Empirical Testing of the Impact of Input Digitization on the Green Transformation in Manufacturing Industry

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Abstract. Green transformation and upgrading of manufacturing industry can promote green GDP growth. This article based on panel data from 30 provinces from 2005 to 2021, using Eviews and Stata tools to conduct regression models and mediating mechanism analysis on variables. The research results indicate that investing in digital technology can significantly promote green upgrading of manufacturing industry; Mechanism analysis shows that investing in digital technology can indirectly promote the Green Total factor productivity by accelerating green technology innovation. Finally, policy recommendations were put forward to speed up the improvement of digital infrastructure, promote the upgrading of manufacturing industries and implement differentiated digital economy development strategies.

Keywords: Regressive analysis; Investing in digitization; Manufacturing; Green Total factor productivity

1 Introduction

The digital economy deeply integrates new productive forces digital technologies with the real economy, promoting the digital upgrading and transformation of traditional industries, ultimately promoting the overall green transformation development of the manufacturing industry.

The research on digitalization of manufacturing investment is less, mainly focusing on the impact of digitalization on innovation efficiency [1], global value chain [2], enterprise value chain [3], industrial upgrading [3], etc. Then, the existing literature mainly focuses on environmental regulations [5], and other aspects. Although some scholars have studied the impact of digital economy on the green economy [6] and industrial green transformation [7], there is little literature considering the comprehensive impact and internal mechanism of digital investment on manufacturing green transformation at the provincial level.

Y. Jiao et al. (eds.), *Proceedings of the 3rd International Conference on Internet Finance and Digital Economy (ICIFDE 2023)*, Atlantis Highlights in Economics, Business and Management 1,
https://doi.org/10.2991/978-94-6463-270-5_58

2 Theoretical analysis and research hypotheses

The green transformation of the manufacturing industry not only reflects the continuous improvement of production efficiency, but also emphasizes the protection of the natural environment. Investing in digitalization can promote information exchange and knowledge sharing among innovation entities, thereby, promoting green transformation of the manufacturing industry. Based on this, the hypothesis is proposed.

The first hypothesis: Investing in digitalization can effectively promote the green transformation of the manufacturing industry. The second hypothesis: Investing in digitalization can promote the manufacturing industry by improving the level of green technology innovation

3 Variable selection and model setting

3.1 Variable selection and measurement

3.1.1 Dependent. Variable.

Green total factor productivity (GTFP).Following the measurement methods of Chen Chaofan[8] and others. The investment indicators mainly include three categories: manpower, material resources, and energy. The expected output indicator is represented by the operating revenue of the manufacturing owner (in 100 million dollar). The unexpected output is measured by Chemical oxygen demand (ten thousand tons), SO2 emissions and industrial solid waste production in industrial waste water, and the weight composite index is calculated by entropy method.

3.1.2 Independent variable.

Input Digitization of manufacturing (Dig). Based on the research conducted by Sun Guofeng et al.[4] Yang Ling et al.[9], the calculation formula is $\sum_d r_{dj} / \sum_k r_{kj}$ .rdj and rkj are the complete consumption coefficients of any department j for all digital economy dependent departments d (7 departments) and any department j for all intermediate input departments k (42 departments), respectively. On this basis, drawing on the research of Chen Lixian et al. [10], the digital level of manufacturing investment in each region is obtained by multiplying the manufacturing added value manoutputc of each province and city by the complete dependence, and then dividing it by the gross domestic product GDPc of each province.

$$Dig_c = \frac{manoutput_c \times \frac{\sum_d r_{dj}}{\sum_k r_{kj}}}{GDP_c}$$

3.1.3 Mediating and control variables.

Mediation variable is Green innovation technology efficiency (TG). Control variables are expressed as the GDP (ECO); the proportion of added value of the Secondary sector of the economy in GDP (IS); Market competition level (MCE); The level of foreign investment is the logarithm of actual utilization (FDI); Energy Consumption Structure (Ene), measured by [1- Coal Consumption/Total Energy Consumption (Standard Coal)].

3.2 Data source

The Panel data of 30 provinces in China from 2005 to 2021 were used as samples for research and analysis. The relevant data mainly comes from the "China Statistical Yearbook" etc. A few missing indicators are supplemented by Linear interpolation. Table 1 shows the descriptive statistics of the selected variables in this article.

Table 1. Descriptive Statistics of Related Variables

index	average	Standard deviation	minimum value	Maximum value	range
GTFP	0. 2922	0. 3650	0. 0122	1. 5229	1. 5107
Dig	0. 4952	0. 2864	0. 0676	1. 7864	1. 7188
TG	7. 3860	1. 8394	1. 5089	11. 0566	9. 5477
Ind	1. 2860	0. 9012	0. 5271	8. 3543	7. 8272
ECO	10. 5343	0. 6867	6. 6248	12. 1226	5. 4978
IS	0. 4032	0. 0952	0. 0607	0. 6325	0. 5718
MCE	8. 8149	1. 2017	5. 8141	11. 1021	5. 2880
FDI	1. 4518	1. 4518	0. 0367	8. 3249	8. 2882
Gov	7. 9143	0. 9159	5. 0189	9. 8118	4. 7929
Ene	0. 6695	0. 3045	0. 0001	1. 8296	1. 8295

