Coupling Coordination Analysis and Obstacle Factor Diagnosis of Sports and Pension Industry Based on Improved Entropy Weight Catastrophe Progression Method

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Abstract. Under the background of the gradual integration and development of the sports and pension industry, this paper constructs the evaluation index system of coupling and coordinated development of the sports and pension industry from four dimensions. Based on the "improved entropy weight catastrophe progression method", the coupling and coordination analysis of sports and the pension industry in 22 regions including Guangdong Province is carried out, furthermore, the cloud entropy weight method is used to improve the weight calculation in catastrophe progression method, which improves the comprehensiveness and objectivity of weight ranking, and makes the evaluation results more scientific and reasonable. Then, combined with the obstacle factor diagnosis model, this paper focuses on the analysis of the coupling coordination time series characteristics and the main obstacle factors of the sports and elderly care industry in Guangdong Province from 2013 to 2017, so as to provide significant reference.

Keywords: sports industry · pension industry · coupling coordination analysis · catastrophe progression method · cloud entropy weight method

1 Introduction

With the continuous development of social economy, great changes have taken place in our population structure. Aging population and empty-nested phenomena are developing rapidly, and China is facing a complex and severe situation in the pension industry. Although sports industry started late in China, it has developed rapidly and become a new economic growth point. However, at the same time, it is also faced with the adjustment and upgrading of industrial structure [1]. In March 2017, the State Council issued the 13th Five-Year Plan for the Development of the National Cause of Aging and the Construction of the Pension System, proposing to support the integrated development of the pension service industry with the health, fitness and leisure industries. In September 2019, the State Council issued the Opinions on Promoting National Fitness and Sports

Consumption to Promote the High-quality Development of the Sports Industry, emphasizing again that the deep integration of sports and health care and other fields should be accelerated to expand the new consumption fields of the pension industry. The sports industry and the pension industry can be deeply integrated, crossed and overlapped in the industrial chain. Promoting the continuous integrated development of two industries is not only an effective measure to deal with population aging, but also provides a new development direction for the transformation and upgrading of sports industries, which is of great significance to our economic growth. In this context, the integration of sports industry and pension industry has gradually become a research hotspot. Up to now, domestic scholars have mainly carried out relevant studies on the integration theory and technology of the two industries, while few studies have demonstrated the relationship between them by combining data and models [2].

For the measurement of the integration of sports industry and pension industry, grey correlation analysis method and coupling coordination degree model are widely used. For instance, Song Z Y used the literature method, entropy method and coupling coordination degree model method to measure the development level of sports industry and pension industry as well as their integrated development in 11 provinces and cities in eastern China [3]. Han S and Wang L used grey correlation analysis to analyze the trend pattern of the integrated development of sports industry and pension industry [4]. Chen H J adopted entropy method and coupling coordination degree model to empirically analyze the comprehensive development level and coupling coordination of sports industry and pension industry in Fujian province [5]. In view of the above research, this paper adopts the coupling coordination degree model to measure the integration of the pension industry and the sports industry. The mutation progression evaluation method derived from the mutation progression theory has the advantages of strong operability, simplicity and high quantification, and is suitable for the mutation phenomenon with discontinuous changes. In consequence, this paper introduces the mutation progression method into the coupling coordination analysis of sports industry and pension industry. However, most of the previous studies used the entropy weight method to calculate the weight of evaluation index factors, so as to rank the importance of evaluation indexes. The traditional entropy weight method cannot objectively and comprehensively reflect the influence of the original data on the calculation results. Therefore, cloud entropy weight method is adopted in this paper to improve the catastrophe progression model [6, 7], so as to determine the importance of the evaluation index. On this basis, a diagnostic model of obstacle factors is constructed to identify the main obstacle factors affecting the integrated development of the two industries. By coupling and coordinating the pension and sports industries, this paper discusses relevant problems and countermeasures, which can provide some reference for promoting the high-quality development of Chinese sports and pension industries.

2   Research Theory and Methodology

2.1   Basic Principle of Mutation Progression Method

Mutation progression method is a comprehensive evaluation method based on mutation theory and fuzzy mathematics. Its theoretical basis includes calculus, topological dynamics, singularity theory and structural stability. It provides a mathematical quantitative explanation of discontinuous changes in the system and can be applied to the mutation phenomena of discontinuous changes in the fields of natural and social sciences [8]. The core idea of the mutation progression method can be described as follows. On the basis of the hierarchical structure of inverted tree objects formed by the decomposition of evaluation objects step by step, the mutation theory and fuzzy mathematics are combined to generate the mutation fuzzy membership function. The total membership degree can be obtained through the normalization of the divergent set equation, so as to comprehensively evaluate the target [9, 10].

