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## Adaptive filtering method-based China sports consumption development research

Mi Tian

Department Of Sports Economy And Sports Management, Xi'an Physical Education University, Xi'An 710068, Shaanxi, (CHINA)

### ABSTRACT

Sports consumption is an important part of Chinese citizen consumption, it has very important significances in Chinese sports industrial sustainable development. The paper firstly makes horizontal and vertical analysis of Chinese sports consumption. Horizontally, it studies on Chinese sports consumption's consumption contents, consumption standard, consumption structure as well as urban and rural sports consumption gap, and points out that affected by economic factors, Chinese sports consumption contents are simple and practical, and is practicability-oriented, aerobics, square dance and other massive activities are well received by broad masses, sportswear and sports product proportions are the biggest in sports consumption, and sports consumption difference between urban and rural is relative obvious. Vertically, though Chinese sports consumption has made faster progress, it still keeps great paces with most of countries in the world, we should refer to world power development experiences, promote Chinese sports consumption. Secondly, utilize adaptive filtering method, make analysis of China sports expenditure during 200~2012, by adjusting weights, it carries on repeatedly analyzing and calculating on the historical observation data, and gets final optimal weight, and further makes prediction on sports expenditure in five years after 2012, the error is smaller, predicted value is relative accurate.

### KEYWORDS

Sports consumption; Adaptive filtering method; Optimal weight; Adjust weight; Sports industry.



## INTRODUCTION

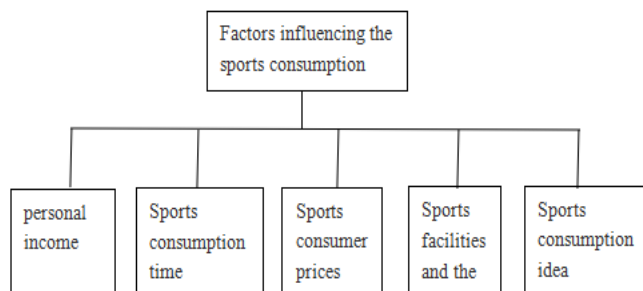
With sports undertakings development as well as national fitness widely spread in China, sports have already become one of important choice for Chinese public to engage in entertainment and leisure, sports consumption also become main part of Chinese citizen consumption. Many scholars have researched on Chinese sports consumption, and got reliable conclusion.

When Liu Zhi-Qiang studied on Chinese sports consumption, by consulting lots of literatures, summarizing formers research experiences, and interviewing, targeted at modern sports consumption behaviors, he made researches and put forward Chinese sports consumption existing problems in 21<sup>st</sup> century that consumption forms got closer to life but were relative simple, and provided feasible countermeasures for problems; When Lei Zhao-Yang studied on Chinese residents sports consumption, he combined current Chinese national economic development status, and residents living standard, fundamentally analyzed Chinese sports consumption existing advantages and shortcomings, and meanwhile compared with world each developed power, and further proposed that Chinese sports consumption should reference experiences of world power, make up for the deficiency, give full play to the superiority so as to promote Chinese sports industries development; When Li Su-Yin studied on Chinese sports consumption, she made questionnaire survey, and utilized logic analysis, mathematical analysis methods, put forward corresponding theoretical basis for practical situations, pointed out that Chinese sports consumption could drive sports industrial development; When Zhang Rui-Lin studied on Chinese sports industry, according to current stage China's national conditions, as well as relative historical information, he pointed out Chinese sports industry existing problems in development process, and finally got reliable optimization countermeasures, which provided theoretical basis for sports industrial sustainable development and meanwhile provide experiences for later generations researches.

When study on Chinese sports consumption, the paper firstly makes horizontal and vertical analysis. Though China sports consumption has made faster progress, it still has a long way to go to catch up most of countries in the world by comparing. China sports consumption's consumption contents, consumption standard, consumption structure mainly suffer economic factors impacts, the contents are simple and practical, and are practicability-oriented, sportswear and sports product proportions are the largest in sports consumption. Secondly, utilize adaptive filtering, analyze China sports expenditure during 200~2012, carry on repeatedly analyzing and calculating on the historical observation data, by adjusting weights, it gets final optimal weight, and further makes prediction on sports expenditure in five years after 2012.

