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INNOVATIONS IN THE FIELD OF SPORTS INDUSTRY MANAGEMENT: ASSESSMENT OF THE DIGITAL ECONOMY'S IMPACT ON THE QUALITATIVE DEVELOPMENT OF THE SPORTS INDUSTRY

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Abstract. The rapid development of the digital economy has promoted industrial transformation and upgrading, brought changes to the production mode and personal consumption mode of enterprises, and the development of traditional industries are constantly being realised in a digital format. The research of current scholars mainly focuses on: the calculation of digital economy comprehensive index, it is only scientific interpretation, lack of empirical research; second, the lack of existing research on digital economy indicators, mostly only from a single perspective; and finally, the lack of analysis of regional heterogeneity of digital economy development. *Methodology*. In the index system weighting method is mainly divided into subjective empowerment and objective empowerment, in terms of subjective empowerment, it is based on the relative importance between the indicators by subjective judgment to give appropriate weight, such as principal component analysis, AHP; and objective empowerment is based on the original information to empower, such as cluster analysis, standard deviation, entropy and extreme method, and so forth. In the selection of measurement method, some scholars believe that the subjective weight method will be disturbed by human factors, which will bias the calculation results, and can not respond to authenticity. In view of this, this paper adopts the entropy method to measure the high-quality economic development level and digital economy development level in 31 provinces in China from 2010 to 2019. The research of current scholars mainly focuses on: the calculation of digital economy comprehensive index, it is only scientific interpretation, lack of empirical research; second, the lack of existing research on digital economy indicators, mostly only from a single perspective; and finally, the lack of analysis of regional heterogeneity of digital economy development. This paper constructs three subsystems and 11 basic indicators to construct the evaluation index of digital economy development, and three subsystems and 9 basic indicators to evaluate the high-quality development of sports industry. To explore the spatial spillover effect of digital economy development on the high-quality development of sports industry, the high-quality development of sports industry in China in 2011–2020 was taken as the explanatory variable, and the development of digital economy was taken as the explanatory variable. The *purpose of the article* is to build spatial measurement model three subsystems, which include 11 basic indicators to construct the evaluation index of digital economy development, and three subsystems and 9 basic indicators to evaluate the high-quality development of sports industry. The base of research is 31 provinces, municipalities, autonomous regions of China. *Conclusion*. First, the digital economy is innovation as the core driving force of the new economic form, and the deep fusion of sports industry can give new impetus to the development of high-quality sports industry, further promote the development of the quality of sports industry. Second, digital economy development through advanced digital technology can directly and indirectly promote the development of sports industry, digital economy and sports industry quality development have significant spatial correlation, "high-high", "low-low" agglomeration characteristics, digital economy development can significantly promote the regional sports industry development, and the quality of sports industry development is also obvious.

Key words: digital economy, sports industry, quality development, spatial measurement, China.

JEL Classification: A13, C50, Z21

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1. Introduction

In 2020, China's digital economy will reach 3.92 trillion RMB, accounting for 38.6% of GDP. The digital economy has become an important channel to drive China's economy to achieve high-quality development. The process of digitalisation is also accelerating the development of the economy through deeply integrated digital industrialisation. In August 2021, the General Administration of Sport of China issued the 14th Five-Year Sports Development Plan to support the innovative application of big data, block chain, cloud computing and other new technologies in the field of sports, and implement the digital strategy of the sports industry. The sports industry is at a critical stage of structural transformation, and there are still a number of problems of unreasonable business structure, low product and service quality, and low brand growth efficiency. With the emergence of a new round of scientific and technological revolution and industrial transformation, the digital economy with data as the core production factor and based on digital information technology is booming, which will play an important role in the high-quality development of the sports industry.

In 2021, China also issued the Opinions on Promoting National Fitness and Sports Consumption and Promoting the High-Quality Development of the Sports Industry, which indicates that China's sports industry has entered a stage from high-speed growth to high-quality development in the new era. In the high-quality development stage, it is necessary to pay attention not only to the speed of scale expansion, but also to the quality of industrial development and the economic and social benefits of industrial development. Therefore, this paper is of great significance to analyse the spatial spillover effect of the digital economy on the high-quality development of the sports industry.

2. Literature Review

– Research on Measuring the Development of the Digital Economy.

