



Constructing Diversified Development Models for the Sports Industry Guided by Technological Innovation Pathways

Xuefeng Fan^{1,*}

¹ Tianjin Chengjian University, Tianjin, 300384, China

SUMMARY: *The paper presents an industry development model based on the diversification of the sports sector that has been developed following the strategic direction of science and technology innovation. The practical suggestions of optimization are given to perfect and enhance applicability of the model. Based on this platform, the research explores the characteristics of agglomeration and development potential of sports industry diversification of 8 Chinese provinces using the multi-distance spatial clustering algorithm, the nearest-neighbor distance algorithm and factor analysis as the main analytical methods. The results reveal that the spatial clustering of diversified sports industry activities can be quantitatively correlated with the distance to urban centers and between cities, whereas the overall level of such agglomeration increases steadily over time. Under the context of science and technology innovation, the diversified sports production has a special spatial pattern, where the extremes have the highest activities while the middle range is relatively less developed. The provincial ranking of internal potential of sports industry diversification can be broadly aligned to the level of economic development in the province. The demand-side potential, nevertheless, shows significant variations and a high degree of concentration leading to large differences between the extent and depth of diversification and integration possibilities between provinces. The paper ends with the recommendation to implement the five guiding principles of development, innovation, coordination, environmental sustainability, openness, and shared growth, as an actionable model of developing the sports industry. Such a strategy aims to overcome the growing heterogeneity, differentiation and individualism of expectations of different residents in all provinces towards the sport sphere.*

KEYWORDS: *Multi-distance spatial clustering; Factor analysis method; Nearest neighbor distance method; Sports industry diversification*

1 Introduction

The development of the sports industry is highly diversified, and this phenomenon has much to do with technological innovations. This connection does not just refer to the profound effect that scientific and technological progress has had on the sports industry but also to the increased accountability of fostering sports talent in a more pluralistic world [1, 2]. The ability to innovate in science and technology is one of the most distinctive features of the current period, which has permeated almost every area of modern social existence [3]. It essentially includes a wide range of creative activities, including the creation of new ideas and theoretical concepts and the design of new products and practical procedures. The common denominator among all these efforts is a common desire to explore virgin territories, to break down the existing traditions,

*fanxuefeng1028@126.com

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and to make a valuable contribution to the further development of the human society [4, 5].

Technological innovation has had a significant and extensive effect on sports industry diversification [6]. On the one hand, the increased development of information technology has introduced a series of new means such as virtual reality and augmented reality into the sphere of sports. The said technologies have added a lot of value to the variety of ways of training available to practitioners [7, 8]. Their implementation is found to be useful in boosting the inner drive of an athlete as well as allowing more immersive simulated settings where technical techniques and tactical knowledge can be learned and honed [9]. Alternatively, technological innovation has improved the average quality of sports science research. By using advanced scientific devices and methodical analysis of data, academics and professionals can now examine the physiological reactions, biomechanics trends, and training patterns of athletes much more accurately than before and provide recommendations on sports achievements based on much stronger scientific evidence [10, 11].

Technology innovation is at the center of promoting the development of new-quality productive forces in the sports sector. It accelerates the growth of these productive forces by spreading and permeating the industry, leading to an increase in the overall quality of sports-related products and services [12]. The authors Nagorna et al. [13] provided a systematic overview of how technological innovation is currently used to transform the sports industry in several ways. The most notable ones include wearable technologies such as fitness trackers, heart rate monitors, and GPS watches which have shown great utility in training athletes since they have measurable positive effects on exercise. Al-Jawahry et al. [14] showed that incorporating Internet of Things technologies, e.g. sensors, microcontrollers and wireless communication protocols into traditional sports equipment enables the real-time tracking of athletes physiological indices, enables the optimization of training programs and contributes to the actual improvements of training performance. Yang et al. [15] created a sports training system based on the wireless sensor network technology, where the motion collectors recorded the parameters of the movement continuously and in real time. The subjects of the study experienced decreases in trunk sway of more than 50 percent at various directions axes and maintained balance for extended periods of time. Motion state recognition, action detection, and intelligent sports equipment were explored by Umek et al. [16] in golf. The pressure sensors were found to be able to differentiate correctly between various types of swings and indicate incorrect motions, providing useful corrective feedback throughout the learning process. Zhen [17] analyzed the use of wearable smart devices in athletic training settings, finding that these devices had statistically significant impacts on performance in 50-meter and 1000-meter running competitions, with p-values <0.05.

The development of artificial intelligence has created new opportunities in the field of sports training especially due to the combination of big data analytics and practical training conditions. Such a combination enables the exact measurement of the amount of training, increases the level of training efficacy, enhances the motivational involvement of athletes, and facilitates the creation of extremely personalized training programs of the best performers [18, 19]. The researchers (Liu et al.) [20] have established that AI-based systems can be used to process the training information of athletes at the moment, based on such indicators as heart rate, speed of movement, and muscular strength, and then change equipment settings based on the performance of the athlete, to obtain the best possible personalized training results. Raman et al. [21] explored how the IoT-enabled smart devices assist in transmitting data between the athletes and coaches, which enables the monitoring and assessment of training performance indicators remotely to make an informed decision. In addition to monitoring capabilities, these devices also create personalized training suggestions based on the constant data analysis.

Similarly, the introduction of technological innovation to physical education has also

presented new opportunities of enriching teaching and learning in PE contexts [22]. In the research conducted by Fu et al. [23], wearable smart devices were integrated into the lessons of physical education open to the public, and it was found that the accuracy of shooting of pupils increased significantly, scoring 21.43 as opposed to 12.80 in the classrooms where the technology was used. These groups scored significantly better in the skills than when taught using traditional instructional methods. Zhang, Z et al. [24] evaluated the monitoring and feedback functions of wearable smart sports glasses in physical education teaching. Classroom experiments revealed that smart glasses are able to correctly monitor students movement postures and technical execution and provide personal, intelligent feedback to the wearer. Zhang, Y et al. [25] developed a continuous training monitoring system based on IoT technology. It was determined that the system can be applied to a variety of sports disciplines and maximizes the training effectiveness of students, and most of the participants in the assessment rated it highly positively.

