Analysis on the Impact of Technology Innovation on Digitalization and Greening Synergies

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Abstract. Technology innovation provides the core driving force for the synergistic development of urban digitalization and greening. This paper empirically examines the impact of technological innovation on the synergistic development of digitalization and greening of cities based on the coupling and coordination degree of the synergistic development of digitalization and greening in 279 cities across China. The empirical results show that technological innovation can significantly enhance the synergy between urban digitalization and greening. Secondly, the heterogeneity results show that the driving effect of technology innovation more significant in the eastern region and non-resource cities.

Keywords: technology innovation; digitalization; greening

1 Introduction

The report of the 20th CPC National Congress clearly puts forward the need to accelerate the green and low-carbon transformation, and to actively push forward the dual-carbon goal, and also makes a major deployment of accelerating the construction of digital China. With the new round of industrial revolution and scientific and technological changes, greening and digitization have gradually become the mainstream trend of social development. In this context, greening and digitization, as the key tenets of the future long-term development, are by no means purely greening and digitization changes, but rather, greening and digitization should be interacted and integrated at a deeper level, so that it produces the effect of "1 + 1 > 2", giving full play to the synergistic effect of the two. The report also pointed out that we should accelerate the implementation of innovation-driven development strategy. Innovation has always had a core position in the overall situation of China's modernization. It can not only optimize and upgrade the traditional way of production and life, but also make the newly formed updating and iteration. Therefore, it is necessary to promote the high-quality development of China's economy and society through "innovation-driven, endogenous growth".

Digital development can be empowered by technological innovation for green development, and similarly, green development can pull the advancement of digital development. Therefore, the synergistic development of digitization and greening can't

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be separated from the support of scientific and technological research and development innovation.

2 Literature Review and Research Hypotheses

2.1 Literature Review

The current research of scholars on technology innovation mainly focuses on the following aspects. On the one hand, some scholars suggest that there is a close connection between innovation drive and economic development. They believe that the realization of a win-win situation between economic development and ecological protection can supported by innovation[1][2]. On the other hand, scholars have researched the internal path, process and way of innovation-driven, and have systematically sorted out the links between many innovation-related concepts[3]. They verified that urban innovation capacity can effectively promote the growth of economic development quality[4].

At present, scholars also have more results on the development relationship between greening and digitization. First, the synergistic mechanism and realization path of digitalization and greening[5][6]. The green attributes contained in the digital technology itself, through the digital construction, accurate control of the production process, thus making the economic and environmental benefits to be synchronized to enhance the optimization of the industrial structure[7][8]. Secondly, they utilize empirical methods to study the effects, influencing factors and mechanisms from the micro and micro levels. Some scholars also measure and analyze the degree of coupling and coordination between digital economy and green economy[9].

Therefore, on the basis of existing research, the possible marginal contributions of this paper are as follows: Firstly, this paper examines the impact of technological innovation on the synergistic development of digitization and greening from the new perspective of synergistic development. Secondly, in this paper, from the municipal level, we construct the index system and measure and analyze the degree of coupling and coordination between the two.

2.2 Research Hypothesis

Technological innovation is not only the basic means of digital construction, but also the power source of greening development. Under the strong impetus of technological innovation, digital technology can be better integrated into the production and living process, provide fine control of energy utilization, further enhance the efficiency of resource and energy utilization, not only save energy consumption, but also reduce sewage, and then promote the transformation and development of urban greening. Through technological innovation, we can meet the needs of green development in terms of data collection technology, network transmission performance and various types of intelligent applications, and thus promote the implementation of "greening leads to digitalization".

Based on the above analysis, the following hypotheses are proposed.

H: Technological innovation can positively contribute to the synergy between digitalization and greening.

3 Research Design

3.1 Construction of an Evaluation Index System

Under the premise of ensuring the scientificity, based on existing research[10][11], completeness and availability of data, the specific construction of the indicator system related to digitization and greening is shown in Table 1. In order to eliminate the bias brought by human subjective factors, the objective weighting method is used to measure the data in this paper.

Table 1. Index Evaluation System for Greening and Digitalization

system level	indicator layer	Meaning of the indicator	Indicator properties
Level of greening	Industrial emissions	Industrial wastewater discharge	—
		Industrial sulphur dioxide emissions	—
		Industrial smoke emissions	—
	carbon dioxide emission	Carbon dioxide emissions	—
	energy consumption	Energy consumption	—
	urban greening	Green area of parks	+
Level of digitization	Level of digital penetration	Cellphone subscribers at the end of the year	+
	Level of application of digital equipment	Number of international Internet users	+
	Level of development of the digital economy	Digital Inclusive Finance Index	+
	Digital inputs	Employees in the information transmission computer services and software industry	+
	Digitized outputs	Revenue from telecommunication services	+

3.2 Model Setting

Based on the previous theoretical analysis, the following benchmark model is constructed.

$$D_{it} = \beta_0 + \beta_1 Inva_{it} + \lambda_i Controls + u_i + v_t + \varepsilon_{it}$$

D_{it} as the explanatory variable. $Inva_{it}$ as the core explanatory variable. $Controls$ for other control variables affecting the synergistic development of digitization and greening. u_i for individual fixed effects, the v_t is a time fixed effect, the ε_{it} is the perturbation term.