## CHINA SPORTS CONSUMPTION STATUS RESEARCH

China sports consumption has a variety of forms, contents are plentiful, but it still keeps certain paces with world partial developed countries. No matter in the aspects of consumption contents, consumption ways or consumption levels, they are obviously different. Economy is the foundation of national development, no doubt, China sports consumption has obvious gap by comparing with world power, and it is mainly affected by economic development, as Figure 1.



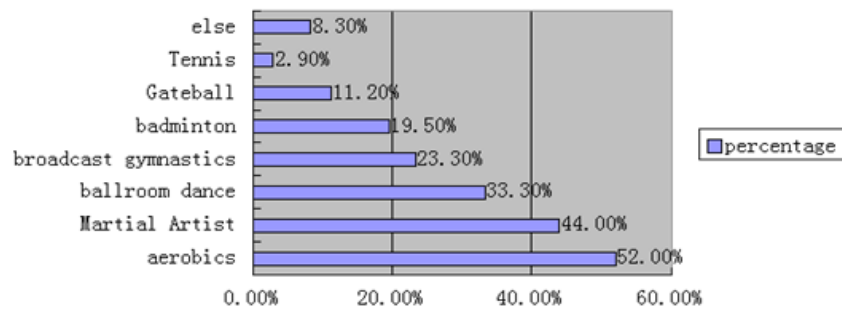
**Figure 1 : Sports consumption influencing factors**

China sports consumption and countries in the world show certain differences, it mainly suffers impact from personal income, individual living standard, sports consumer prices, sports consumption time, sports fields and environment facilities construction as well as sports consumption idea, these are main factors that restrict China sports consumption development. Sports consumption development will also have impacts on China sports industrial development, therefore research on sports consumption has very important significances in driving China sports industry.

**Public sports consumption contents**

Sports is one of important selection of China public to engage in leisure and entertainment, with sports development and national fitness widely spread in China, sports consumption has already become main part of China public consumption. However, on a whole, China sports consumption way is relative simple, is practicability- oriented, and usually non-operating sports venues are well-received, and operation procedure is self-management.

According to investigation, China public sports consumption contents are mainly badminton, swimming, football, basketball, volleyball, gymnastics, mountain climbing, dance, billiards, bowling, rope skipping and so on. Below figure is China public sports consumption main events, data is from general administration of sport of China and China statistics yearbook data, and draw its own following statistical Figure 2.



**Figure 2 : Sports consumption content comparison**

By above bar statistics Figure 2, it is clear that China sports consumption contents are simpler and practical, which are well received by most of public. Among them, aerobics proportion is the largest, secondly is martial arts, ballroom dance and broadcast gymnastics also cover larger proportions, people that engage in such sports consumption are mainly middle-aged and old population. Badminton, gateball, tennis kind of activities proportions are relative smaller, but they are also hot in public sports consumption; it mainly is teenagers to select such contents to do sports consumption. To sum up, activities that get close to nature and are aerobics consumption type as above will be more popular among public in some time of future.

**Public sports consumption standard**

Sports consumption is one of sports industrial main income source, public sports consumption standard also have impacts on sports industrial development to a certain extent. Below is China citizen sports consumption standard investigation, data is from China adults’ fitness and health monitoring bulletin as well as China statistics yearbook relative data, as TABLE 1.

**TABLE 1 : Some China’s representative first-tier, second-tier cities family sports consumption comparison**

Sports expenditure (Yuan)	Shanghai	Jilin	Zhengzhou	Fuzhou
2009	537.85	195.96	228.77	305.33

2010	915.71	340.63	342.31	765.44
2011	907.99	383.76	412.99	806.30

Above selects China’s some representative first-tier cities and second-tier cities, makes comparative analysis, and draws above table into statistical Figure 3, and then analyzes each city sports consumption changes, and gets conclusion.

