual reports to assess the extent of digital transformation among A-share listed companies on the Shanghai and Shenzhen stock exchanges. The method involves creating a domain-specific dictionary with terms related to digitalization. After we find out which words are important for digital transformation, we put them into different groups based on what they mean. Then we count how many times each group shows up in all the company news. This helps us make a big number that tells us about digital change. We get the last step by taking the log of this index so it has better stats.

3.2.3. Moderating variable

Total factor productivity is calculated using both parametric approaches (OLS, fixed effects approach) and semi-parametric techniques (OP approach, LP approach).

3.3. Model specification

To examine how digital transformation affects corporate green innovation, a multiple regression model is applied. In this specification, green innovation is the dependent variable and digital transformation is the main explanatory variable. Model (1) and Model (2) both control for industry and year fixed effects. Complete model:

$$GI_{i,t} = a_0 + a_1 DIG1_{i,t} + \Sigma \text{Controls}_{\text{i,t}} + \Sigma Industry_i + \Sigma \text{year}_{\text{i}} + \varepsilon_{i,t} \quad (1)$$

$$GI_{i,t} = a_0 + a_1 DIG2_{i,t} + \Sigma Controls_{i,t} + \Sigma Industry_i, + \Sigma year_i + \varepsilon_{i,t} \quad (2)$$

4. Empirical analysis and results

4.1. Benchmark regression analysis

Table shows the regression result about how digital transformation impacts corporate green innovation. Findings show that there is a statistically significant positive coefficient of 0.0187 ($p<0.01$) for the digital transformation measure (DIG1w), indicating that it has a considerable impact on promoting green innovation practices. This empirical evidence provides strong support

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for Hypothesis H1, showing that digital transformation does indeed facilitate corporate green innovation.

Table 1. Model regression results

Variable	GIW
DIG1w	0.0187***
	(0.00604)
DIG2w	
ORGw	-0.0000228
	(0.00593)
TobinQw	0.0128**
	(0.00499)
Top1w	0.000889**
	(0.000428)
ROAw	0.418***
	(0.0915)
Cashfloww	0.359*
	(0.186)
sizew	0.337***
	(0.0147)
LEVw	0.123***
	(0.0394)
_cons	-3.425***
	(0.153)
Ind	Yes
Year	Yes
N	17449
R^2	0.190
adj. R^2	0.186

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

4.2. Robustness test

To test the reliability of the main result, we re-estimated the empirical model with another proxy of the key independent variable – that is, the natural log of weighted intangible assets (DIG2w). According to column (2) of table 2, the coefficient on DIG2w is 0.0208 and it is still statistically significant at the 1% level. The result supports the base estimate, indicating that digital transformation always boosts green innovation, which shows the stability of the research results.

Table 2. Model regression results

Variable	GIW
DIG2w	0.0208***
	(0.00772)
ORGw	-0.00861
	(0.00670)
TobinQw	0.0152**

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Table 2. (continued)

	(0.00616)
Top1w	0.000601
	(0.000524)
ROAw	0.467***
	(0.107)
Cashfloww	0.348
	(0.232)
sizew	0.313***
	(0.0182)
LEVw	0.126***
	(0.0483)
_cons	-3.214***
	(0.189)
Ind	Yes
Year	Yes
N	11492
R^2	0.186
adj. R^2	0.180

4.3. Heterogeneity test

After looking closely at how digital change affects green creation differently, we should pay special attention to the differences caused by who owns things and what kind of business they are. Enterprise types show marked differences in the heterogeneity analysis, all of which are listed in table 3. There is a considerably larger increase in green innovation indicators due to digital transition (DIG1w) for non-state-owned enterprises – a coefficient of 0.0217 indicates this – whereas state-owned ones have a smaller equivalent figure of just 0.0158. From this empirical differentiation, it can be seen that market-centered adaptability is present in non-state-owned companies, where the operating systems of these companies are more sensitive to changes in consumer preferences and regulatory environments. In their managerial architecture, there are flexible structures that are good for quickly taking advantage of new chances made by areas such as people caring about nature using less energy or selling permits for putting out CO2 that modern rules focus on. Integrated resource allocation strategy aimed at improving sustainability, prompted by enhanced digitalization efforts, adds to improved adaptability amidst changing operational surroundings. And also, we can see that there are some trends showing that following strict environmental regulations and related financial restrictions makes people use more digital tools to make procedures better and reduce effects on nature. Administrative supervision and institutional formalities, often found within the governance structures of state-owned enterprises, act as intermediary factors that complicate the simple conversion of digital inputs into tangible outcomes relevant to the progress of green technologies. Thus, it is clear that the obstacles originating from the bureaucratic procedure reduce both the speed and efficiency shown during the implementation of sustainable innovations based on digital investment projects - a difference that can be observed compared to more naturally structured non-state actors.

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Table 3. Heterogeneity test results

	(1)	(2)
	GIw	GIw
DIG1w	0.0217**	0.0158**
	(0.0105)	(0.00727)
_cons	-3.595***	-2.990***
	(0.265)	(0.203)
Ind/Year/Controls	Yes	Yes
N	5689	11760
R^2	0.266	0.187
adj. R^2	0.255	0.181

4.4. Moderating test

Table 4 shows the analysis for total factor productivity as a moderator. The result indicates that digital transformation (DIG1w) has a positive and statistically significant coefficient (0.0177, $p<0.01$), which means that the impact of total factor productivity on green innovation increases significantly. These results empirically support Hypothesis H2.