Physical fitness and mental health are two well-known factors of the overall well-being of individuals and remain in the focus of the broader health discussion on personal health. Despite the ongoing difficulties with introducing artificial intelligence into medical devices, monitoring systems based on smart devices have been gaining more and more academic interest and turned into a research field [26, 27]. Postolache [28] investigated the application of smart walkers and crutches in order to display personal health information via mobile devices and specialized software applications, which would create smart rehabilitation information capable of being used in a meaningful manner to train patients recovering. Kos et al. [29] suggested a small wearable apparatus combined with a custom-designed system that would identify and register the physical activities and biometric information of users during their sports exercises. The device has wide areas of use, including both professional and recreational sports activities and general health monitoring, and the ability to monitor some physiological indicators, such as the skin temperature and pulse rate.

In order to give automatic suggestions on how to keep working out and what to alter the equipment in the course of physical exercises, it is necessary to have models that can detect and categorize existing movement patterns by means of smart devices [30]. The intelligent wearable motion recognition and interaction system proposed by Liang et al. [31] is a motion data processing technology such as neural networks, which recognizes and interacts with the human body. This system correctly detects the human movement properties, which has practical application worth in sport activities. Wang [32], a researcher, used a human sensor network to train table tennis players by evaluating the characteristics of their strokes by collecting data and using support vector machine algorithms to recognize and classify the actions of a table tennis player. X [33], Zhang combined the use of deep learning algorithms with smart devices to investigate the recognition of human motion behavior using methods such as convolutional feature extraction. The method was highly effective in improving the sensitivity and accuracy of sensors in smart wearables, assisting athletes in their training.

The constant technological innovations drive physical training into new ideas, technology and equipment. Nevertheless, there are still obstacles, including measurement error of wearable devices during training which affects validity and reliability of the data obtained [34]. In light of the new era, the demands of the society regarding athletic talent are becoming more varied and individualized. It requires the sports industry to keep up with changing times and actively seek new forms of talent development.

The proposed study is based on the principles of science and technology innovation and it creates a novel model of industry development of the diversified sports industry. The analysis next focuses on the spatial clustering tendencies of sports industry diversification in this innovation-focused context using an integrated approach of the nearest neighbor index and

multi-distance spatial clustering analysis. Empirical focus is done on eight provinces only that are considered to be: Yunnan, Heilongjiang, Sichuan, Qinghai, Shanxi, Guangdong, Zhejiang and Jiangsu. Taking factor analysis as a main evaluative instrument, the research goes further to evaluate the supply potential, demand potential, and integration potential of sports industry diversification in those eight provincial cases. The paper ends with the identification of major flaws in the existing model of diversified sports industry development in terms of science and technology innovation and suggestions of feasible optimization paths to solve them.

2 Research design for the construction of diversified development mode of sports industry

2.1 New business development mode of diversified sports industry under science and technology innovation

The novel approach to diversified sports industry development based on the principles of science and technology innovation has three underlying dimensions: the development of industrial structure, the development of industrial organization, and the industrial development policy. Under this innovation-oriented architecture, there has been a proposed specific development model that will help to ensure healthy and sustainable growth of sports industry diversification; its overall structure is depicted in Figure 1. The model is analyzed in each of the three dimensions mentioned above according to the existing theories of industrial development. Concerning industrial structure, the goal is to achieve the development orientation of diversified sports industry, i.e., high-end and new, through the process of industrial integration, agglomeration and optimization of industry chains, and matching of industrial supply and demand. It allows the new industrial structure to move towards high-end innovative development. In regard to industrial organization, the diversified and emerging industrial structure of the sports industry is organized in a grouping manner of organization under the overarching influence of science and technology innovation. Within the context of the joint failure of both governmental interventions channels and market channels, the research is integrated with the results of economic scholarship to explore the agglomeration effects and development opportunities of diversified sports industries. Based on these considerations, a more reasonable development model of diversified sports industry under science and technology innovation is introduced, whereby the final goal is to reach full optimization in the industry as a whole.

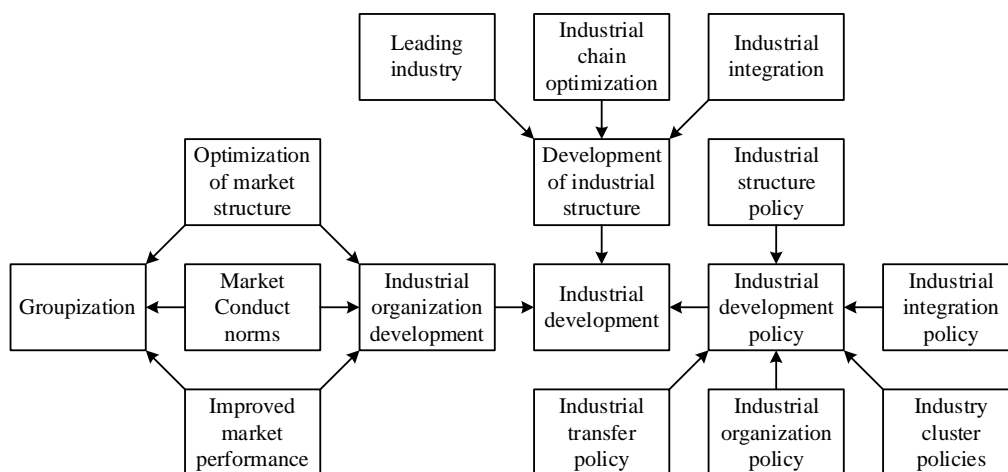


Figure 1: A new business model and development mode of diversified sports industry

2.2 Study population

The empirical data of this research are eight provinces located in China, namely Yunnan, Heilongjiang, Sichuan, Qinghai, Shanxi, Guangdong, Zhejiang, and Jiangsu. The research creates a vivid image of the existing developmental situation in every provincial setting through the systematic examination of the multifaceted agglomeration properties and development opportunities of the sports industries in these provinces. Based on these results, the paper offers specific suggestions on the development of diversified sports industry development models with the help of science and technology innovation.

