An Analysis of the Advantage Effect of Sports Health Industry Clusters and Research on the Optimisation of Public Service Systems Based on Complex Network Theory

Zhuo Yao[1], Mingyuan Cao[2*]

Abstract
The collaboration between economic units in the sports health industry leads to increased efficiency compared to individual businesses. Additionally, the concentration of these units in a specific region promotes division of labor and cooperation within the industry. The current body of research on the sports health industry, which encompasses both public welfare and commercial aspects, remains inadequate. Specifically, there is a lack of information on how to establish a robust and efficient public service system that can contribute positively to the growth of sports health industry clusters. For this reason, this article examines the positive impact of the sports health industry cluster and investigates the improvement of the public service system using complex network theory. It also establishes a network for expanding the sports health industry cluster, providing a basis for further analysis and research. An extensive public service system was established for the sports health industry cluster, allowing for a thorough quantitative analysis of its impact. A new three-stage mathematical envelope analysis model was developed to assess the overall efficiency of the newly established basic industrial capacity of the sports health industry cluster. In this report, we present the analysis results of various sports health industry clusters and public service systems. We examine the growth and impact of sports health industry clusters under different circumstances and put forth several recommendations to enhance the spillover effect of innovative technology and improve the quality of scientific and technological services. To optimise the industrial chain at the base, it is crucial to strengthen cooperation between enterprises at the core network level. This will contribute to the advantage effect analysis of the sports health industry cluster and the optimisation of the publishing service system.
Keywords: Sports Health, Industrial Cluster, Advantage Effect, Public Service System.

Introduction

In light of societal progress, the public's interest in sports has shifted from exercise tools to health-oriented consumer products. As a result, a growing number of businesses specialize in the production and operation of sports health service products. Numerous studies have explored this topic (Atalay, 2022; Atat et al., 2017; Chen et al., 2017; Colucci, 2015; Deng et al., 2018; Doraiswami & Cheded, 2015; Ebrahimi et al., 2016; Hu et al., 2018; Hugues Hernandorena et al., 2018; Hwang & Lee, 2017; Shan et al., 2016; Sultoni & Fitri, 2017; Yun & Gao, 2018). In contrast to sports and health endeavours, the sports and health industries prioritise economic gains while also striving for social and spiritual progress, showcasing a clear commercial aspect (Bhatia, 2020; Ditizio, 2018; Dong, 2017; Li et al., 2020; Li & Tong, 2017; Sawan et al., 2020; Yu & Xu, 2024). Sports health products encompass both physical sports health products and intangible sports health services. In the field of sports health, the economic unit comprises not only businesses operating in the sports health market but also a range of institutions, social groups, and individuals involved in sports health-related activities. Research studies have shown that the concentration of industries in a specific area can enhance the effectiveness of production and manufacturing processes (Li et al., 2020; Li et al., 2017; Sawan et al., 2020; Li, 2022). Thus, the consolidation of economic units in the sports health industry leads to increased efficiency compared to individual enterprises. Additionally, when these units are geographically concentrated, it fosters a greater division of labour and cooperation within the region.

To address the issue of underdeveloped potential and low industrial quality in related industries, Dong (2022) put forward a study on the dynamic modelling of high-quality development in the sports industry driven by the digital economy and big data. By studying the interplay between the sports industry and the digital economy, we can gain insights into the high-quality development mechanism.

[1] School of Mathematics and Statistics, Beihua University, Jilin 132013, China
[2] School of Mathematics and Statistics, Beihua University, Jilin 132013, China.
*Correspondence: cmy0918@beihua.edu.cn

This knowledge can help us establish an evaluation system for sports advancement. To enhance the quality of daily health services and foster the growth of sports health services, Kong and Sun (2022) presented an overview of the current state of outdoor sports in China. Sports health services play an important role in the health care industry. This paper examines the factors contributing to the growth of the sports health service industry, including the ageing population, the prevalence of chronic diseases, and government support. It also identifies the obstacles to outdoor sports development and offers recommendations for ensuring long-term and healthy growth of the health service industry in China. Examining the correlation between the concentration of the sports industry and economic growth can have a dual impact, fostering the advancement of the sports industry and assuming a pivotal role in the economy. Zeng and Liang (2021) conducted a quantitative analysis on the impact of sports industry agglomeration on China's economic growth. They used data from 2003 to 2019 to support their findings.

