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The impact mechanism of green technology innovation on urban green development: Evidence from Central China

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Abstract: In order to further promote urban green development in Central China, the research uses panel data from 80 cities in Central China from 2011 to 2022 as a sample and employs the linear regression method, mediating effect, and threshold effect to empirically test the impact mechanism of green technology innovation on urban green development in Central China. The results show that: first, green technology innovation significantly promotes urban green development, and the conclusion still holds when considering endogeneity. Second, the regional heterogeneity test found that the differences in resource endowments among provinces lead to significant differences in the impact of green technology innovation on urban green development. Third, the mediating effect found that digital inclusive finance and industrial structure upgrading both play partial mediating roles between green technology innovation and urban green development. Fourth, the threshold effect found that urban environmental infrastructure investment has a positive single threshold effect between green technology innovation and urban green development. This paper not only enriches the research on urban green development at the academic level but also provides reference value for the sustainable development of cities in other developing countries and regions. The objective of this study is to explore how to promote the green development of cities in Central China from the perspective of green technology innovation and to provide a reference for other developing countries and regions. In this topic, the main concepts and theories that underpin the research are presented. First, the concept of sustainable development lays the main tone of this study. Second, Schumpeter's innovation theory provides theoretical support for establishing the connection between green technology innovation and urban green development. The methodology adopted for this research comprises the entropy method, panel multiple linear regression model, mediation effect model, and threshold effect model. The original data used in this study are authoritative secondary data from the official statistical yearbooks of various provinces in Central China. The results obtained revealed that green technology innovation has a significant positive promoting effect on urban green development in Central China, and digital inclusive finance and upgrading of industrial structure have significant partial mediating roles in the process of green technology innovation promoting urban green development in Central China. The threshold effect found that urban environmental infrastructure investment has a significant single threshold effect in the process of green technology innovation promoting urban green development in Central China. In the discussion section, these results are contextualized in light of the theoretical framework, highlighting the implications and relationships identified. Possible discrepancies and limitations of the study are also considered in this section. The practical and theoretical implications of this research are

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discussed, providing insights into how the results can be applied or influence practices in the field of urban green development. First, this study provides new ideas for policymakers in urban green development in Central China. Second, this study provides a reference for urban green development in other developing countries and regions. These implications could encompass green technology, green lifestyle, green production, and green industry, etc. This study contributes to the literature by considering new ideas for green technology innovation, as well as the intermediary effect of digital inclusive finance and the threshold effect of green investment. The relevance and value of this research are evidenced by the fact that green technology innovation, digital inclusive finance, and green investment provide new ideas for policymakers and enterprises for urban green development.

Keywords: *Digital inclusive finance, Green technology innovation, Green development, Upgrading of industrial structure.*

1. Introduction

With the increasing destruction of natural resources and environmental pollution around the world, ecological problems are increasingly restricting urban development. Green development is considered an effective way to achieve a win-win situation between economy and environment, which means that development and environmental protection are compatible. Urban green development referred to in this article highlights the concept of "sustainable development" and emphasizes the possibility of achieving coordinated development of economy, society and environment [1]. Green development has become the fundamental driving force for sustainable cities. How to improve urban green development has become the focus of academic attention.

In the current era, the implementation of an innovation-led development strategy requires technological transformation to support a systematic response to ecological pollution without giving up social development and economic growth. Schumpeter [2] innovation theory confirms that economic development would be stimulated by innovation [2]. Then most scholars believed that green technology innovation is an important driving force for achieving green development [3, 4]. With the increasing shortage of resources and severity of environmental pollution problems, the focus of academic research has gradually shifted to how to achieve regional development driven by technological innovation in an environmentally friendly way.

This study selects Central China as the research sample. Central China is a developing region in China with a strong industrial and agricultural base and a dense population. Therefore, it is very important to study the role of green technology innovation in Central China in achieving urban green development, and it also has important reference significance for other developing countries and regions.

2. Theoretical Framework

The world is currently facing multiple environmental crises, such as global warming, extreme weather and severe pollution. Green development is oriented to achieve harmony between man and nature, emphasizing the overall coordination of economic, social and environmental systems [5]. It is an economic development model that takes into account both ecological sustainability and development goals, and has become a hot topic in academia. In this context, green technology innovation is considered to be a key means to achieve a green development model, by significantly reducing the environmental effects of fossil energy consumption, to improve green total factor productivity and achieve sustainable development goals Dam, et al. [6]. Obobisa and Ahakwa [7] found that green technology innovation significantly improved the carbon emission efficiency of European countries. Feng, et al. [8] believed that technological innovation is a significant factor in promoting regional green growth. However, there is currently a lack of direct research on the relationship between green technology innovation and urban green development. Therefore, the study takes Central China as the background and proposes the first hypothesis: H1: Green technology innovation positively affects urban green development in Central China.