2.3 Research methodology

2.3.1 Diversified Sports Industry Agglomeration Measurement

The research uses the multi-distance spatial cluster analysis model and the nearest neighbor distance approach to explore the clustering influences of sports industry diversification in various regional environments. This analysis is performed in a larger context of science and technology innovation pathways. These clustering patterns are mapped out by the study and an empirical base is formed on which the developmental potential of diversified sports industries in different areas may be evaluated even more strictly and methodically.

(1) Multi-distance spatial clustering analysis model

Ripley's K function [35] analysis regards the local sports industry as a point in space, draws the distribution map of the point location, and analyzes the spatial distribution pattern of the sports industry on the basis of the point map, which is the most commonly used method for point pattern analysis. Let n be the number of sports industry points in the study area, A be the area of the study area, and Ripley's K function is defined as:

$$K(d) = A \sum_{i=1}^n \sum_{j=1}^n \frac{d_{ij}(d)}{n^2} \quad (i, j = 1, 2, \dots, n, i \neq j, d_i \leq d) \quad (1)$$

where: n is the number of sport industry points; d is the distance scale; d_i is the distance between landscape points i and j ; and A is the area of the study area. Besag proposed replacing $K(d)$ with $L(d)$ and making an open square linear transformation of $K(d)$ to keep the variance stable. Under the assumption of random distribution $L(d)$ expectation is 0 and $L(d)$ is:

$$L(d) = \sqrt{\frac{K(d)}{\pi}} - d \quad (2)$$

Point location maps of every landscape type in the study years underwent Ripley's K-function analysis and associated significance tests. It was done through multi-distance spatial cluster analysis tool that is implemented using Ripley's K-function, a part of the spatial statistics toolbox of ArcGIS software.

The calculated results in dbf format were imported into Excel software to generate a plot of the relationship between the distance value d , the observation value $L(d)$, the upper envelope trace, the lower envelope trace, and the difference between the d and $L(d)$ values of DiffK. If the value of $L(d)$ is larger than the upper envelope trace, the landscape type is significantly clustered distribution; if the value of $L(d)$ is smaller than the lower envelope trace, the

landscape type is significantly uniformly distributed; if the value of $L(d)$ is located between the upper and lower envelope traces, the landscape type is significantly randomly distributed. When the value of $L(d)$ is greater than d , and the farther the two curves are from each other, i.e., the larger the DiffK value is, the stronger the spatial distribution of the landscape type is aggregated; when the value of $L(d)$ is smaller than d , and the farther the two curves are from each other, i.e., the smaller the DiffK value is, the stronger the spatial distribution of the landscape type is dispersed.

(2) The nearest neighbour distance measurement is a measure of the distance between a given point and its nearest neighbour in space. It is a geographical indicator that measures the level of proximity of point-like features in relation to one another within geographic space. The exact calculation formula is given as:

$$\bar{r}_E = \frac{1}{2\sqrt{n/A}} = \frac{1}{2\sqrt{\lambda}} \quad (3)$$

$$R = \frac{\bar{r}_i}{\bar{r}_E} \quad (4)$$

In Eq. (3): \bar{r}_E is the theoretical closest neighbor distance; n is the number of points; A is the area of the study area; and λ is the point density. In equation (4): R is the nearest neighbor distance index, and \bar{r}_i stands for the actual nearest neighbor distance measured in practice. Depending on the nearest neighbor distance index values, three different spatial distribution types can be distinguished. At $R > 1$, the measured nearest neighbor distance between points is larger than the theoretically predicted distance, meaning that the points are repelling each other and will tend to a spatially even distribution. At $R = 1$, the point pattern is consistent with a fully random layout, indicating spatial randomness without any observable grouping or patterning. At $R < 1$, the measured nearest neighbor distance is less than the theoretical distance, implying that points are attracted together and show a propensity towards spatial agglomeration. The nearest neighbor distance approach has been used in the current research to determine the nearest neighbor index of small towns across the nation and province levels to describe the spatial distribution patterns of these towns. Then, the tendencies of the distributions of small towns, working at various scales, are analyzed and discussed on a macro level.

2.3.2 Measuring the potential for diversification of the sports industry

(1) The basic concept of factor analysis method

Since the development of computer technology has been quite rapid, factor analysis has been widely used in many areas. It is considered to be an objective, quantitative and holistic evaluation tool, which has shown to especially be useful when performing activities like financial quality evaluation.

The Factor Analysis [36] is a member of the family of multivariate statistics and works by reducing an extensive list of related original variables down to a limited number of dominant factors. The internal logic depends on the clustering of variables based on the level of their intercorrelations. Highly correlated variables are grouped together, whereas weakly correlated ones are put in separate categories. All subsequent categories are believed to be the basic underlying structures, often known as the common factors or a public factor. It becomes much easier to derive the main trends and the key features inherent in the research problem by

representing the initial observations as linear combinations of a small number of these common factors.

(2) The mathematical model of the factor analysis method

Let P variables have m common factors ($m < p$), which are standardized variables with zero mean and standard deviation of 1; F_1, F_2, \dots, F_m are uncorrelated with each other and have variance 1; $\varepsilon_1, \varepsilon_2, \dots, \varepsilon_p$ are independent of each other and have different variances; then the formula can be expressed as:

$$\begin{cases} X_1 = a_{11}F_1 + a_{12}F_2 + \dots + a_{1m}F_m + a_1\varepsilon_1 \\ X_2 = a_{21}F_1 + a_{22}F_2 + \dots + a_{2m}F_m + a_2\varepsilon_2 \\ \dots \\ X_p = a_{p1}F_1 + a_{p2}F_2 + \dots + a_{pm}F_m + a_p\varepsilon_p \end{cases} \quad (5)$$

Among them:

$$A = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1m} \\ a_{21} & a_{22} & \dots & a_{2m} \\ \dots & \dots & \dots & \dots \\ a_{p1} & a_{p2} & \dots & a_{pm} \end{pmatrix} \quad (6)$$

A is the factor loading matrix, a_{ij} is the factor loading, which is the loading of the i-th original variable on the j-th factor variable.

