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Analysis of the spatio-temporal effect of urban sports industry on economic development: based on regression analysis method

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Abstract This paper constructs a model of coupled coordination level of sports industry and economic development, and proposes to combine spatial measurement model and regression analysis model to explore the spatio-temporal characteristics of coupled coordination level. Combined with the panel data of nine cities in Province A from 2019-2024, the dynamic impact of the sports industry on economic development and its spatial heterogeneity are systematically analyzed. It is found that, firstly, the sports industry and economic development present highly coupled characteristics, and the coupling coordination level is raised from on the verge of dysfunction (0.455) in 2019 to barely coordinated (0.517) in 2024, indicating that the level of synergistic development of the two is significantly enhanced. Second, there is a significant spatial positive correlation between the coupling coordination degree of sports industry and economic development (Moran's I value of 0.3208~0.4297), and the spatial agglomeration characteristics gradually evolve from mono-core driving to multi-center networking. Third, the regression analysis shows that the coefficient of the total scale variable of the sports industry is 0.6186, the elasticity coefficient of the government input variable is 0.2854, the coefficient of the demand-side variable is 0.4175, and the elasticity coefficient of the human resource variable is 0.1575, i.e., the expansion of the scale of the sports industry, the improvement of human resource reserve, the enhancement of governmental financial support and the optimization of the structure of the market demand have a significantly positive promotion effect.

Index Terms sports industry, economic development, coupled coordination degree model, spatial measurement model, regression analysis

I. Introduction

Sports industry is an important industry that has developed rapidly in recent years, characterized by a long industrial chain, many employment opportunities and large profit margins, and thus can drive the development of urban economy [1], [2]. First of all, the development of sports industry creates more employment opportunities, improves the employment rate, and then promotes the growth of urban economy [3], [4]. The development of sports industry can not be separated from the professional talents in various fields, as well as the manufacture of sports equipment, the construction of stadiums and so on, including athletes, coaches, referees, managers and so on, which provides employment opportunities and reduces the pressure of urban employment [5]-[7]. Secondly, the development of sports industry can improve the popularity and attractiveness of the city and promote the economic growth of the city [8]. Sports competitions and events are one of the effective ways to increase the visibility of cities, for example, large-scale events such as the Olympic Games and the World Cup can attract global attention [9], [10]. By organizing these events, a large number of spectators and tourists can be attracted to visit and travel, leading to the development of hotels, catering, transportation and so on [11], [12]. In addition, the development of sports industry can lead to the vigorous development of related industries and form a good industrial ecosystem, which in turn promotes the growth of urban economy [13], [14]. The development of sports industry is closely related to tourism, culture, entertainment and other industries, forming a huge industrial ecosystem [15]. For example, sports and entertainment activities have led to the development of industries such as sporting goods, leisure clothing, and e-sports [16], [17]. Sports tourism activities have led to the prosperity of related industries such as hotels, restaurants, travel agencies, etc., and the prosperous development of these related industries have effectively promoted the economic growth of the city [18]-[20].

Based on the theoretical foundation of the intrinsic connection between sports industry and economic development, this paper firstly constructs a measurement index system for the coupling and coordination of sports industry and economic development. The spatial measurement model and the coupling coordination degree model

are selected to quantitatively assess the level of synergy and spatial differences between the two. Taking 9 cities in Province A as research objects, the sports industry and economic development level of them from 2019 to 2024 are measured by entropy value method. Calculate the coupling coordination degree of the two systems of sports industry and economic development in 9 cities of Province A, and assess the coordinated development level of sports industry and economy. Combine spatial correlation analysis and spatial structure analysis to explore the spatial evolution characteristics of the coupled coordination level of sports industry and economic development in Province A. Using the regression analysis model, the impact of each sports industry indicator on economic development is examined.

II. Construction of the coupling model of sports industry development and economic development

Under the dual background of global economic structural transformation and health consumption upgrading, the sports industry, as an emerging sunrise industry, has attracted much attention for its interaction with economic development. The scale of China's sports industry continues to expand, but the mechanism of its contribution to economic development and the differences in time and space still lack systematic research. The existing literature mostly focuses on the influence path of a single dimension, ignoring the dynamic characteristics and spatial correlation effect of the synergistic evolution of the two. Based on this, this paper takes the theory of political economy and industrial synergy as the basis, constructs an evaluation system including industry scale, human resources, government input and demand structure, and combines the spatial Durbin model and the coupling coordination degree model to reveal the spatial and temporal coupling law between sports industry and economic development.