The essence of digital inclusive finance is the combination of intelligent digital technology innovation and traditional finance. Through innovative technical support, it provides the public with personalized, low-cost, sustainable and comprehensive financial services. Many scholars have studied the green effects of digital inclusive finance. Digital inclusive finance can promote regional green growth [9] improve regional green development efficiency [9] and reduce regional carbon emissions [10]. At present, there is no literature in the academic community that studies the mediating effect of digital inclusive finance between green technology innovation and urban green development. However, Xie, et al. [11] and Qin, et al. [12] found that financial technology innovation can indirectly promote green economic growth and improve the green environment index through green finance. Therefore, this study proposes the second hypothesis. H2: Digital inclusive finance plays a mediating role in the impact of green technology innovation on urban green development in Central China.

Industrial structure upgrading refers to the transformation of a country's economic growth mode, including the transformation from labor-intensive growth mode to capital-intensive and knowledge-intensive growth mode, and the transformation of economic growth momentum from factor-driven to investment-driven and innovation-driven. Existing scholars have found that industrial structure upgrading often drives regional green development, including reducing carbon dioxide emissions [13] improving regional green development efficiency [14] and promoting green economic growth [15]. Among the driving factors of industrial structure upgrading, technological innovation is undoubtedly the most critical, because technological progress caused by technological innovation affects the direction and speed of industrial development [3] and is an important driving force for promoting industrial intensive and large-scale development [16]. However, the academic community has not directly studied the transmission mechanism of industrial structure upgrading between green technological innovation and green development of Central China cities. Therefore, this study proposes the third hypothesis. H3: Industrial structure upgrading plays a mediating role in the impact of green technology innovation on urban green development in Central China.

Urban environmental infrastructure investment in this study belongs to macro-government green investment, which is conducive to promoting the development of circular economy, reducing environmental pollution and preventing natural disasters, and is a necessary government fiscal means to achieve urban green development. Tan and Zhou [17] and Hao, et al. [18] found that green investment has a nonlinear threshold effect on environmental pollution and carbon emission intensity. Huang and Chen [19] used government environmental governance investment as a proxy indicator and found that green investment has a threshold effect on environmental quality. However, there is no literature in the academic community on the threshold effect of green investment in the process of green technology innovation affecting urban green development. Therefore, this study proposes the fourth research hypothesis. H4: Green investment plays a threshold effect in the impact of green technology innovation on urban green development in Central China.

3. Methodology

3.1 Data Sources

Central China includes 6 provinces, including 82 cities. The data of Xiangxi and Enshi were seriously missing, so they were excluded. Finally, 80 cities in Central China were used as samples for this study. This paper uses panel data of 80 cities in Central China from 2011 to 2022, and the original data comes from China Statistical Yearbook, Shanxi Statistical Yearbook, Henan Statistical Yearbook, Hubei Statistical Yearbook, Hunan Statistical Yearbook, Jiangxi Statistical Yearbook and Anhui Statistical Yearbook. For few missing data, interpolation method is used to fill in.

3.2. Variables

Dependent variable: Urban green development (UGD). Urban green development is a comprehensive concept. This study establishes an urban green development index system from three aspects: government management, enterprise development, and residents' lives. The urban green development level score calculated by the entropy method is used as a proxy for the dependent variable. Figure 1 shows the indicator framework of it.

Alternative Indicators		Unit
Green Production	Investment for R&D	10,000CNY
	The proportion of the tertiary industry in GDP	%
	Energy consumption per unit of GDP	Ton of standard coal/10,000CNY
	Water consumption per unit of GDP	Ton/10,000CNY
	Electricity consumption per unit of GDP	KW.h/10,000 yuan
	Wastewater discharge per unit of GDP	Ton/10,000CNY
	Sulfur dioxide emissions per unit of GDP	kg/10,000CNY
	Soot emissions per unit of GDP	kg/10,000CNY
Government Management	Built-up area per unit of GDP	Sq.km/10,000CNY
	Forest coverage rate	%
	Proportion of artificial afforestation area in urban area	%
	Per ca-pita park green space area	sq.m
	Comprehensive utilization rate of general industrial solid waste	%
	Domestic sewage treatment rate	%
	Annual average concentration of PM2.5	Microgram/Per cubic meter
	Number of public toilets per 10,000 people	Unit/10,000people
Green Lifestyle	Gas penetration rate	%
	Per capita daily domestic water consumption	kg
	Domestic waste harmless treatment rate	%
	Number of public transportation vehicles per 10,000 people	Vehicle/10,000 people
	Household motor vehicle exhaust emissions	kg
	Green coverage rate of urban built-up areas	%
	Regional noise level	value