2.2   Construction of Improved Entropy Weight - Mutation Progression Model

The mutation progression method needs to rank the importance of indexes according to the weight of evaluation indexes. At present, the entropy weight method is mainly used to calculate the indexes weight. Although entropy weight method is a kind of objective weight method, the traditional entropy weight method cannot objectively and comprehensively reflect the influence of original data on the calculation results. As a consequence, after referring to existing related studies, this paper introduces entropy and super-entropy eigenvalues into the cloud model and uses the cloud entropy weight method to determine the importance of indexes at all levels [6, 7].

First, experts are invited to score the underlying evaluation index, with a score ranging from 1 to 100. The higher the score, the more important it is. The expert scores each item with $X = X_i$ ($i = 1, 2, 3, …, N$). i parameters are converted into expectation (Ex), entropy (En) and super-entropy (He) by an improved reverse cloud generator [11]. The calculation method is as follows:

$$Ex = \exp\left[\frac{-(x - Ex)^2}{2En^2}\right] \tag{1}$$

$$En = \sqrt{\frac{\pi}{2}} \frac{i}{N} \sum_{i=1}^{N} (X_i - Ex) \tag{2}$$

$$He = \sqrt{S^2 - En^2}, \ S^2 = \frac{1}{N-1} \cdot \sum_{i=1}^{N} (X_i - Ex)^2 \tag{3}$$

On this basis, the improved formula for calculating index weight ω of cloud entropy weight is obtained as follows:

$$\omega = \begin{cases} \frac{Ex_j}{1 + In(1 + En_j)} \frac{1}{\lg He \sum_{j=1}^{n} \frac{Ex_j}{1 + In(1 + En_j)}} & (En_j \neq 0) \\ \frac{Ex_j}{\sum_{j=1}^{n} Ex_j} & (En_j \neq 0) \end{cases}$$

The coupling coordination analysis of sports industry and pension industry is carried out by using the improved entropy weight-mutation progression method. Firstly, the coupling coordination evaluation objectives of sports industry and pension industry are decomposed at multiple levels until the indexes can be quantified. Then, after the experts score the weights, the cloud entropy weight method is used to calculate the weights of indexes at each level, and the importance of indexes is ranked according to the weight value and the relationship between indexes is determined. On this basis, based on the mutation progression model, the indexes of each level are normalized and calculated to obtain the corresponding mutation membership degree. Finally, the total membership degree of the same evaluation object is calculated by taking the average value or adopting the method of taking the small from the medium.

2.3   Coupling Coordination Model

In order to further study the coordination relationship between sports industry and pension industry, the coupling coordination model is introduced to calculate. The coupling coordination model of sports industry and pension industry originates from the concept of coupling in physics. Coupling coordination model includes coupling degree and coupling coordination degree [12]. The calculation formula of coupling degree function C is:

$$C = \sqrt{\frac{f_1 \times f_2}{(f_1 + f_2) \times (f_1 + f_2)}} \tag{4}$$

The larger the value of C is, the better the coupling is; on the contrary, the smaller the value of C is, the worse the coupling is. C is between [0 ~ 1], and f_1 and f_2 respectively represent the comprehensive development level of the sports industry and the pension industry. In this paper, the synthetic value is calculated by using the improved entropy weight - mutation progression method.

On this basis, the calculation formula of coupling coordination degree D is obtained as follows:

$$D = \sqrt{C \times (\alpha f_1 + \beta f_2)} \tag{5}$$

Among them, α and β are undetermined coefficients. Since there is no significant difference in the economic contribution of the sports industry and the pension industry to industrial integration, the coefficients α and β are both set as 0.5. In order to directly reflect the development status of sports industry and pension industry, the evaluation grade standard of mutation progression model is formulated according to the total membership value, which is divided into five grades: high, relatively high, medium, relatively low and low. In the meanwhile, the uniform distribution function value method is used to grade the coupling coordination degree of the development of the two industries, which is divided into 10 levels, as shown in Table 1.