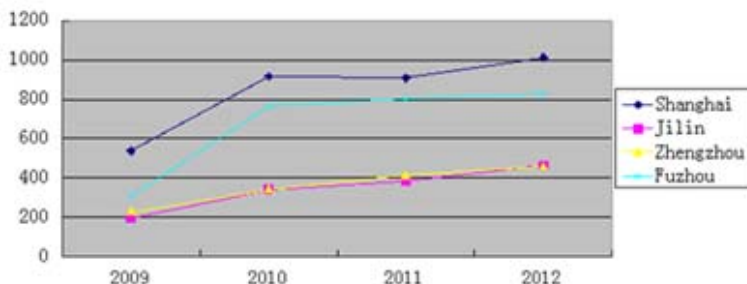


Figure 3 : Residents' sports consumption in China

From above statistic Figure 3, it can get conclusion that in recent years, with economy constant growth, China urban sports consumption has increased, no matter in first-tier city, or second-tier city, both have changes in certain ranges, which is also profit from China sports development and sports impacts constantly increasing among masses.

**Public sports consumption structure**

In China, public engaged sports consumption forms are various, contents are plentiful, and therefore sports consumption structure is also accordingly different. Among them, main structure contains sports organizations membership dues, sports training and consulting, watching sports competitions, sportswear, sports goods, sports newspapers and books, as well as sports lotteries so on. However these sports structure occupied proportions in China public sports consumption are not fully the same, which also causes China sports development having different development speeds in different sports structures, and further affecting Chinese sports development to a certain degree.

TABLE 2 : Sports consumption structure comparison

	Nationwide	Shanghai	Wuhan	Lanzhou
Sports organizations membership dues	5.2%	4.4%	5.3%	6.0%
Sports training and consulting	4.3%	3.0%	5.0%	4.0%
Watching sports competitions	8.5%	9.6%	8.4%	7.4%
Sportswear	37.5%	16.0%	38.7%	36.4%
Sports goods	21.6%	21.3%	20.9%	23.7%
Sports newspapers and books	11.8%	11.9%	11.9%	11.3%
Sports lotteries	11.1%	14.1%	9.7%	11.2%

Above TABLE 2 is China each kind of sports structure proportions comparison, combine with nationwide sports consumption structure, make comparison of selected some representative cities, and draw into following statistic Figure 4, and make further analysis.

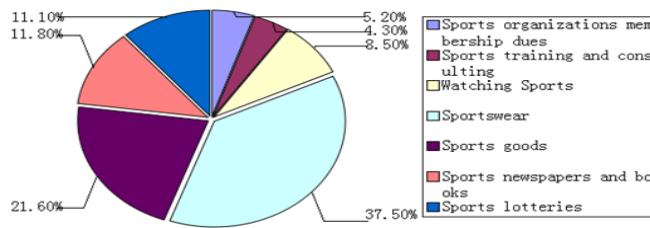


Figure 4 : The national sports consumption structure

From China nationwide range sports consumption structure comparison pie chart, it can get conclusion that in Chinese sports consumption structure, sportswear and sports goods proportions are the largest that are respectively 37.5% and 21.6%. Secondly, there are sports newspapers and books and sports lotteries, sports organizations membership dues, sports training and consulting, watching sports competitions are the least.

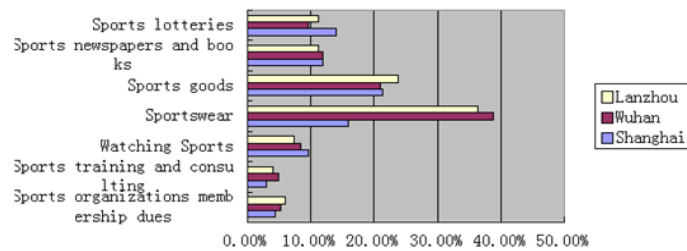


Figure 5 : Three urban sports consumption structure

From three cities sports consumption structure comparison bar Figure 5, it is clear that among the three cities sports consumption, it is similar to nationwide sports consumption, sportswear and sports goods proportions are the largest. Secondly, there are sports newspapers and books and sports lotteries, sports organizations membership dues, sports training and consulting, watching sports competitions are the least.

In respectively analysis process of nationwide sports consumption structure and three cities sports consumption structure, we can see that public sports consumption is practicability-oriented, compares with sports organizations membership dues, sports training and consulting, watching sports competitions, citizens are more inclined to sportswear and sports goods, and consumption of sports newspapers and books and sports lotteries are also relative more. It indicates that when China citizens carry on sports consumption, they give more priority of the one gets closer to life, focus on practicability, and are not so positive to higher level as sports newspapers and books, watching sports competitions and other spiritual layer consumption.