Kang Tiexiang (Kang, 2008) also agreed that the premise of digital economy development is digital technology, and pointed out that the digital economy, the transaction mode of generation is carried out through bit flow, and it is believed that the development of digital economy is virtual and highly addictive. With regard to the characteristics of high permeability, the paper also points out that the digital economy includes basic industries and this industry is conducive to digital industry development, for the second part of the value-added calculation method is borrowed from Maclup and the United States measurement system, and puts forward the specific measurement method to measure the development of the digital economy in China in 2002 research. Turcan Viorica, Gribincea Alexandru and Birca Iulita. (Turcan et al., 2014) pointed out that the key to the development of the digital economy lies in information, which can promote the generation of new products and services in the development of the digital economy and create new values for society in the process of economic development. Le Ying, Jin Bo and co-authors of the publication (Ying, Bo et al., 2020) pointed out that the core of the digital economy between digital knowledge and information, digital technology is the premise of the development of the Internet, the purpose is the digitization of the whole process of the development of the real economy, promoting economic restructuring and development, and points out that the characteristics of the digital economy is the development of information technology as a premise. In this projection, databases become the main mode of digital development. Xu Xianchun and Zhang Meihui (Xianchun and Meihui, 2020) say that digital economy is based on the premise of digital technology development, with the help of digital platform of economic activities, digital economy rapid development is mainly reflected in promoting the development of traditional industries in a digital format, mainly includes three parts, infrastructure, digital trade and trade products, and the measurement results are compared with other countries. Analysed studies confirm the role of digital economy in promoting economic growth.

– Evaluation and Research of the Qualitative Development of the Sports Industry.

The academic circle has made a preliminary exploration on the construction of the high-quality development index system and the evaluation operation mechanism of the sports industry. Guo Han and Ren Baoping (Han and Baoping, 2020) believe that the high-quality development of sports industry includes five dimensions: product supply, market units, industrial integration, development force and high quality of governance systerнорм. Li Ronggri and Liu Ningning (Ronggri and Ningning, 2020) put forward the evaluation structure of high-quality development of sports industry in the new era, which consists of core elements (happiness) and system elements (development force, industrial main body, industrial structure, industrial operation and industrial layout). Zhang Qing and Chai Wangjun (Qing and Wangjun, 2020) and other officials put forward the realisation path of high-quality development of sports industry from the overall performance of low development quality of sports industry, the main limiting factors and the internal reasons of development difficulties. Wang Xianliang and Zhang Ruilin (Xianliang and Ruilin, 2020), based on the "three-level" theory and two-dimensional evaluation theory of high-quality development, explored the direction, value, power and approach of high-quality development of the sports industry.

Ren Bo and Huang Haiyan (Bo and Haiyan, 2021) analysed the value and power of the supply-side reform of the sports industry and the connotation and power of high-quality development, and clarified the difficulties in the current supply-side reform of the sports industry. In the future, the internal logic of the supply-side reform of the sports industry in the government, market, society and industry should be improved.

– Research on the Qualitative Development of the Sports Industry through the Digital Economy.

Shen Keyin et al. (Keyin et al., 2022) believe that digital economy can improve the efficiency of government management and governance, promote the all-round transformation and refined operation of the sports industry, and enhance the competitive awareness and scene building ability of sports enterprises. Pan Wei, Shen Keyin (Wei and Keyin, 2022) based on the nature and characteristics of digital economy, from the perspective of industrial integration, innovation and development, long-tail effect, supply and demand, explain the theory of promoting the development of sports industry, the economic environment, political environment, consumption environment. Traction digital economy boosts sports industry quality external power, and technological change, industrial change, business innovation is the digital economy driving sports industry transformation and upgrading endogenous power. Luo Yuxin et al. (Yuxin et al., 2022) believe that digital economy mainly reduces industrial costs and improves industrial efficiency by forming platform economic effect, supplemented by business model upgrading, and enables digital innovation to achieve a leading role in the sports industry. Ren Bo, Huang Haiyan (Bo and Haiyan, 2021) analysed the connotation and dimension of sports quality development and the role and significance of digital economy, at the macro level, digital economy can increase production factors, change resource allocation, improve total factor productivity, drive the sports industry organization, promote sports industry structure, at the micro level, digital economy can drive sports enterprises to produce scale economy and economy of scope. Wang Jian xun, Shen Keyin (Jian xun and Keyin, 2020) point out that digital economy era to realize the development of sports industry high quality, can speed up the sports industry supply chain and the global value chain, build and demand supply system to support the transformation to accelerate the digital sports industry, accelerate the sports industry in the field of digital chain and establish special digital economy policies and regulations.

By combing the research of relevant scholars, it is found that the research of digital economy on the high-quality development of sports industry in the digital economy mainly focuses on theoretical research, and few scholars confirm it from the empirical aspect. This paper uses the spatial measurement method to analyse the spatial spillover effect of digital economy on the high-quality development of sports industry.

3. Research Methodology

(1) Data source and index indicators

Based on the balance between the comprehensiveness of the index system and the availability of data, the data of 31 provinces in China from 2010 to 2019 (excluding Hong Kong, Macao and Taiwan) are selected and processed as follows: first, the missing data are interpolated or compared; second, the proportion of some indicators is calculated on the basis of the original indicators. Data are taken from the China Statistical Yearbook, the China Science and Technology Statistical Yearbook, the China Population and Employment Statistical Yearbook, the China Education Statistical Yearbook, the China Information Yearbook, the Sports Yearbook, provincial statistical yearbooks and the China Digital Economy Development Report over the years.