II. A. Theoretical basis for coupling sports industry development and economic development

II. A. 1) Economic development as the basis for the development of the sports industry

According to the theory of political economy, the economic base determines the superstructure. Sport is a product of economic development to a certain extent, and economic development provides a material basis for the development of sport. Macro speaking, the rapid economic development increases the government's financial income, which makes the government have more financial resources to invest in the construction of stadiums and sports facilities. At the same time, the government's policy support makes the relevant sports enterprises invest more development factors into the sports industry, such as the wide application of digital technology in the sports industry, on the one hand, optimize the product production process of the sporting goods manufacturing industry, improve the scientific and technological content of the products; on the other hand, through the enhancement of the wisdom of the service capacity, to promote the efficiency of the sports service industry, and to promote the development of the sports service industry. Microscopically speaking, according to Maslow's hierarchy of needs theory, with the improvement of residents' income, people will look for higher-level needs after satisfying the low-level needs, and the change of this demand structure will determine the change of consumption structure. Since the reform and opening up, China's economic development has achieved rapid development, with the continuous improvement of income level, people need a healthier lifestyle, the pursuit of higher quality of life, people will have more ability to participate in sports activities and sports consumption.

II. A. 2) The development of the sports industry promotes economic development

At present, China's sports industry is in a booming stage, and the rapid development of the sports industry has effectively promoted economic growth.

First, the sports industry is of great significance to adjusting structure and stabilizing investment. At present, China's sports industry has formed a pattern of coordinated development in many fields such as sports goods manufacturing, sports services and sports facilities construction. The integration and development of sports industry with culture, tourism, recreation and health care industry can effectively boost the development of tertiary industry. At the same time, the construction of stadiums and sports facilities can also effectively promote investment.

Secondly, the event economy can effectively promote consumption and expand domestic demand. Major sports events not only attract a large number of spectators and media attention, but also drive the development and consumption of tourism, accommodation, catering and other related industries, and stimulate the vitality of the local consumer market.

Thirdly, consumption upgrading has become the driving force for the development of sports industry. Sports consumption has a broad prospect and huge potential, and is an important area for promoting consumption. Consumers' increasingly diversified and personalized demands for sports products and services have prompted sports enterprises to continuously innovate their product and service models. The enrichment of sports consumption

modes and scenarios not only enhances consumer experience, but also brings new growth points for the sports industry.

To sum up, the sports industry and economic development promote each other and develop symbiotically, and both promote each other while realizing the mutual coupling between the two.

II. B. Construction of Indicator System of Coupling Degree of Sports Industry and Economic Development

II. B. 1) Principles for the construction of the indicator system

This paper tries to construct the index system for measuring the coupling degree of sports industry development and economy, and strives to satisfy the following principles: firstly, the principle of scientificity, the selected indexes can scientifically reflect the modernization level of the coupling degree of sports industry development and economy; secondly, the principle of systematicity, the construction of the index system is hierarchical and coordinative; thirdly, the principle of typicality, the selected indexes are representative as far as possible, and the complexity and simplicity are appropriate; fourthly, the principle of data availability, all data of selected indexes have statistics, which can be obtained from the existing statistics. The data of the selected indexes are statistically available and can be obtained from the existing statistical information.