**Urban and rural sports consumption comparison**

Sports consumption suffers per capita income influence; it will present different features in different regions. Economic development generates important impacts on sports development; therefore it will affect residents' sports consumption status in a certain degree. Urban and rural gap of wealth causes people living level, sports awareness differences, so that when carry on sports consumption, it will generate great gap. Below TABLE 3 are times and proportions that Chinese urban and rural residents enter into charging public sports venues, data is from general administration of sport of China and China statistics yearbook.

TABLE 3 : Urban and rural residents entering into charging public sports venues consumption times and proportions

	1 time	2~4times	5~8 times	9~11 times	Above 11times
Cities and towns	1.8%	7.5%	4.4%	6.2%	11.4%
Country	1.6%	5.1%	1.5%	1.8%	2.4%

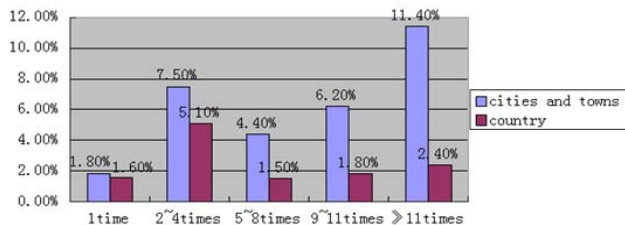


Figure 6 : Urban and rural sports consumption

From above bar Figure 6, it is clear that China urban and rural sports consumption gap is larger, cities and towns sports consumption is relative frequent, times that entering into charging public sports venues are mostly above 11 times. While affected by economic development, rural living level is poor with respect to cities and towns, its public sports venues construction is also inferior to cities and towns, which causes when country masses go in for sports consumption, they are inferior to cities and towns.

### CHINA AND FOREIGN SPORTS CONSUMPTION VERTICAL COMPARISON

#### China sports consumption structure and world partial countries comparison

In sports consumption structure, Chinese sports service consumption and sports physical consumption structure have obvious differences with world partial economic power, below TABLE 4 is Chinese sports consumption structure and France, Germany, America and other economic powers comparison status, data is extracted from China’s statistical yearbook and general administration of sport of China.

TABLE 4 : China sports consumption and world power comparison

	China	France	Germany	Spain	Sweden	Netherlands	Portugal	America
Sports service consumption ratio%	28	62	62	78	45	45	42	35
Sports physical consumption ratio%	67	38	38	22	55	55	58	65

Draw above table into statistic Figure 7, and analyze conclusion :

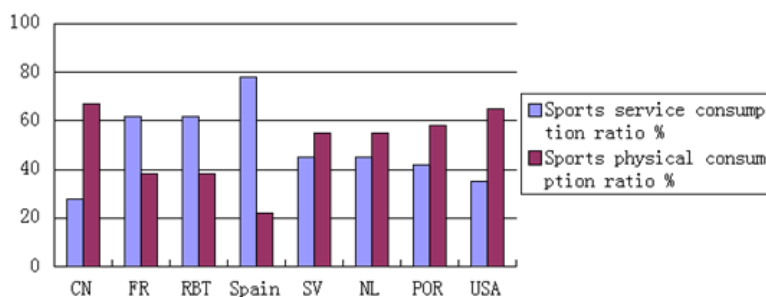


Figure 7 : Our country sports consumption compared with world powers

From above statistic Figure 7, it is clear that in sports service consumption, Spain is the highest, it is 78%; in sports physical consumption ratio, China is the highest, it is 67%. It shows China public sports physical consumption level is so high while sports service consumption is so low, which is up to China economic development. When consume, China citizens relative focus on practicability, such consumption idea also affects China sports service consumption structure in a certain degree.