Figure 1.
Original Indicators System for Urban Green Development

Independent variable: Green technology innovation (GTI). In this study, the sum of green invention patents and green new utility patents will be used as a proxy indicator of green technology innovation.

Control variables: First, the level of opening up to the outside world (OPEN). This study uses the proportion of foreign direct investment to GDP as a proxy indicator of opening up. Second, the level of education (EDU). This study uses the proportion of education expenditure to GDP as a proxy indicator of education level. Third, population density (PD). Population density is directly related to the pressure of urban development. In this paper, population density is measured by the number of urban populations per square kilometer. Fourth, the level of urban economy (UECO). This study uses the per capita GDP growth rate as a proxy indicator of urban economic level, which can better reflect the dynamic quality of urban economic.

Mediating variables: First, digital financial inclusion (DFI). The digital financial inclusion data uses the Peking University Digital Financial Inclusion Index released by the Peking University Digital Finance Research Center. Second, upgrading of industrial structure (UIS). This study uses the Theil Index as a proxy indicator to measure industrial structure upgrading.As the formula of Thayer Index shows, TL is the Thayer Index, w_i is the ratio of the output value of industry i to GDP, and e_i is the ratio of the number of employees in industry i to the total number of employees:

$$TL = \sum_{i=1}^{n} w_i * \log(\frac{w_i}{e_i})$$

3.3. Entropy Method

"Entropy" is a term coined by German physicist R.J.E. Clausius in 1850 to indicate the uniformity of energy distribution in space, which belongs to the category of thermodynamics. Later, this method was cited by other disciplines. The larger the entropy, the greater the degree of dispersion of the indicator, and the greater the impact of the indicator on the comprehensive evaluation. It can reduce the influence of human subjectivity on the evaluation results and make the evaluation results more realistic. In this study, the entropy method is used to measure the UGD index.

3.4. The Panel Regression Model

The study would use the panel regression model to prove the direct impact of GI on UGD. Its general formula is as follows, where β0 represents the intercept term of the Y axis, β_1 to β_5 represent the coefficients of the independent variable, and ε represents the error term.

$$UGD = \beta_0 + \beta_1 GTI + \beta_2 OPEN + \beta_3 EDU + \beta_4 PD + \beta_5 UECO + \varepsilon$$

3.5. Mediating Effect Model

The formula of mediating effect model is following. In the above formula: a represents the direct effect of the independent variable on the mediating variable; b represents the direct effect of the mediating variable on the dependent variable; c and c' represent the direct effect of the independent variable on the dependent variable; e_1, e_2 and e_3 represent error terms.

$$UGD = cGTI + e_1$$

$$DFI = aGTI + e_2$$

$$UIS = aGTI + e_2$$

$$UGD = c'GTI + bDFI + e_3$$

$$UGD = c'GTI + bUIS + e_3$$

3.6. Threshold Effect Model

The threshold effect refers to the situation that when an economic parameter reaches a specific value or a specific range, it would cause another economic parameter to undergo a sudden change or qualitative change. The basic formula of the threshold effect is as follows:

$$UGD_t = \alpha + GTI\beta_1 + \varepsilon_t (GTI_t \le \gamma)$$

$$UGD_t = \alpha + GTI\beta_2 + \varepsilon_t (GTI_t > \gamma)$$

In the above formula, β_1 and β_2 represent different threshold intervals, the influence coefficient of GTI on UGD; GTI_t represents the threshold variable; γ represents the threshold value.

4. Results and Discussions

4.1. Test of Correlation and Multicollinearity

Table 1 shows the results of the correlation test and multicollinearity test of the main variables. The dependent variable urban green development and the core independent variable green technology innovation are significantly positive at the 10% level, which preliminarily verifies the correlation between green technology innovation and urban green development. At the same time, the multicollinearity test results show that the VIF values of each variable are less than 5, which indicates that there is no multicollinearity problem in the model.