In the index system weight method is mainly divided into subjective empowerment and objective empowerment, in terms of subjective empowerment, it is based on the relative importance between the indicators through subjective judgement to give corresponding weight, such as principal component analysis, AHP; and objective empowerment is based on the original information to empowerment, such as cluster analysis, standard deviation, entropy and extreme method, and so on. In the choice of measurement method, some scholars believe that (Xu Zhi, Ding Renzhong, 2019), the subjective weight method will be disturbed by human factors, which will bias the calculation results, and can not respond to authenticity. In view of this, this paper adopts the entropy method to measure the level of high-quality economic development and the level of digital economy development in 31 provinces in China from 2010 to 2019. The calculation steps are as follows:

Step 1. Standardise the data:

Forward pointer:

$$x_{ij}^* = \frac{x_{ij} - m_j}{M_j - m_j} \quad (1)$$

Negative indicators:

$$x_{ij}^* = \frac{M_j - x_{ij}}{M_j - m_j} \quad (2)$$

$M_j = \max\{x_{ij}\} m_j = \min\{x_{ij}\}$

Step 2. Calculate the share of the index:

$$p_{ij} = x_{ij} / \sum_{i=1}^{n} x_{ij} \quad (3)$$

Step 3. Calculate the information entropy of each component based on its specific gravity:

$$e_j = -\frac{1}{\ln n}\sum_{i=1}^{m} p_{ij} \ln(p_{ij}) \quad (4)$$

Step 4. Calculate the excess information entropy:

$$d_j = 1 - e_j \quad (5)$$

Step 5. Calculate the weight of each indicator:

$$w_j = d_j / \sum_{i=1}^{n} d_j \quad (6)$$

Step 6. Calculate the final composite score.

w_j is the composite development index of region j, which ranges from 0 to 1. The higher the w_j, the higher the level of development, and vice versa, the lower the w_j, the lower the level of development.

It was found that the research of modern scholars mainly focuses on: firstly, the calculation of a comprehensive index of the digital economy, which is only a scientific interpretation, lacking empirical research; secondly, the lack of existing studies of

Table 1
Digital Economy Development Index System

Overall performance	Secondary indicators	Basic indicators	Indicator measure	Unit	Indicator attribute
Digital economy	Digital infrastructure	Internet penetration rate	Broadband Internet users / resident population at the end of the year	%	+
		Long-distance optical cable line density	Long-distance optical cable line length / urban area * 10,000	%	+
		Internet infrastructure	Total assets of the information transmission, computer services and software industries	Wan Yuan	+
		The proportion of Internet users	Internet access number / permanent resident population at the end of the year	%	+
	Digital industry scale	Software business revenue	Total revenue from software sales	Wan Yuan	+
		Number of Internet-related employees	Information transfer, software and information technology, staffing services	thousands of people	+
		The proportion of high-tech products exports in the export volume of commodities	Exports of high-tech products / total exports of goods	%	+
	Digital R&D investment	Computer and office equipment manufacturing industry investment	Total expenditure for the computer and office equipment manufacturing industry	Wan Yuan	+
		Investments in the production of electronic and communication equipment	Total expenditure for the electronic and communication equipment manufacturing industry	Wan Yuan	+
		Investment in introducing high-tech industries	Total funds for the introduction of high-tech industries	Wan Yuan	+
High-quality development of the sports industry	Sports industry structure	Rationalization of the sports industry structure	Added value of sports industry / GDP	%	+
		Advanced sports industry structure	Sports attendant added value / GDP	%	+
	Sports industry scale	Sports industry operating income	Sports industry, the total income	Wan Yuan	+
		Number of people in the sports industry	Number of people in the sports industry	thousands of people	+
		Number of sports enterprises	The number of sports enterprises	individual	+
		Sports industry patent	Sports industry application for a patent	part	+
	Sports industry research and development investment	Investment in sports science and technology	Sports expenditure on science and technology / total sports expenditure	%	+
		Investment in new technology introduction in the sports industry	Total funds for the introduction of new technology in the sports industry	Wan Yuan	+
		Innovations by sports enterprises and investments in research and development	Total amount of innovation and research and development funds of sports enterprises	Wan Yuan	+

Source: authors' own elaboration

Table 2
Variable setting

Type of variable	Variable name	Measure	Variable symbol	Unit
Explained variable	High-quality development of the sports industry	The entropy value method was calculated	HQDS	
Explanatory variable	Digital economy development	The entropy value method was calculated	DIGIT	
Controlled variable	Sports industry, the infrastructure	Number of stadiums	Sta	Pcs
	Economic development level	GDP per capita	Eco	Yuan
	financial support	Investment in the sports industry	Fis	%
	Sports industry scale	Value-added value of the sports industry	Spo	%
	Level of urbanization development	Urbanization rate	Urb	%
	educational input	Number of sports institutions	Edu	Pcs

