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The Impact of Digital Economy on the Green Development of Chian' s Economy

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Abstract— This study, based on sustainable development theory and the Environmental Kuznets Curve (EKC), examines how the digital economy drives green development across 30 Chinese provinces (excluding Tibet) from 2012 to 2021. By optimizing resource allocation, improving energy efficiency, promoting industrial upgrading, and fostering green innovation, the digital economy supports sustainable growth. However, high energy consumption, environmental pollution, and regional digital disparities remain challenges, and its mechanisms and spatial spillover effects are not yet fully understood.Existing research mainly focuses on national or city levels, lacking provincial empirical analysis, while measurement frameworks often overlook environmental governance, social equity, and policy impacts. Additionally, studies on spatial spillover effects are limited. To bridge these gaps, this study develops a scientific measurement system and applies spatial econometric methods to assess the direct and spillover effects of the digital economy on green development, providing insights for theory and policy.

Keywords: Digital Economy;Green Development; Spatial Econometrics

I. INTRODUCTION

The rise and transformation of the digital economy are closely linked to the promotion of green economic development. With the rapid advancement of technologies such as 5G, big data, and artificial intelligence, China's digital economy has grown from 11.2 trillion yuan in 2012 to 53.9 trillion yuan in 2023, accounting for 42.8% of national GDP (CAICT, 2024). This emerging force plays a key role in improving resource allocation, enhancing energy efficiency, and driving low-carbon transformation, making it a vital component of high-quality development.

Green economic development aims to achieve harmony between economic growth and ecological protection. According to Shi Minjun (2018), green development requires decoupling economic expansion from environmental degradation, while Zhu Dongbo (2020) emphasized the importance of Xi Jinping's green development philosophy in constructing a low-carbon, circular economy. However, challenges such as a coal-dominated energy structure and significant regional development imbalances persist.

Recent studies have begun to explore the interactions between the digital economy and green development. Wu Rui et al. (2022) identified significant regional disparities in how the digital economy supports economic quality. Liu Weilin and Wang Yibin (2022) pointed out the existence of a "digital divide" that may hinder coordinated green progress. Xu Junwei (2023) highlighted the spatial heterogeneity of digital-green integration across regions. These findings suggest that the digital economy may produce both direct and spatial spillover effects on green development.

Therefore, this study aims to explore the impact of the digital economy on green development across Chinese provinces. By constructing a comprehensive evaluation framework and employing spatial econometric models, the research seeks to assess the mechanisms of influence and provide empirical evidence for promoting regional coordination and sustainable transformation.

II.METHODOLOGY & DATA RESOURCE

2.1 Methodology

This study employs a two-way fixed effects panel regression model combined with a Spatial Durbin Model (SDM) to explore the impact of the digital economy on green development. The fixed effects model accounts for both temporal and provincial heterogeneity, enabling a more accurate analysis of regional trends. The entropy weight method is used to construct composite indices for the digital economy and green development, following the framework of Li Min & Chen Zhaowei (2022) and Wang Jun et al. (2021).

The spatial econometric model addresses spatial dependence and spillover effects between regions. Elhorst (2014) emphasized that regional economic activities often influence one another, making spatial modeling essential in panel data analysis. The spatial weight matrix is constructed based on economic geographic distance, capturing both adjacency and economic similarities. Anselin (1988) introduced the concept of spatial autocorrelation, which justifies the use of the Spatial Durbin Model in this study.

To ensure data validity, all indicators are normalized, and missing values are interpolated using linear methods. Baltagi (2005) suggested that panel models with fixed effects are suitable when unobservable individual characteristics may correlate with explanatory variables, enhancing consistency.

Furthermore, the model is tested for multicollinearity using VIF, and spatial correlation is assessed through Global and Local Moran's I statistics (Moran, 1950). The robustness of the spatial model is confirmed through LM, LR, Wald, and Hausman tests, ensuring the SDM is the most appropriate framework for capturing both direct and spatial effects.

2.2 Model Formula

In order to test the above, this part uses the two-way fixed effect model and the spatial Dubin model to test the influence of digital economy level on green development level and its spatial spillover effect. The design of the two-way fixed effect model is as follows:

$$Green_{it} = \alpha_0 + \beta_1 Digital_{it} + \beta_2 controls_{it} + \mu_i + \eta_t + \varepsilon_{it} \tag{1}$$

In the equation, i represents individual firms, and t represents the year. The dependent variable in this study indicates the level of green economic development in province i in year t. The core independent variable represents the level of digital economy in province i in year t. It includes a series of control variables, which, according to existing literature, are selected as industrial structure (industrial), economic development level (economic), environmental regulation (environ), regional openness (FDI), and fiscal expenditure level (fiscal). It also represents fixed effects for both provinces and years.

