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Article

Research on the Spatial Effect of Government Science and Technology Expenditure on the Development of Digital Economy

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Abstract: In the context of a unified large market, the development of digital economy has become the focus. Based on the panel data of 31 provinces in China from 2011 to 2020, this paper uses the spatial Durbin model to examine the impact of government spending on digital economy through different spatial weight matrices. The research results show that: 1) The government science and technology expenditure in all provinces in China has a significant positive spatial correlation with the level of digital economy development; 2) The comparative analysis of different weight matrices show that the impact of local government science and technology expenditure on the level of digital economy development is significant and positive, and there is a certain spatial spillover effect; 3) Through the heterogeneity test, the spillover effect of the central and western regions of China is more obvious under the setting of the geographical weight matrix, and the spillover effect of the east is more obvious under the setting of the economic matrix weight. At the same time, this study expands the research on the influencing factors of the development level of the digital economy, and puts forward policy recommendations corresponding to government science and technology expenditure and the development of the digital economy based on the empirical results.

Keywords: Digital Economy; Government Science and Technology Expenditure; Spatial Spillover Effect

1. Introduction

The digital economy is a new development trend formed after the agricultural economy and the industrial economy. It promotes greater alignment of fairness and efficiency. The development speed, radiation scope, and degree of influence of the digital economy is all at the forefront, constantly promoting the transformation of production, living and governance methods, and gradually becoming the key to the competition and transformation of world resources, structures and patterns. During the "13th Five-Year Plan" period, China has deepened the digital economy development strategy, strengthens and improves digital infrastructure, and continuously cultivates new business forms and new models, resulting in remarkable achievements in digital industrialization and industrial digitization. During the "14th Five-Year Plan" period, China digital economy has turned to a new stage of development. In 2021, the Notice of the State Council on Printing and Distributing the "14th Five Year" Digital Economy Development Plan mentions that the added value of China's digital economy core industry will reach 7.8% of gross domestic product (GDP) in 2020, and the digital economy will continue to promote the sustainable and healthy development of the economy and society. The digital economy continues to promote the sustainable and healthy development of the economy and society. According to the data released by the Ministry of Science and Technology recently, in 2021, the whole country's R&D investment will reach 2.79 trillion yuan, a year-on-year increase of 14.2%, and the intensity of R&D investment will reach 2.44%. In 2020, Longhua District proposes to accelerate the development of "Digital Longhua". Now, "Digital Longhua, Urban Core" has become a business card of Longhua District. The development of Digital Longhua cannot be separated from scientific and technological innovation, which cannot be separated from the support of government scientific and technological expenditure. At the same time, in the context of a unified large market, the government requires to continuously increase digital construction, promote the integration of online and offline, and use the digital economy to break the regional limitations of the region.

At present, the development of a new round of technological revolution and industrial transformation has accelerated the digital transformation. Through the influence of multiple internal and external factors, the situation facing the development of China digital economy is also constantly changing. So, can increasing local financial support for the development of the digital economy significantly affect the level of development level of the digital economy in the corresponding region? Will local financial support have spatial spillover effects? Through the exploration of the above problems, this study can provide useful policy inspiration for the development of China digital economy to a certain extent.

2. Literature Review

2.1. Digital Economy

Entering the 21st century, digital technology is advancing by leaps and bounds around the world. Since the outbreak of the Covid-19 epidemic, the world pattern has undergone tremendous changes. On the one hand, the world economy has been seriously damaged, but on the other hand, the development of the digital economy has also received attention from countries around the world. In view of the existing literature, the relevant literature on the development and impact of the digital economy is excavated, and it is concluded that the research direction of the existing literature is mainly concentrated in the following aspects:

The first is the level of macroeconomic development. Sun et al (2021) [1] believe that the development level of the regional digital economy shows significant spatial imbalance characteristics. Jiao (2021) [2] studies the regional differences and dynamics of the development of the digital economy, and uses the natural fracture method to develop the digital economy. The levels are divided into five classes.

The second is industry and governance. The first is industrial digitization. Zhang (2018) [3] points out that to promote the development of the digital economy, it is necessary to develop the manufacturing industry firstly, pay attention to the transformation and upgrading of the real economy, and transform the industrial structure to the mid-to-high end. Zheng et al (2020) [4] find that the digital development of the industrial chain can be promoted through clustering; followed by the digital industry, Liu et al (2022) [5] believe that the focus should be on how to give full play to the penetration of digital technologies such as big data. The role is the main task of the digital industry;

the last is digital governance. Zhao et al (2022) [6] believe that it is necessary for us to systematically analyze the mechanism and dilemma of the digital economy to promote the reform of government governance, seek countermeasures, and promote the digitalization of government governance.

The third is to combine the digital economy with urban development, consumption or enterprises. Gao et al (2022) [7] link the digital economy with consumption, and believe that the digital economy is an important focus for driving consumption upgrades. Liao et al (2021) [8] believe that the digital economy can improve the ability of enterprises to allocate resources and then promote the transformation of the manufacturing industry upgrade.

2.2. Financial Support

At present, there are limited studies on finance and digital economy, and related literatures are mostly studied from both macro and micro aspects. First, at the macro level, Fan et al (2020) [9] accelerate the construction of new infrastructure and improve the global competitiveness of China digital economy from the perspective of supply and demand. Fan (2021) [10] believes that the reform of the fiscal and taxation system should conform to the trend of economic digitization, make effective efforts in employment and other aspects, carry out macro-coordination in terms of supply and demand, and guide the formation of a unified large market from the perspective of financial system and mechanism. Li et al (2021) [11] believes that digital finance can drive the upgrade of public consumption and stimulate the demand for digital consumption in the field of public services. With the help of digital technology, it can accurately grasp the trend of social and economic operation and effectively carry out macro-control. Deng et al (2021) [12] obtain through the mediation effect test that the development of digital economy can affect local fiscal sustainability through fiscal revenue. At the micro level, Li et al (2021) [13] analyze the financial system from five aspects: the legal system and development environment of the digital economy, the macro layout of infrastructure optimization projects, the integration with traditional industries, the guidance of consumption upgrades, and the synergy of fiscal, taxation and financial policies. Combined with the digital economy, we will continue to promote the positive effect of financial support on the development of the digital economy. Jiang (2022) [14] combines finance and digital innovation, and believes that government preference can significantly improve the effect of regional digital innovation, but the incentive effect on regional digital innovation efficiency is not significant.

