

The Impact of Digital and Intelligent Transformation on Green Innovation in Manufacturing Enterprises: An Analysis Based on the Mediating Mechanism of Media Attention

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Abstract. With global environmental pollution becoming increasingly severe and significantly impacting economic development, promoting green development among enterprises has become a critical task. At present, economic development is focusing on both digital upgrading and green and low-carbon transformation. How digital and intelligent technologies can help manufacturing enterprises manage to accomplish green technological advancement is one of these topics with great research and practical value at this stage. Panel data from manufacturing firms listed on the Shanghai and Shenzhen Stock Exchanges from 2013 to 2024 are used to empirically analyze the role of digital and intelligent transformation (Digital) in green innovation (Green) within manufacturing enterprises (MFEs), and test the mediating effect of media attention(Media). The findings reveal that Digital process substantially enhances Green development in MFEs, a result that remains consistent even after rigorous robustness checks and endogeneity adjustments. The test of intermediary effect demonstrates that Digital can obviously increase the attention of media reports and promote Green of MFEs. This paper also did a heterogeneity analysis, which shows that, compared with small and medium-sized MFEs, the beneficial influence of Digital in enabling Green is stronger among large manufacturing firms.

Keywords: Digital and intelligent transformation, media attention, manufacturing enterprises' green innovation

1. Introduction

The extensive and high-speed economic growth in China has caused a great deal of consumption of limited natural resources and destruction of ecological environment, and resource shortage and environmental pollution have also seriously restricted the sustainability of economic development since the reform and opening-up began. Advancing an eco-friendly, low-carbon economy and society constitutes China's core approach to resolving its resource scarcity, environmental degradation, and ecological challenges. In current context, pursuing high-quality development has emerged as the central objective guiding China's socioeconomic advancement. The characteristics of this stage are the continuous improvement of the environment and a significant reduction in carbon

emissions. Therefore, the cost of resources and environment must be reduced through high-quality development.

The green development level of China's MFEs is gradually improving, and digital and intelligent transformation can significantly advance Green's development [1]. The transformation of digital intelligence mainly promotes green collaborative innovation of enterprises by improving the efficiency of green innovation, strengthening industrial collaborative agglomeration and promoting the upgrading of human capital of enterprises [2]. Digital and intelligent transformation directly advances the green technology innovation. Furthermore, it enhances this promotion by improving ESG performance, forming a virtuous circle [3].

This paper utilizes panel data from MFEs listed on the Shanghai and Shenzhen Stock Exchanges until 2013 and 2024. By examining the implications of media information dissemination and applying the theory of mediating mechanism, it seeks to address two interrelated research questions; thereby bridging key theoretical and empirical gaps: (1) To what extent does Digital affect Green of MFEs? (2) Does Media undertake the intermediary transmission path between digital and intelligent transformation and manufacturing enterprises' green innovation? In order to answer these questions, this paper integrates the second-hand data of corporate annual report, green patents and media reports to carry out empirical analysis. This findings reveal that enterprise-level Digital exerts a statistically robust positive effect on Green performance. Moreover, Media plays a significant mediating role in this association—amplifying and channeling the impact of technological upgrading toward sustainability-oriented innovation. The research contribution lies in: putting digital intelligence, green innovation and media attention into an integrated framework of the analysis, breaking through the previous form of taking media attention as an explanatory variable, introducing it into the intermediary mechanism of digital intelligence affecting green innovation, and enriching theoretical explanation chain regarding digitalization impacts eco-innovation performance in manufacturing enterprises.

2. Theoretical analysis and research hypotheses

Digital transformation enables listed manufacturing enterprises to boost their green innovation efficiency substantially [4]. By adopting big data, artificial intelligence and other digital and intelligent technologies, enterprises can grasp market trends, cutting-edge technologies and green development opportunities in real time. Concurrently, relying on the ability of digital information dissemination and traceability, media attention can be strengthened, forming external constraints to promote the construction of green norms for the manufacturing industry. The digital intelligent collaborative innovation ecosystem can better integrate and allocate all kinds of innovative resources such as data, talents and funds, reduce knowledge barriers and stimulate the vitality of green innovation [4]. In light of the above analysis, the hypothesis H1: Digital and intelligent transformation is positively associated with green innovation in manufacturing enterprises.

Past studies have shown that media attention has significantly improved the substantive and strategic green innovation of MFEs, especially in heavily polluted and state-owned enterprises [5]. A common understanding is that when enterprises implement the digital transformation strategy, they are easily concerned by the media, get more interviews and reports, and then further standardize their behavior under the supervision of the media and the public. Based on the above analysis, it is assumed that H2: media attention plays an intermediary role between Digital and Green of MFEs.