To further enhance the sports industry and conduct a thorough assessment of athletes' physical fitness, Yu (2021) directed their attention towards a block-chain-based sports health data collection system. An analysis of the health data collection system includes evaluating its demand, accuracy, and recall. This is done by utilising accuracy indicators and data return formulas. Thanks to the constant advancements in information technology, the sports industry has undergone a significant upgrade and transformation, largely due to the support of the Internet. The topic of "Internet plus sports health" has garnered significant attention. In this study, Gou (2021) initially examined the background and core concept of the integration of the Internet and sports health. Subsequently, the author delved into the current state of development in this field. The Internet of Things service operation platform can achieve a high level of personalisation through extensive data analysis. In the future, health management will emerge as the leading trend and key advancement in the sports health industry. The use of big data will unlock the vast potential of the expanding health industry (Alvaro, 2021).

Scholars in the field of industrial cluster aggregation's analysis and research reveal a deficiency in current studies on the sports health industry, which integrates both public welfare and commercial elements. Specifically, there is a need for more research on how to establish a robust and efficient public service system that can contribute to the growth of the sports health industrial cluster. This article conducts an analysis of the positive impact of sports health industry clusters and investigates the optimization of public service systems using complex network theory. Not many studies took into account the foundation of the sports industry. Therefore, this paper conducted research using the theories from previous studies. The study focuses on the production bases of sports goods at the national and provincial levels, gathering relevant data for analysis. The organisation of this paper is: Using complex network theory, the second section of the article establishes the sports health industry cluster expansion network, which serves as the basis for further analysis and research. Section 3 develops the public service system for the sports health industry cluster, presenting a diagram of the production model that highlights the advantages of this cluster.

Additionally, we conduct a quantitative analysis of the cluster's impact on the sports health industry. In the fourth chapter, the study incorporated existing literature and introduced environmental factors and random noise into the traditional three-stage Data Envelop Analysis (DEA) model. This resulted in the development of a new three-stage DEA model, which allowed for a more accurate evaluation of the overall efficiency of the basic capacities of the newly formed sports health industry cluster. Finally, the study presents the analysis of the advantages of various sports health industry clusters and public service systems. The achieved results could offer valuable insights for the stable and sustainable growth of industry clusters in sports goods production bases in other regions in the future.

Construction of Complex Network of Sports and Health Industry Cluster

This paper starts by constructing the sports health industry cluster's expansion network using complex network theory. In the complex network of the sports and health industry cluster, the distance between any two economic unit nodes is determined by δij. M represents the total number of nodes, enabling the calculation of the average path length using a specific formula:

$$K = \frac{1}{M(M-1)} \sum \xi_{ij} \tag{1}$$

In an academic context, it is worth noting that if there are li nodes connected to node i of an economic unit in a network, the maximum number of possible edges between the li connection paths can be calculated using the formula li (li-1)/2. To calculate the clustering coefficient of i, we can use the formula that involves the representation of the actual number of edges in the li connection paths as Oi:

$$D_i = \frac{2O_i}{l(l-1)} \tag{2}$$

O_i can be calculated through the following formula:

$$O_i = \frac{1}{M(M-1)} \sum \frac{1}{\xi_{ij}} \tag{3}$$

The sports health industry cluster has a positive impact by accumulating and integrating financial and non-financial resources, which in turn promotes the growth of the cluster and the improvement of the public service system. Next, this paper looks at the monetary and non-monetary assets used by the sports health industry cluster to achieve the desired advantage effect. These assets are considered endogenous elements in the analysis model, which aims to facilitate effective management of the sports health industry cluster.