2.4   Diagnosis Model of Obstacle Factors

After using the improved entropy weight-mutation progression model to grasp the coupling coordination degree between the sports industry and the pension industry, the

Table 1. Evaluation standard of coupling coordination level between sports industry and pension industry

Total membership value	Development level	Degree of coupling coordination
> 0.90	high	0.00–0.09
0.80 ~ 0.90	relatively high	0.10–0.19
0.70 ~ 0.80	medium	0.20–0.29
0.60 ~ 0.70	relatively low	0.30–0.39
< 0.60	low	0.40–0.49
Coordination level	Degree of coupling coordination	Coordination level
extreme imbalance	0.50–0.59	bare coordination
serious imbalance	0.60–0.69	primary coordination
moderate imbalance	0.70–0.79	intermediate coordination
mild imbalance	0.80–0.89	good coordination
tend to imbalance	0.90–1.00	high quality coordination

obstacle factor diagnostic model is introduced to quantitatively analyze the obstacle factors for the integrated development of the sports industry and the pension industry, so as to improve the development level of the sports industry and the pension industry [13, 14]. The calculation formula is as follows:

$$D_{ij} = 1 - Y_{ij} \tag{6}$$

$$I_{ij} = \frac{(D_{ij} \times \omega_{ij})}{\sum (D_{ij} \times \omega_{ij})} \tag{7}$$

In the formula, D_{ij} is index deviation degree, representing the gap between a single index and the target condition; I_{ij} is the obstacle degree coefficient, the larger the value, the stronger the obstacle force to the total target; ω_{ij} is the index weight calculated by the cloud entropy weight method; $D_{ij} \times \omega_{ij}$ is the contribution of the factor.

3   Indicator System and Data Sources

According to the integration concept, mode and mechanism between sports industry and pension industry, the evaluation index system is adjusted and optimized by referring to existing studies [8, 9, 15] and consulting relevant experts, so as to construct the coupling and coordination evaluation index system between sports industry and pension industry in China. On this basis, the weight of evaluation index is calculated by Matlab software based on cloud entropy weight method. According to the weight, the importance of the quantitative indexes in the same dimension is sorted, and the evaluation index system for the systematic coupling and coordinated development of the sports industry and the pension industry is obtained, as shown in Table 2.

The research data of this paper mainly come from the *Data Analysis of Sports Undertakings Statistical Yearbook in China*, *the Statistical Yearbook of Civil Affairs of China*, *the Statistical Yearbook of Guangdong Province* and the statistical bulletins published on the official website of the Sports Bureau of each region from 2013 to 2017. Due to the serious lack of data in some provinces, this paper selected 22 samples from Beijing, Hebei, Jiangsu and other regions for analysis. The index values that cannot be obtained directly are obtained by statistical collation. For individual index values with missing data in some regions, linear interpolation or proportional spatial interpolation is used to calculate and obtain [16].

Table 2. Evaluation index system of coupling and coordinated development of sports industry and pension industry

System layer	Subsystem layer	Expression layer	Index layer
Evaluation index system of coupling and coordinated development of sports industry and pension industry	Pension industry development evaluation index(0.5318)	Factor level of pension industry B_1(0.5030)	C_{11} Number of elderly care service institutions / unit (0.2539)
			C_{12} Number of employees / 10000 (0.2497)
			C_{13} Number of elderly care service beds / piece (0.2491)
			C_{14} Number of elderly activity rooms / piece (0.2473)
		Economic benefits of pension industry B_2(0.4970)	C_{21} Population over 65 years old /% (0.2622)
			C_{22} Pension service unit assets / 100 million yuan (0.2504)
			C_{23} Unit income of pension service industry / 100 million yuan (0.2481)
			C_{24} Investment in undertakings for the elderly / 100 million yuan (0.2392)
	Sports industry development evaluation index(0.4682)	Factor level of sports industry B_2(0.5842)	C_{31} Sports System Personnel/person (0.2514)

(*continued*)

Table 2. (*continued*)

System layer	Subsystem layer	Expression layer	Index layer
			C_{32} Number of Sports institutions/unit (0.2510)
			C_{33} Sports ground area per capita in the province /m^2 (0.2496)
			C_{34} Number of sports venues / piece (0.2480)
		Economic benefits of sports industryB_4(0.4158)	C_{41} Added value of sports industry / 100 million yuan (0.3350)
			C_{42} Total output of sports industry / 100 million yuan (0.3331)
			C_{43} Sports Lottery sales / 100 million yuan (0.3319)

4   Evaluation Results and Analysis

4.1   Evaluation Results of the Coupling and Coordinated Development of Sports Industry and Pension Industry

1) Study on the measurement results of the coupling and coordinated development of sports industry and pension industry in related regions.