3. Research design

3.1. Sample selection and data sources

The research sample comprises manufacturing firms publicly traded on the Shanghai and Shenzhen A-share markets over the period spanning 2013 to 2024. Considering data availability and validity, the sample was processed as follows: ST and *ST companies were excluded, samples with missing values were removed, and outliers were trimmed to the 1st–99th percentiles. The variable data use are primarily derived from two databases: the China Research Data Services Platform (CNRDS), which is a leading academic database widely used in China, and the Guotai-An (CSMAR) database, which is also extensively used in academic research.

3.2. Variable selection

The dependent variable is the level of green innovation performance in manufacturing firms (Green). This measurement is primarily based on the research conducted by Wang Xin et al. and Li Qingyuan et al., and considering data availability, the volume of green invention patent applications was adopted as a proxy for corporate eco-innovation. The core independent variable is digital and intelligent transformation (Digital). Drawing on the research of Wu Fei [6], text mining methods were employed to search for and match keywords related to digital and intelligent transformation, yielding the frequency of such terms, which were then log-transformed after being normalized by adding 1. The mediating variable is media attention (Media), and its quantitative indicator is the annual number of reports in print and online media regarding the listed company, which is also processed by adding 1 and taking the logarithm. The control variables selected include manufacturing enterprise size (Size), financial leverage (Lev), manufacturing enterprise age (FirmAge), average age of management (AverageAge), total number of employees (StaffNumber), concurrent positions (ConcurrentPosition), and growth ability (Growth), return on assets (ROA),

3.3. Model specification

To test H1, this paper constructs a baseline regression model:

$$\text{Green}_{i,t} = \alpha_0 + \alpha_1 \text{Digital}_{i,t} + \sum \alpha_k \text{Controls}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

In this model, α_0 is the constant term; $\text{Green}_{i,t}$ represents corporate green innovation; $\text{Digital}_{i,t}$ represents digital and intelligent transformation; $\text{Controls}_{i,t}$ represents a group of control variables; μ_i is the firm-level fixed effect; λ_t is the year-level fixed effect; and $\varepsilon_{i,t}$ is the error term.

To test H2 (mediation effect), this paper constructed a recursive model:

$$\text{Media}_{i,t} = \beta_0 + \beta_1 \text{Digital}_{i,t} + \sum \beta_k \text{Controls}_{i,t} + \mu_i + \lambda_t + \delta_{i,t} \quad (2)$$

$$\text{Green}_{i,t} = \gamma_0 + \gamma_1 \text{Digital}_{i,t} + \gamma_2 \text{Media}_{i,t} + \sum \gamma_k \text{Controls}_{i,t} + \mu_i + \lambda_t + \sigma_{i,t} \quad (3)$$

4. Empirical analysis

4.1. Descriptive statistic

Table 1 presents the descriptive statistics for the variables employed in the benchmark regression analysis. These annual observations of manufacturing listed firms included in the regression is 25,786. The level of Green is 5.580. Its standard deviation is 15.528. These findings reveal notable heterogeneity in Green performance across the sampled firms. The mean value of the main explanatory variable, digital and intelligent transformation (Digital), is 1.489, with a standard deviation of 1.291, suggesting that there exist marked variations in the class of Digital among manufacturing enterprises.

Before regression analysis, this paper explores the potential relationship among the key variables. Green and Digital correlate at 0.172 (significant at 1% level), indicating that Digital positively promotes Green, which initially supports the possibility of assuming H1. Manufacturing enterprise size (Size), financial leverage (Lev), manufacturing enterprise age (FirmAge), average age of management (AverageAge), total number of employees (StaffNumber), concurrent positions (ConcurrentPosition), and growth ability (Growth) are all significantly related to Green at the level of 1%, and return on assets (ROA), and Green is 0.05. The mean VIF is 1.72, which is much lower than the commonly accepted critical level of 10, indicating that it does not have the multicollinearity issue and that empirical analysis can proceed.

Table 1. Summary statistics

VarName	Obs	Mean	SD	Min	Max
Green	25786	5.580	15.528	0.000	112.000
Digital	25786	1.489	1.291	0.000	4.820
Size	25786	22.143	1.177	19.953	25.751
Lev	25786	0.397	0.193	0.059	0.896
ROA	25786	0.039	0.068	-0.224	0.226
FirmAge	25786	2.993	0.294	2.197	3.611
AverageAge	25786	49.602	3.121	42.000	56.930
StaffNumber	25786	7.672	1.145	5.187	10.844
ConcurrentPosition	25786	0.335	0.472	0.000	1.000
Growth	25786	0.135	0.337	-0.518	1.915