By combing the relevant literature on the digital economy through fiscal policy, it is found that the existing literature has the following characteristics: First, regarding the digital economy, most literatures in the past five years have studied the digital economy and the real economy, technological innovation, and industrialization and innovation. The combination of efficiency and the combination of finance and the digital economy is relatively rare; secondly, most of the current research focuses more on the theoretical level, and there is less research on the spatial effect of finance and the digital economy. Therefore, after measuring the development level of the digital economy, on the basis of sorting out relevant theories, this paper uses the dynamic panel data of 31 provinces in China from 2011 to 2020 to test the impact of government science and technology expenditure on the development level of the digital economy. From the perspective of spatial spillover effects government science and technology expenditure and the level of development of the digital economy will be studied. The innovation of this paper is to study whether there is a spillover effect of government science and technology expenditure on the development level of digital economy from a spatial perspective through a spatial econometric model.

3. Theoretical Analysis and Research Assumptions

Keynesian fiscal expenditure theory believes that due to insufficient effective demand, government intervention is needed, and the main means of government intervention is fiscal expenditure. Therefore, Keynes put great emphasis on the role of financial expenditure means. According to the classification of government revenue and expenditure by the Ministry of Finance, as government science and technology expenditure is a part of financial expenditure, this paper studies the impact of government science and technology expenditure on digital economy from the perspective of government science and technology expenditure. Lu et al (2020) [15] believe that the development of digital economy can significantly improve the quality of urban economic development in the region, and significantly promote the economic development of neighboring regions. Not only that, Yang et al (2021) [16] believe that the impact of digital economy development is heterogeneous. The study found that the spatial distribution of my country's digital development level is not completely random, but presents a state of agglomeration, but the problem of regional imbalance in the development of digital economy is prominent. Based on the previous research by scholars, it can be concluded that there is a significant spatial effect in the development of the digital economy. Fiscal policy, as a basic criterion formulated by the state to know fiscal distribution activities and deal with various fiscal distribution relationships, reflects the state's focus on economic development to a certain extent. Therefore, this paper focuses on the study of the impact of government science and technology expenditure on the development level of the digital economy influences. Based on the above analysis, this paper proposes the following two hypotheses:

Hypothesis 1: Government science and technology expenditure can promote the level of development of the digital economy, and government science and technology expenditure have a certain spatial effect on the level of development of the digital economy.

Hypothesis 2: Government science and technology expenditure has different effects on the development level of the digital economy in different regions.

4. Research Design

4.1. Variable Selection

4.1.1. Explained Variable

Digital economy development level (dig). By borrowing the method of Zhao et al (2020) [17], the core of the measurement is set to the development of the Internet, and the construction idea of the indicator system of digital transactions is added to measure the development level of the digital economy from both the Internet and digital financial inclusion. The raw data for the indicators can be obtained from the China Urban Statistical Yearbook.

Starting from the comprehensive development index of digital economy, this paper selects five secondary indicators. The construction of indicators is shown in Table 1. After that, the weight and comprehensive index of the indicators are calculated by the entropy method, and the comprehensive development level of the digital economy in 31 provinces in China from 2011 to 2020 is obtained, which is recorded as dig.

Table 1. Construction of regional digital economy comprehensive development indicators.

First-level indicator	Secondary indicators	Indicator properties	Index weight
Digital Economy Comprehensive Development Index	Internet penetration	Positive indicators	0.079
	Number of Internet-related employees	Positive indicators	0.315
	Internet related output	Positive indicators	0.423
	Number of mobile internet users	Positive indicators	0.091
	Digital financial inclusion development	Positive indicators	0.094

The main purpose of this paper is to investigate the spatio-temporal evolution pattern of China's digital economy development from 2011 to 2020. In order to ensure the comparability of the time series of relevant indicators, first, the indicators of different properties and units are dimensionless. In order to avoid the uneven distribution caused by the large difference of indicator values, the data shall be standardized as follows.

$$X_{ij} = \frac{X_{ij} - \min(X_{1j}, X_{2j}, \ldots, X_{nj})}{\max(X_{1j}, X_{2j}, \ldots, X_{nj}) - \min(X_{1j}, X_{2j}, \ldots X_{nj})} \tag{1}$$

$$X_{ij} = \frac{\max(X_{1j}, X_{2j}, \ldots, X_{nj}) - X_{ij}}{\max(X_{1j}, X_{2j}, \ldots, X_{nj}) - \min(X_{1j}, X_{2j}, \ldots X_{nj})} \tag{2}$$

Formula (1) is a positive indicator formula, and Formula (2) is a negative indicator formula. Among them, X_{ij} refers to the value of index j of province i before standardization, X_{ij} refers to the value of index j of province i after standardization, and n refers to provinces, autonomous regions, and municipalities directly under the Central Government (due to the availability of data, this paper considers excluding Hong Kong, Macao, and Taiwan, so n is 31), and m refers to the number of indicators (building a digital economy development evaluation index system that includes one level one indicator and five level two indicators, so m is 5).