Based on the improved entropy weight-mutation progression model, the composite index of 22 regions involved in the study in 2017 is calculated. In order to further evaluate the development status of sports industry and pension industry in the regions involved in the study, the economic benefits of the sports industry, the level of factors of the sports industry, the economic benefits of the pension industry, and the level of factors of the pension industry are analyzed. The evaluation results are shown in Table 3.

According to Table 3, the top five provinces are Jiangsu, Shandong, Guangdong, Zhejiang and Sichuan according to the comprehensive index of the development level of sports industry and pension industry. Except Sichuan Province, which is located in the central and western regions, the rest are economically developed areas in the east coast. In contrast, Guizhou Province, Guangxi Zhuang Autonomous Region, Tianjin municipality, Shanxi Province and Inner Mongolia Autonomous Region ranked the lowest among the 22 regions studied in 2017. Except Tianjin, the rest are in the central and western

Table 3. Evaluation results and ranking of the development level of sports industry and pension industry in the regions involved in the study

Region	Economic benefits of sports industry	Factor level of sports industry	Economic benefits of pension industry	Factor level of pension industry	sport industry	Pension industry	composite index	ranking
Jiangsu	0.9733	0.9286	0.8935	0.9425	0.9547	0.9179	0.9351	1
Shandong	0.8483	0.8837	0.7880	0.9074	0.8630	0.8473	0.8547	2
Guangdong	0.9960	0.9778	0.5761	0.8059	0.9885	0.6903	0.8299	3
Zhejiang	0.7636	0.7860	0.7603	0.8308	0.7729	0.7953	0.7849	4
Sichuan	0.5421	0.7961	0.8319	0.9032	0.6477	0.8673	0.7645	5
Hubei	0.6428	0.8215	0.6959	0.7662	0.7171	0.7308	0.7244	6
Hebei	0.6391	0.7438	0.7174	0.7500	0.6826	0.7336	0.7097	7
Hunan	0.5898	0.7905	0.6687	0.7300	0.6733	0.6992	0.6871	8
Liaoning	0.5205	0.8352	0.7099	0.7087	0.6513	0.7093	0.6822	9
Henan	0.6442	0.7864	0.5706	0.7135	0.7033	0.6416	0.6705	10
Beijing	0.5396	0.6478	0.8349	0.6308	0.5846	0.7335	0.6637	11
Anhui	0.5163	0.6581	0.6772	0.7082	0.5753	0.6926	0.6377	12
Shanghai	0.4660	0.5206	0.8050	0.6524	0.4887	0.7292	0.6166	13
Fujian	0.9326	0.7183	0.4558	0.3625	0.8435	0.4094	0.6126	14
Jiangxi	0.4508	0.6463	0.4794	0.6608	0.5321	0.5696	0.5521	15
Heilongjiang	0.4184	0.7073	0.5227	0.5716	0.5385	0.5470	0.5430	16
Chongqing	0.4026	0.4254	0.6702	0.5251	0.4121	0.5981	0.5110	17
Inner Mongolia	0.3757	0.6772	0.5523	0.3676	0.5011	0.4605	0.4795	18
Shanxi	0.1931	0.6124	0.4472	0.4617	0.3675	0.4544	0.4137	19
Tianjin	0.2952	0.4544	0.5074	0.2904	0.3614	0.3996	0.3817	20
Guangxi	0.1538	0.6866	0.4190	0.3235	0.3754	0.3716	0.3733	21
Guizhou	0.1187	0.4095	0.4006	0.4073	0.2396	0.4039	0.3270	22

regions. It follows that the sports industry and pension industry on the whole present the characteristics of regional unbalanced development.

In terms of the dimension of economic benefit of sports industry, three regions scored higher than 0.9: Guangdong (0.9960), Jiangsu (0.9733) and Fujian (0.9326). There are also three regions with scores lower than 0.2: Shanxi Province (0.1931), Guangxi Zhuang Autonomous Region (0.1538) and Guizhou Province (0.1187). From the highest 0.9960 to the lowest 0.1187, it can be seen that there is a great difference in the benefit scores of sports industries in different regions. This reflects the differences in investment efficiency and management level of sports industry in different regions.