II. B. 2) Content of the indicator system

The sports industry mainly includes 11 categories such as sports management activities, sports economic performance activities, etc., while the statistics of the General Administration of Sport of China on the sports industry divides the sports industry into 3 categories, namely, the manufacturing of sports goods and related products, the construction of sports venues and facilities, and the sports service industry. Sports industry should be the government invested relevant funds and facilities to provide products and services for the public, to meet the consumption demand of the public, and at the same time drive the development of related industries. At present, the statistics of sports industry is not very perfect, and China Statistics Bureau does not have a unified regulation on the accounting of the added value of sports industry, and the provinces and cities have not formed a unified consensus on the accounting of the added value of sports, so that it is not possible to obtain the added value of the sports industry in each province and city. Therefore, this study measures the development level of the sports industry from three aspects: the scale of the sports industry, human resources, and government input. In terms of the scale of the industry, this study adopts the sum of the culture, sports and entertainment industry in the tertiary industry and the manufacturing industry of cultural, educational, industrial and aesthetic, sports and recreational goods manufacturing industry as a proxy indicator for the sports service industry and the sports manufacturing industry, adopts the number of employed persons in the culture, sports and entertainment industry and the urban wage in the culture, sports and entertainment industry as a proxy indicator for the human resources of the sports industry, adopts the local financial expenditure on culture, sports and media's financial expenditure and the growth rate of fixed asset investment in culture, sports and entertainment as a proxy indicator for government investment in the sports industry. According to the above analysis, when the residents' income increases, more people will choose sports activities or sports consumption, so the residents' income has a great influence on the demand of sports industry, and the disposable income of urban residents and disposable income of rural residents are adopted as the demand of sports industry. The explanation for the validity of the alternative indicators is as follows: on the one hand, the statistics of the sports industry mainly include the sports service industry and the sports and related products manufacturing industry, which are included in the culture, sports and entertainment industry and the cultural, educational, industrial and aesthetic, sports and recreational goods manufacturing industry respectively; on the other hand, the sports industry is very much integrated with the culture and recreation industry, and the sports industry has a strong cultural characteristic and recreational character, therefore, the disposable income of urban residents and disposable income of rural residents are adopted as the demand of the sports industry. Therefore, the overall situation of the culture, sports and entertainment industry can reflect the development of the sports industry to a large extent.

The level of economic development is measured in four dimensions: economic scale, economic growth level, industrial structure and external economy. Specifically, it includes GDP per capita, total retail sales of consumer goods, GDP growth rate, fixed-asset investment growth rate, advanced level of industrial structure, the proportion of GDP accounted for by the sales revenue of new products above the scale, the proportion of GDP accounted for by foreign direct investment and the proportion of GDP accounted for by the total import and export of goods.

By synthesizing the above relevant discussions on the sports industry and economic development level, the coupling degree index system of the sports industry and economic development level is constructed, and the specific indexes are shown in Table 1.

Table 1: Coupling Index System of Sports Industry and Economic Development

Target layer	Indicator layer	Criterion layer
Sports industry	Industrial scale	Operating income from culture,sports and entertainment industries
		Total assets in the cultural,sports and entertainment industries
		Operating income of the sports manufacturing industry
		Sales of sports lottery
	Human resources	Employees in the cultural,sports and entertainment industries
		Urban wages in the culture,sports and entertainment industries
	Government investment	Local fiscal expenditure on culture,sports and media
		Fixed asset investment in the culture,sports and entertainment industries
	The demand of the sports industry	Per capita consumption of urban residents
		Per capita consumption of rural residents
Economic development level	Economic scale	Per capita GDP
		Total retail sales of consumer goods in society
	Economic growth level	GDP growth rate
		Growth rate of fixed asset investment
	Industrial structure	Index of Industrial structure upgrading
		The proportion of new product sales revenue from large-scale enterprises to GDP
	Foreign economy	The proportion of foreign direct investment in GDP
		The proportion of total import and export volume of goods in GDP

II. C. Coupling model construction and research methodology of sports industry and economic development

II. C. 1) Spatial measurement models

Spatial correlation is reflected in two main dimensions: spatial substantive correlation reveals the nature of the interactions inherent in geographic space, which effectively shape the dynamics of physical features in each geographic location. Spatial disturbance correlations, on the other hand, arise from the spatial correlation of influences that are not included as explanatory variables but are categorized as random disturbance terms. Such correlations may arise due to a variety of unconsidered factors that affect the overall spatial distribution and relationships. In the field of economics, researchers have developed various spatial econometric models to study spatial correlation in depth. The following three models are the more widely used spatial econometric models, and their basic forms are as follows:

(1) Spatial lag model SAR

Spatial lag model is also known as spatial autoregressive model, the form can be expressed as follows

$$Y = \rho WY + X\beta + \varepsilon \tag{1}$$

Eq: W - spatial weight matrix, WY - the spatial lag term of the dependent variable, ρ - spatial autocorrelation coefficient, measuring the spatial interaction of the dependent variable, β - parameter vector, measuring the spatial interaction of the independent variables, ε - white noise interference term.

(2) Spatial error model SEM

The spatial error model is a random disturbance term with spatial correlation, which can be formally expressed as

$$\begin{aligned} Y &= X\beta + \varepsilon \\ \varepsilon &= \lambda W\varepsilon + \mu, \mu \sim N\left(0, \sigma^2 I_n\right) \end{aligned} \tag{2}$$

Eq: ε - vector of regression residuals, following a normal distribution, λ - autoregressive coefficient of spatial error, which measures the impact of neighboring region Y on this region Y.