The weight is calculated by entropy method. The entropy method reflects the information content of the same index difference, which can effectively avoid the influence of subjective factors in the weight setting process. Before calculating the weight of each indicator, first calculate its information entropy. The formula is as follows.

$$E_j = \frac{1}{n} \sum_{i=1}^{n} \left(\frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \ln \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \right) \tag{3}$$

Secondly, calculate the weight of each evaluation index. The formula is as follows.

$$W_j = \frac{(1 - E_j)}{\sum_{j=1}^{m} (1 - E_j)} \tag{4}$$

Finally, based on the standardized value X_{ij} of each indicator and the weight W_j of each indicator, the multi-objective linear weighting function method is used to calculate the digital economy development level at the national and provincial levels from 2011 to 2012. The calculation formula as follows.

$$D_i = \sum_{j=1}^{m} W_j X_{ij} \tag{5}$$

4.1.2. Explanatory Variables

Local Government Science and Technology Expenditure (GOV): the new infrastructure such as 5G networks, data centers, and industrial Internet that China is focusing on promoting the construction of, is essentially the digital economic infrastructure around the science and technology innovation industry. Therefore, this paper expresses the proportion of government science and technology expenditure in fiscal spending to measure government science and technology expenditure.

4.1.3. Control Variables

The selection of control variables refers to the practices of Sun et al. (2021) and Liang et al. (2021), considering the theme of this study. The control variables selected in this paper are as follows:

1) Regional R&D investment (R&D): expressed by the ratio of the internal expenditure of scientific research funds in each province to GDP.

2) Regional economic development level (ECO): by GDP.

3) Urbanization level (URB): measured by dividing the urban population of each province by the total population.

4) Industrial structure (IND): dividing by the output value of the tertiary industry in each province expressed by gross output value.

5) Financial development level (FINANCE): expressed by the ratio of institutional deposit and loan balance to regional GDP.

4.2. Econometric Model

In order to verify the impact of local government science and technology expenditure on the development level of the digital economy, the linear model form of this paper is set as follows.

$$dig_{it}=a+\varrho Wdig_{it}+\beta GOV_{it}+\beta_1 X_{control}+\delta WGOV_{it}+\delta_1 WX_{control}+\mu_i+\theta_t+\varepsilon_{it} \tag{6}$$

In formula (6), dig represents the regional digital economy development level of 31 provinces in my country; GOV represents the scientific and technological expenditure of local governments, $X_{control}$ is a control variable, a is a constant term, ϱ is a spatial autoregressive coefficient, and W is the standardized value. Spatial weight matrix, β represents the regression coefficient of the independent variable, δ represents the influence coefficient vector of the spatial lag term of the dependent variable, μ_i is the time effect, θ_t is the spatial effect, and ε_{it} represents the random error term.

Government science and technology expenditure contribute to some extent to the level of digital economic development, but endogeneity problems may arise when unobserved variables confound the level of digital economic development and government science and technology expenditure, or when measurement errors in government science and technology expenditure are significant. In order to solve the problem of endogeneity and consider the interdependence of space, this paper constructs a dynamic space panel for analysis, and the model is set as follows.

$$dig_{it}=a+\tau dig_{it-1}+\xi Wdig_{it-1}+\varrho Wdig_{it}+\beta GOV_{it}+\beta_1 X_{control}+\delta WGOV_{it}+\delta_1 WX_{control}+\mu_i+\theta_t+\varepsilon_{it} \tag{7}$$

The dig_{it-1} is the first-order lag term of the explained variable. The implication is the impact of the previous period's local government science and technology expenditure on the level of digital economy development. τ is the regression coefficient of the first order lag term of the development level of the digital economy, ξ is the spatial autoregressive coefficient and other variables are explained in the same way as formula (6).

4.3. Data Sources and Descriptive Statistics

The data sources and calculation methods of each variable are obtained from the table below.

Table 2. Variable selection and indicator description.

Variable type	Variable name	Variable symbol	Indicator explanation	Data Sources
Explained variable	Digital economy development level	dig	Calculated using the entropy method	Calculated by the author
Explanatory variables	Government science and technology expenditure	GOV	Government Technology Expenditure/Fiscal Expenditure	"China Science and Technology Statistical Yearbook"
	Regional R&D Investment	R&D	Internal expenditure of scientific research funds in various provinces/GDP	
Control variable	Regional economic development level	ECO	Regional GDP per capita by GDP deflator	National Bureau of Statistics
	The level of urbanization	URB	Urban population/Total population of each city	
	Industrial structure	IND	Tertiary industry output value/Total output value of each province	
	level of financial development	FINANCE	Institutional Deposit and Loan Balance / Gross Regional Product	

Table 3. Descriptive statistics of each variable from 2011 to 2020.

Variable	Variable name	Mean	Std. Dev.	Min	Max
dig	Digital economy development level	0.371	0.174	0.0773	0.982
GOV	Government science and technology expenditure	2.039	1.471	0.3	6.76
R&D	Regional R&D Investment	1.628	1.141	0.19	6.44
ECO	Regional economic development level	5.104	2.409	1.602	14.096
URB	The level of urbanization	0.577	0.132	0.227	0.896
IND	Industrial structure	0.494	0.089	0.327	0.837
FINANCE	level of financial development	0.031	0.011	0.012	0.073

Descriptive statistics for each variable can be obtained from the table below. According to Table 3, the average value of the digital economic development level of the explained variable is 0.371, the maximum value is 0.982, and the minimum value is 0.0773, indicating that there are differences in the development level of digital economy in different regions. Explanatory variables the average value of government science and technology expenditure is 2.039, the maximum value is 6.76, and the minimum value is 0.3, indicating that there are significant differences in the level of government science and technology expenditure in different regions. There are also significant differences in regional R&D investment, regional economic development level, urbanization level, industrial structure and financial development level of control variables.