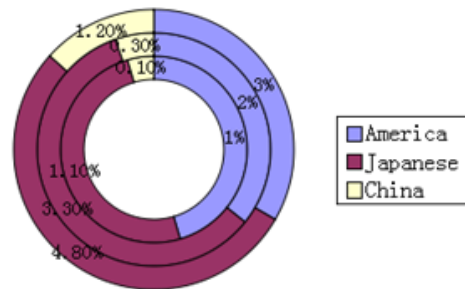
### Comparison between China sports industry proportion in national economy and other countries in the world

China sports industry proportion in national economy has been improved, which has very important connections with China economic constantly development, sports power awareness constantly strengthening. However compare to world other countries, China still keeps certain paces. Below TABLE 5 is comparison between China and other countries in the world, comparison of sports industry occupied proportions in national economy, data is from general administration of sport of China and China statistical yearbook.

Process above data table, it can get Figure 8.

**TABLE 5 : China sports industry and world other countries comparison**

	America	Japan	China
80s	1%	1.1%	0.1%
90s	2%	3.3%	0.3%
Up to now	3%	4.8%	1.2%



**Figure 8 : Our country sports industry with the world**

By above statistic Figure 8, it is clear that though China sports industry proportions in national economy have increased, compare with America and Japan, it still has a big gap, and has 10 times differences by comparing with America. With respect to this, we should focus on sports promotion in nationwide, thoroughly implement sports power idea into masses, speed up sports industrial development, and enlarge sports industry impacts on national economy.

## ADAPTIVE FILTERING METHOD-BASED CHINA SPORTS CONSUMPTION RESEARCH

### Guiding thought of adaptive filtering

Similar to moving average method and exponential smoothing method, adaptive filtering method is on the basis of historical observation value with time developing and changing, do weighted average on it and then go ahead with prediction. Adaptive filtering method should define optimal weight that has smallest errors. The method is utilizing a group of given historical data to calculate corresponding predicted value, and calculate errors, according to calculated errors, it adjust pre-defined weights, so that let predicted value error to reduce to the lowest. In general, once calculation cannot get optimal weight, so we need to repeatedly predict, by constantly calculating, adjusting defined weights, then get a group of weight when predicted value error being the lowest that is solved optimal weight.

Adaptive filtering method basic prediction formula is:

$$\hat{y}_{t+1} = \omega_1 y_t + \omega_2 y_{t-1} + \dots + \omega_N y_{t-N+1} = \sum_{i=1}^N \omega_i y_{t-i+1} \tag{1}$$

In formula,  $\hat{y}_{t+1}$  is the  $t+1$  predicted value,  $\omega_i$  is the  $t-i+1$  observation weight,  $y_{t-i+1}$  is the  $t-i+1$  observation value,  $N$  is the number of weights. Below is formula of weight adjustment :

$$\omega'_i = \omega_i + 2k \bullet e_{i+1} y_{t-i+1} \tag{2}$$

Among them,  $i=1,2,\dots,N$ ,  $t=N,N+1,\dots,n$ ,  $n$  is the number of sequence data,  $\omega_i$  is the  $i$  weight before adjusting,  $\omega'_i$  is the  $i$  weight after adjusting,  $k$  is learning constant,  $e_{i+1}$  is the  $t+1$  predicted error.

Above formula shows after adjustment weight is equal to the sum of original adjustment weight and error adjustment item, and the adjustment item mainly includes prediction error, original historical observation value, learning constant.

### Adaptive filtering method data processing

TABLE 6 : Nationwide sports expenditure

Nationwide sports expenditure (Yuan)	2008	2009	2010	2011	2012
	292.72	316.98	591.02	880.76	889.21

According to TABLE 6 data,  $N = 2$ . Take initial weight  $\omega_1 = 0.97, \omega_2 = 0.96$ , and set  $k = 0.9$ ,  $t$  value starts from  $N = 2$ , that when  $t = 2$ ,  
According to prediction formula, solve prediction value when  $t+1 = 3$  :

$$\hat{y} = \hat{y}_3 = \omega_1 y_2 + \omega_2 y_1 = 588.24$$

Calculate predicted errors:

$$e_{t+1} = e_3 = y_3 - \hat{y}_3 = 2.78$$

According to above formula:

$$\omega'_i = \omega_i + 2k \bullet e_{i+1} y_{t-i+1}$$

Adjust weight as:

$$\omega'_1 = \omega_1 + 2k \bullet e_3 y_2 = 0.975$$

$$\omega'_2 = \omega_2 + 2k \bullet e_3 y_1 = 0.964$$

Above (1)~(3) ends that fulfills the weight adjusting, then  $t+1$  repeats above steps. When  $t = 3$  :