Source: authors' own elaboration

digital economy indicators, mostly from only one point of view; and finally, the lack of analysis of regional heterogeneity in the development of the digital economy. How to construct and measure the development of digital economy development is an important suggestion to pursue the high-quality development of sports industry in the new era, which is particularly important for the sustainable and healthy development of China's sports industry. This paper constructs three subsystems and 11 basic indicators to construct the evaluation index of digital economy development, and three subsystems and 9 basic indicators to evaluate the high-quality development of sports industry. It is as follows:

Variable specification

In order to investigate the spatial impact of the development of the digital economy on the qualitative development of the sports industry, the qualitative development of the sports industry in China in 2011–2020 was taken as the explanatory variable and the development of the digital economy as the control variable. Six control variables were constructed based on the data of other scholars. In concrete terms, this is expressed in the following:

Spatial correlation model

Before deciding whether to use the spatial measurement method, spatial correlation of the subjects should be checked before deciding whether to use it. The spatial measurement method can only be used if there is spatial correlation. Therefore, the spatial correlation of qualitative economic development and digital economy development is first checked.

1. Spatial correlation test method

Global autocorrelation. To study the spatial interaction and spillover effects of the digital economy on the quality development of the sports industry, the global Moran's I index was used to test the spatial correlation. The calculation formula is as follows:

$$Moran's\ I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j}(Y_{it}-\bar{Y})\left(Y_{jt}-\bar{Y}\right)}{S^2\sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j}} \quad (7)$$

The weight matrix $w_{i,j}\bar{Y}Y_{it}Y_{jt}$, defined above as the average development level, is the development level in year t for i and j fields, respectively.

Local autocorrelation. The local Moran index is calculated as follows:

$$\text{Local Moran's } I_i = \frac{\left(Y_{jt}-\bar{Y}\right)}{S^2}\sum_{j=1}^{n} w_{i,j}\left(Y_{jt}-\bar{Y}\right) \quad (8)$$

The range of values of the Moran's I index is [-1,1]; if the index is positive, there is a spatial positive correlation, otherwise, there is a spatial negative correlation.

2. Spatial weight matrix setting

The spatial weighting matrix $(w_{i,j})$ can be used to reflect spatial relationships and dependency characteristics, so the adjacent spatial matrix, geospatial matrix, and economic spatial matrix were used.

The adjacency space matrix, a simple weight matrix of a binary space, is defined as follows:

$$W_{i,j} = \begin{cases} 1, & i = j \\ 0, & i \neq j \end{cases} \quad (9)$$

Geospatial matrix. Wang Shoukun (2013) suggests that the closer the distance between two places, the greater the weight, which is set as follows:

$$W_{i,j} = \begin{cases} \frac{1}{d_{ij}} & i \neq j \\ 0 & i = j \end{cases}$$

$W_{i,j}$ refers to the distance between the two provincial capitals, which better reflects the relationship between social and economic development between cities.

Economic spatial matrix. Geographical factors are not the only factor leading to spatial effects. Using an inverse distance matrix construction (Lin Guangping, 2006), the economic matrix is defined as follows:

$$W_{i,j} = \begin{cases} \frac{1}{\left|Y_i - Y_j\right|} & i \neq j \\ 0 & i = j \end{cases} \quad (11)$$

Economic variables $(Y_i Y_j)$ representing region i and region j, were measured using GDP per capita.

Construction of a Spatial Measurement Model

3. Spatial measurement model

In order to further analyse the impact of the digital economy on the qualitative development of the sports industry, a spatial auto-regressive model (SAR), a spatial error model (SEM) and a spatial Dubin model (SDM) were created, and then the most appropriate model was determined using various tests for empirical analysis. The details are as follows:

Spatial auto-regressive model (SAR)

$$y = \lambda Wy + X\beta + \varepsilon \quad (12)$$

They indicate the qualitative level of development of the sports industry, W is the spatial weight matrix, X is the n*k data matrix, the corresponding coefficient and the regression coefficient (² »)

Spatial Error Model (SEM)

The spatial dependence can also be reflected by error terms, which allows to build a spatial error model (SEM)

$$y = X\beta + \varepsilon$$
$$\mu = \rho M\mu + \varepsilon,\ \varepsilon \sim N(0, \sigma^2 I_n) \quad (13)$$

ρM is a spatial weighting matrix representing the spatial error coefficients, X, y and above.

Spatial Durbin Model (SDM)

$$y = \lambda Wy + X\beta + WX\delta + \varepsilon \quad (14)$$

WXδ explains the effect of variables for adjacent regions, X, y indicated ibid.