(3) Spatial Durbin Model SDM

Spatial Durbin is a combination of spatial lag model and spatial error model, which can be formally expressed as follows

$$Y = \rho WY + X\beta + \nu WX + \varepsilon \tag{3}$$

Eq: β - The effect of changes in the explanatory variables of a region on its own explanatory variables, ν - the effect of changes in the explanatory variables of a region on the explanatory variables of other spatial units.

The general form of the spatial Durbin panel model is:

$$Y = (1-\rho W)^{-1}(X\beta + \nu WX) + \varepsilon \tag{4}$$

(4) Decomposition of spatial spillover effects

Y The following equation is obtained by taking a partial derivation of the explanatory variable X_n

$$\begin{bmatrix} \frac{\partial y_1}{\partial x_{1j}} & \frac{\partial y_1}{\partial x_{2j}} & & \frac{\partial y_1}{\partial x_{nj}} \\ \frac{\partial y_2}{\partial x_{1j}} & \frac{\partial y_2}{\partial x_{2j}} & \cdots & \frac{\partial y_2}{\partial x_{nj}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial y_n}{\partial x_{1j}} & \frac{\partial y_n}{\partial x_{2j}} & \cdots & \frac{\partial y_n}{\partial x_{nj}} \end{bmatrix} = (1-\rho W)^{-1} \begin{bmatrix} \beta_j & w_{12}v_j & & w_{1n}v_j \\ w_{21}v_j & \beta_j & \cdots & w_{2n}v_j \\ \vdots & \vdots & \ddots & \vdots \\ w_{n1}v_j & w_{n2}v_j & \cdots & \beta_j \end{bmatrix} \tag{5}$$

Eq: β_j - direct effect parameter, $w_{nn}\nu_j$ - indirect effect parameter.

II. C. 2) Coupling harmonization model

In this paper, a two-system coupling model is constructed. The coupling degree of multi-system is modeled as:

$$C = \left[\frac{\prod_{i=1}^{n} U_i}{\left(1/n \sum_{i=1}^{n} U_i\right)^n} \right]^{\frac{1}{n}} \tag{6}$$

In this formula, n is the number of subsystems; U_i is the value of each subsystem, and its distribution interval is $[0,1]$, so the coupling degree C value interval is $[0,1]$. The larger the value of C, the smaller the degree of discrete between subsystems, the higher the degree of coupling; on the contrary, the system disorder is enhanced, and the lower the degree of coupling between subsystems. This paper constructs two subsystems of sports industry development and economic development, and the coupling degree formula is:

$$C = \frac{2\sqrt{U_1 U_2}}{U_1 + U_2} \tag{7}$$

Coupling degree measures the strength of coupling between subsystems and subsystems, and reflects poorly on the overall coordinated development of the whole system, which may not fully and accurately reflect the synergistic effect between two systems in some situations. In some contexts, the coupling degree is difficult to truly show the coordination effect of the two systems. Therefore, this study introduces the coordination degree model, and the coupling coordination degree model can better analyze the interaction and synergistic effect between the systems. Firstly, the coordination degree index T is calculated:

$$T = \sum_{i=1}^{n} \alpha_i \times U_i \tag{8}$$

where U_i is the standardized value of the i nd subsystem; α_i is the weight of the i th subsystem. Given that the two subsystems are complementary, the development of sports industry and economic development of the two systems are equally important, set $\alpha_i = 1/2$, at this time, the degree of coupling and coordination of the two systems is:

$$D = \sqrt{C \times T} \tag{9}$$

Although simple, the coupled coordination degree model integrates the C, T and D of the two systems, which can more flexibly take into account the characteristics and demands of different systems, more comprehensively describe and quantify the interaction and regulation relationship between the components within the system, and thus more accurately reveal the system's dynamic behaviors and evolutionary characteristics.

The division standard of coupling coordination level can help assess the degree of interaction between different systems, and the scientific and reasonable coordination level division standard is conducive to clarifying the stage at which the coordinated development of subsystems is in, this paper combines the actual situation and constructs the division standard of coupling coordination level of sports industry development and economic development. The degree of coupling coordination is divided into the class of dysfunctional recession, transitional reconciliation and coordinated development, and the closer the value is to 1, the better the degree of coupling coordination is.