3.3 Model construction

Based on variable settings of this article, the following regression model is constructed:

$$GTFP_{it} = \alpha_0 + \alpha_1 Dig_{it} + \alpha_2 Control_{it} + \mu_i + \nu_i + \varepsilon_{it}$$

$$\mathrm{Med} = \beta_0 + \beta_1 \mathrm{Dig} + \beta_2 \mathrm{Control} + \mu_i + \nu_i + \varepsilon_{it}$$

$$GTFP_{it} = \gamma_0 + \gamma_1 \mathrm{Dig}_{it} + \gamma_2 \mathrm{Med}_{it} + \gamma_3 Control_{it} + \mu_i + \nu_i + \varepsilon_{it}$$

4 Empirical Result Analysis

4.1 Benchmark regression

Based on the constructed empirical model, a bidirectional fixed effects model was selected for stepwise regression analysis. The results are shown in Table 2. From the regression results, it can be seen that digital investment has a significant promoting effect on the green transformation of the manufacturing industry. With the addition of control variables, the impact coefficient of digital investment on the green transformation of the manufacturing industry continues to increase, indicating that increasing digital investment is beneficial for the green transformation of the manufacturing industry. From the estimation results of the control variables, it can be seen that the level of economic development, market competition, and government policy support have a positive impact on the green transformation of the manufacturing industry, while the level of industrial structure, foreign investment, and energy consumption structure have a negative impact on the green transformation of the manufacturing industry.

Table 2. Benchmark Regression Results of Digital Input on Manufacturing GTFP

Index	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dig	0.1559*** (2.8267)	0.1619*** (3.0033)	0.1977*** (3.3607)	0.2048*** (3.6567)	0.2069*** (3.7196)	0.2193*** (3.9516)	0.2270*** (4.1067)
ECO		0.1496*** (4.7581)	0.1516*** (4.8244)	0.0779** (2.4533)	0.0825*** (2.6134)	0.0649** (2.0223)	0.0576* (1.7975)
IS			-0.2776 (-1.5095)	-0.3133* (-1.7885)	-0.2258 (-1.2767)	-0.2678 (-1.5168)	-0.3140* (-1.7783)
MCE				0.2474*** (6.9614)	0.2546*** (7.1953)	0.2055*** (5.1515)	0.2184*** (5.4557)
FDI					-0.0409*** (-2.7315)	-0.0480*** (-3.1762)	-0.0498*** (-3.3076)
Gov						0.2304*** (2.6039)	0.2311*** (2.6261)
Ene							-0.1758** (-2.4535)
Constant term	0.1824*** (5.5251)	-1.2473*** (-4.1275)	-1.1565*** (-3.7583)	-2.5447*** (-7.1797)	-2.5257*** (-7.1746)	-3.3965*** (-7.0180)	-3.2948*** (-6.8197)
Observations	510	510	510	510	510	510	510
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.0970	0.1373	0.1397	0.2200	0.2308	0.2404	0.2486
Hausman test	Chi2=74.8,p=0.0000						

Note: * * *, * *, and * represent significant levels of 1%, 5%, and 10%, respectively. The values in parentheses are T-values, the same below.

4.2 Analysis of impact mechanism

In terms of the mediating effect of green technology innovation ,it can be seen that digital investment has a significant promoting effect on the green transformation of the manufacturing industry. it can be seen from the model (2) and model (3) of Table3 that Mesomeric effect in the process of green transformation of manufacturing driven by digital input, and the Mesomeric effect accounts for 31.99% of the total effect.

Table 3. Intermediary mechanism testing

Index	(1)	(2)	(3)
	GTFP	TG	GTFP
Dig	0.2270***	0.6675***	0.1543***
	(4.1067)	(5.3045)	(2.7943)
TG			0.1088***
			(5.4617)
ECO	0.0576*	-0.0096	0.0588*
	(1.7975)	(-0.1319)	(1.8878)
IS	-0.3140*	-0.9446**	-0.2065
	(-1.7783)	(-2.3579)	(-1.1934)
MCE	0.2184***	0.2351***	0.1936***
	(5.4557)	(2.5946)	(4.9417)
FDI	-0.0498***	-0.1140***	-0.0419**
	(-3.3076)	(-3.0348)	(-2.5738)
Gov	0.2311***	0.7817***	0.1519*
	(2.6261)	(3.9115)	(1.7413)
Ene	-0.1758**	-0.1921	-0.1593**
	(-2.4535)	(-1.1830)	(-2.2824)
Constant term	-3.2948***	1.2647	-3.6750***
	(-6.8197)	(1.0940)	(-7.4522)
Observations	510	510	510
Fixed Effect	Yes	Yes	Yes
R^2	0.2486	0.9643	0.8354

5 Conclusion and suggestions

In a view, investing in digitalization can significantly drive the green transformation of the manufacturing industry. Digital input can indirectly promote green transformation of manufacturing industry by improving the Mesomeric effect of green technology innovation. Therefore, increasing digital investment in manufacturing can promote sustainable development of GDP.

Therefore, this article proposes the following suggestions: Firstly, we need to accelerate the improvement of digital infrastructure construction. Increase support for company and investment in information network construction. Secondly, we need to improve the level of green technology innovation. Promote the full application of digital elements in enterprise research and development design. Finally, we need to focus on coordinated development and implement differentiated development strategies.

Fund

Heilongjiang Province Philosophy and Social Sciences Research Planning Project "Research on the Green Development Path of Industrial Structure in Heilongjiang Province under Carbon Constraints"(22JYE463)

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