In order to fully consider the influence of spatial factors, a spatial econometric model is constructed to explore the spatial spillover effect of the impact of digital economy level on green development level. The following models are constructed:

$$Y = \rho WY + X\beta + \theta WX + \mu \tag{2}$$

$$\mu = \lambda W\mu + \varepsilon, \varepsilon \sim N[0, \sigma^2 I] \tag{3}$$

In formula (2), Y represents the explained variable Green; X stands for all explanatory variables; W represents an n*n dimensional spatial matrix, which in this paper is chosen to be the economic distance matrix, measured by the reciprocal of the absolute difference in per capita GDP between provinces; represents the correlation coefficient with X; and represent the spatial correlation coefficients; represents the spatial error coefficient; and represent random errors, which follow a normal distribution.

When $\rho \neq 0, \theta = 0, \text{and } \lambda = 0$, it conforms to the spatial autoregressive model (SAR);

When $\rho = 0, \theta = 0, \text{and } \lambda \neq 0$, it conforms to the spatial error model (SEM);

When $\rho \neq 0, \theta \neq 0, \text{and } \lambda = 0$, it conforms to the spatial Dubin model (SDM).

In the process of testing spatial spillover effects, this paper uses the Moran index, Moran scatter plot, LM test, Hausman test, LR test, and Wald test to ultimately determine the spatial Durbin bidirectional fixed model as the spatial spillover effect model for this study. The results are decomposed to explore the spatial spillover effects of digital economy levels on green development levels.

III.DATA SOURCES

This study uses panel data from 30 Chinese provinces (excluding Tibet) for the years 2012–2021. Data are obtained from the China Statistical Yearbook, China Informatization Yearbook, provincial yearbooks, and the EPS database.

The digital economy index includes internet penetration, e-commerce volume, and informatized enterprises, constructed using the entropy weight method. Green development is measured via pollution intensity, forest coverage, and energy efficiency, also processed with entropy weights.

Control variables—such as industrial structure, economic level, environmental regulation, openness (FDI), and fiscal expenditure—are derived from official statistical sources. A spatial adjacency matrix is used to model spatial effects between provinces.

IV. EMPIRICAL ANALYSIS

4.1Descriptive statistics

Table 1 shows that all variables are reasonably distributed. The green development level (Green) averages 0.418, indicating a generally low level with notable regional disparities. The digital economy level (Digital) has a mean of 0.146, reflecting its early-stage development and uneven regional distribution. The industrial structure (industrial) mean of 1.374 suggests a dominant tertiary sector in most areas, with some regions showing strong service advantages. Economic development (economic) varies moderately, while environmental regulation (environ) and openness (FDI) show low averages but high maxima, indicating strengths in some regions. Fiscal expenditure (fiscal) shows moderate variation. Overall, the data quality supports further regression analysis.

Table1:Descriptive Statistics

	count	mean	sd	min
Green	300	0.418	0.151	0.097
Digital	300	0.146	0.111	0.024
industrial	300	1.374	0.738	0.611
economic	300	10.912	0.429	9.889
environ	300	0.014	0.010	0.002

Source: Author's Calculation

4.2Correlation Analysis

Table 2 presents the results of the correlation analysis. A significant positive correlation exists between green development (Green) and digital economy level (Digital), with a coefficient of 0.103 (significant at the 10% level), suggesting that digital development may promote green growth. Green is strongly correlated with industrial structure (0.587) and economic development (0.192), both significant at the 1% level, indicating that industrial upgrading and stronger economic performance support green development.

Environmental regulation (environ) shows a significant negative correlation with Green (-0.262), possibly reflecting a short-term “governance over transformation” effect in some regions. The correlation between FDI and Green is weak and insignificant (0.039), suggesting an unclear impact of foreign investment on green development. Fiscal expenditure (fiscal) is positively correlated with Green (0.137, significant at the 5% level), indicating a potential supportive role of government spending.