4.4. Spatial Econometric Methods

Based on the methods and principles of spatial econometrics, the idea of spatial econometric analysis of factors affecting the development level of digital economy is as follows: First, Moran's I index method is used to test whether there is spatial autocorrelation in the level of digital economy development of the dependent variable; if there is spatial autocorrelation, then a spatial econometric model is established to estimate and test the spatial econometric factors influencing the development level of the digital economy.

4.4.1. Spatial Autocorrelation

First, the global Moran's I index is used to test the spatiality of the development level of the digital economy. The formula is as follows.

$$Moran's\ I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(Y_i-\overline{Y})(Y_j-\overline{Y})}{S^2\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \tag{8}$$

In Equation (3), n is the total number of regions, Y_i is the observation value of i region, W_{ij} is the spatial weight and S is the standard deviation, S^2 is the variance. The value range of Moran's I index is [-1, 1]. If Moran's I>0, the variables are considered to have positive spatial correlation; if Moran's I<0, it is spatially negative correlation; if Moran's I=0, there is no spatial correlation sex.

There are three types of weight matrices constructed in this paper: the first one is the geographic distance weight matrix (W_1), in which this paper calculates the geographic distance between provincial capitals through latitude and longitude and then takes the reciprocal; the second one is the economic distance weight matrix (W_2), which is calculated by the inverse of the absolute value of the difference in per capita GDP between the two regions; the third is the geographic and economic nested weight matrix (W_3), the formula is $W_3=kW_1+(1-k)W_2$, where k is the value The range is between 0 and 1, indicating the proportion of the geographic distance weight matrix. This part refers to the practice of Shao Shuai et al. (2016), and the value of k is set to 0.5.

4.4.2. Spatial Measurement Model

The spatial measurement model mainly includes the spatial Durbin model (SDM), the spatial lag model (SLM) and the spatial error model (SEM). Regarding the selection of the spatial econometric model in this paper, it is first assumed that the optimal spatial econometric model in this paper is the Spatial Doberman Model (SDM), which will be selected based on the following tests.

5. Analysis of Empirical Results

5.1. Spatial Correlation Test

Table 4 shows the spatial Moran index results of the digital economy development index. It can be seen from the results in the table that under the settings of the three weight matrices, the global Moran index of the development level of the digital economy is all greater than 0 and very significant. This results in a significant spatial effect on the distribution of development level of the digital economy in various provinces in my country. In these study samples, however, Moran index values show a volatile downward trend over time. This also shows that the spatial agglomeration effect of the development level of the digital economy may gradually weaken over time. At present, the economic level of various regions in China has been significantly improved, and the imbalance between regions is also weakening. In particular, the national policies of "western development" and "the rise of the Central Plains" have accelerated the economic development of the central and western regions. In addition, the digital economy development pilot zone set by the state covers the east, the central, and the west. Chongqing, Guizhou and other places in the west have accelerated the development of digital economy, which has weakened the spatial agglomeration effect of the development level of digital economy to a certain extent. Therefore, the spatial cluster effect of the development level of digital economy will gradually weaken over time.

In addition, the Moran value of the digital economy development index is generally larger than the geographic distance weight matrix and the geographic economy nested weight matrix under the economic distance weight matrix, which shows that the economy plays a promoting role in the spatial impact of the development level of the digital economy. The spatial influence of economic development level plays a narrowing role.

Table 4. Spatial Moran's I Index of Regional Digital Economy Development Index.

Year	Weight matrix W_1		Weight matrix W_2		Weight matrix W_3	
	Digital economy		Digital economy		Digital economy	
	Moran's I	Z value	Moran's I	Z value	Moran's I	Z value
2011	0.058***	3.085	0.405***	4.945	0.210***	3.275
2012	0.060***	3.192	0.403***	4.969	0.206***	3.251
2013	0.053***	2.940	0.425***	5.202	0.204***	3.213
2014	0.044***	2.673	0.421***	5.271	0.195***	3.157
2015	0.032**	2.287	0.410***	5.165	0.184***	3.014
2016	0.042***	2.666	0.416***	5.304	0.192***	3.165
2017	0.030**	2.219	0.408***	5.140	0.182***	2.984
2018	0.023*	1.918	0.380***	4.720	0.169***	2.750
2019	0.018*	1.772	0.372***	4.671	0.162***	2.677
2020	0.012	0.029	0.364***	4.620	0.147**	2.504

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.2. Analysis of Spatial Measurement Results

5.2.1. Model Selection and Related Tests

The first step is to test the model. Table 5 shows the diagnostic test results of the spatial econometric model. The LM statistics in the table are all significant at the 1% level under the three weight matrices, indicating that the SEM model and the SAR model can be selected, so we choose the

SDM model combining the two. Secondly, the Hausman test is carried out, and it is concluded that the results are significant under the three weight matrices, and the fixed effect model is better than the random effect model, so the fixed effect model is better selected in this paper. After the fixed effect model is determined, it is necessary to test the three fixed effects and choose the most suitable model for this paper. The test results shows that the region fixed effect and the time fixed effect is very significant. Therefore, when choosing the SDM model in this paper, it is better to choose the time-space double-fixed effect model. The Wald test shows that the null hypothesis that the SDM model can degenerate into SAR and SEM is rejected, and the SDM model is accepted. From the results of the LR test, it can be concluded that under the three matrix settings, the LR statistic has passed the significance test at the 1% level, which is consistent with the previous Wald test results. SDM cannot be degenerated into SAR model or SEM model. Therefore, the model can be extended to a time-space bidirectional fixed effect model.

To sum up, this paper chooses the SDM under double fixed effects to test the spatial effect of local government science and technology expenditure on the development level of the digital economy.