4. Threshold regression model

The digital economy may have heterogeneity in the qualitative development of the sports industry. Therefore, construct the threshold panel model:

$$HQDS_{it} = \beta_0 + \beta_1 DIGIT_{it} I(q_{it} \le \gamma) +$$
$$+ \beta_2 DIGIT_{it} I(q_{it} > \gamma) + \alpha Z_{it} + \mu_i + \varepsilon_{it} \quad (15)$$

$HQDS_{it} DIGIT_{it} Z_{it} \mu_i \lambda_t \varepsilon_{it} q_{it}$, is a control variable indicating individual fixed effect, time fixed effect and residual term. Represents a threshold variable, indicates the level of development of the digital economy or the level of regional economic growth in the estimation of the threshold panel model, indicates the threshold value and indicates the impact of the development of the digital economy on the quality development of the sports industry when the threshold variable is greater than or less than the threshold value, respectively. Unless there is a non-linear impact on regional economic growth, the development of the digital economy or on underdeveloped areas.

$\gamma, \beta_1, \beta_2; \beta_1 = \beta_2 \beta_1 < \beta_2 \beta_1 > \beta_2$

4. Results

1. Spatial autocorrelation analysis

Based on the high-quality development index and digital economy development level index of China's sports industry measured by the entropy method, and combined with four spatial weight matrices, the global Moran's I index of China's high-quality sports development and digital economy development in 2011–2020 is calculated, as shown in Table 3.

According to the above measures, the comprehensive index of China's digital economy development level and high-quality development level of sports industry, combined with the setting of adjacent space matrix, geographical matrix and economic space matrix and nested matrix, respectively, calculated the global Moran's I index of China's digital economy and sports industry from 2010 to 2019, as shown in Table 3.

From the Moran's I index of the four space weight matrices in the above table, the high-quality development of digital economy and sports industry has passed the significance test under the four weight spaces, and the embedded matrix is the most significant under the economic space weight matrix. Digital economy and sports industry high-quality development in four space weight matrix has certain differences, but in general, China's digital economy and sports industry high-quality development has significant positive global space autocorrelation, that China's digital economy and sports industry high-quality

Table 3
Global Moran's I Index for High-quality Development of Digital Economy and Sports Industry

Year	Adjacency space matrix		Geographic distance matrix		Economic space matrix		Nested matrix	
	DIGIT	HQDS	DIGIT	HQDS	DIGIT	HQDS	DIGIT	HQDS
2011	0.098*	0.120*	0.053	0.081	0.302***	0.344***	0.572***	0.537***
2012	0.110*	0.165**	0.002	0.092*	0.267***	0.367***	0.567***	0.577***
2013	0.065	0.185**	-0.003	0.097*	0.253***	0.369***	0.551***	0.529***
2014	0.068	0.194**	-0.012	0.099*	0.217***	0.364***	0.517***	0.274***
2015	0.051	0.168**	-0.016	0.104*	0.222***	0.339***	0.512***	0.569***
2016	0.029	0.163**	-0.016	0.108*	0.184***	0.340***	0.584***	0.540***
2017	0.038	0.143*	-0.011	0.097*	0.173***	0.328***	0.513***	0.438***
2018	0.043	0.162**	0.001	0.124**	0.171***	0.320***	0.511***	0.512***
2019	0.012	0.136**	0.002	0.087*	0.141***	0.278***	0.531***	0.558***
2020	0.002	0.139**	0.006	0.096*	0.133***	0.262***	0.540***	0.535***

Source: the authors calculated it using STATA16

*** is significant at 1%; ** is significant at 5%; * is significant at 10%.

development is not completely in a state of random development, and will be affected by similar spatial characteristics.

In order to further investigate the agglomeration characteristics of the spatial distribution of the high-quality development of the digital economy and sports industry, this paper uses the nested matrix to draw the local Moran index distribution table for the high-quality development of the digital economy and sports industry in China in 2011 and 2020.

As can be seen from Table 4-7, in the Moran scatter map of the high-quality development of China's digital economy and sports industry under the economic space matrix, the vast majority of provinces are in the first and third quadrants, which further shows that there is a high degree of spatial agglomeration in the high-quality development of China's digital economy and sports industry.

2. Spatial measurement model test

Through the aforementioned spatial autocorrelation test, it was found that the digital economy has a significant spatial correlation with the quality development of the sports industry. In order to obtain the best regression results, a series of tests are needed to determine the specific form of the spatial measurement model before analysing the spatial measurement model. Select the spatial panel model based on the following steps.

The first step was to perform the LM test. The nested spatial weight matrix was used for the SEM model

Table 4
Local Moran index distribution of digital economy in 2011

Quadrant	Space-related patterns	Region	Amount
一	H-H	Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong	7
二	L-H	Inner Mongolia, Anhui, Shandong	3
三	L-L	Hebei, Shanxi, Jilin, Heilongjiang, Jiangxi, Henan, Hubei, Hunan, Guangxi, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang	17
四	H-L	Liaoning, Hainan, Chongqing, Sichuan	4