ε is the special factor, which represents the portion of the original variable that cannot be explained by the factor variable. Thus it can be expressed as:

$$X = AF + a\varepsilon \quad (7)$$

(3) The basic steps of factor analysis

① Standardize the original data

On the basis of standardized data, factor analysis of the overlapping information in the original variables.

② Factor analysis suitability test

Factor analysis applicability is established by first standardizing the initial data. If there are sufficiently high correlations between the original variables, it will be possible to choose a limited number of representative factor variables that reflect the common features present in the dataset. This study uses two conventional diagnostic methods to achieve this end, which are the KMO test and the Bartlett test of sphericity.

KMO statistic measures the extent of partial correlation between variables. A greater KMO number indicates the existence of additional common factors and means that the sample size and data structure can be adapted to the factor analysis. The indication that the selected indicators are appropriate to factor analysis is made when the KMO value is over 0.5, whereas an indicator of poor appropriateness is made when it is below this level. In contrast, the Bartlett test of sphericity examines the correlation structure of data using two main criteria: the approximate chi-square statistic and its significance level. If the observed chi-square value is considerably high and the probability is lower than the 0.05 significance level, the original

variables are regarded as suitable to factor analysis. When the significance level is greater than 0.1, the data are considered inappropriate to use this method.

③ Calculate the correlation coefficient matrix R and eigenvalues.

Correlation coefficient matrix R is then developed based on the variables used in the research. The eigenvalues of R and their respective unit eigenvectors are then determined and these are used as the starting point of the factor analysis process. Cumulative contribution rate is calculated using the first m eigenvalues and their associated eigenvectors. Sample data is then processed by using the extracted factor variables and the variance contribution rates which are attributed to each factor are considered as weights that correspond to the original variable scores. Based on this, the functional formula that governs the analysis is set up.

④ Calculate the composite score:

$$F_j = \beta_{j1}X_1 + \dots + \beta_{jp}X_p \quad j=1,2,\dots,m \quad (8)$$

The composite score is calculated by a weighted average summation process in which each of the public factors are given weights that are equal to the ratios of their individual variance contributions to the overall cumulative variance contributions.

3 Analysis of diversified agglomeration and development potential of sports industry under science and technology innovation

In this paper, 5,000 citizens between the ages of 15 and 55 were recruited through an online platform from eight provinces, namely Yunnan, Heilongjiang, Sichuan, Qinghai, Shanxi, Guangdong, Zhejiang and Jiangsu, and then 1,000 people were randomly selected to conduct an online questionnaire survey. All 1,000 questionnaires that were sent to the target population were received, 854 of them in a proper and full-fledged format, resulting in a recovery rate of 85.45 percent. The reliability and validity of the questionnaires are both greater than 0.8, and the credibility and generalizability meet the requirements of this paper.

3.1 Analysis of sports industry agglomeration results under the guidance of science and technology innovation

3.1.1 Analysis of the results of the nearest neighbor analysis of the sports industry

In this paper, eight regions, namely Yunnan, Heilongjiang, Sichuan, Qinghai, Shanxi, Guangdong, Zhejiang and Jiangsu, were selected to analyze the agglomeration effect of diversification of sports industry by introducing the nearest neighbor index.

By using the average nearest-neighbor analysis tool in Arcmap, the sports industry within the scope of eight provinces and the five objects it contains, namely, sports fitness and leisure activities, stadium services, sports sales and sports training services, were analyzed to obtain the nearest-neighbor indexes of different categories of data. The results of the nearest-neighbor analysis for sports industry evaluation are shown in Table 1. It can be seen that the \bar{r}_E of the studied local sports industry diversification as well as the five objects of sports product diversification and development activities, stadium services, sports sales industry and sports training services that it contains are not more than 1, and the P-value is less than 0.005, which shows a significant clustering state. The Z-value of the five objects in this analysis is less than -5, indicating that the diversification of the sports industry within the local area shows a

significant spatial agglomeration. Among them, sports fitness and leisure activities \bar{r}_E are the smallest, with the highest degree of clustering at -15.736; the other degrees of clustering in descending order are sports sales industry (-11.495), stadium services (-9.437) and sports training services (-5.383).

Table 1: Sports industry evaluation nearest neighbor analysis results

Type of sports industry	Quantity	\bar{r}_E	Z	P	Distribution pattern
Sporting and recreation activities	287	0.474	-15.736	0.000	Significant clustering
Sports venue services	80	0.524	-9.437	0.000	Significant clustering
Sports merchandise industry	115	0.364	-11.495	0.000	Significant clustering
Sports training services	55	0.616	-5.383	0.000	Significant clustering
Overall sports industry (including others)	528	0.388	-26.726	0.000	Significant clustering

3.1.2 Analysis of multi-distance spatial clustering results of sports industry

The analysis of Ripley's K-function considers each local sports industry entity as a separate dot in geographic space to create a map of a point location distribution. The spatial analysis of the heterogeneous development of sports industry is subsequently performed using that point map. In the current section, the results of spatial clustering of the eight provincial research objects at three time points (i.e., 2016, 2020, and 2024) are considered.

When setting up the multi-distance spatial clustering analysis, the initial distance was fixed at 1,000 meters and the increment distance at 500 meters. Information obtained on the sports industries of the eight provinces was processed by 25 rounds of value extraction. The confidence interval was set at 99 percent and the Monte Carlo approach was used to test the significance of departures in Ripley's K index relative to a random distribution. The simulated outer boundary values approach was used to deal with the boundary correction.

Figure 2 depicts the results of Ripley's K-function analysis of the sports industry data with panels (a)-(c) corresponding to the years 2016, 2020, and 2024 respectively. There are several patterns that can be observed in the findings. The diverse spatial disposition of the sports industry in 2016 shows strong agglomeration within a radius of 11.4 kilometers. This agglomeration is intense and has a curve that climbs slowly until it peaks at a distance of 4.36 kilometers. The distribution changes to a form of spatial dispersion after the 11.4-kilometer cutoff point. 2020, the diversified distribution of the sports industry presents the distribution characteristics of significant agglomeration, with the agglomeration distribution at 3.67km, and the distribution of the diversified distribution of the sports industry is not significant. In 2024, the diversified distribution of sports industry still shows the distribution characteristics of significant agglomeration in general, the cluster level is relatively uniform in multiple distances, and the cluster level outside 11.4km also shows the trend of uniform change, and the cluster distribution reaches the most significant level at 4.38km. The clustering distribution reaches the most significant level at 4.38km.