III. Empirical analysis of the synergistic effect between sports industry development and economic development

Due to the difficulty of obtaining the data of sports industry and the prevalence of some provinces and cities that have not yet published the data of sports industry. Taking the availability of data as the basic principle, the data related to the sports industry of nine cities (numbered X1~X9) in Province A are selected as the basis, and the data of the sports industry evaluation index system are derived from relevant information. Part of the data comes from the data published on the websites of relevant departments, and for the missing data of individual indicators in some cities from 2019 to 2024, the linear interpolation method and other statistical methods such as linear interpolation method to fill in the missing values are processed by Stata 16.0 measurement software based on the nature of each indicator, using the principle of linear regression and average value, using the linear trend of nearby points and the average value of nearby points.

III. A. Measurement and analysis of the sports industry and economic development level in Province A

III. A. 1) Measurement and analysis of the level of development of the sports industry

Entropy value method is an objective method of empowerment, which is a mathematical processing method to judge the degree of influence of a certain indicator on the comprehensive index, and it can also be used as a calculation method of comprehensive evaluation index, which requires that the indicators have isotropy. First of all, the original index value is globally normalized to eliminate the influence of the index data scale. Then the entropy value method of panel data is used to determine the weights of the indicators, and the evaluation scores of the development of the sports industry in nine cities of Province A in 2019-2024 are measured, and the calculation results are shown in Table 2.

From the perspective of time, the development of the sports industry in the nine cities of Province A from 2019 to 2024 shows distinctive characteristics and trends. On the whole, the development level of the sports industry in 9 cities is constantly improving, and the score of the sports industry development level in X1 city fluctuates greatly, showing a trend of fluctuating growth. The development of the sports industry in X4 shows a continuous downward trend, while the overall level of the development of the sports industry in other cities shows a year-on-year growth trend, indicating that the sports industry in Province A has strong development vitality and good development trend as a whole.

In terms of the overall development trend, the development of the sports industry in Province A is characterized by obvious stratification. According to the sports industry development evaluation score in 2024, the nine cities in Province A are divided into four echelons. The first echelon includes X2, X7 and X6, all of which have a score of more than 0.4; the second echelon includes X5, X1 and X3, which have a score of between 0.3 and 0.4; the third echelon consists of X8 and X9, which have a score of between 0.2 and 0.3; and the fourth echelon consists of X4, which has a sports industry development level The fourth echelon is X4, whose sports industry development level scores between 0.1 and 0.2, and it is the region with the lowest sports industry development level in Province A. Due to the relative backwardness of the economy and the weak foundation of the sports industry, the development of the sports industry faces greater challenges.

III. A. 2) Measurement and analysis of the level of economic development

The entropy method was applied to measure the score index situation of the economic development level of 9 cities in Province A from 2019-2024, and the calculation results are shown in Table 3.

Similar to the development trend of the sports industry, the degree of economic development of the nine cities in Province A continued to increase during the period 2019-2024, and their economic development level also increased year by year, showing that the economy of Province A presents a good development trend, and presents a trend of stable growth year by year.

Similar to the development of the sports industry, the economic development of Province A also shows obvious stratification characteristics. Based on the score of economic development level in 2024, it is divided into four

echelons. The first echelon, X8, X2 and X1, all have a score higher than 0.4; the second echelon, X7, has a score of 0.3-0.4; the third echelon, X5, X3 and X9, have a score of 0.2-0.3; and the fourth echelon, X6 and X4, have a score between 0.1 and 0.2. The first tier is densely populated and economically more developed due to its good industrial infrastructure; X8 injects strong impetus into its economic development due to a series of initiatives to promote stable economic and social operation, enhance scientific and technological innovation capacity, and promote social and livelihood development. X7 in the second echelon focuses on promoting industrial upgrading and innovative development, and has an overall higher level of economic development. X3, X9 and X5 of the third echelon have accelerated their economic development in recent years and achieved obvious development results, but due to the weak development foundation of each industry, their development speed is slow and the overall development level is low. The fourth echelon, X6, has a relatively low proportion of tertiary industries, which makes X6 have no obvious advantage in consumer-based economic development and face a series of challenges in economic development, resulting in its low level of economic development; the economic level of X4 has always been at the lowest level in China.