Source: authors' own elaboration

Table 5
Local Moran index distribution of digital economy in 2020

Quadrant	Space-related patterns	Region	Amount
一	H-H	Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Shandong, Guangdong	7
二	L-H	Inner Mongolia	1
三	L-L	Hebei, Shanxi, Jilin, Liaoning, Heilongjiang, Fujian, Jiangxi, Henan, Hunan, Guangxi, Sichuan, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang	19
四	H-L	Anhui, Hubei, Hainan, Chongqing	4

Source: authors' own elaboration

Table 6
Local Moran index distribution of sports industry in 2011

Quadrant	Space-related patterns	Region	Amount
一	H-H	Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong	8
二	L-H		0
三	L-L	Hebei, Shanxi, Jilin, Liaoning, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang	22
四	H-L	Inner Mongolia	1

Source: authors' own elaboration

Table 7
Local Moran index distribution of sports industry in 2020

Quadrant	Space-related patterns	Region	Amount
一	H-H	Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong	8
二	L-H		0
三	L-L	Hebei, Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang	19
四	H-L	Hebei, Liaoning, Jilin and Heilongjiang	4

Source: authors' own elaboration

and the SAR model through the spatial correlation test of ordinary static panel regression (OLS), including LM-Lag and robust LM-Lag test and LM-Error and robust LM-Error test. If the LM test passes one or two of the models, the choice of spatial model must be determined using the Wald test. If the test results reject both null assumptions, the Dubin spatial model is selected.

Table 8
Spatial dependence test

LM checkout	LM	P
LM_test_Error	18.830	0.000
RobustLM_test_Error	16.250	0.001
LM_test_Lag	20.730	0.000
RobustLM_test_Lag	27.432	0.000

Source: the authors calculated it using STATA16

Table 8 shows that LM_test_Error and robust LM_test_Error pass the 1% significance test, while LM_test_Lag and robust LM_test_Lag also pass the 1% significance test, indicating that the subjects have a double effect of both spatial lag and spatial autocorrelation of error, and that the chosen spatial Dubin model should be considered.

In the second step, the LR test and Wald test were performed. Whether the spatial Dubin model can be transformed into spatial lag model (SDM SAR) and spatial error model (SDM SEM), using LR test and Wald test respectively, the test results show that the SDM model can reject the null hypothesis of SAR model and SEM model, and accept the SDM model. Table 9 shows that the LR test values are 25.75 and 19.91, respectively, and the null hypothesis is rejected at the 1% significant level, indicating that the spatial Dubin model does not degenerate into spatial lag model and spatial error model, and it is most appropriate to select the SDM model for empirical analysis.

The third step, the Hausman test, after selecting the SDM model, determines which effect (fixed or random) will be chosen for analysis. The results of the test showed a chi2 (7) value of 38.79 and a P-value of 0.000 at the 1% significance level, indicating that the SDM model should be analysed using fixed effects.

Spatial Dubin model regression analysis. Column (1) – (3) respectively said time fixed effect, regional effect and double fixed effect of the digital economy under the influence of high-quality sports industry development coefficient, (4) – (6) column respectively represents time fixed effect, regional effect and double fixed effect of the digital economy for other areas of sports industry development of high-quality space spillover coefficient.

Based on the regression results of the spatial Dubin model, the combined significance test of the regional fixed effect, the time fixed effect and the study of this paper, some conclusions can be drawn. The P value is 0.0003 for the regional fixed effect and the two-way fixed effect test. For the time fixed effect test, the P value is 0.0000, which is significant at the 1% significance level, indicating that the null hypothesis is rejected and the regression results of the two-way fixed effect model prevail.

Main is the coefficient of influence of the variable on the region, Wx is the coefficient of spatial overflow of the variable to other regions, and rho is the coefficient of spatial overflow of the explained variable to the adjacent territory.

Effect decomposition. Dubin's spatial model is decomposed, and the direct effect of the digital economy represents the impact of digital economy changes on the quality of the sports industry in the surrounding area.

According to the results of the effect decomposition of the SDM model, the coefficient of digital economy in the region is 0.1333, which promotes the digital economy in the region and further shows that the sustainable development of sports industry.

3. Threshold model evaluation

In the threshold model 1, the digital economy level was used as the threshold variable, with a corresponding threshold of 3.121. In regions with a digital economy level below 3.121, the coefficient of the digital economy variables is -0.003; in regions with a digital economy level above 3.121, the coefficient is 0.169. To some extent, this shows that in places

Table 9
Results of the L R test and the Wald test

LR checkout	Likelihood-ratio test	L R chi2(9)	25.75
	(Asumption:sar nested in sdm)	P rob>chi2	0.0022
	Likelihood-ratio test	L R chi2(9)	19.91
	(Asumption:semested in sdm)	P rob>chi2	0.0022
wald checkout	Wald Test for SAR	chi2(7)	15.2
		P rob>chi2	0.0335
	Wald Test for SEM	chi2(9)	26.66
LR checkout	Likelihood-ratio test	L R chi2(9)	25.75
	(Asumption:sar nested in sdm)	P rob>chi2	0.0022