The analysis of the year-on-year changes in clustering intensity at the three time points demonstrates that there exists a certain trend that can be observed in 2016, 2020, and 2024 in particular. The distance range with the highest level of clustering is located in the vicinity of about 4 kilometers of the urban center in each of the three years. Sports industry diversification outside the 11.4-kilometer limit experienced a significant shift throughout the period between 2016 and 2020, shifting out of the spatially dispersed condition and into the agglomerative one. The extent to which there was a change in clustering intensity during this period was relatively small and insignificant in the other distance ranges that were already characterized by agglomeration. All the distances included in the study are within an agglomeration distribution

state in 2020-2024. However, the K-function line in 2024 is much flatter compared to the one in 2020. This flattening indicates a phenomenon of sports industry diversification agglomeration spreading outwards through the city centre to more remote regions. The extent of agglomeration intensity decreases with distance to the center. Nevertheless, despite this spatial decline, the average agglomeration intensity in the local area keeps increasing annually indicating that the agglomeration has a constant and steady growth over time.

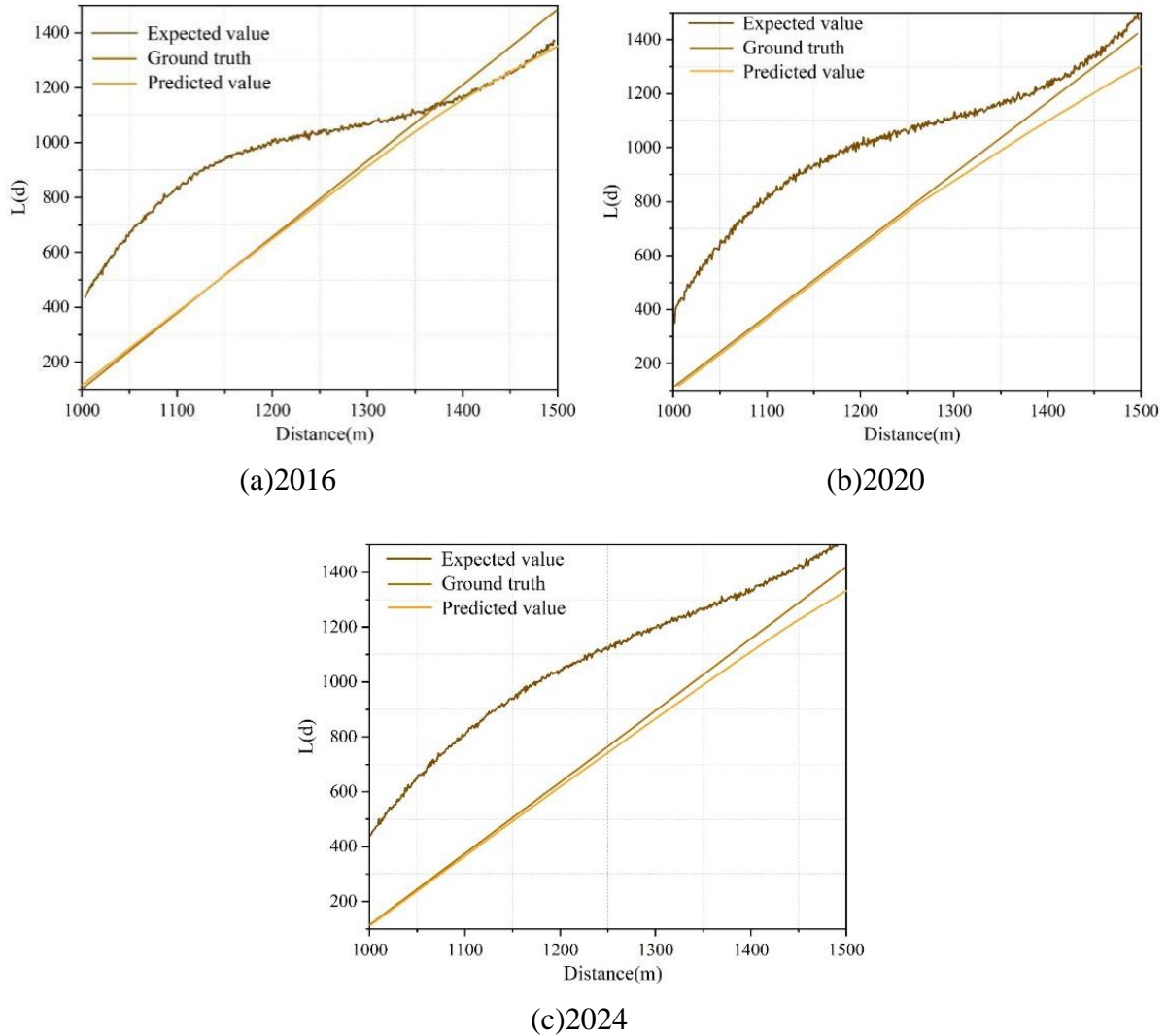


Figure 2: Sports industry Ripley's K function analysis results

3.1.3 Uneven development of sports industry diversification

A comparative analysis of the diverse added value of the sports industry within the eight provinces is given in Table 2. Development of sports, fitness, and leisure industries are under active pursuit all over China, including economically developed provinces and cities where the fitness and leisure industry keeps evolving due to changing circumstances and economic limitations. The statistical information regarding diversified value added in the eight provinces reveals that there are significant differences in the developmental directions of the sports, fitness, and leisure industry between different provinces. Although discrepancies in the standard of statistical measurements could explain part of the observed disparities, the disparities in the degree of sports product diversification efforts among various provinces and cities are still clearly visible. By 2024, the additional value created by sports fitness and leisure industrial

activities was 4.6975 billion yuan, and the additional value of sports industry diversification and its associated industries was 98.0333 billion yuan. The percentage of sports product diversification development activities in the total incremental output value of sports industry diversification was equal to 4.792%. Moving on to the absolute growth rates of sports product diversification activities, the average in the provinces and cities surveyed was 263.9 million yuan. The added values of Guangdong, Zhejiang, and Jiangsu were higher than the national average, whereas Yunnan, Heilongjiang, and Sichuan were slightly lower. By comparison, Qinghai and Shaanxi were much lower than the national standard. Combining all these data suggests that with the help of the science and technology innovation route, the diversification of sports products exhibits a spatial trend where the activity is active at either end of the regional scale but is relatively low in the central part of the scale.