Table 5. Diagnostic tests of spatial econometric models.

Diagnostic tests	Weight matrix W_1		Weight matrix W_2		Weight matrix W_3	
	Value	P-Value	Value	P-Value	Value	P-Value
LM-error	1054.179***	0.000	37.011***	0.000	57.565***	0.000
Robust LM-error	767.219***	0.000	12.446***	0.000	22.738***	0.000
LM-lag	353.917***	0.000	46.446***	0.000	60.532***	0.001
Robust LM-lag	66.957***	0.000	21.881***	0.000	25.705***	0.000
Hausman test	20.33***	0.0024	14.08**	0.0288	21.57***	0.0014
Wald test-SAR	45.29***	0.0000	105.90***	0.0000	24.64***	0.0004
Wald test-SEM	43.82***	0.0000	97.97***	0.0000	24.68***	0.0004
LR-SDM-SAR	42.36***	0.0000	89.72***	0.0000	23.72***	0.0006
LR-SDM-SEM	42.12***	0.0000	89.78***	0.0000	23.75***	0.0006
LR-both-ind	46.02***	0.0000	102.51***	0.0000	109.64***	0.0000
LR-both-time	308.85***	0.0000	805.58***	0.0000	389.41***	0.0000

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

5.2.2. Measurement Results of the SDM

1) Analysis of the impact of government science and technology expenditure on the development level of the digital economy.

Table 6 shows the estimated results of the SDM. Among them, the columns (1), (3) and (5) are the estimation results of the static SDM under the three weight matrix settings, respectively, and the columns (2), (4) and (6) are the three dynamic SDM estimation results under the weight matrix setting. According to Table 6, under the economic distance weight matrix and the economic geography nested weight matrix, the coefficient of local government science and technology expenditure is 0.007 and 0.004 are both positive. And both are significant for the weight matrices W_2 and W_3, indicating that the government's science and technology expenditure. It has a positive role in promoting the development level of the digital economy. Under the setting of weight matrix W_1 and W_2, the coefficient of local government science and technology expenditure is significantly -0.043 and -0.012, indicating that local government's financial expenditure on science and technology can restrain the development level of digital economy in regions with similar geographical locations or similar economic conditions to a certain extent. That is to say, the local government's science and technology expenditure have a spatial effect on the development level of the digital economy to a certain extent. So, Hypothesis 1 is verified. The continuous increase in the proportion of local governments in science and technology expenditure can promote the transformation and upgrading of enterprises to a certain extent, spawn new digital enterprises, and improve the development level of the local digital economy. Due to the scarcity of resources, the increase in the proportion of local government science and technology expenditure will attract many companies to influx. While improving the development level of the digital economy in the region, it will also inhibit the development of the digital economy in areas with similar geographical locations or economic conditions.

Table 6. Estimation results of spatial panel model under three weight matrix settings.

Variable	Weight matrix W_1		Weight matrix W_2		Weight matrix W_3	
	(1)	(2)	(3)	(4)	(5)	(6)
dig_{t-1} (τ)		1.504*** (32.31)		1.814*** (36.52)		0.928*** (20.12)
$Wdig_{t-1}$ (ξ)		4.476*** (11.13)		3.204*** (22.59)		0.638*** (3.52)
WGOV (ϱ)	-0.043*** (-2.62)	0.072*** (6.24)	-0.012** (-2.25)	0.0006 (0.16)	-0.004 (-0.56)	0.008* (1.85)
GOV	-0.0002 (-0.11)	0.006*** (4.06)	0.007*** (3.74)	0.011*** (7.42)	0.004* (1.82)	0.006*** (3.87)
R&D	0.001 (0.17)	-0.010** (-2.18)	-0.0004 (-0.07)	-0.016*** (-3.38)	0.002 (0.32)	-0.011** (-2.36)
ECO	0.012*** (3.36)	-0.002 (-0.58)	-0.018*** (-3.73)	-0.015*** (-3.64)	0.012*** (2.88)	0.009*** (3.01)
URB	-0.289*** (-3.72)	0.218*** (3.66)	0.227*** (2.71)	0.285*** (4.10)	-0.100 (-1.28)	0.087 (1.52)
IND	-0.228*** (-4.77)	-0.241*** (-6.70)	-0.191*** (-4.66)	-0.073** (-2.16)	-0.248*** (-5.51)	-0.148*** (-4.42)
FINANCE	-0.519** (-2.24)	1.898*** (11.61)	-0.589*** (-2.77)	-0.663** (-4.03)	-0.533** (-2.23)	0.225 (1.36)
N	310	279	310	279	310	279

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Test statistics with Z test in ( ).

In order to reduce the error of the model and make the dynamic change of the spatial spillover effect of the model more accurate, the following part will focus on analyzing the estimation results of the dynamic spatial model.

According to the columns (2), (4) and (6) of Table 6, the time lag coefficient under three weight matricesτ1.504, 1.814 and 0.928 respectively, significantly positive at the 1% level, indicating that at the time dimension level, urban there is an obvious path dependence in the development of the digital economy, and the development level of the digital economy in the next period can be predicted by the results of the current period, which also means that the improvement of the development level of the digital economy is a long process that requires a lot of accumulation. The spatial lag coefficient ϱ is significantly positive when it is 0.07 and 0.008 under the weight matrix W_1 and W_3, indicating that the level of development level of the digital economy in geographically similar regions has a significant positive impact on the development of digital economy in the region, that is, there is a spatial spillover effect. Under the weight matrix of W_1, W_2 and W_3, the space-time lag coefficient ξ 4.476, 3.204 and 0.638 respectively, significantly positive at the 1% level, which indicates that under the influence of the two dimensions of time and space, the number of areas with similar geographical locations or similar economic conditions in the previous period. The level of economic development has a significant positive impact on the current level of digital economy development in the region. This shows that the increase in the level of development level of the digital economy in regions with similar geographical locations or economic conditions in the previous period will affect the current level of development level of the digital economy in this region to a certain extent, causing it to rise to a certain extent. This article attributes the reason of the fact that when a region has a relatively high level of development level of the digital economy, it will produce "spillover effects" and "demonstration effects", which in turn stimulates the level of development level of the digital economy in regions with similar geographical locations or economic conditions.