Source: the authors calculated it using STATA16

Table 10
Results of the SDM model

	(1)	(2)	(3)	(4)	(5)	(6)
DIGIT	0.5860***	0.1359***	0.1313***	-0.0413	-0.1325*	-0.1246
	(0.0200)	(0.0331)	(0.0325)	(0.0609)	(0.0736)	(0.0759)
Sta	0.0000**	0.0000	0.0000	0.0000**	0.0000**	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Eco	-0.0001	0.0005	0.0003	-0.0002	0.0010*	-0.0001
	(0.0003)	(0.0003)	(0.0003)	(0.0006)	(0.0005)	(0.0007)
Fis	2.0133***	1.0073***	1.1304***	0.7182	0.1069	1.5609**
	(0.2791)	(0.2163)	(0.2106)	(0.6558)	(0.4713)	(0.5733)
Spo	0.0000	0.0000	0.0001	0.0001	-0.0001	0.0001
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
Urb	-0.0005	0.0026***	0.0042***	-0.0016**	-0.0042**	-0.0029*
	(0.0004)	(0.0007)	(0.0009)	(0.0006)	(0.0016)	(0.0017)
Edu	0.0005*	0.0008**	0.0009***	0.0001	-0.0006*	0.0002
	(0.0003)	(0.0002)	(0.0002)	(0.0007)	(0.0003)	(0.0005)
Spatial rho	-0.1230	0.1284	-0.0360	-0.1230	0.1284	-0.0360
	(.)	(0.0896)	(0.0984)	(.)	(0.0896)	(0.0984)
Variance sigma2_e	0.0008***	0.0002***	0.0002***	0.0008***	0.0002***	0.0002***
	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)
N	310	310	310	310	310	310
R^2	0.957	0.688	0.690	0.957	0.688	0.690

Source: the authors calculated it using STATA16

*** is significant at 1%; * * is significant at 5%; * is significant at 10%.

Table 11
The SDM model effect decomposition

	Direct	**Indirect**	**Total**
DIGIT	0.1333***	0.1198*	0.2531***
	(0.0331)	(0.0707)	(0.0780)
Sta	0.0023**	0.0031**	0.0054***
	(0.0330)	(0.0870)	(0.7600)
Eco	0.0003*	-0.0000	0.0003**
	(0.0003)	(0.0007)	(0.0008)
Fis	1.1178***	1.4277**	2.5455***
	(0.2079)	(0.5446)	(0.5686)
Spo	0.0021***	0.0031**	0.0052***
	(0.0321)	(0.0042)	(0.0022)
Urb	0.0043***	-0.0031*	0.0012
	(0.0009)	(0.0016)	(0.0018)
Edu	0.0009***	0.0002	0.0010**
	(0.0002)	(0.0005)	(0.0004)
N	310		
R^2	0.890		

Source: the authors calculated it using STATA16

*** is significant at 1%; * * is significant at 5%; * is significant at 10%

with a high level of digital economy, the development of the digital economy can better promote the high-quality development of the sports industry, and the backward areas have a digital disadvantage, as the coefficient and threshold P value of the digital economy variables are not significant. In the threshold panel model 2, GDP per capita was used as the threshold variable, with a corresponding threshold value of 12.9. In regions where the GDP per capita is lower than 12.9, the coefficient of the digital economy variables is 0.279; in regions where the digital economy level is higher than 12.9, the coefficient of the digital economy variables is 0.592, and the coefficient and threshold P-value of the digital economy variables are significant at 10%. Therefore, in regions with a high level of economic development, the development of the digital economy can better promote the high-quality development of the sports industry.

Table 12

Results of assessing the impact of digital economy development on regional economic growth using a threshold panel model

Variable	Threshold panel model 1		Threshold panel model 2	
	DIGIT≤3.121	DIGIT>3.121	PGDP≤ 12.900	PGDP>12.900
DIGIT	-0.003(-0.00)	0.169(1.01)	0.279*(1.86)	0.592***(3.69)
Sta	-5.939**(-2.20)	-5.939**(-2.20)	-3.893(-1.58)	-3.893(-1.58)
Eco	-0.0002(-1.27)	-0.0002(-1.27)	-0.0003(-2.35)	-0.0003(-2.35)
Fis	-0.225***(-4.13)	-0.225***(-4.13)	-0.0648(-1.14)	-0.0648(-1.14)
Spo	-10.348***(-6.19)	-10.348***(-6.19)	-7.929***(-5.06)	-7.929***(-5.06)
Urb	-0.433(-1.42)	-0.433(-1.42)	-0.213(-0.77)	-0.213(-0.77)
Edu	1.382(0.39)	1.382(0.39)	5.810*(1.78)	5.810*(1.78)
Constant term	-1312.248***(-5.33)	-1312.248***(-5.33)	-781.079***(-3.32)	-781.079***(-3.32)
Sample capacity	310	310	310	310
R^2	0.739	0.77		
Gate limit P value	0.157	0.007		