Notably, Digital is highly correlated with economic development (0.749) and negatively with fiscal expenditure (-0.555), pointing to possible multicollinearity among variables. Overall, the correlation results offer preliminary insights and a theoretical basis for the construction of regression models.

Table2:Correlation Analysis

	Green	Digital	Industrial	Economic	Environ	FDI	Fiscal
Green	1.000						
Digital	0.103*	1.000					
industrial	0.587***	0.460***	1.000				
economic	0.192***	0.749***	0.445***	1.000			
environ	-0.262***	-0.302***	-0.036	-0.226***	1.000		
FDI	0.039	0.360***	0.120**	0.372***	-0.069	1.000	

fiscal	0.137**	-0.555***	0.081	-0.514***	0.444***	-0.278***	1.000

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

Source: Author's Calculations

4.3Multiple Collinearity Analysis

To test for multicollinearity among explanatory variables, a Variance Inflation Factor (VIF) analysis was conducted. Results show that all VIF values are below 10, with an average of 2.02, well under the commonly used thresholds (5 or 10), indicating no serious multicollinearity. The digital economy variable (Digital) has the highest VIF at 2.99, followed by industrial structure (2.65) and economic development (2.26), all within acceptable limits. Other control variables, including environmental regulation (environ), openness (FDI), and fiscal expenditure (fiscal), have VIFs below 2, suggesting low inter-variable correlation. Overall, the model is well-specified, and regression results are likely to be reliable and robust.

Tbale3: Multiple Collinearity Analysis

	VIF	1/VIF
Digital	2.99	0.3344
industrial	2.65	0.3772
economic	2.26	0.4418
environ	1.76	0.5690
FDI	1.27	0.7868
fiscal	1.2	0.8351
MeanVIF	2.02	

Source: Author's Calculations

4.4Benchmark Regression

Table 4 presents the baseline regression results using a two-way fixed effects model. In Model (1), Digital has a positive and significant effect on green development (coef. = 0.121, 5% level). After adding control variables in Model (2), the coefficient rises to 0.176 (1% level), confirming a robust and strengthened effect.

Fiscal expenditure positively impacts green development (coef. = 0.366, 1% level), while FDI shows a significant negative effect (-0.444), possibly due to pollution-intensive foreign investments. Other controls—industrial structure, economic development, and environmental regulation—are not significant, potentially due to measurement or regional differences.

The models show strong explanatory power ($R^2 = 0.982$ and 0.984), and the digital economy consistently promotes green development, supporting the study's hypothesis and laying the groundwork for spatial analysis.

Tbale4: Benchmark Regression

	(1) Green	(2) Green
Digital	0.121**	0.176***
	(2.546)	(2.867)
industrial		-0.002
		(-0.103)
economic		0.007
		(0.515)

environ		-0.206
		(-0.935)
FDI		-0.444***
		(-3.642)
fiscal		0.366***
		(4.150)
_cons	0.400***	0.242
	(55.404)	(1.650)
Province_FE	Yes	Yes
Year_FE	Yes	Yes
N	300	300
r2	0.982	0.984

T-statistics in parentheses， *p<0.1,**p<0.05,***p<0.01

4.5Benchmark Regression

4.5.1 Spatial Correlation Test

(1) Global Moran Index

Global Moran's I was calculated for green development and digital economy levels from 2012 to 2021 to assess spatial correlation. Green development consistently shows positive Moran's I values (0.1212–0.1492), mostly significant at the 10% level, indicating moderate spatial clustering with "green belts" in high-performing areas and "green gaps" in low-performing ones. The digital economy exhibits stronger spatial correlation, with Moran's I values ranging from 0.2514 to 0.2959, all significant at the 1% level, highlighting clear regional clustering and spillover effects. These results justify the use of spatial econometric models to better capture and analyze the spatial impact of the digital economy on green development.