4.2. Benchmark regression analysis

Table 2. Results of baseline regression

	(1)	(2)
	Green	Green
Digital	0.757***	0.506***
	(8.82)	(5.94)
Size		3.085***

Table 2. (continued)

		(14.13)
Lev		-2.577***
		(-4.03)
ROA		0.357
		(0.28)
FirmAge		-7.337***
		(-5.17)
AverageAge		0.0387
		(1.06)
StaffNumber		1.425***
		(6.49)
ConcurrentPosition		0.0629
		(0.34)
Growth		-0.284
		(-1.54)
_cons	4.452***	-53.35***
	(32.31)	(-9.39)
id	Yes	Yes
year	Yes	Yes
N	25786	25786
r2	0.758	0.765

Regarding the association between MFEs' transformation of digital intelligence and green innovation, this paper employed a stepwise regression approach. As shown in Table 2, first pay attention to the regression analysis in the first column. In this column, the direct influence of Digital on Green is discussed, and no control variables have been included. The results show that it has a statistical significance level of 1%, which means that this positive influence is highly significant within the 99% confidence interval. This discovery initially reveals the promotion of Digital to Green, but it should be noted that the results have not excluded the interference of other potential factors, such as ROA, Lev, firm age and other factors that may affect Green at the same time. Therefore, although the estimation results in column (1) point to clear correlation, there may be estimation bias caused by missing variables.

This objective is to strictly assess the actual causal effect that digital and intelligent transformation (Digital) has on green innovation (Green). After controlling these potential factors by introducing several control variables in column (2), the estimated coefficient for Digital drops

substantially from 0.757 to 0.506, but the Digital coefficient remains statistically significant and positive at the 1% level. These indicate that the independent promotion of Digital to Green still exists steadily and is not only driven by other factors. The results show that, when other variables are controlled, digital and intelligent transformation (Digital) still exerts a robust, positive, and statistically significant effect on green innovation within manufacturing firms (Green), assuming that H1 holds.

4.3. Mechanism testing (testing for mediation effects)

To examine whether media attention serves as a mediating mechanism linking Digital to Green, this paper conducted mediation analysis, following the mediating effect testing approach proposed by Jiang Ting [7], and adopting a two-step analytical strategy. A large body of empirical literature has strongly supported that media attention drives enterprises to engage in substantive and strategic green innovation [5]. In particular, negative media coverage can stimulate enterprises to innovate their green technologies through the pressure exerted by consumers' purchasing choices with a higher degree of marketization and a stronger public awareness of environmental protection [8]. Media reports not only can draw public attention to environmental issues, thereby increasing the legitimacy pressure faced by enterprises and compelling them to pursue green innovations to comply with the implicit social contract [9], but also can help enhance the green innovation capabilities and social responsibility performance of enterprises, thereby advancing MFEs' green transformation [10]. Furthermore, industry instability has intensified the connection between environmental news reporting and corporate green innovation, while greater factor market maturity and executives' international work experience tend to weaken this connection [11]. With the support of the aforementioned theory, therefore, this main focus was on analyzing the effect of Digital on media attention, a critical indicator for verifying the validity of the mediating pathway. The detailed test results are presented in Table 3. The results show that the coefficient of Digital is 0.0235($t=4.73$), which is significant at the level of 1%. This indicate that Digital has significantly enhanced media attention. Combined with the benchmark regression, the total impact of Digital upon Green is significant, which meets the conditions for the existence of intermediary effect, indicating that media attention has an intermediary role and H2 is supported.

Table 3. Results of the mediation effect test

	(1)
	Media
Digital	0.0235*** (4.73)
Size	0.112*** (8.84)
Lev	0.327*** (8.78)
ROA	0.710*** (9.73)

Table3. (continued)

FirmAge	0.00715 (0.09)
AverageAge	0.000416 (0.20)
StaffNumber	0.0170 (1.33)
ConcurrentPosition	-0.0264** (-2.42)
Growth	0.0832*** (7.75)
_cons	2.679*** (8.10)
id	Yes
year	Yes
N	25786
r2	0.749

4.4. Robustness tests

This paper employs the quantity of authorized green innovation patents obtained by MFEs (Green2) instead of Green for measuring firms' green innovation levels, relevant results are displayed in Table 4. A coefficient of 0.140 ($t = 2.67$) is estimated for Digital and found to be statistically meaningful. The results attest to the robustness of benchmark regression findings.