As shown in columns (2), (4) and (6) of the above table, the level of urbanization has a positive and significant relationship with the level of digital economy development. The reason is that the higher the level of urbanization, the higher the level of digital industries in the region The investment and construction of the region will be improved, which will significantly improve the development level of the digital economy in the region. On the contrary, the industrial structure has a significant negative impact on the development level of the digital economy under the three weight matrices. The reason may be that the development of the digital economy in my country at this stage is mainly concentrated in the tertiary industry. The lack of motivation for development can even lead to the preemption of digital economic resources between cities, and then there will be a "crowding-out effect", which will make the industrial structure have an inhibitory effect on the development level of the digital economy. The financial development level and the regional economic development level have different effects under different spatial weight settings, but in general, combined with the geographic and economic weight matrix, the regional economic development level has a significant role in promoting the development of the digital economy, and the level of financial development also has a positive impact on the development of the digital economy. The general view is that regional R&D investment has a promoting effect on the development level of the digital economy, and the results show that regional R&D investment has a certain negative impact on the development level of digital economy in geographically similar regions. The reason may be that the R&D investment in regions with high economic development level is high, while the R&D investment in regions with low economic development level is small. Due to the imbalance of economic development, the development level of digital economy in this region has been restrained to a certain extent.

2) The decomposition effect of government science and technology expenditure on the digital economy development.

Under the influence of the spatial spillover effect, changes in one of these factors will not only affect the development level of the local digital economy, but also affect the development level of the digital economy in areas with similar geographical locations or economic conditions. The level of development of the digital economy. Because the change of the explanatory variables associated with a spatial individual will affect the spatial individual itself, this impact is the direct effect described in the traditional regression model, and it will also indirectly affect other spatial individuals, producing indirect effects. Table 6 is an analysis of the spatial effect of government science and technology expenditure on the development level of the digital economy. However, in order to see the impact of government science and technology expenditure on the development level of the digital economy more intuitively, the results are decomposed into direct effects and indirect effects for analysis. The results are shown in Table 7.

Table 7. Decomposition results of government science and technology expenditures on the development level of digital economy under three weight matrices.

Matrix type	**Effect**	**lnGOV**	**R&D**	**ECO**	**URB**	**IND**	**FINANCE**
	Direct effect	-0.0002	0.001	0.013***	-0.282***	-0.226***	-0.512**
		(-0.10)	(0.12)	(3.58)	(-3.38)	(-4.67)	(-2.13)
W_1	Indirect effect	-0.045**	-0.057	0.063**	2.886***	0.434	-8.373***
		(-1.97)	(-1.32)	(2.07)	(3.09)	(0.94)	(-2.70)
	Total effect	-0.045*	-0.056	0.076**	2.604***	0.208	-8.865***
		(-1.91)	(-1.28)	(2.48)	(2.74)	(0.44)	(-2.79)
	Direct effect	0.007***	-0.002	-0.015***	0.173**	-0.192***	-0.456**
		(3.18)	(-0.26)	(-3.33)	(2.08)	(-4.77)	(-2.04)
W_2	Indirect effect	-0.013	-0.023	0.071***	-1.325***	-0.039	3.037***
		(-1.61)	(-1.02)	(4.34)	(-3.71)	(-0.31)	(3.45)
	Total effect	-0.006	-0.024	0.057***	-1.152***	-0.231	2.581***
		(-0.63)	(-0.96)	(3.45)	(-2.95)	(-1.64)	(2.61)
	Direct effect	0.004*	0.002	0.012***	-0.100	-0.250***	-0.520**
		(1.80)	(0.30)	(3.12)	(-1.25)	(-5.68)	(-2.14)
W_3	Indirect effect	-0.004	-0.052**	0.021	0.012	-0.098	2.949***
		(-0.51)	(-2.08)	(1.42)	(0.03)	(-0.78)	(3.34)
	Total effect	0.0004	-0.050*	0.033**	-0.086	-0.348***	2.429**
		(0.05)	(-1.88)	(2.31)	(-0.23)	(-2.65)	(2.53)

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Test statistics with Z test in ( ).

From the above results, it can be concluded that under the weight setting of W_1, the indirect effect and total effect of local government science and technology expenditure are negative, which indicates that government science and technology expenditure not only has an impact on the development level of the digital economy in the region, but also has an impact on the geographically similar regions. With certain spillover effects, Hypothesis 1 is confirmed again. Under the weight matrix of W_2 and W_3, the science and technology expenditure of local governments has only a direct effect, indicating that the increase of science and technology expenditure in a region will improve the development level of the digital economy in the region, but it has no significant effect on the development level of the digital economy in regions with similar economic conditions. Spillover Effect. It can be seen from the above that increasing the development of the digital economy in regions with similar geographical locations or similar levels of economic development will increase government science and technology expenditure in the region in the next period and improve the development level of the region's digital economy. The increase in the ratio will only have a negative impact on regions with similar geographical locations, and although there is a certain negative impact on regions with similar economic development conditions, the results are not significant. The reason may be that financial agglomeration makes regions with similar geographical locations compete for resources, while regions with similar economic development levels have different strategic orientations, and the level of economic development is similar, so that the competition for resources is not so fierce, and then the level of development level of the digital economy in a region. It does not significantly affect the level of development level of the digital economy in another region.