In terms of factor level dimension of sports industry, the average value of 22 regions is 0.7052. The highest score is 0.9778 in Guangdong Province, followed by 0.9286 in Jiangsu Province. Three regions scored between 0.8 and 0.9. There are seven regions

with scores between 0.7 and 0.8, accounting for 31.82% of the total. Six regions scored between 0.6 and 0.7, and four regions scored below 0.6. Guizhou province has the lowest score of 0.4095. Through comparative analysis, it can be found that the economic benefit gap of the sports industry in the regions involved in the study is significantly larger than the level of factor input, and the level of factor input in the sports industry is relatively balanced. It can also be seen that the regions with the backward comprehensive level of sports industry should pay more attention to the investment efficiency of sports industry.

In terms of economic benefits of the pension industry, Jiangsu Province, Beijing and Sichuan Province are at the top of the list. The pension industry in Shanghai, Shandong Province and Zhejiang province has the second highest economic benefit. Shanxi Province, Guangxi Zhuang Autonomous Region and Guizhou Province in the central and western regions are relatively low on the list. Each region should strengthen the endowment fund, the senile enterprise fund and other resources reasonable allocation, and improve the endowment industry economic benefit.

In terms of factor level dimension of pension industry, the average value of the regions involved in the study is 0.6373. Among them, Jiangsu Province, Shandong Province and Sichuan Province have a high score in the factor level of the pension industry, which reflects that the investment intensity of the pension industry in these regions is relatively large and the policy support intensity is at a high level. The regions with low scores are Tianjin Municipality, Guangxi Zhuang Autonomous Region, Fujian Province and Inner Mongolia Autonomous Region. These areas should strengthen the pension industry factor input to improve the comprehensive level of the pension industry.

In 2017, the development of Chinese sports industry and pension industry has been gradually decreasing from the East to the Midwest. The average of sports industry was 0.6125, and the average of pension industry was 0.6365. In general, the score gap of the sports industry in the regions involved in the study is larger than that of the pension industry, which shows that the unbalanced development characteristics of the sports industry are more significant. In addition, through the calculation, it is found that the score difference between the sports industry and the pension industry in some regions is large. In Fujian Province, the score of sports industries was 0.8435, and the score of pension industry was 0.4094. These regions should take corresponding measures to gradually narrow the gap between the two industries to achieve balanced and coordinated industrial development.

According to the calculation, the coupling coordination levels and types of the 22 regions involved in the study in 2017 are obtained (Table 4). As can be seen from Table 4, there are 6 regions that have achieved primary coordination, including Jiangsu, Zhejiang, Shandong, Hubei, Guangdong and Sichuan, accounting for 27.27%. The number of regions with bare coordinated status is the largest, with 10, accounting for 45.45%. Five regions are on the verge of disorder, including Tianjin municipality, Shanxi Province, Inner Mongolia Autonomous Region, Guangxi Zhuang Autonomous Region and Chongqing Municipality. Except for Tianjin, these areas are concentrated in the central and western regions. The lowest level of coupling coordination is found in Guizhou Province, which showed primary disorder. In general, the level of coupling coordination in the study area is not high. It can also be seen that the integration degree of sports industry and pension industry in all regions is low in 2017.

According to the relationship between the comprehensive development level f_1 and f_2 of sports industry and pension industry, the coupling coordination type is divided. When $f_1 > f_2$, the pension industry lags behind the sports industry; otherwise, the sports industry lags behind the pension industry. When the two values are equal, it means that the pension industry and the sports industry develop synchronously. The coupling coordination types of the regions involved in the study in 2017 are obtained. Among them, Fujian Province, Shandong Province, Henan Province, Inner Mongolia Autonomous Region, Guangdong Province, Guangxi Zhuang Autonomous Region and Jiangsu Province are lagging behind in pension industry, accounting for about 31.82%, while the rest of the regions are lagging behind in sports industry. It can be seen that the sports industry in most regions involved in the study cannot meet the development needs of the pension industry.