Source: the authors calculated it using STATA16

*** is significant at 1%; ** is significant at 5%; * is significant at 10%.

4. Endogeneity analysis

In the basic model, this paper introduces more control variables and controls for time and regional fixed effects in order to minimise the possible endogenous problems. The endogeneity problem arises mainly from two aspects: one is the omission of explanatory variables, and the other is bidirectional causality. On this basis, the 2SLS method is used to reduce the regression error caused by endogeneity. Following the practice of Chen Xiaohui et al. (2020), the 2SLS regression took the lag phase of the average square of digital economy development in other provinces and municipalities as the instrumental variable of digital economy development level. The results are presented in Table 13. Regardless of whether the variables are controlled, the coefficient of the digital economy variables in the two models is significantly positive, indicating that the development of the digital economy can still promote the high-quality development of the sports industry after considering the endogenous problems.

Table 13

Results of the endogenous regression

Variable	2SLS	
	Model 1	Model 2
DIGIT	0.751***(6.45)	10.38**(2.35)
Constant term	4.133***(10.20)	12.495(0.92)
Controlled variable	deny	yes
Area fixed	yes	yes
Sample fixed	yes	yes
Sample capacity	310	310
R^2	0.561	0.523

Source: the authors calculated it using STATA16

*** is significant at 1%; ** is significant at 5%; * is significant at 10%.

5. Robustness test

Firstly, the nested spatial weighting matrix is replaced by the contiguous spatial weighting matrix, the economic distance spatial weighting matrix, and the geospatial weighting matrix, and then the Dobbin spatial double fixed effect model is used for regression analysis; secondly, the lagged phase of the level of development of the digital economy is taken as the main explanatory variable, and then the Dobbin spatial double fixed effect model is used for regression analysis. The regression results in Table 14 show that the symbols of each explanatory variable are basically consistent with the previous results, so the spatial spillover effect of the development of the digital economy on the quality development of the sports industry is robust.

5. Conclusions

This paper selects 2010–2019 years of 31 provinces, municipalities, autonomous regions of the panel data, builds spatial measurement model for empirical test, draws the following conclusion: firstly, the digital economy is innovation as the core driving force of the new economic form, and the deep fusion of the sports industry can give new impetus to the development of high-quality sports industry, further promote the development of the quality of the sports industry. Secondly, the development of digital economy through advanced digital technology can directly and indirectly promote the development of sports industry, digital economy and the development of sports industry quality have a significant spatial correlation, the characteristics of agglomeration "high-high", "low-low", the development of digital economy can greatly promote the development of regional sports industry, and the quality of sports industry development is also obvious. Based on

Table 14
Results of the robustness test

Variable	Adjacency matrix	Geospatial matrix	Economic distance matrix	First order lag term
DIGIT	0.142***	0.0777***	0.0860***	0.327*
	(0.0249)	(0.0358)	(0.0267)	(0.1344)
W*DIGIT	0.101**	0.135	0.0346	0.655*
	(0.0411)	(0.1455)	(0.0583)	(0.3218)
Direct effect	0.218***	0.0749***	0.0868***	0.3510*
	(0.0333)	(0.0420)	(0.0329)	(0.1343)
Indigo effect	0.0862*	0.188**	0.0295**	0.3960**
	(0.0607)	(0.2448)	(0.0462)	(0.2552)
Gross effect	0.3042**	0.2629**	0.1163**	0.7470***
	(0.0480)	(0.2641)	(0.0592)	(0.2269)
Individual fixed	yes	yes	yes	yes
Time fixed	yes	yes	yes	yes
Log-L	766.5266	.4735647	73342.53	275.0553
R-squared	0.8127	0.8755	0.8974	0.8823
N	310	310	310	279

Source: the authors calculated it using STATA16

*** is significant at 1%; ** is significant at 5%; * is significant at 10%.

the above conclusions, the following suggestions are proposed to better realise the role of the digital economy in the quality development of the sports industry.

Cultivate digital economy talents in sports and break through digital development. Scientific and technological innovation needs talents as support, and the scale and quality of digital talents in sports industry will become the key elements in determining the digital transformation of sports industry. Governments at all levels should actively build a service platform for talent innovation in the sports industry, guide the reform of talent training and talent introduction in the sports industry, and optimise the environment for talent training. Explore the flexible and market-oriented talent introduction mode of sports industry, attract more high-quality digital economy talents to the sports industry, and provide a good environment for their development.

Accelerating the digital transformation of sports enterprises is possible through the extensive use of digital technology to improve their supply capacity. Sports enterprises should fundamentally increase investment in sports science and technology innovation, extensively use digital technology, improve the production level of sports manufacturing industry, promote the rapid development of sports service industry, and improve the effective supply of the industry. The authors will promote the deep integration of advanced sports manufacturing industries and modern service industries, as well as improve the efficient supply capacity of sports enterprises.

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