Table 1.
Test of Correlation and Multicollinearity

	UGD	GTI	OPEN	EDU	PD	UECO
UGD	1.000					
GTI	0.058*	1.000				
OPEN	0.028	0.230***	1.000			
EDU	-0.007	-0.310***	-0.128**	1.000		
PD	-0.385***	0.353***	0.174***	-0.235***	1.000	
UECO	0.157***	-0.015	0.02	-0.007	0.109***	1.000
VIF		1.26	1.19	1.13	1.07	1.02

4.2. Benchmark Panel Regression

This section analyzes the direct impact of GTI on UGD in Central China. To improve the robustness of the regression results, this paper adopts ordinary least squares (0LS), random effects regression (REs) and fixed effects regression (FEs). The empirical results shown in Table 4.2 show that the regression estimation coefficients of GTI on UGD in the three equations are all significantly positive. And the conclusions of the three models are consistent regardless of whether the control variables are included. In particular, the regression results of the random effects model show that for every unit increase in GTI, the level of industrial pollution emissions increases by 0.012 units. The above results strongly prove the role of GTI in promoting UGD in Central China, thus proving Hypothesis 1.

Regarding control variables, the effect of the level of opening up to the outside world on UGD is not significant. The effect of education on UGD is significantly negative, and the possible reason is that Central China cannot attract talents well, resulting in the loss of human resources. The effect of population density on UGD is significantly negative, which just proves that the higher the population density, the more unfavorable it is for urban green development. The effect of urban economy on UGD is significantly positive, which shows that the economic growth of Central China cities has provided good financial support and promoted urban green development.

Table 2.
Results of Benchmark Panel Regression

	OLS		FE		RE	
GTI	0.004* (0.002)	0.014*** (0.002)	0.009*** (0.003)	0.010*** (0.003)	0.008*** (0.003)	0.012*** (0.002)
OPEN		0.002* (0.001)		0.001 (0.001)		0.001 (0.001)
EDU		-0.004* (0.002)		-0.011*** (0.004)		-0.007** (0.003)
PD		-0.073*** (0.004)		0.031 (0.068)		-0.071*** (0.009)
UECO		0.012*** (0.002)		0.011*** (0.002)		0.011*** (0.001)
Constant	0.551*** (0.011)	0.924*** (0.028)	0.525*** (0.014)	0.342 (0.409)	0.531*** (0.014)	0.939*** (0.056)
N	960	960	960	960	960	960
R2	0.002	0.238	0.013	0.090	0.013	0.425
F Value/Wald Chi2	3.25	60.79	11.15	14.10	9.84	123.44

4.3. Robustness Test

To ensure the robustness of the empirical results, this paper mainly uses three methods to conduct robustness tests. First, this study excludes half of the sample period and samples of provincial capital cities. There are significant differences between the green development of provincial capital cities and other ordinary cities, and this difference may affect the empirical results. Second, this study replaces the core explanatory variables. This study cites the number of green patent authorizations as a new proxy variable for green technology innovation, named GTIX. Third, this study shrinks the variables to reduce the impact of extreme values on the overall data analysis. Fourth, in order to eliminate the endogeneity problem, this study selects the independent variable with a lag of one period, named LGTI, as an instrumental variable for regression with Two-Stage Least Squares Method.

Table 3.
Results of Robustness Test

	Reducing sample size	Replacing independent variable	Winding data
GTI	0.014*** (0.003)		0.010*** (0.003)
GTIX		0.015*** (0.003)	
OPEN	0.000 (0.001)	0.000 (0.001)	-0.001 (0.003)
EDU	-0.017*** (0.005)	-0.003 (0.004)	-0.009** (0.004)
PD	0.146 (0.101)	0.014 (0.067)	0.077 (0.073)
UECO	0.010*** (0.002)	0.011*** (0.002)	0.011*** (0.002)
Constant	-0.349 (0.599)	0.404 (0.403)	0.063 (0.437)
N	518	960	960
R2	0.476	0.097	0.214
F	12.20	18.76	11.27

The regression results of the robustness test shown in Table 3 show that after reducing the sample size, replacing the explanatory variables and shrinking the data, the direct impact of green technology innovation on the green development of central China cities is still significant. The endogeneity analysis results shown in Table 4 show that after introducing instrumental variables, the direct impact of green technology innovation on the green development of Central China cities is still significant. The above results verify the robustness of the empirical model of this study.