Table 4. Coupling coordination levels and types of sports industry and pension industry in the regions involved in the study

region	Coupling coordination scheduling	Coupling coordination level	Coupling coordination type
Beijing	0.5722	bare coordination	Sports industry lags behind
Tianjin	0.4359	Verge of disorder	Sports industry lags behind
Hebei	0.5948	bare coordination	Sports industry lags behind
Shanxi	0.4520	Verge of disorder	Sports industry lags behind
Inner Mongolia	0.4901	Verge of disorder	Pension industry lags behind
Liaoning	0.5830	bare coordination	Sports industry lags behind
Heilongjiang	0.5209	bare coordination	Sports industry lags behind
Shanghai	0.5463	bare coordination	Sports industry lags behind
Jiangsu	0.6841	primary coordination	Pension industry lags behind
Zhejiang	0.6261	primary coordination	Sports industry lags behind
Anhui	0.5618	bare coordination	Sports industry lags behind
Fujian	0.5421	bare coordination	Pension industry lags behind

(continued)

Table 4. (*continued*)

region	*Coupling coordination scheduling*	*Coupling coordination level*	*Coupling coordination type*
Jiangxi	0.5247	bare coordination	Sports industry lags behind
Shandong	0.6539	primary coordination	Pension industry lags behind
Henan	0.5796	bare coordination	Pension industry lags behind
Hubei	0.6016	primary coordination	Sports industry lags behind
Hunan	0.5857	bare coordination	Sports industry lags behind
Guangdong	0.6427	primary coordination	Pension industry lags behind
Guangxi	0.4321	Verge of disorder	Pension industry lags behind
Chongqing	0.4982	Verge of disorder	Sports industry lags behind
Sichuan	0.6122	primary coordination	Sports industry lags behind
Guizhou	0.3944	Mild disorder	Sports industry lags behind

2) Measurement results of the coupling and coordinated development of sports industry and pension industry in Guangdong Province.

In this paper, Guangdong Province is selected as the research object to measure the coupling and coordinated development level of sports industry and pension industry in Guangdong Province from 2013 to 2017, in order to further analyze the sequence characteristics of the coupling coordinated development of Chinese sports industry and pension industry. The results are shown in Table 5.

The comprehensive index of sports industry and pension industry in Guangdong Province increased from 0.3278 in 2013 to 0.9064 in 2017. It slightly decreased in 2015, and decreased by 8.88% compared with 2014, and then increased steadily, showing an overall upward trend in the five years.

The sports industry index of Guangdong Province increased from 0.3591 in 2013 to 0.8710 in 2017. The comprehensive level increased year by year, showing an overall upward trend, and the development of the sports industry gradually matured. In these five years, the development in 2014 was fast, with an increase of 42.52% compared with 2013. The main reason is that the economic benefits of the sports industry in Guangdong Province developed rapidly in 2014 and achieved a good level of growth in the total output of the sports industry and the sales of sports lottery. In addition, the sports industry factor

Table 5. Coupling coordination levels and types in Guangdong Province

Year	Comprehensive level of sports	Comprehensive level of pension industry	comprehensive index	Coupling coordination scheduling	Coupling coordination level	Coupling coordination type
2013	0.3591	0.3002	0.3278	0.4052	Verge of disorder	pension industry lags behind
2014	0.5118	0.6607	0.5910	0.5392	bare coordination	Sports industry lags behind
2015	0.6167	0.4697	0.5385	0.5188	bare coordination	pension industry lags behind
2016	0.8515	0.7383	0.7913	0.6296	primary coordination	pension industry lags behind
2017	0.8710	0.9375	0.9064	0.6722	primary coordination	Sports industry lags behind

level index in 2016 increased by 38.07% compared with that in 2015. The index was 0.8515 in 2016, which showed the rapid growth of the per capita sports field area and the increase of sports lottery sales.

The comprehensive level of the pension industry in Guangdong Province has fluctuated and risen. In 2013, the comprehensive level of the pension industry in Guangdong Province was 0.3002, and in 2014, the pension industry in Guangdong Province developed rapidly, reaching 0.6607. There are two main reasons for this. Firstly, the factor level of the pension industry in Guangdong Province has been improved in 2014, which is mainly manifested by the large increase in the number of pension service institutions, employees and beds compared with 2013. Secondly, in terms of the efficiency level of the pension industry, the unit income of the pension service industry and the funds for the elderly undertakings have grown rapidly, which fell in 2015 and steadily increased thereafter. In 2017, the comprehensive level of the pension industry in Guangdong Province was 0.9064.