Tbale5: Moran Index of Spatial Level of Green Economic Development

Year	I	E(I)	Sd(I)	Z	P-value
2012	0.1325	-0.0345	0.0914	1.8274	0.0676
2013	0.1410	-0.0345	0.0917	1.9129	0.0558
2014	0.1296	-0.0345	0.0922	1.7806	0.0750
2015	0.1345	-0.0345	0.0923	1.8301	0.0672
2016	0.1492	-0.0345	0.0909	2.0208	0.0433
2017	0.1255	-0.0345	0.0910	1.7592	0.0785
2018	0.1212	-0.0345	0.0912	1.7066	0.0879
2019	0.1275	-0.0345	0.0920	1.7614	0.0782
2020	0.1340	-0.0345	0.0927	1.8166	0.0693
2021	0.1482	-0.0345	0.0933	1.9570	0.0504

Tbale6: Moran Index of Spatial Level of Green Economic Development

Year	I	E(I)	Sd(I)	Z	P-value
2012	0.2929	-0.0345	0.0874	3.7468	0.0002
2013	0.2739	-0.0345	0.0873	3.5317	0.0004
2014	0.2959	-0.0345	0.0877	3.7684	0.0002
2015	0.2919	-0.0345	0.0880	3.7089	0.0002
2016	0.2770	-0.0345	0.0879	3.5423	0.0004
2017	0.2644	-0.0345	0.0880	3.3977	0.0007
2018	0.2514	-0.0345	0.0873	3.2734	0.0011
2019	0.2573	-0.0345	0.0869	3.3591	0.0008
2020	0.2584	-0.0345	0.0869	3.3714	0.0007
2021	0.2607	-0.0345	0.0867	3.4046	0.0007

(1) Local Moran Scatter Plot

Local Moran Scatterplots from 2012 to 2021 show clear spatial clustering for both green development and digital economy levels. Green development exhibits high-high clusters in developed eastern provinces (e.g., Jiangsu, Zhejiang) and low-low clusters in less developed western regions (e.g., Qinghai, Gansu), indicating spatial agglomeration. The digital economy shows even stronger clustering, with core regions like Beijing and Shanghai consistently in high-high zones, while central and western areas remain in low-low clusters, highlighting a persistent digital divide. These patterns confirm spatial spillover effects and justify the use of spatial econometric models.