Table 2: Scores of the sports industry Development level of 9 cities in Province A

Region	2019	2020	2021	2022	2023	2024
X1	0.268	0.279	0.311	0.254	0.306	0.309
X2	0.379	0.392	0.441	0.498	0.522	0.571
X3	0.183	0.218	0.245	0.281	0.285	0.305
X4	0.291	0.205	0.153	0.121	0.108	0.106
X5	0.302	0.311	0.338	0.335	0.371	0.386
X6	0.194	0.266	0.283	0.327	0.368	0.401
X7	0.283	0.301	0.318	0.362	0.427	0.431
X8	0.211	0.232	0.234	0.251	0.263	0.266
X9	0.201	0.192	0.203	0.218	0.227	0.245

Table 3: Scores of Economic Development Levels of 9 Cities in Province A

Region	2019	2020	2021	2022	2023	2024
X1	0.258	0.302	0.341	0.355	0.371	0.409
X2	0.303	0.321	0.345	0.371	0.394	0.433
X3	0.118	0.147	0.162	0.185	0.197	0.218
X4	0.058	0.069	0.078	0.102	0.109	0.128
X5	0.147	0.166	0.179	0.194	0.209	0.228
X6	0.088	0.094	0.108	0.127	0.142	0.173
X7	0.208	0.229	0.252	0.279	0.302	0.347
X8	0.412	0.426	0.455	0.471	0.511	0.602
X9	0.125	0.146	0.161	0.172	0.183	0.204

III. B. Measurement of the coupling and coordination degree of sports industry and economic development in Province A

According to the measured score index of sports industry and economic development level of province A substituted into formula (7), the value of coupling degree C is calculated, and the calculation results are shown in Table 4.

As can be seen from Table 4, the coupling values of the sports industry and economic development of the nine cities in Province A are all at a high level, and except for X4, the coupling C values of each province and city in different years have reached more than 0.90, which indicates that the sports industry and the economy in Province A as a whole show a highly coupled trend.

However, the value of coupling degree D does not reflect the overall coordination between the sports industry and economy. Taking X3 and X9 as an example, the average value of coupling degree C is as high as 0.93, but the actual development level of sports industry and economy is relatively low. In order to more accurately understand the synergistic development between the sports industry and the economy in Province A, the value of the coupling coordination degree D of the two should be measured. Through formula (9), the value of the coupling coordination degree D between the sports industry and the economy in Province A from 2019 to 2024 is calculated, and the results are shown in Table 5.

Table 4: The coupling degree C value of Province A

Region	2019	2020	2021	2022	2023	2024
X1	1.000	0.999	1.000	0.985	0.996	0.990
X2	0.993	0.995	0.982	0.961	0.941	0.912
X3	0.964	0.958	0.951	0.942	0.938	0.935
X4	0.745	0.702	0.652	0.645	0.667	0.678
X5	0.902	0.908	0.905	0.904	0.900	0.902
X6	0.947	0.928	0.919	0.917	0.916	0.908
X7	0.954	0.962	0.968	0.973	0.977	0.979
X8	0.912	0.928	0.942	0.956	0.969	0.981
X9	0.912	0.975	0.996	0.985	0.976	0.971

As can be seen from Table 5, the degree of coupling synergy between the sports industry and the economy in Province A has shown a steady upward trend in recent years. From 2019 to 2024, the overall degree of coupling synergy grows from 0.455 to 0.517, and the coordination grade develops from on the verge of dysfunction in 2019 to the stage of barely coordinated in 2024, which indicates that the synergy between the sports industry and the economy is significantly improved, and the level of integration between the two is also increasing. From the situation of each province and city, between 2019 and 2024, all nine cities in Province A showed a stable upward trend in the coupling and coordination degree of the sports industry and the economy, and by 2024, the coupling and coordination degree of each province and city had been significantly improved, but the specific coupling and coordination degree values showed significant differences. Among them, the coupling and coordination degree of sports industry and economy of X2 has exceeded 0.772, ranking first among 9 cities. This fully indicates that X2 has achieved remarkable results in the coupling and coordinated development of sports industry and economy in recent years. the developed economy of X2 creates a good environment for the development of sports industry, and at the same time, the rapid development of sports industry further promotes the improvement of the economy, which creates a virtuous circle of mutual promotion and synergistic development between the two. In contrast, the coupling degree of sports industry and economy of X4 in 2024 is still at a relatively low level of 0.319, which is mainly due to the low level of coupling and coordination of X4 in the early stage, and the relatively weak coupling foundation, which leads to the failure of rapid improvement of the coupling level of the two over a period of time. In addition, the province and city with the lowest growth rate during the study period is also X4, indicating that there is still much room for X4 to make progress in improving the coupling and coordination level of sports industry and economy.