From 2013 to 2017, the average coupling coordination degree of sports industry and pension industry in Guangdong Province was 0.5530, which increased from 0.4052 to 0.6722, showing an overall upward trend in 5 years. The corresponding level of coupling coordination develops from verge of disorder to primary coordination. This paper summarizes it into three stages. The first stage is the verge of disorder stage (2013). The coupling coordination degree value of sports industry and pension industry in Guangdong Province is 0.4052, which is the smallest in five years, and the coupling coordination level is on the verge of disorder. During this period, the coupling coordination effect of the two industries is not obvious. The second stage is the bare coordination phase (2014–2015). In 2014, the coupling coordination degree of sports industry and pension industry in Guangdong Province rose to 0.5392, and the coupling coordination level

rose to bare coordination. During this period, the pension industry grew rapidly, the pension industry drove the development of the sports industry, and the two industries gradually began to integrate with each other and promote development together. In 2015, the comprehensive level of the rapid development of the sports industry increased, while the development of the pension industry lagged behind. The development between the two showed a certain gap, and the development was out of step. The coupling coordination degree slightly decreased to 0.5188. Overall, the synergistic effect between the two industries has been enhanced during this period. The third stage is the primary coordination stage (2016–2017). At this stage, the coupling coordination degree of the two industries increased steadily, with the growth rate of 21.36% in 2016 and 6.77% in 2017 compared with the previous year. The synergistic effect between the two industries was steadily enhanced. In general, the coupling between the interactive development of the sports industry and the pension industry in Guangdong Province has gradually improved in the past five years, but the coupling coordination level is still not high.

It can be seen from Table 6 that in 2013, the development of pension industry in Guangdong Province lagged behind that of sports industry. In 2014, the pension industry developed rapidly, and the comprehensive level of pension industry exceeded that of sports industry in the same period, transforming from pension industry lag to sports industry lag. In 2015 and 2016, the sports industry in Guangdong Province developed rapidly, which turned into the lagging development of the pension industry. In 2017, Guangdong Province issued relevant policies to support the development of the pension industry, and the pension industry gained rapid growth, which showed the lagging development of the sports industry in 2017. From the perspective of the coupling coordination types of sports industry and pension industry in Guangdong Province in the past five years, the development of the two industries lags behind and coexist, and the two industries have begun to influence each other.

4.2 Diagnosis of Obstruction Factor

In order to find out the key shortcomings restricting the coupled and coordinated development of sports industry and pension industry in Guangdong province, the obstruction factor diagnosis model is used to diagnose the limiting factors of the development of sports industry and pension industry in Guangdong province, and the calculation results of index obstacle degree are obtained. At the same time, in order to reflect the key factors, the index layer obstacle factors are ranked. The results are shown in Table 6.

According to Table 6, there is a large gap in the barrier degree of each index layer in different years from 2013 to 2017, which has different impacts on the development level of the sports industry and the pension industry. Among them, the top three obstacles of single index affecting the development of sports industry and pension industry in Guangdong Province in 2015 are C_{13} (number of beds for pension service), C_{11} (number of pension service institutions), and C_{22} (unit assets of pension service industry). The top three in 2016 are C_{11} (number of elderly care institutions), C_{14} (number of activity rooms for the elderly), and C_{31} (personnel in sports institutions). In 2017, it is C_{34} (number of stadiums), C_{11} (number of pension service institutions), and C_{32} (number of sports system institutions). Through comparison, it is found that the main factors restricting the development of the sports industry and the pension industry in Guangdong Province

Table 6. Development index obstacle degree of sports industry and pension industry in Guangdong Province from 2013 to 2017

region	object	Index ranking				
		1	2	3	4	5
2013	Obstacle index	Sales of sports lottery C_{43}	Total output of sports industry C_{13}	Total output of sports industry C_{42}	Percentage of population over 65 years old C_{21}	Added value of sports industry C_{41}
	Obstacle degree	0.4775	0.4718	0.4340	0.4301	0.3818
2014	Obstacle index	Sports system personnel C_{31}	Number of sports system institutions C_{32}	Number of elderly activity rooms C_{14}	Added value of sports industry C_{41}	Pension service industry unit income C_{23}
	Obstacle degree	0.5107	0.3962	0.3664	0.3053	0.3034
2015	Obstacle index	Number of elderly care beds C_{13}	Number of elderly care service institutions C_{11}	Pension service unit assets C_{22}	Percentage of population over 65 years old C_{21}	Number of employees C_{12}
	Obstacle degree	0.3979	0.3715	0.3381	0.3213	0.3024
2016	Obstacle index	Number of elderly care service institutions C_{11}	Number of elderly activity rooms C_{14}	Sports system organization personnel C_{31}	Number of employees C_{12}	Investment funds for the elderly C_{24}
	Obstacle degree	0.3134	0.3115	0.2707	0.2482	0.2305
2017	Obstacle index	Number of stadiums C_{34}	Number of elderly care service institutions C_{11}	Number of sports system institutions C_{32}	Number of elderly activity rooms C_{14}	Sports system organization personnel C_{31}
	Obstacle degree	0.2963	0.2370	0.1698	0.1495	0.0763