Table 2: Comparison of diversified added value of sports industry in 8 provinces

Area	Value added of sports, fitness and leisure activities (100 million yuan)	Value added of sports and related industries (100 million yuan)	The proportion of added value of sports, fitness and leisure activities in the added value of sports and related industries (%)
Nationwide	46.975	980.333	4.792
Average	2.639	49.35	3.572
Yunnan	1.911	7.617	25.089
Heilongjiang	1.086	6.372	17.043
Sichuan	1.083	7.106	15.241
Qinghai	0.62	0.888	69.820
Shanxi	0.534	7.536	7.086
Guangdong	7.286	157.265	4.633
Zhejiang	4.641	88.155	5.265
Jiangsu	3.953	146.797	2.693

3.2 Evaluation results of the potential for diversified development of the sports industry

3.2.1 Construction of evaluation indicator system

Based on the concept of science and technology innovation path as an organizational structure, the current paper is aimed at summarizing the results of previous research to come up with a well-rounded assessment indicator system that can be used to evaluate the varied opportunities of the sports industry. The generated system, which is shown in Table 3 contains three main dimensions of development, namely supply potential, demand potential, and integration potential. The particular composition of evaluation index system is as follows.

Table 3: Evaluation index system of sports industry diversification potential

Primary indicators	Secondary indicators	Third-level indicators		
Supply potential	Supply has inherent potential	GDP (in billion yuan)		
		Sports industry scale (100 million yuan)		
		Number of employees in sports industry (person)		
		Number of sports industry policies (per)		
		The government's positioning of the sports industry		
	Potential for supply expansion	Number of sports venues (per)		
		Per capita area of facilities (square meters)		
		Number of second class and above passengers		
		Number of second-level referees and above		
		Number of MEDALS in major sporting events		
		Number of patents granted per year (per)		
		Scientific research investment (100 million yuan)		
		Potential demand	The inherent potential of demand	Number of social sports instructors (10,000)
				Number of mass fitness activities (groups)
Sports lottery sales (100 million yuan)				
Community health service institutions (individuals)				
Participation rate in physical fitness activities (%)				
Residents' satisfaction rate with physical fitness activities (%)				
Awareness rate of residents' physical fitness activities (%)				
Demand support potential	Urban per capita disposable income (yuan)			
	Urban per capita consumption expenditure (yuan)			
	Urban residents' savings (100 million yuan)			
Convergence potential	Potential for tourism integration	Total population (per 10,000)		
		Number of regular university students (per 10,000)		
		Number of Grade A scenic spots (number)		
		Number of tourists (10,000)		
	Potential for cultural integration	Total tourism revenue (100 million yuan)		
		Number of days with good air (days)		
		Number of cultural venues (units)		
		Number of legal persons in culture, sports and recreation (no)		
		Number of self-employed persons in culture, sports and recreation (no)		
		Types of newspapers, periodicals and books (types)		
	No. of cable TV households (10,000)			
	Mobile phone subscribers (10,000)			

3.2.2 Evaluation of intrinsic supply potential

Factor analysis (exploratory) was used to investigate the sample data based on every indicator of the intrinsic supply potential of sports industry diversification in eight Chinese provinces. The KMO value came out as 0.8224 which is an indication of high sampling adequacy. Sphericity test of Bartlett produced 97.4108 at 8 degrees of freedom, and the corresponding significance level of Sig. = 0.00 is far less than 0.005. The diagnostic results are both confirming the fact that the sample can be considered to have adequate quality and it is properly selected to conduct factor analysis. Analysis of the main components of the intrinsic potential of the

sports supply in China showed that there are negative values within the results. In order to put these scores in line with intuitive interpretation, a transformation was performed to transform all values into positive numbers in the form of the equation: $F = F + [|\text{Min}(F)| + 1]$.

Five constituent indicators, which include regional GDP, the level of sports industry diversification, the number of people employed in the sector, the size of industrial policies in place, and the extent of government orientation towards diversification of sports industries, reflect the inherent value of diversified sports industry supplies in China. In Table 4, the final scores of intrinsic sports supply potential of all eight provinces are presented. In the context of eight provinces, the order of intrinsic potential of sports industry diversification is rather similar, as the intrinsic potential of all eight provinces is arranged in accordance with the overall local economic development level, indicating a positive correlation between these two dimensions. Among them, Zhejiang, Jiangsu and Guangdong are in the top three of the 8 provinces in terms of the intrinsic potential of industry diversification with absolutely obvious advantages. Shaanxi and Yunnan exceed the GDP ranking of the region by two or more places in the ranking of intrinsic potential for diversification of the sports industry, presenting a strong intrinsic potential advantage. Heilongjiang and Sichuan's ranking in terms of the potential for diversification of the sports industry is on par with the GDP ranking of the region. Qinghai lags behind the GDP ranking of the region in terms of the inherent potential of diversification of the sports industry.