Table 5: A Provincial Coupling coordination degree D values

Region	2019	2020	2021	2022	2023	2024
X1	0.513	0.539	0.571	0.548	0.581	0.596
X2	0.582	0.601	0.614	0.632	0.691	0.772
X3	0.467	0.489	0.508	0.525	0.533	0.541
X4	0.361	0.331	0.306	0.300	0.311	0.319
X5	0.376	0.387	0.396	0.403	0.410	0.417
X6	0.342	0.357	0.367	0.375	0.382	0.389
X7	0.483	0.501	0.517	0.531	0.546	0.554
X8	0.582	0.601	0.614	0.628	0.642	0.656
X9	0.389	0.394	0.399	0.404	0.408	0.413
Mean value	0.455	0.467	0.477	0.483	0.500	0.517

III. C. Characteristics of the spatial evolution of the coupled coordination level of sports industry and economic development in Province A

III. C. 1) Spatial correlation analysis

In order to further the degree of correlation of the spatial distribution of the coupled coordination of the sports industry and economic development in Province A, Moran's I is utilized, and the results of the calculation are shown in Table 6.The estimated values of Moran's I for the coupled coordination of the sports industry and economic development in Province A from 2019 to 2024 are all greater than 0, and the values of the normal statistic z are all are greater than the confidence level critical value of 2.58, and the P values are all less than 0.01. That is, the possibility of randomly generating this clustering pattern is <1%. Therefore, the test effect is more significant, indicating that the spatial distribution of sports industry and economic development coupled and coordinated in province A has significant spatial positive correlation, and the spatial clustering characteristics are more obvious.

Table 6: A Provincial Coupling coordination Moran's I index

Year	Moran's I index	z	p
2019	0.3752	3.6364	0.0002
2020	0.3862	3.6353	0.0003
2021	0.3208	3.2756	0.0015
2022	0.4297	4.1974	0.0002
2023	0.3972	3.9725	0.0001
2024	0.3821	3.6862	0.0003

III. C. 2) Analysis of space structure

The size of the network density reflects the strength of the sports industry links among the cities in the network, as well as the degree of openness of the network as a whole and the ability to obtain resources, which is a powerful tool to reflect the degree of synergy and the effect of the nine cities in province A in the sports industry. The degree centrality of each city in 2019 and 2024 was calculated respectively, and the degree centrality of the sports industry linkage network of 9 cities in Province A in 2019 and 2024 was measured by point-in and point-out degrees, and the data were organized and summarized by Ucinet calculation as shown in Table 7

From the value of the index of point-in degree, it can be seen that X8, X2 and X1 are always in the top two. From the value of the point out degree indicator, it can be seen that the point out degree of X8 and X2 are always in the first two places, which fully demonstrates the characteristics of their “dual-city” engine. The average point out degree of each city in 2019 is 4.22, and in 2024 it will be 4.56, which is a significant increase, indicating that the degree of connection between cities has increased, especially X8 and X2 are regional center cities that mainly amplify the function of sports resources aggregation and implement open empowerment. Resource aggregation function, the implementation of open empowerment of the regional center city, in recent years, constantly enhance the joint development and utilization of sports resources with neighboring cities and interaction, on the city cluster within the city of industrial division of labor core driving role of province A is still in the absolute dominant position, but from the 2019 degree of association of the more single single single-core association posture evolved into 2024 different The diversified association trend of circles indicates that the sports industry among cities in Province A is accelerating the integration and development.

Table 7: Analysis of the sports industry centrality in Province A in 2019 and 2024