5.3. Heterogeneity Analysis

Due to the agglomeration effect of economic development, this paper divides the eastern, central and western region into three regions and further analyzes the regional heterogeneity of the impact of government science and technology expenditure on the development level of the digital economy. The specific results are shown in Table 8.

Table 8. Heterogeneity test in eastern, central and western regions.

Variable	W_1			W_2			W_3		
	East	Centra	West	East	Centra	West	East	Centra	West
WGOV (ρ)	0.033	0.057***	0.144***	-0.028**	-0.0004	-0.014	0.002	0.002	-0.021
	(1.91)	(3.73)	(3.54)	(-3.23)	(-0.08)	(-0.83)	(0.11)	(0.39)	(-1.12)
GOV	0.009**	0.014***	0.026***	0.004	0.005*	0.007	0.004	0.003	0.002
	(2.26)	(4.57)	(3.05)	(1.06)	(1.89)	(0.87)	(0.99)	(1.03)	(0.23)
R&D	0.012	-0.11	-0.020	0.007	-0.014	-0.028	0.013	-0.011	-0.026
	(1.27)	(-1.16)	(-1.27)	(0.79)	(-1.24)	(-1.48)	(1.28)	(-1.07)	(-1.57)
ECO	0.014***	-0.039***	-0.015	-0.021**	0.011	-0.007	0.018***	0.022**	0.002
	(3.43)	(-2.67)	(-1.57)	(-2.26)	(0.86)	(-0.59)	(3.26)	(1.99)	(0.25)
URB	-0.517***	-0.001	-0.558*	0.358*	0.559***	0.181	-0.417***	0.419**	0.124
	(-3.82)	(-0.00)	(-1.83)	(1.88)	(2.89)	(0.79)	(-2.23)	(2.04)	(0.53)
IND	-0.083	0.151**	-0.212***	-0.096	-0.079	-0.168**	-0.143	-0.045	-0.158**
	(-0.52)	(2.29)	(-3.05)	(-0.67)	(-1.44)	(-2.38)	(-1.84)	(-0.85)	(-2.55)
FINANCE	0.346	-0.719	-1.341***	-0.166	0.225	-0.790***	0.384	-0.154	-0.736***
	(0.72)	(-1.53)	(-4.82)	(-0.34)	(0.43)	(-3.20)	(0.73)	(-0.31)	(-3.15)
N	120	90	100	120	90	100	120	90	100

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Test statistics with Z test in ( ).

It can be seen from the table that under the setting of the W1 weight matrix, the spatial spillover effect of government science and technology expenditure in the central and western regions is significantly positive, and the government science and technology expenditure in the three regions is very significant. This shows that in the eastern, central and western regions, government science and technology expenditure will significantly promote the development level of the digital economy in the region. In the central and western regions, an increase in government science and technology expenditure in one region will lead to an increase in government spending in regions with similar geographical locations, and then drive the level of development of the digital economy to improve. Although the government science and technology expenditure in the east, middle and west is very significant, the absolute value of the coefficient is the west > the middle > the east. This shows that the lower the level of economic development in the region, the more the government's technology spending can stimulate the development level of the digital economy in the region. Under the setting of the W_2 weight matrix, the spatial spillover effect of government science and technology expenditure in the eastern region is significantly negative. The reason may be that due to the better economic development conditions in the eastern region, the increase in government science and technology expenditure in a region will cause more resources to flow into the region, and then it has squeezed the digital economy development market in areas with similar economic conditions in the east, and has a certain negative impact on the development of the digital economy in other areas with similar economic conditions.

Table 9. Replacement core explanatory variables.

Variable	Weight matrix W_1		Weight matrix W_2		Weight matrix W_3	
	(1)	(2)	(3)	(4)	(5)	(6)
dig_{t-1} (τ)		1.934***		1.583***		5.149***
		(41.34)		(31.37)		(110.61)
$Wdig_{t-1}$ (ξ)		7.622***		1.755***		29.225***
		(18.73)		(12.15)		(158.53)
WlnGOV (ϱ)	-0.154**	0.238***	-0.041**	0.013	-0.021	0.489***
	(-2.37)	(4.98)	(-2.21)	(0.88)	(-0.88)	(29.38)
lnGOV	-0.004	0.020***	0.021***	0.026***	0.012	0.172***
	(-0.51)	(3.37)	(2.94)	(4.36)	(1.44)	(29.94)
R&D	0.002	-0.003	0.001	-0.015***	0.003	0.006
	(0.32)	(-0.60)	(0.20)	(-3.17)	(0.39)	(1.17)
ECO	0.012***	0.007***	-0.018***	-0.007*	0.011***	-0.120***
	(3.41)	(-2.63)	(-3.66)	(-1.75)	(2.69)	(-38.56)
URB	-0.269***	0.236***	0.194**	0.164**	-0.107	-0.327***
	(-3.37)	(3.86)	(2.29)	(2.34)	(-1.33)	(-5.50)
IND	-0.225***	-0.204***	-0.193***	-0.088**	-0.248***	0.104***
	(-4.65)	(-5.54)	(-4.71)	(-2.59)	(-5.51)	(3.07)
FINANCE	-0.541**	2.205***	-0.604***	-0.343**	-0.561**	-4.289***
	(-2.34)	(13.42)	(-2.85)	(-2.07)	(-2.36)	(-25.83)
N	310	279	310	279	310	279

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Test statistics with Z test in ( ).