Figure 1: Partial Moran Scatter Plot of Economic Green Development Level

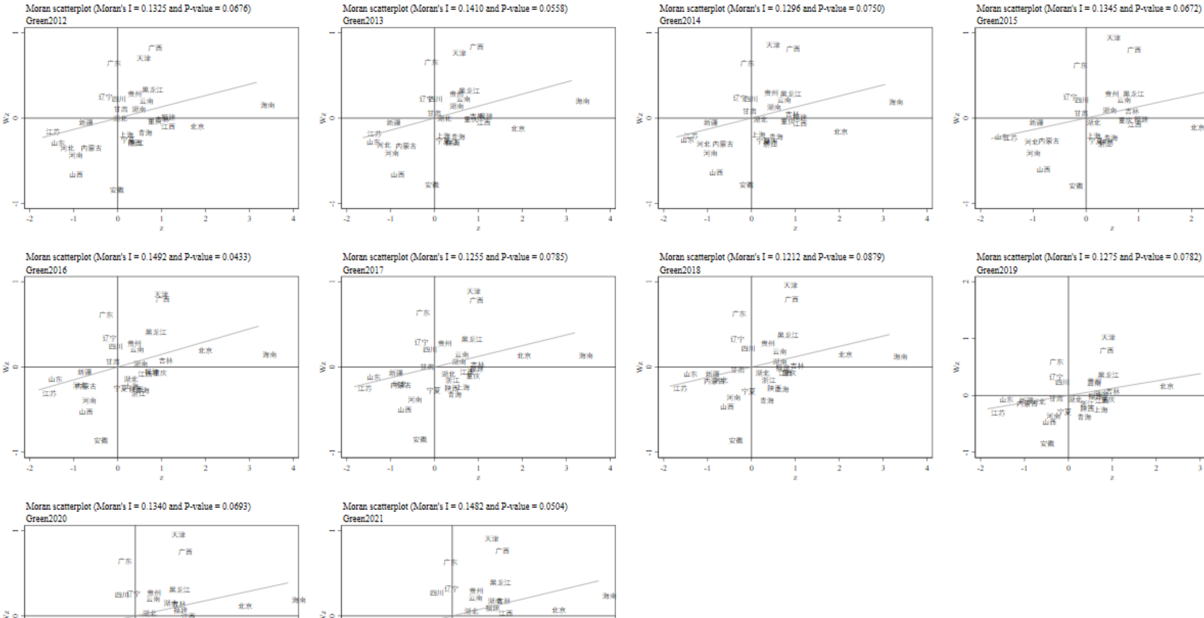
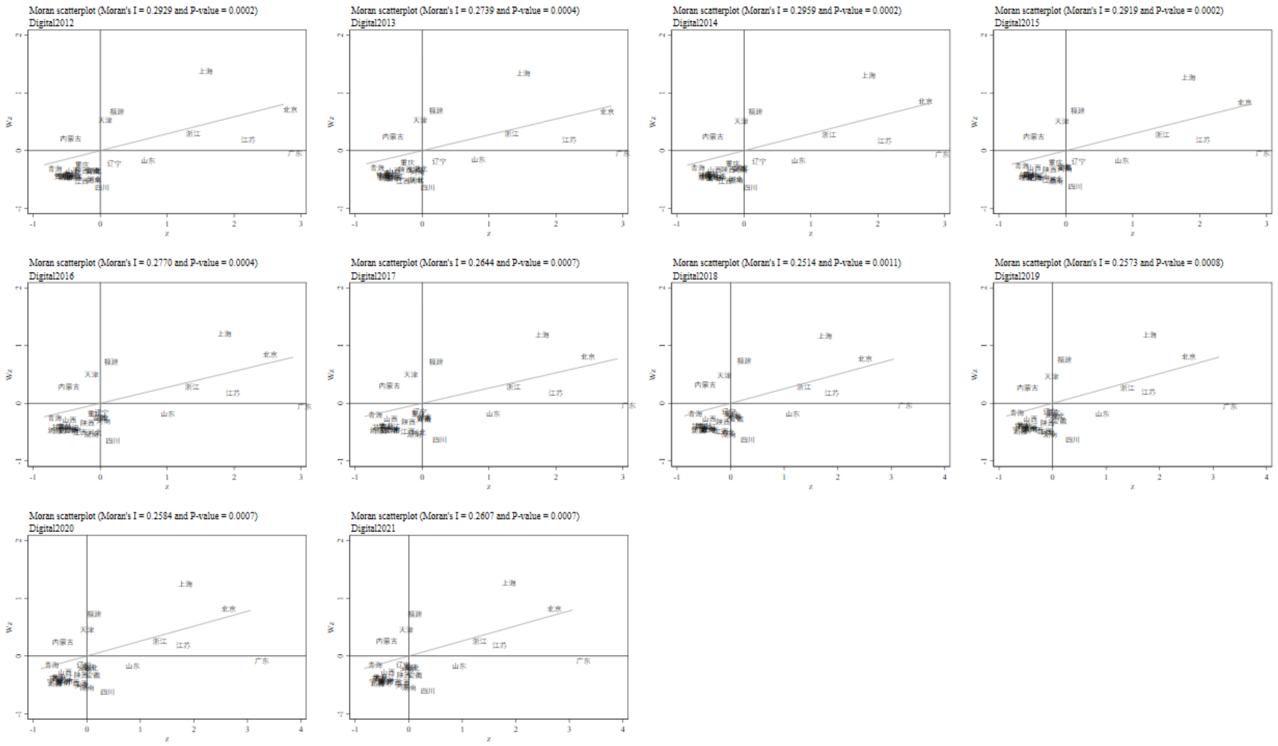


Figure 2: Moran Scatter Plot of Local Digital Economy Development Level



4.5.2 Selection of Spatial Econometric Models

Moran’ s I and Local Moran Scatterplots confirm significant spatial correlation between the digital economy and green development, justifying spatial econometric analysis. This study conducts model tests from three aspects to better capture the direction and strength of the digital economy’ s impact.

(1) LM Test

The first strp is LM tests. To identify spatial effects, LM-Lag, Robust LM-Lag, LM-Error, and Robust LM-Error tests were conducted based on the OLS model. As shown in Table 7, all tests significantly reject the null hypothesis, indicating the presence of both spatial lag and spatial error dependence. Since the Spatial Durbin Model (SDM) accounts for both effects, it is preliminarily selected as the appropriate model.

Tbale7: LM Test

Test	Statistic	df	p-value
The Moran index	2.9530	1	0.0030
LM-Lag checkout	7.0420	1	0.0080
Robust LM-Lag test	8.9550	1	0.0030
LM-error test	1.5680	1	0.2110
Robust LM-error test	3.4810	1	0.0620

(2) LR test and Wald test

LR and Wald tests were conducted to determine whether the SDM can be simplified to SAR or SEM models. As shown in Table 8 , both tests are highly significant ($p < 0.01$), rejecting the null hypothesis of model simplification. Therefore, the Spatial Durbin Model is confirmed as the appropriate model for analyzing spatial spillover effects (see Table 8).