Table 4.
Results of Endogeneity Test

	The First Step	The Second Step
LGTI	0.388*** (0.035)	
GTI		0.067*** (0.023)
OPEN	-0.006 (0.013)	-0.004 (0.005)
EDU	-0.007 (0.024)	0.012 (0.010)
PD	1.015*** (0.375)	0.015 (0.124)
UECO	-0.003 (0.006)	0.007** (0.003)
Anderson-Rubin Wald value	10.07***	
Kleibergen-Paap rk LM value	37.76***	
Cragg-Donald Wald F value	166.63	
Weak Identification Test Critical Value at 10% Level	16.38	

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4.4. Regional Heterogeneity Test

The above conclusions confirm that GTI has a significant role in promoting urban green development in Central China. However, due to the vast territory of Central China and the uneven development of cities in various provinces, this study will conduct regression analysis on the six provinces in Central China. As shown in Table 5, the results show that: First, in Henan Province, Hunan Province and Anhui Province, the impact of GTI on urban green development is significantly positive. Second, in Shanxi Province, the impact of GTI on urban green development is significantly negative. The possible reason is that Shanxi Province is underdeveloped and the level of green technology innovation is in the primary stage, so promoting urban green development by developing green technology innovation is counterproductive. Third, in Hubei Province and Jiangxi Province, the impact of GTI on urban green development is not significant. The possible reason is that Hubei and Jiangxi are already in the late stage of urban green development, with a high green development index, so the role of GTI on urban green development is not obvious.

Table 5.
Results of Regional Heterogeneity Test

	SHANXI	HENAN	HUBEI	HUNAN	JIANGXI	ANHUI
GTI	-0.096*** (0.008)	0.052*** (0.006)	0.002 (0.005)	0.015** (0.007)	-0.001 (0.008)	0.029*** (0.006)
OPEN	0.011** (0.005)	-0.001 (0.001)	-0.019** (0.009)	-0.006 (0.006)	0.005 (0.013)	0.001 (0.005)
EDU	0.035*** (0.008)	-0.034*** (0.010)	-0.042*** (0.013)	-0.030** (0.012)	-0.009 (0.011)	-0.010 (0.011)
PD	0.448 (0.292)	0.183* (0.109)	0.245 (0.210)	-0.003 (0.192)	0.099 (0.325)	-0.163 (0.100)
UECO	-0.002 (0.002)	0.014*** (0.004)	0.005 (0.006)	-0.007 (0.006)	0.012 (0.008)	0.014*** (0.005)
Constant	-1.585 (1.587)	-0.876 (0.716)	-0.783 (1.231)	0.642 (1.120)	0.056 (1.863)	1.418** (0.645)
N	132	204	144	156	132	192
R2	0.624	0.426	0.247	0.074	0.338	0.648
F Value	38.47	27.05	4.10	2.19	1.12	14.23

4.5. Mediating Effect Results

This section will test the mediating role of digital inclusive finance and industrial structure upgrading in the process of GTI promoting urban green development in Central China with Bootstrap Method. The mediation effect regression results shown in Table 6 show that for the mediating variables DFI and UIS, the direct effect and the mediating effect are both positive and significant, and there is no 0 value in the confidence interval. This means that digital inclusive finance and industrial structure upgrading play a partial mediating role in the process of green investment affecting urban green development in Central China.

Table 6.
Results of Bootstrap Method for Mediating Effect

Mediating Variables	Effect	Regression Results	[95% conf.interval]
DFI	_bs_1: r (Mediating Effect)	0.005*** (0.002)	[0.002 , 0.008]
	_bs_2: r (Direct Effect)	0.009*** (0.003)	[0.004 , 0.014]
UIS	_bs_1: r (Mediating Effect)	0.004*** (0.001)	[0.002 , 0.005]
	_bs_2: r (Direct Effect)	0.010*** (0.002)	[0.006 , 0.015]

4.6. Threshold Effect Results

In this study, urban environmental infrastructure investment would be used as a threshold variable and named UEI. In Table 7, after 100 times of Bootstrap repeated sampling, preliminary verification found that when UEI is as the threshold variable, only the single threshold effect is significant. Therefore, it is necessary to re-verify single-threshold regression separately.