Table 4: The final results of the inherent potential of sports supply in 8 provinces

Province	Endogenous supply potential final score	Supply expansion potential score	Supply potential final score
Yunnan	0.9678	1.0668	1.0255
Heilongjiang	0.8271	0.9873	0.8472
Sichuan	0.8798	0.5198	0.8834
Qinghai	0.8983	0.3824	0.6513
Shanxi	0.9431	1.4337	1.2432
Guangdong	2.5769	2.4512	2.3912
Zhejiang	3.8234	2.3718	2.7204
Jiangsu	2.6042	2.0718	2.4761

3.2.3 Evaluation of demand potential

The analysis of factors was performed on the obtained data related to every indicator of the intrinsic demand potential of sports industry diversification in eight Chinese provinces. The return KMO value was 0.8308 which indicates a moderate to high degree of sampling adequacy. Sphericity test by Bartlett generated a value of 110.352 at 8 degrees of freedom and its significance value of Sig. = 0.00 is less than the cut-off of 0.005. Both statistical indicators when put together affirm that the sample data are of acceptable quality and appropriate to factor analysis.

The final scores of the intrinsic potential of diversified demand for sports industry in the eight provinces are shown in Table 5. The differences in the intrinsic potential of demand for diversification of the sports industry among the eight provinces in China are huge and highly concentrated, with Guangdong having the largest intrinsic potential of demand for diversification of the sports industry, Jiangsu ranking second and Zhejiang third, and its final score of intrinsic potential of demand is much higher than that of the other provinces, while the other provinces either have more (0.3694 for Heilongjiang) or fewer (0.8518 for Yunnan) intrinsic potentials of demand that are insufficient.

Table 5: The internal potential of diversified demands in sports industry final score

Province	Internal demand potential final score	Demand support potential final score	Demand potential final score
Yunnan	0.9276	0.5544	0.8518
Heilongjiang	0.4846	0.3429	0.3694
Sichuan	0.7349	1.0126	0.8179
Qinghai	0.6487	0.7171	0.5523
Shanxi	0.4015	0.1589	0.5364
Guangdong	3.4703	3.9177	3.5377
Zhejiang	2.3963	2.9909	2.6675
Jiangsu	3.4228	3.5334	3.3336

3.2.4 Evaluation of integration potential

The data were subjected to factor analysis with respect to the indicators related to the integration potential of sports tourism in eight Chinese provinces. The obtained KMO value of 0.7503 indicates a fair degree of sampling appropriateness. Sphericity test of the Bartlett test gave a calculated value of 73.418 at 8 degrees of freedom and the significance level of Sig. = 0.00 which meets the condition of being below the 0.005 threshold. Taken together, both indicators suggest that the sample is of good quality and can be further used in factor analysis.

The sports integration potential scores of the 8 provinces are shown in Table 6. From the data of sports industry diversification and integration potential, among the 8 provinces, only Guangdong, Jiangsu, Zhejiang and Yunnan show strong sports industry diversification and integration potential, especially Guangdong and Zhejiang. The diversified integration potential of the sports industry in Qinghai is average (0.8593), while other cities are weaker.

Table 6: Score of sports integration potential in each city

Province	Tourism integration potential score	Potential score for cultural integration	Combine potential to get a final score
Yunnan	0.8024	1.3142	1.0155
Heilongjiang	0.3792	0.4454	0.4577
Sichuan	0.2973	0.7447	0.5376
Qinghai	0.9035	1.0123	0.8593
Shanxi	0.3859	0.2085	0.3848
Guangdong	3.9324	3.6423	3.7012
Zhejiang	2.7961	2.696	2.5708
Jiangsu	3.3623	3.5415	3.4294

3.2.5 Comprehensive evaluation of the potential of the sports industry

Figure 3 shows a detailed overview of the potential scores in the sports industry in the provinces under survey. The composite scores of the potential of diversification of the sports industry in Jiangsu, Guangdong, and Zhejiang were 3.4697, 3.4519, and 2.7522 respectively, which ranked the three provinces first out of the eight surveyed provinces, indicating that these areas have relatively large space to develop. Other provinces showed much more modest diversification potential on each of the dimensions measured.

Jiangsu, Guangdong and Zhejiang, as coastal provinces, fully grasp the strategic opportunity of the country to vigorously develop the diversification of the sports industry. They make use of their resource advantages to continuously meet the growing diversified,

differentiated and individualized needs of the general public through the construction of regional sports center cities, the construction of Healthy China and industrial agglomeration. It not only guides residents to engage in physical exercise, but also cultivates their sports consumption habits, changes their sports values and attitudes, integrates sports as the most basic need into the basic life of the common people, and continuously improves the physical quality and sense of well-being of the nation.

The other five provinces have very low rates of sports industrialization, and the assistance that has been offered through different policy frameworks has not been adequate to enable all the potential benefits of these areas to be maximized. Inequality in sports development among various regions, as well as between cities and villages, is a significant and unsolved problem. The sports industry in these provinces is limited in size, and institutional structures and mechanisms aimed at promoting sports industry development do not have adequate vitality. There are short supply chains in the sports industry, and it is structurally unbalanced, and the intention of social actors and private players to participate in sports is minimal. To add to these challenges, the creation of sports social groups in China, especially those working at the local level, is still very incomplete. Therefore, the task of arranging sports events remain unfairly burdensome on state agencies, which is unfavorable to the development of the sports industry in diverse ways under the influence of science and technology innovation.