Table 8 : Results of LR Test and Wald Test

Model	LR checkout		Wald checkout	
	X^2	P price	X^2	P price
Whether it degenerates into SAR	53.87***	0.000	110.74***	0.000
Whether it degenerates into SEM	54.12***	0.000	101.08***	0.000

(3) Hausman Test

The Hausman test (Table 4-9) strongly rejects the random effects model (χ^2=51.49, p=0.000), confirming that a two-way fixed effects Spatial Durbin Model is the appropriate final specification.

Table 9 : Hausman Test Results Table

Model	Hausman test	
	X^2	P price
Whether to choose the random effect	51.49***	0.000

In summary, based on LM, LR, Wald, and Hausman tests, this study selects the two-way fixed effects Spatial Durbin Model (SDM) as the core model to examine the spatial spillover effects of the digital economy on green development. The model is well-specified, robust, and effectively captures the spatial transmission mechanism of regional green development.

4.5.3 Spatial Econometric Model

(1) Spatial Spillover Effect

Using Spatial Durbin Models with varying fixed effects, the digital economy consistently shows a strong positive impact on local green development, especially under two-way fixed effects (coefficient 0.265, $p<0.01$). However, its spatial spillover effect is significantly negative (−0.452), suggesting digital growth in one region may hinder neighboring areas due to competition for resources.

FDI negatively affects green development, likely linked to pollution-heavy foreign investments, while fiscal expenditure positively supports local green growth but shows limited or negative spillovers to nearby regions.

The spatial lag coefficient ρ is positive without year effects but turns negative with two-way fixed effects, indicating complex spatial interactions.

In summary, the digital economy promotes green development locally but may create regional imbalances through negative spillovers, highlighting the need for coordinated policies to foster balanced, sustainable growth.

Table 10 : Results of Spatial Spillover Effect

	(1) Green	(2) Green	(3) Green
Main			

Digital	0.230***	0.274***	0.265***
	(3.462)	(4.300)	(4.617)
industrial	0.001	-0.006	-0.003
	(0.065)	(-0.541)	(-0.306)
economic	-0.008	-0.013	0.002
	(-0.521)	(-0.969)	(0.186)
environ	-0.193	-0.163	-0.198
	(-1.034)	(-0.922)	(-1.240)
FDI	-0.478***	-0.494***	-0.546***
	(-3.860)	(-4.202)	(-5.148)
fiscal	0.283***	0.278***	0.299***
	(3.613)	(3.664)	(4.190)
_cons	-0.351		
	(-1.164)		
Wx			
Digital	-0.496***	-0.589***	-0.452***
	(-3.573)	(-4.433)	(-3.681)
industrial	0.153***	0.152***	0.124***
	(5.529)	(5.538)	(4.465)
economic	0.069**	0.102***	0.199***
	(2.301)	(3.194)	(4.494)
environ	-0.612	-0.457	-0.159
	(-0.864)	(-0.680)	(-0.236)
FDI	0.170	0.454	-0.169
	(0.303)	(0.851)	(-0.340)
fiscal	-1.119***	-1.062***	-0.432*
	(-6.539)	(-6.238)	(-1.701)
Spatial			
rho	0.424***	0.413***	-0.198*
	(6.806)	(6.717)	(-1.959)
Variance			
lgt_theta	-3.201***		
	(-21.479)		
sigma2_e	0.000***	0.000***	0.000***
	(11.499)	(12.170)	(12.204)
PROVINCE_FE	NO	Yes	Yes
YEAR_FE	NO	NO	Yes
N	300.	300	300
r2	0.055	0.017	0.007

T-statistics in parentheses,*p<0.1,**p<0.05,***p<0.01

(2) Decomposition of Spatial Spillover Effect

Using a two-way fixed effects Spatial Durbin Model, effects were split into direct (local) and indirect (neighboring) impacts on green development. Digital economy (Digital) has a strong positive direct effect (0.282, $p<0.01$) but a significant negative spillover (−0.428, $p<0.01$), resulting in a slightly negative total effect (−0.146, $p<0.1$), indicating regional competition and uneven growth.

Industrial structure and economic development show positive indirect and total effects, aiding green growth locally and regionally. Environmental regulation is insignificant. FDI negatively impacts local green development (−0.549), suggesting environmental risks. Fiscal expenditure helps local green growth (0.319) but negatively affects neighbors (−0.396, $p<0.1$), implying fiscal competition.