Table 7.
Verification for Threshold Type for UEI

Threshold Type	Bootstrap	F-Statistic	P-value	Crit10	Crit5	Crit1
Single Threshold	100	23.29	0.030	19.377	21.381	27.686
Double Threshold	100	4.52	0.960	18.814	22.538	30.564
Triple Threshold	100	6.25	0.860	16.980	19.630	26.057

Table 8.
Retesting and Separately Estimating of Single Threshold Effect for UEI

Threshold Type	Bootstrap	F Statistic	P-value	Crit10	Crit5	Crit1	Threshold value estimation	[95% conf. Interval]
Single Threshold	50	23.29	0.040	19.329	23.052	33.057	2.168	[2.133, 2.176]

Retesting and Separately Estimating the Single Threshold Effect for UEI. As seen from Table 8 ,the single threshold effect of UEI is significant, and the single threshold value is 2.168.

Single Threshold Effect Regression Results for UEI as Threshold Variable. Table 9 shows the single threshold effect regression results for UEI as threshold variable. First, when the logarithm of UEI is less than 2.168, the coefficient of GTI on UGD is 0.005. Second, when the logarithm of UEI is greater than or equal to 2.168, the coefficient of GTI on UGD is 0.012. It can be understood that the increase in urban residents' income would promote green consumption, thereby giving rise to a series of green and environmentally friendly products, and promoting the green economy and green development of cities.

Table 9.
Results of Threshold Effect Regression.

Variables	GTI (UEI＜2.168)	GTI (UEI≧2.168)	OPEN	EDU	PD	UECO	Constant	R2	F
Threshold Regression Results	0.005* (0.003)	0.012*** (0.003)	0.001 (0.001)	-0.012*** (0.004)	0.036 (0.067)	0.010*** (0.002)	0.319 (0.405)	0.096	15.38

Source: Based on Empirical Analysis by Stata.17.0.

5. Conclusion

Green technology innovation is an organic combination of environmental protection concepts and emerging technologies, and is a key tool for achieving green development in the future. This study uses the panel data of cities in Central China to test the impact mechanism of green technology innovation on urban green development through multiple empirical models. The results show that: First, green technology innovation has a significant promoting effect on urban green development in Central China, and the conclusion still holds when considering endogeneity. Second, the regional heterogeneity test found that the differences in resource endowments among provinces lead to huge differences in the impact of green technology innovation on urban green development. Third, the mediating effect found that digital inclusive finance and industrial structure upgrading are important transmission paths for green technology innovation to promote urban green development in Central China. Fourth, the heterogeneity test found that based on resource endowment conditions, the degree of influence between green technology innovation and urban green development in the six provinces of Central China is different. Fifth, the threshold effect test found that as a green investment, urban environmental infrastructure investment plays a single threshold effect in the process of green technology innovation affecting urban green development. The above research conclusions not only provide ideas for urban green development in Central China, but also have reference significance for other regions and developing countries.

Based on it, this article puts forward the following policy recommendations: First, the Central China government should continue to strengthen support for green technology innovation and reduce the innovation costs of enterprises by strengthening tax exemptions, R&D subsidies, etc. At the same time, strengthen the control of industry green technology standards, improve the green patent review mechanism and efficiency, and encourage the transformation of technological achievements. In addition, the government should promote cooperation between local enterprises and universities, research institutes and international platforms, and focus on key technological innovation. Second, the central China government should accelerate the promotion of industrial structure upgrading, clarify the future direction of industrial development, gradually eliminate backward industries, develop new energy and energy-saving and environmental protection industries, and promote low-carbon transformation of high-energy-consuming industries. Third, Central China belongs to a developing region, and its digitalization level needs to be improved. Therefore, the central China government should further consolidate the basic support of digital inclusive finance, clarify the key service objects by improving digital infrastructure and formulating special plans for digital inclusive finance, and help the green and inclusive development of cities. Fourth, the government should formulate a green investment strategic plan and clarify the mandatory proportion of green investment. And strengthen the construction of green infrastructure, such as low-carbon transportation networks, ecological restoration projects, etc. Fifth, differentiated policy measures should be formulated according to local conditions. Since green technology innovation and urban green development vary greatly among provinces and cities, governments in central China should formulate targeted policy plans. For example, in ecologically fragile areas, support for green technology innovation should be strengthened, while in areas with better ecological benefits, environmental assessment and green technology innovation audits need to be strengthened.

The limitations of this study depend on data availability. The first, since the original data is secondary data from the official statistical yearbooks of various provinces, it is limited to 2011 to 2011, and the sample size is relatively small. Second, there are countless indicators that constitute the urban green development system, but due to academic research, this article only obtained a dozen research indicators, so it cannot fully represent the true level of urban green development. In the future, researchers can consider increasing the time period to explore the relationship between the two under long-term effects, or take other countries and regions as research objects to further expand the research results.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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