3.3 Description of Variables

Explained variable: The synergy between urban digital development and greening development. The indicator takes the value range of [0,1], the larger the value, the better the synergy between digitalization and greening development.

Core explanatory variables: The number of inventions filed in the current year (Inva). Refer to the practice of Feng Ming (2023), and use the number of invention patent applications in the year, add 1 and take the logarithmic treatment as a proxy variable for technological innovation.

Control variables: First, economic development (pGDP); second, the degree of openness (For); third, the level of education (Edu); fourth, the structure of the industry (Ind); fifth, the construction of infrastructure (Inf); sixth, population density (Pop); sixth, population density (Pop); and sixth, population density (Pop). Control variables are treated as logarithms.

4 Empirical Results and Analysis

4.1 Benchmark Begression

Table 2 reports the results of the regression estimates. Column (1) reports the regression estimates without the control variables; column (2) is with the relevant control variables. Both regressions control for time and area effects. As can be seen from the data in the table, the regression coefficient of the core explanatory variable, Inva, is 0.0747, which is positively significant at the 1% level of significance. After adding a series of control variables, the regression coefficient of the core explanatory variable Inva is 0.0726, which is still significant at the 1% level of significance. Moreover, the values of these two regression coefficients do not change much, which indicates that the regression results are relatively stable. Therefore, the previous hypothesis is verified. Technology innovation, as the core driving force of development, can efficiently and further promote the synergistic development of digitalization and greening.

Table 2. Benchmark Regression

Variable	(1) D	(2) D
Inva	0.0747***	0.0726***
	(3.97)	(3.90)
lnpGDP		0.0171***
		(3.88)
lnFor		0.0013***
		(3.26)
lnEdu		0.0078**
		(2.20)
lnInd		-0.0120
		(-1.52)

lnInf		-0.0011
		(-0.37)
lnPop		0.0005
		(0.32)
Constant	0.1858***	0.1858***
	(4.59)	(4.59)
city	YES	YES
year	YES	YES
Observations	2,503	2,503
R-squared	0.860	0.860

4.2 Regional Heterogeneity

This paper divides all the samples into cities in the eastern, central and western regions, and carries out regression tests for them respectively. The results are shown in columns (1)-(3) of Table 3. Column (1) shows the regression results for the eastern region sample, and the regression result indicating that in the eastern region, the development of technology positively promotes the synergistic development of digitalization and greening. As for the central and western regions, according to the regression results in columns (2) and (3), the results are not good. The main reason may lie in the fact that the eastern region has faster economic development; the quality of the population and industrial structure are ahead of other region, so they can accept, master and apply new technologies faster. While the central and western regions are relatively backward, the sudden influx of technological innovation requirements may disperse the original funds and other financial and material resources, which will easily lead to a waste of resources.

Table 3. Heterogeneity Analysis

Variable	(1) D	(2) D	(3) D
Inva	0.0762***	0.0923*	0.1736
	(3.82)	(1.84)	(1.08)
Controls	YES	YES	YES
city	YES	YES	YES
year	YES	YES	YES
Observations	900	900	703
R-squared	0.851	0.887	0.854

5 Conclusions and Suggestions

5.1 Conclusions

In this paper, the coupling and coordination degree of the synergistic development of "dualization" in 279 cities in China is firstly measured, and on this basis, the impact of

technological innovation on the synergistic development of "dualization" is empirically examined. The empirical results show that technological innovation can significantly enhance the synergy of urban digitalization and greening development. Second, the heterogeneity results show that the driving effect of technological innovation is more significant in the eastern region.

5.2 Suggestions

On the one hand, it is necessary to further accelerate the research and development and verification of new technologies, improve the application and transformation efficiency of technological innovation. Strengthen the cooperation between industry, academia and research institutes; improve the construction of the supporting facilities for dual-chemical synergistic related technological innovations to improve reliability and safety, and enhance the popularization and application degree. On the other hand, it is necessary to implement[t differentiated development strategies according to local conditions. Technological innovation policies can be appropriately tilted toward cities in the central and western regions to promote scientific and technological progress in the region, and then promote the coordinated development of digitalization and greening.

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