Overall, digital economy and fiscal support promote local green development but cause negative spatial spillovers, highlighting the need for coordinated regional policies for balanced green transformation.

Table 11 : Spatial Spillover Effects—Effect Decomposition

	(1)	(2)	(3)
	LR_Direct	LR_Indirect	LR_Total
Digital	0.282***	-0.428***	-0.146*
	(4.626)	(-3.931)	(-1.680)
industrial	-0.007	0.104***	0.097***
	(-0.756)	(4.566)	(4.191)
economic	-0.003	0.170***	0.168***
	(-0.204)	(4.535)	(4.567)
environ	-0.201	-0.083	-0.284
	(-1.300)	(-0.146)	(-0.493)
FDI	-0.549***	-0.055	-0.605
	(-5.395)	(-0.132)	(-1.450)
fiscal	0.319***	-0.396*	-0.078
	(4.477)	(-1.763)	(-0.326)
PROVINCE_FE		Yes	
YEAR_FE		Yes	
N		300.000	
r2		0.007	

T-statistics in Parentheses,*p<0.1,**p<0.05,***p<0.01

V. CONCLUSION

This study analyzes data from 30 Chinese provinces from 2012 to 2021 to examine the impact of the digital economy on green development and its spatial spillover effects, using two-way fixed effects and Spatial Durbin Models (SDM). Significant regional differences exist in both green development and digital economy levels, which show a positive correlation. The digital economy strongly promotes local green growth, while fiscal spending also has a positive effect. In contrast, foreign direct investment (FDI) negatively impacts green development, likely due to the transfer of high-pollution industries.

Spatial analysis confirms positive clustering in green development and digital economy levels, justifying the use of SDM to capture spatial interactions. The SDM results reveal that while the digital economy has a robust positive effect on local green development, it produces negative spillover effects on neighboring regions, indicating competition and resource concentration. Effect decomposition further shows that the digital economy has a significant positive direct effect but a significant negative indirect effect, resulting in an overall negative total effect. Meanwhile, economic development and industrial upgrading exhibit positive spatial spillovers, benefiting neighboring areas.

In summary, the digital economy promotes green development locally but may widen regional disparities due to negative spatial spillovers. These findings suggest that policies should emphasize regional coordination, optimize digital infrastructure, and promote resource sharing to achieve balanced and sustainable green growth across the country.

REFERENCES

1. Tapscott, D. (1996). The digital economy: Promise and peril in the age of networked intelligence. McGraw-Hill.
2. Moulton, B. R. (1999). GDP and the digital economy: Keeping up with the changes. Understanding the digital economy data.
3. Kling, R., & Lamb, R. (1999). IT and organizational change in digital economies. ACM SIGCAS Computers and Society, 29(3), 17-25.
4. Brynjolfsson, E., Hu, Y., & Smith, M. D. (2003). Consumer surplus in the digital economy: Estimating the value of increased product variety at online booksellers. Management Science, 49(11), 1580-1596.
5. Liu, Z. R. (2001). The driving forces behind the development of the digital economy in the United States and their implications. Science & Technology Information Development & Economy, 2001(4), 72-74.
6. Li, C. J. (2017). A preliminary discussion on the connotation of the digital economy. E-Government, 2017(9), 84-92.
7. Zhang, X. L., & Jiao, Y. X. (2017). An initial exploration of the digital economy development index in China and its applications. Zhejiang Social Sciences, 2017(4), 32-40 + 157.
8. Bukht, R., & Heeks, R. (2017). Defining, conceptualising, and measuring the digital economy. Development Informatics Working Paper, 68.
9. Zhao, T., Zhang, Z., & Liang, S. K. (2020). Digital economy, entrepreneurial activity, and high-quality development: Empirical evidence from Chinese cities. Management World, 36(10), 53-69.
10. Zhu, J. X., & Li, J. J. (2023). Digital economy, technological innovation, and urban green economic efficiency: An empirical analysis based on spatial econometrics and mediation effects. Economic Issues Exploration, 487(2), 111-125.
11. China Academy of Information and Communications Technology. (2024). China Digital Economy Development Report 2024. People’s Publishing House.
12. Li, J., & Zhang, T. D. (2021). Input-output analysis and measurement of the scale of China’s digital economy. Contemporary Economic Management, 43(10), 66-73.
13. Xu, J., & Tang, Q. (2019). A literature review on digital economy and national economic accounting. Economic Dynamics, 2019(10), 117-131.
14. Cai, Y. Z., & Niu, X. X. (2021). Estimation and structural analysis of the value-added scale of China’s digital economy. Chinese Social Sciences, 2021(11), 4-30.
15. Xu, X. C., & Zhang, M. H. (2020). A study on the measurement of China’s digital economy scale: A perspective from international comparisons. China Industrial Economics, 2020(5), 23-41.
16. Wang, J., Zhu, J., & Luo, X. (2021). The development level and evolution measurement of China’s digital economy. Quantitative Economics and Technical Economics Research, 38(7), 26-42.
17. He, W. D., Wen, J. L., & Zhang, M. Y. (2022). The impact of digital economy development on China’s green ecological efficiency: Based on the bidirectional fixed-effect model. Economic Issues, 2022(1), 1-8 + 30.