	2019				
	Degree centrality		Proximity centrality		Intermediary centrality
	Inward	Outward	Inward	Outward	
X1	5.000	6.000	11.597	18.536	7.296
X2	11.000	6.000	93.208	10.000	7.872
X3	4.000	2.000	65.536	9.974	0.000
X4	0.000	4.000	7.397	22.486	0.000
X5	2.000	4.000	10.497	16.397	0.388
X6	2.000	3.000	10.497	15.388	0.000
X7	4.000	3.000	59.397	9.947	0.000
X8	12.000	7.000	100.000	10.000	9.783
X9	1.000	3.000	10.974	15.388	0.000
	2024				
	Degree centrality		Proximity centrality		Intermediary centrality
	Inward	Outward	Inward	Outward	
X1	6.000	6.000	12.747	19.473	8.284
X2	11.000	6.000	93.974	11.297	11.864
X3	4.000	3.000	65.536	12.084	0.000
X4	0.000	5.000	7.397	28.908	0.000
X5	2.000	4.000	13.974	20.022	0.388
X6	3.000	3.000	12.183	20.018	0.500
X7	5.000	3.000	60.000	10.497	0.000
X8	12.000	7.000	100.000	11.297	14.085
X9	1.000	4.000	12.000	20.021	0.388

III. D. Regression analysis of sports industry and economic development in Province A

The logarithm of the annual GDP of province A is taken as the dependent variable, the logarithm of the total scale of the sports industry, human resources, government input, and the value added of the demand of the sports industry are taken as the independent variables, and the data are regressed by using the STATA15.0 statistical analysis software, and in order to make sure that the explanatory variables that are finally kept in the model are both important and at the same time do not have serious multiple covariance, the regression process adopts the stepwise regression analysis method, and the regression results of each variable factor are shown in Table 8. From the point of view of statistical significance, all the explanatory variables pass the significance test at 1% level (p-value=0.000), indicating that the expansion of the scale of the sports industry, the enhancement of human resource reserves, the strengthening of government financial support and the optimization of market demand structure have a significant positive role in promoting economic growth. Among them, the coefficient of the total scale of the sports industry variable is 0.6186, whose economic meaning is that every 1% increase in the scale of the industry will lead to the growth of regional GDP by about 0.62%. The elasticity coefficient of the government input variable is 0.2854, reflecting the leverage effect of public resource allocation. The coefficient of the demand-side variable is 0.4175, which verifies the pulling effect of consumption upgrading on industrial development, while the elasticity coefficient of the human resource variable is relatively low (0.1575), which may be originated from the insufficient adaptability of the talent structure to the industrial demand.

Table 8: Regression results of each variable factor

Y	Regression coefficient	Standard deviation	t	P	95% confidence interval	
Industrial scale	0.6186	0.0083	58.2733	0.000	0.5856	0.6275
Human resources	0.1575	0.0094	22.6346	0.000	0.5573	0.5727
Government investment	0.2854	0.0093	28.9743	0.000	0.5697	0.5973
The demand of the sports industry	0.4175	0.0084	40.8361	0.000	0.5753	0.6053
Constant	8.0844	0.0372	142.9741	0.0000	7.0842	7.2971

IV. Conclusion

This paper empirically analyzes the synergistic effect of sports industry development and economic development based on panel data of nine cities in Province A from 2019 to 2024.

In the time dimension, the coupling value of the sports industry and economic development of the nine cities in Province A is at a high level, and the coupling C value of each province and city in different years reaches 0.90 or more, except for X4. The degree of coupling synergy between the sports industry and the economy has shown a steady upward trend in recent years, with the overall degree of coupling coordination growing from 0.455 to 0.517 from 2019 to 2024, and the coordination level developing from on the verge of being dysfunctional in 2019 to the barely coordinated stage in 2024. However, the X4 coupled coordination degree of the sports industry and economy is still at a relatively low level of 0.319 in 2024.

In the spatial dimension, the Moran's I estimates of the coupling and coordination of the sports industry and economic development in Province A from 2019 to 2024 are all greater than 0, and the z-values of the normal statistic are all greater than the confidence level critical value of 2.58, and the P-values are all less than 0.01. The average point out of the cities in 2019 is 4.22, and the average point out of 2024 is 4.56, which is a significant improvement, indicating that the the correlation between cities has increased, indicating that the sports industry is accelerating the integration and development among cities in Province A.

Regression analysis shows that all explanatory variables pass the significance test at 1% level (p-value=0.000), the coefficient of the variable of the total scale of sports industry is 0.6186, the elasticity coefficient of the variable of the governmental input is 0.2854, the coefficient of the variable of the demand side is 0.4175, and the elasticity coefficient of the variable of the human resources is 0.1575, and the expansion of the scale of the sports industry, the enhancement of the human resources reserve, the increase of the governmental The expansion of the scale of the sports industry, the enhancement of human resource reserves, the strengthening of financial support and the optimization of market demand structure have a significant positive role in promoting economic growth.

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