are reflected in the factor input of the pension industry. Among them, the common main obstacle in the past three years is the number of pension service institutions. After 2016, the top three obstacles have increased the factor input of the sports industry. Therefore, Guangdong Province should continue to increase the investment in the pension industry and sports industry and increase the number of pension service institutions and beds for the elderly. At the same time, the number of stadiums and sports institutions should be further increased to meet the needs of diversified leisure sports and elderly care services for the elderly.

5 Conclusions and Suggestions

5.1 Main Conclusions

In this paper, the coupling coordination evaluation index system of the sports industry and the pension industry is constructed from four dimensions: the level of sports industry elements, the economic benefits of the sports industry, the level of pension industry elements, and the economic benefits of the pension industry. The comprehensive level and coupling coordination of sports industry and pension industry in 22 regions including Guangdong Province are analyzed by using the "improved entropy weight - mutation progression method". Combined with the diagnostic model of obstacle factors, this paper also focuses on the analysis of the coupling coordination time series change characteristics and main obstacle factors of sports industry and pension industry in Guangdong Province from 2013 to 2017. Studies have shown that:

- In 2017, the average index of the coupling and coordination development of sports industry and pension industry in the regions involved in the study was 0.6252. The comprehensive level of sports industry and pension industry presents the characteristics of unbalanced development in different regions, and there is a big gap between different regions. The comprehensive level of eastern coastal areas such as Jiangsu Province, Shandong Province and Guangdong Province is significantly higher than that of central and western regions. In terms of specific index dimensions, the industrial benefit gap of the regions involved in the study is larger than the industrial factor input. At the same time, the coupling coordination level of all regions is low, and most regions are bare coordinated. It can be seen that the integration degree of sports industry and pension industry in all regions is also low. As far as the type of coupling coordination is concerned, the development of sports industry in most areas is lagging behind.
- From 2013 to 2017, the comprehensive development level of sports industry and pension industry in Guangdong Province showed an overall upward trend. The growth rate of the pension industry is faster than that of the sports industry. The level of coupling coordination keeps rising and developing, from the verge of disorder in 2013 to the primary coordination in 2016. In terms of the type of coupling coordination, the two industries interact strongly and have begun to influence each other. According to the diagnosis of obstruction factors, the disorder factors in each year are not the same. In 2017, the number of stadiums, the number of pension service institutions and the number of sports system institutions became the main factors affecting the development of the sports industry and pension in Guangdong Province.

5.2 Countermeasures and Suggestions

In view of the unbalanced development of sports industry and pension industry in various regions, the following two measures should be implemented. On the one hand, it is necessary to further increase the input of industrial factors in areas with low scores, especially the input of the main obstacle factors affecting industrial development. On the other hand, these regions should improve the efficiency of industrial investment, actively promote the reform of industrial upgrading, and innovate the industrial development

model, so as to gradually narrow the industrial level gap in each region, and realize the balanced and sustainable development of the sports industry and the pension industry.

At present, the degree of integration of the two industries in various regions is still low. The government should build a good policy system, deepen the supply-side reform, increase the investment in the sports industry and the pension industry, improve the level of pension services, and improve the scope and space of industrial development to promote the deep integration of the sports industry and the pension industry. A top-down industrial integration system should also be established to promote the deep integration and development of sports industry and pension industry.

The coupling coordination type in most regions is manifested as the development lag of sports industry. It will lead to the supply of sports products and services cannot meet the needs of the elderly in pension and sports health care, and then affect the organic integration of the sports industry and the pension industry. These regions should vigorously increase the supply of sports industry, further realize the diversification of "sports + pension" products. By constructing sports theme parks, sports characteristic towns, forest health bases and urban sports service complexes, the potential demand of the sports market can be fully tapped. In the meanwhile, regions with lagging pension industry should also put forward corresponding measures to increase the allocation of pension service facilities and build a richer, comprehensive and perfect pension service system, so as to realize the coordinated development of sports industry and pension industry.

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