Table 4. Results of robustness test

	(1)
	Green2
Digital	0.140*** (2.67)
Size	2.084*** (15.49)
Lev	-1.907*** (-4.84)
ROA	-1.351* (-1.75)
FirmAge	-5.295*** (-6.05)

Table 4. (continued)

AverageAge	0.0138 (0.62)
StaffNumber	1.086*** (8.02)
ConcurrentPosition	0.0931 (0.81)
Growth	-0.542*** (-4.78)
_cons	-34.98*** (-10.00)
id	Yes
year	Yes
N	25786
r2	0.764

4.5. Endogeneity test

Considering lag effects, this paper included a one-period lag of digital and intelligent transformation as an instrumental variable and re-estimated the model using two-stage least squares (2SLS). Table 5 column (1) shows that the instrument is strongly correlated with the endogenous variable (coefficient = 0.3835, $p < 0.01$). Column (2) presents the results: Digital's coefficient remains significantly positive (1.4529, $p < 0.01$), further proving this baseline regression is free from endogeneity disturbances.

Table 5. Results of endogeneity test

	(1)	(2)
VARIABLES	first Digital	second Green
IV	0.3835*** (56.448)	
Digital		1.4529*** (5.686)
Size	0.1083*** (5.897)	3.1180*** (11.640)
Lev	-0.0964* (-1.829)	-2.9326*** (-3.855)
ROA	0.1144 (1.149)	-0.5032 (-0.351)
FirmAge	-0.1206 (-0.983)	-8.1697*** (-4.618)
AverageAge	-0.0098*** (-3.305)	0.0548 (1.274)
StaffNumber	0.0559***	1.4402***

Table 5. (continued)

	(3.005)	(5.356)
ConcurrentPosition	0.0178	-0.0496
	(1.186)	(-0.230)
Growth	0.0487***	-0.2580
	(3.262)	(-1.198)
Observations	21,223	21,223
R-squared		0.077
Number of id	3,164	3,164
Individual FE	YES	YES
Year FE	YES	YES

4.6. Heterogeneity analysis

In this study, the samples are divided into large-scale MFEs and small-scale MFEs for grouping regression. It is implemented to test whether Digital's impact upon MFEs' Green will be different due to different enterprise scales. As shown in Table 6, in the large-scale enterprise group (Green_Size_high), the Digital coefficient is 1.021($t=6.50$), which is significant at the level of 1%; In the small-scale enterprise group (Green_Size_low), the Digital coefficient is 0.0469($t=0.76$), which is not significant. These results show that the promotion of Digital to MFEs' Green mainly exists in large-scale enterprises, which may stem from their inherent strengths in capital, talents and media resources.

Table 6. Results of heterogeneity analysis

	(1)	(2)
	Green_Size_high	Green_Size_low
Digital	1.021***	0.0469
	(6.50)	(0.76)
Size	5.578***	1.203***
	(12.21)	(6.09)
Lev	-2.815**	0.449
	(-2.10)	(0.99)
ROA	0.573	-0.968
	(0.23)	(-1.16)
FirmAge	-9.495***	0.786
	(-3.53)	(0.70)
AverageAge	0.0704	-0.0242
	(0.97)	(-0.97)
StaffNumber	1.829***	0.546***
	(4.24)	(3.31)

Table 6. (continued)

ConcurrentPosition	0.0283 (0.08)	0.0601 (0.47)
Growth	-0.243 (-0.71)	0.0185 (0.14)
_cons	-109.6*** (-9.44)	-28.90*** (-6.01)
id	Yes	Yes
year	Yes	Yes
N	12894	12892
r2	0.787	0.624

5. Conclusion

Based on the panel data until 2013 and 2024, this article, through empirical research, explores the impact and mechanism of Digital upon Green of MFEs . Those conclusions obtained are as follows:

First, digital and intelligent transformation obviously promotes green innovation among manufacturing firms, and this conclusion has been verified through a series of endogeneity tests and robustness checks, so believe it holds true.

Second, media attention plays an intermediary role between digital and intelligent transformation and green innovation. Digital has enhanced the media's attention to enterprises, and subsequently encouraged the widespread adoption of green innovation by enterprises that were heavily covered.

Third, Green effect of Digital has significant heterogeneity of enterprise scale, mainly concentrated in large-scale enterprises.

The following three policy suggestions are formulated by based on these three conclusions:

First, government fully encourages enterprises to carry out digital and intelligent transformation, gives policy dividend support, provides relevant tax incentives, and promotes manufacturing enterprises to scale up their green innovation investments. .

Second, for large-sized enterprises, they should be incentivized to use their access rights and influence over media channels more strategically, actively disclose green innovation behaviors, and form reputation incentives; For small and medium-sized enterprises, constructing digital intelligent infrastructure should be given priority, so as to lower the threshold for small and medium-sized manufacturing enterprises to carry out transformation.

Third, attach importance to the governance function of media attention. Government departments and industry associations can establish an incentive mechanism for green innovation news reports, guide the media focus on the environmental protection practices of manufacturing enterprises, and foster a positive interaction between social supervision and market incentives.

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