5.4. Robustness Test

Zeng et al. (2022) [18] re measure the development of digital finance by using the logarithm of the digital financial index (InDf). This paper uses Zeng et al. to re measure the level of government science and technology expenditure by using the logarithm of government science and technology expenditure. In order to avoid differences in conclusions due to the selection of core explanatory variables, this paper refers to the method of Zeng et al. to conduct the following robustness tests:

5.4.1. Replace the Core Explanatory Variables

In order to avoid differences in conclusions due to the selection of core explanatory variables, this paper uses the logarithm of government science and technology expenditure (lnGOV) to re-measure the level of government science and technology expenditure. The results are shown in Table 9. The results are basically consistent with the benchmark regression conclusions, indicating that the results of this paper are robust.

5.4.2. Exclude Autonomous Regions

Table 10. Exclude autonomous regions.

Variable	Weight matrix W_1		Weight matrix W_2		Weight matrix W_3	
	(1)	(2)	(3)	(4)	(5)	(6)
dig_{t-1} (τ)		2.664***		1.730***		2.664***
		(56.29)		(35.37)		(56.29)
$Wdig_{t-1}$ (ξ)		3.763***		0.457***		3.763***
		(9.84)		(3.63)		(9.84)
WGOV (ϱ)	-0.039**	0.165***	-0.014***	0.020***	-0.039**	0.165***
	(-2.51)	(16.39)	(-2.21)	(6.05)	(-2.51)	(16.39)
GOV	-0.002	0.012***	0.007***	0.004***	-0.002	0.012***
	(-0.81)	(8.66)	(3.29)	(2.76)	(-0.81)	(8.66)
R&D	-0.002	0.016***	-0.001	-0.002	-0.002	0.016***
	(-0.31)	(3.55)	(-0.13)	(-0.35)	(-0.31)	(3.55)
ECO	0.010***	0.013***	-0.023***	0.006*	0.010***	0.013***
	(2.72)	(5.30)	(-4.80)	(1.77)	(2.72)	(5.30)
URB	-0.340***	1.898***	0.306***	-0.074	-0.340***	1.898***
	(-4.08)	(31.30)	(3.62)	(-1.17)	(-4.08)	(31.30)
IND	-0.238***	-0.777***	-0.160***	-0.115***	-0.238***	-0.777***
	(-4.25)	(-19.38)	(-3.35)	(-3.20)	(-4.25)	(-19.38)
FINANCE	-0.381	7.842***	-0.652**	0.740***	-0.381	7.842***
	(-1.11)	(35.18)	(-2.19)	(3.54)	(-1.11)	(35.18)
N	260	234	260	234	260	234

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Test statistics with Z test in ( ).

Since the government management of autonomous regions is quite different from other regions, this may make the growth of digital economy development different from the influence of government spending. Therefore, in order to verify the generality of the conclusions of this study, we chose to exclude the panel data of the five autonomous regions of Inner Mongolia, Guangxi, Tibet, Ningxia and Xinjiang. The regression results are shown in Table 10. It can be seen that the estimated parameters and significance are basically consistent with the basic regression results, which again shows that the results in this paper are robust.

The Table 9 and Table 10 shows the estimated results of the SDM. Among them, columns (1), (3) and (5) are the static SDM estimation results under the three weight matrix settings respectively, and columns (2), (4) and (6) are the dynamic model estimation results under the three weight matrix settings respectively.

6. Conclusions and Policy Recommendations

The continuous development of the digital economy not only points out the way for my country's future economic development, but also accelerates my country's socialist modernization to a certain extent, and continuously promotes the steady development of the development path of socialism with Chinese characteristics. And how we should promote the development of the digital economy and further promote the economic development of our country is an urgent problem to be solved today. Based on China's provincial panel data from 2011 to 2020, this paper uses three weight matrices and a SDM to verify the promoting effect of local government science and technology expenditure on the development of regional digital economy. Finally, the following conclusions are drawn: First, based on different spatial weight matrices, the distribution of provincial government science and technology spending and the level of digital economy development shows a positive correlation. The more science and technology spending by local governments, the better the level of local digital economy development; Expenditure can significantly improve the development level of the local digital economy. Under the three weight matrix settings, the spatial spillover effect of government science and technology expenditure in areas with similar geographical locations or similar economic conditions are significantly positive; finally, from the perspective of location, government spending from the perspective of economic development, the spatial spillover effect of government science and technology expenditure in the eastern region is greater. The research of this paper also has the following shortcomings: because the provincial data of the subdivisional subjects under the government science and technology expenditure project cannot be obtained, this paper lacks mechanism analysis, and does not better present the impact of government science and technology expenditure on the development level of the digital economy. In the future, based on this, we will increase the number of data samples, take a more micro perspective, consider the impact of government science and technology expenditure on the development level of the digital economy from various aspects, and improve its transmission mechanism.

Based on the above conclusions, this paper puts forward the following policy suggestions:

1) Since local government science and technology spending have a significant role in promoting the development level of the digital economy, regional governments should continue to increase financial investment in the development of the digital economy to stimulate the development of digital industries in the region. Development, by strengthening policy guidance, constantly regulates the development of the digital economy. In addition, it is necessary to change the talent training plan and cultivate more "digital" talents.

2) It is necessary to increase economic support for the central and western regions, increase research and development expenses, and continuously promote the balanced development of the digital economy. It is necessary to fully consider the laws of spatial heterogeneity, and based on the

advantages of the region, create a digital economy development circle and increase the demonstration effect of the digital economy development pilot zone, formulate corresponding preferential fiscal policies to enhance the attractiveness of the digital economy.

3) Local financial science and technology expenditure will affect the development level of digital economy in regions with similar geographical locations or economic conditions. At the same time, we should consider the time effect of government science and technology expenditure on the development level of digital economy, and consider the effect of regional digital economy development level from the two dimensions of space and time. Therefore, when formulating financial budgets, we should fully consider the impact across regions, and build a network platform for digital economy from the overall situation, promote the circulation of digital resources, and accelerate the creation of "digital finance".

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