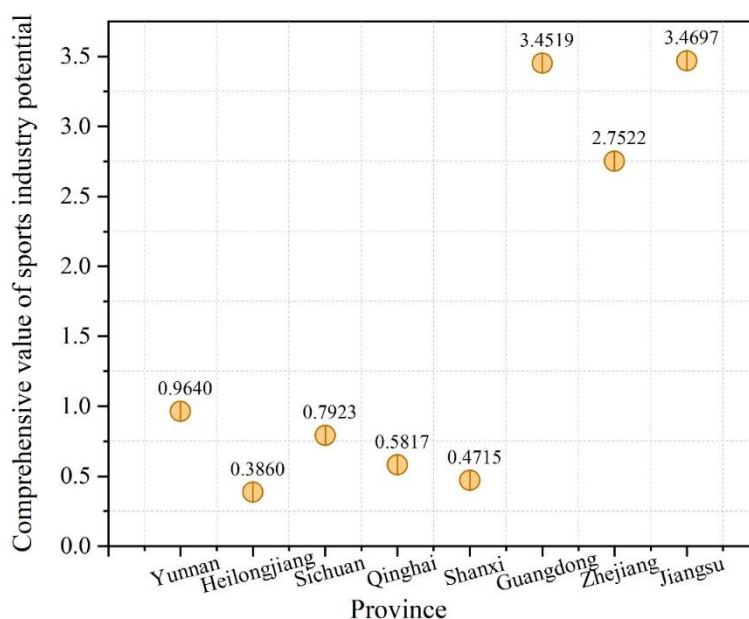


Figure 3: Comprehensive potential score of sports industry in each city

3.3 Suggestions for diversified development mode of sports industry under science and technology innovation

3.3.1 Enhancing the competitiveness of the sports industry

The diversified development of sports industry should set up the concept of innovative development, strengthen the cognition of innovation, promote the new generation of information technology represented by cloud computing, Internet of Things, big data, sports enterprises take the innovative technology as the driving force, design and develop sports derivatives, and actively explore the new development path of “Internet + sports”. With the help of e-commerce and other emerging trading technologies, we are constantly promoting the construction of sports business e-commerce trading platforms, expanding the sales business of

sports enterprises, and creating a business model combining online and offline. Through big data analysis, enterprises form user labels and conduct accurate marketing for target user groups. Taking the Sports Industry Diversification Investment Promotion Conference and the Sports Marketing Summit Forum as a platform, taking the sports industry diversification as the focus point, taking the characteristic sports events as the gripping hand, building the characteristic sports diversification industry of the city circle, digging deeply into the unique ecological advantages, and exploring the development road of the integration of the diversified industries of sports and tourism, real estate, and health.

3.3.2 Building a diversified system for the sports industry

Various aspects of the sports industry should be integrated into the wider context of the regional socio-economic planning in every region. It is necessary to aim at creating one center of local sports industry diversification and at the same time strengthen the diversified sports industries of the neighboring cities of the metropolitan circle. Developing recognizable local landmarks as the focus of sports industry development in the city circle is regarded as a strategic priority. Regions can create an up-to-date sports industry model that has authentic local features by building off the abundant and unique sports resource endowments offered nearby, thus becoming the leading vehicle of sports industry expansion in the larger city circle. The centralisation of the core of the local sports industry should be the key goal, and professional football and professional tennis should be seen as the most significant entry points to other developmental programs. It is important in the process to actively use the functional capabilities of local sports centers to encourage the development of industries where the region is competitively strong. This strategy will see locally distinctive sports industries developed into true strengths that make a significant contribution to the overall strength and competitiveness of the regional sports economy.

3.3.3 Shaping a low-carbon brand for the sports industry

Sports enterprises should establish a low-carbon image in the minds of consumers, publicize low-carbon knowledge, establish a good low-carbon reputation, and enhance the trust between enterprises and consumers. Sports enterprises should not only provide sports consumers with sports products and services, but also allow consumers to master low-carbon knowledge related to sports products and services, strengthen the low-carbon concept in the sales process, establish a low-carbon brand image of sports enterprises, and create a low-carbon marketing model for sports enterprises. With low carbon and green as the direction of development, the city circle must make efforts to cultivate sports leading green enterprises, carry out the identification of leading enterprises in sports industry diversification, actively integrate all kinds of industrial resources, form the sports industry diversification group in the city circle, and improve the strength and competitiveness of sports industry diversification in the city circle.

3.3.4 Promoting the open operation of sports venues

Adhering to the open development of venues and facilities, the government has increased the financial investment in purchasing public sports services, opened large sports venues to the public for free in the form of issuing free fitness coupons or experience coupons, and opened small and medium-sized high-grade stadiums to sports consumers at a low charge, gradually attracting the masses to enter the venues, stimulating sports interests, cultivating sports habits and promoting sports consumption. Using core technology to create smart venues, the company utilizes the Internet and cell phone platforms to provide convenient and fast venues, coaching reservations and other services.

3.3.5 Expansion of sports consumption

Enlarging community involvement in sports and fitness is a significant way of developing consumption in the sector. The sports companies also have the equivalent obligation to come up with a wide array of products and services that can meet the individual needs of various consumer categories. It is also essential to note that the total quality of these offerings should be improved since this will directly define whether or not the growing variety of sports consumption requirements of the populace in general will be sufficiently addressed. Enterprises may contribute to the stimulation and growth of sports consumption on a larger scale through persistent innovation of products and enhancement of services. Sports enterprises can cooperate with finance to develop sports consumption financial products. Schools, for example, should carry out sunshine sports activities, ensure that young people have one hour of extracurricular activities every day, and organize various types of sports competitions to drive young people's sports consumption.

4 Conclusion

The paper uses multi-distance spatial clustering algorithm, nearest neighbor distance approach, and factor analysis to analyze the clustering tendencies and development opportunities of sports industry diversification under the influence of science and technology innovation. Based on this, an optimization pathway has been proposed to the diversified new business development model of the sports industry. The main findings that have been identified through the analysis are:

Every region has unique resource advantages which may be strategically exploited to meet the increasing demands of the people on the diversification of the sports industry. By constructing regional sports center cities, promoting the Healthy China program, and enhancing industrial agglomeration, each region has the opportunity to develop varied pathways of sports consumption and fully utilize the latent development capacity available in their respective sports industries. In addition to these, it is necessary to respond to some ongoing structural issues with a package of specific actions, such as regional disparities in sports development, the rural-urban divide in sports participation, the limited scale of the sports market, and the lack of full-fledged grass-root sports organizations. The innovation must dominate the process of developing the sports industry competition. Coordination ought to be considered as one of the conditions of creating a diverse and internally cohesive sports industry system. The green development orientation could lead the industry to form a visible low-carbon identity. Openness ought to act as a structural mechanism to facilitate the liberalization of sports venue operations. Ultimately, an intent to share ought to inform attempts to expand the consumption of sports and expand availability to a broader section of the population.

About the Author

Xuefeng Fan was born in Datong, Shanxi Province, China, in 1988. She received her master's degree from Wuhan Sports University. Now, she works in Tianjin Chengjian University. Her main research interests are traditional sports, school sports and sports industry.

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