18. Zhang, Z. H., Sun, J. W., & Zhao, H. D. (2019). Path analysis of achieving green and high-quality development in Inner Mongolia under dual constraints. Inner Mongolia Social Sciences (Chinese Edition), 40(5).
19. Shi, M. J., & Xu, Y. (2018). The current status and implementation paths of China’s green economic development. Environmental Protection, 46(10), 14-18.
20. Zhu, D. B. (2020). Xi Jinping's concept of green development: Its ideological foundation, connotation system, and contemporary value. Economist, 2020(3), 5-15.
21. Qian, Y. (2020). Efforts to achieve ecological prioritization and green development. Environmental Science Research, 33(5).
22. Han, X. F., Zheng, Z. J., & Yin, Y. P. (2024). Innovation-driven policies, government environmental attention, and green high-quality development: Evidence from the National Independent Innovation Demonstration Zones. Soft Science, 1-12.
23. Qi, Y., & Zhao, W. X. (2020). Fiscal expenditure structure and green high-quality development: Evidence from Chinese prefecture-level cities. Environmental Economics Research, 5(4), 93-115.
24. Liu, N. Q., Deng, M., & Cao, X. G. (2021). Does the e-commerce transformation of cities promote green high-quality development? Evidence from quasi-natural experiments based on the construction of national e-commerce demonstration cities. Financial Research, 47(4), 49-63.
25. Lu, F. Z., Wang, Q. Y., & Li, Z. W. (2023). Does digital finance promote China’s green high-quality development? China Population, Resources and Environment, 33(11), 142-151.
26. Ma, Z. G., Zhao, Q. Q., & Jiang, Y. X. (2022). Evaluation of green high-quality development in national independent innovation demonstration zones. China Population, Resources and Environment, 32(2), 118-127.
27. Liu, K., Shi, D., Xiang, W., et al. (2022). How has the efficiency of China's green development evolved? An improved non-radial directional distance function measurement. Science of The Total Environment, 815, 152978.
28. Sui, D. C., Zhang, Y., & Meng, W. S. (2023). Measurement of green development efficiency and spatial differentiation in the Yellow River Basin. Statistics and Decision, 39(2), 116-119.
29. Wang, B., Wu, Y. R., & Yan, P. F. (2010). Regional environmental efficiency and growth of total environmental factor productivity in China. Economic Research, 45(5), 95-109.
30. Wu, R., Li, B., & Yuan, S. W. (2022). The impact of digital economy on regional high-quality economic development. Industrial Technology and Economic Research, 41(1), 29-36.
31. Zhang, T., Jiang, F. X., & Wei, Z. T. (2021). Can the digital economy become a new driver for promoting China's high-quality economic development? Economic Issues Exploration, 2021(1), 25-39.
32. Liu, W. L., & Wang, Y. B. (2022). Effects and mechanisms of digital economy empowering urban green high-quality development. Southern Economics, 2022(8), 73-91.
33. Zhang, X., Wei, F. L., & Yuan, X. M. (2020). Evaluation and evolution of the high-quality green development level in China’s provinces. Economic Geography, 40(2), 108-116.
34. Li, P. R. (2022). Digital economy, technological innovation, and green development. Technology Economics and Management Research, 313(8), 46-51.
35. Xu, J. W., & Liu, Z. H. (2023). Measurement and collaborative interaction effects of provincial digital economy and green economy in China. Ecological Economics, 1-14.