Utilize obtained weight, calculate predicted value when  $t+1=4$  that is to take one headmost observation value  $y_1$ , add a new observation value  $y_3$ . Then:

$$\hat{y}_{t+1} = \hat{y}_4 = \omega'_1 y_3 + \omega'_2 y_2 = 881.81$$

Calculate prediction error:

$$e_{t+1} = e_4 = y_4 - \hat{y}_4 = 1.05$$

Adjust weight:

$$\omega'_1 = \omega_1 + 2k \cdot e_4 y_4 = 0.989$$

$$\omega'_2 = \omega_2 + 2k \cdot e_4 y_3 = -0.02$$

When  $t = 5$ ,

Utilize obtained weight, calculate predicted value when  $t+1=6$  :

$$\hat{y}_{t+1} = \hat{y}_4 = \omega'_1 y_4 + \omega'_2 y_3 = 880.56$$

(8) Calculate prediction error:

$$e_{t+1} = e_5 = y_5 - \hat{y}_5 = 8.45$$

Adjust weight:

$$\omega'_1 = \omega_1 + 2k \cdot e_5 y_4 = 0.9892$$

$$\omega'_2 = \omega_2 + 2k \cdot e_5 y_3 = -0.0251$$

And then, by three times adjusting weights, finally it gets optimal weight group is :

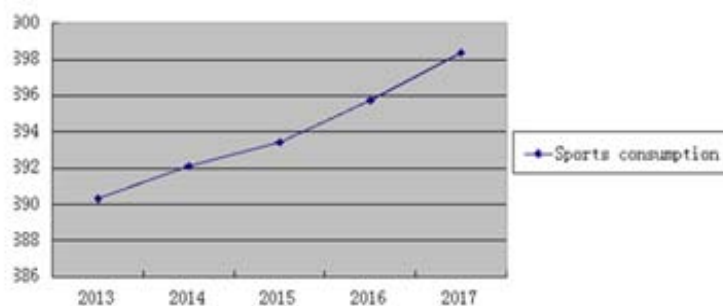
$$\omega'_1 = 0.9892, \omega'_2 = -0.0251$$

By optimal weight group, it predicts sports expenditure in five years after 2012 is TABLE 7.

**TABLE 7 : 2013~2017 sports expenditure predicted value**

	2013	2014	2015	2016	2017
Sports consumption (Yuan)	890.32	892.11	893.43	895.74	898.37

Draw above predictions China sports expenditure into following broken line Figure 9, better analyze sports consumption trend:



**Figure 9 : Sports consumption forecast figure from 2013 to 2017**

From above broken line Figure 9, it is clear that China sports consumption is in the rising trend, which suffers China economic development impact to a certain extent. China has gradually developed into world power, economy gradually strengthens, comprehensive strength also gets improved, people's living standard is gradually improving, and people's pursuit of spiritual life also gets higher and higher. Sports consumption as an indispensable part in public life surely suffers impacts to a certain degree.

### CONCLUSION

The paper makes horizontal and vertical analysis of China sports consumption status. Horizontally, it analyzes Chinese sports consumption's consumption contents, consumption standard, consumption structure as well as urban and rural sports consumption gap, and gets Chinese sports consumption contents are simple and practical, aerobics, square dance and other massive activities are well received by broad masses, sports consumption focuses on practicability, consumption difference between urban and rural is larger, which is mainly affected by economic factors. Vertically, it makes comparison of China sports consumption and sports industry proportions in national economy and world partial power, and further analyzes China and world other countries existing gap, and references world power development experiences to promote China sports consumption.

Utilize adaptive filtering method, make analysis of China sports expenditure during 200~2012, by calculation and adjusting weights methods, finally it gets optimal weight, and further makes prediction on sports expenditure in five years after 2012. The method carries on repeatedly analyzing and calculating on historical observation data till it gets optimal weight that the error is the smallest, let predicted value to be more accurate.

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