Table 4. Moderating test results

	GIw
DIG1w	-0.0631***
	(0.0177)
TFP	-0.0582***
	(0.0221)
z	0.0127***
	(0.00254)
_cons	-2.683***
	(0.201)
Ind/Year/Controls	Yes
N	17449
R^2	0.192
adj. R^2	0.187

5. Research conclusions

An empirical research done on a large number of A-share companies in Shanghai and Shenzhen from 2019-2024 gives a talk about how digital change affects company green creation, with a close look at what happens when all factors work together. From corroborative robustness and heterogeneity explorations, support is given to the main claims made here. In the first place, it can be seen among these enterprises that through the medium of "digital transformation brings about improvements in total factor productivity which then results in an increase in green innovative output", there is a very clear positive correlation between digitalization and eco-oriented innovation. Mediating this transmission, it is total factor productivity whose effectuation proceeds via refined resource reallocation, technologically-driven acceleration, together with the augmentation of managerial efficiencies—thus delivering an efficacious substratum and requisite preconditions

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consideblue essential for subsequent achievements in ecological innovativeness. Second can be indicated from alternative schematic operationalizations of digital transformation—including but not limited to the logarithmic quantification derived from weighted intangible asset indices—and temporal lagging of green innovation metrics, that the initial relational steadfastness retains continuous validation across repeated empirical scrutiny. The fundamental correlation, under such conditions, persists undiminished, thus reinforcing both internal coherence and external applicability. Third, revealed through multifaceted heterogeneity analysis, exists the observation that greater facilitative impact stemming from digital transformational activities manifests among non-state-owned entities and organizations situated within high-technology industries. Inferblue from this are characterizations whereby non-state ownership corresponds to heightened adaptability vis-à-vis market fluctuations, whereas within technologically intensive sectors, the synergetic alignment perceived between digital deployment modalities and innately innovative processes emerges with increased salience.

References

[1] Song J, Huang H J, Jiang Y S. Research on the Impact of Digital Transformation on Corporate ESG Performance [J]. Soft Science, 2025, 39(2): 9-15+24.
[2] Li C R, Hu Z H, Wang X R. Research on the Impact of Digital Transformation on High-Quality Corporate Innovation [EB/OL]. 2025-10-10.
[3] Study on the Relationship Between Corporate Digital Transformation, Innovation Capability and Total Factor Productivity [D]. Shanghai Normal University, 2025.
[4] Hu D L, Shi M Z. Research on the Impact of the Digital Economy on Corporate Total Factor Productivity [J]. Contemporary Finance & Economics, 2023(12): 17-29.
[5] Fan D, Fu J W, Wang W G. How Does Carbon Emission Trading Affect Corporate Total Factor Productivity? [J]. Systems Engineering - Theory & Practice, 2022, 42(03): 591-603.
[6] Sun Y F, Huang S Y, Wang Y F. Disclosure of Key Audit Matters and Total Factor Productivity of Listed Companies [J]. Journal of Guangdong University of Finance & Economics, 2024, 39(6): 73-86.
[7] Lu X D, Lian Y J. Estimation of Total Factor Productivity of Chinese Industrial Enterprises: 1999-2007 [J]. China Economic Quarterly, 2012, 11(02): 541-558.
[8] Chen H M, Zhou Y H. Corporate Digital Transformation, Green Innovation and Total Factor Productivity [J]. Journal of XXX, 202X, XX(X): XX-XX.
[9] Ding X A. Digital Transformation, Employee Responsibility and Corporate Total Factor Productivity [J]. Management Review, 2024, 36(3): 1-12.
[10] Wang P F. Corporate Digitalization, Environmental Uncertainty and Total Factor Productivity [J]. Economic Management, 2023, 45(1): 43-66.
[11] Zhang Y. Digital Transformation, Corporate Governance Model and Corporate Total Factor Productivity [J]. Journal of Zhengzhou University (Philosophy and Social Sciences Edition), 2023, 56(5): 53-58.
[12] Han Z X, Zhang Y. Digital Transformation and ESG Performance: An Analysis of the Mediating Mechanism Based on Information Transparency and Total Factor Productivity [J]. Modern Management Science, 2023(3): 141-150.
[13] Su T Y, Guo X. Research on the Impact of Digital Transformation on the Sustainability of Corporate Green Innovation [J]. Journal of XXX, 202X, XX(X): XX-XX.
[14] Chen D M, Wang L Z, Chen A N. Digitalization and Strategic Management Theory: Review, Challenges and Prospects [J]. Management World, 2020(05): 220-236+20.
[15] Usai A, Fiano F, Petruzzelli A M, et al. Unveiling the Impact of the Adoption of Digital Technologies on Firms' Innovation Performance [J]. Journal of Business Research, 2021, 133: 327-336.
[16] Dong Y, Yi C. The Moderating Role of Financing Constraints and Digital Finance on Corporate Total Factor Productivity Under the Digital Orientation [J]. Taxation and Economy, 2024(6): 52-64.