First, the Cobb-Douglas production function $B=XG\ (L,\ K)$ is constructed in this paper. Three assumptions about the function are described as follows:

I Assuming that the output of the sports health industry cluster is consistently increasing with certain factors, and slightly decreasing with other factors, then there are:

$$\frac{\partial G}{\partial L} \geq 0, \frac{\partial G}{\partial K} \geq 0; \frac{\partial^2 G}{\partial L^2} < 0, \frac{\partial^2 G}{\partial K^2} < 0 \tag{4}$$

II. Assuming the return to scale is a constant, for any χ greater than 0, $G\ (\chi L,\ \chi K)$ equals to $\chi G\ (L.K)$.

III It is supposed that the primary derivative of the output of the sports health industry cluster is positive, and the secondary derivative is negative, that is the factor input is inversely proportional to its marginal output. It is assumed that $h_{K=}K_{p+r}\text{-}K_p/K_p, h_X=X_{p+r}\text{-}X_p/X_p$, the depreciation rate of fixed assets is determined by η and the proportion of working capital is represented by r. If b=B/XK, l=L/XK, then:

$$b = \frac{B}{XK} = g\left(\frac{L}{XK}\right) = g(l) \qquad L_{p+1} = (1-\eta)L_p + DU_p \ \frac{L_{p+1}}{(XK)_{p+1}} - \frac{L_p}{(XK)_p} = r\frac{B_p}{(XK)_p} - \eta\frac{L_p}{(XK)_p} = rg(L_p) - \eta L_p\frac{dL}{dp} = \frac{d\left(\frac{L}{(XK)}\right)}{dp} = \frac{1}{XK}\cdot\frac{dL}{dp} - \frac{L}{(XK)^2}\left(X\frac{dK}{dp} + K\frac{dX}{dp}\right) = \frac{1}{XK}\cdot\frac{dL}{dp} - (h_X + h_K)\cdot l_p = rg(l_p) - (\eta + h_X + h_K)\cdot l_p \tag{5}$$

The conditions for the stability of sports health industry cluster to produce advantageous effects are indicated by dl/dp=0, so when the sports health industry cluster has stable advantageous effects, there is $rg(l_d)=(\eta+h_K+h_X)l_p$.

Analysis on The Cluster Effectof Sports Health Industry

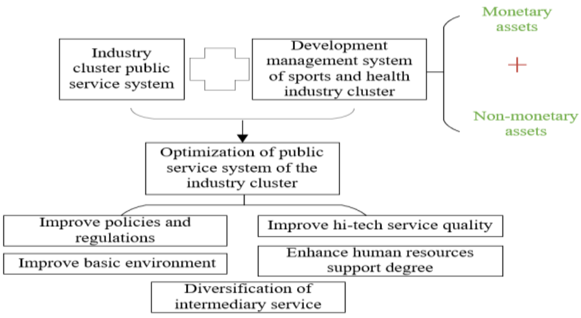

Figure 1: Constructionof Public Service System of Sports and Health Industry Cluster.

Various factors contribute to the optimisation of the public service system, such as policies and regulations, the basic environment, scientific and technological services, talent support, and intermediary services. Figure 1 illustrates the structure of the public service system within the sports health industry cluster. From the figure, it is evident that the sports health industry cluster possesses various forms and mechanisms of action for promoting the growth of the industry and improving the public service system. Financial resources play a crucial role in driving the growth of the sports health industry cluster and improving the public service system. The sports health industry cluster primarily achieves this through its advantages in scale, cost, technology, resources, and human resources. Non-financial assets, on the other hand, contribute to monetary assets by creating a regional sports health brand effect. This leads to the continuous accumulation and integration of financial resources, which indirectly supports the expansion of the sports health industry cluster and the improvement of the public service system. Thus, in constructing the endogenous growth model of the sports health industry cluster, this study emphasises the distinction between two key factors: monetary assets and non-monetary assets.

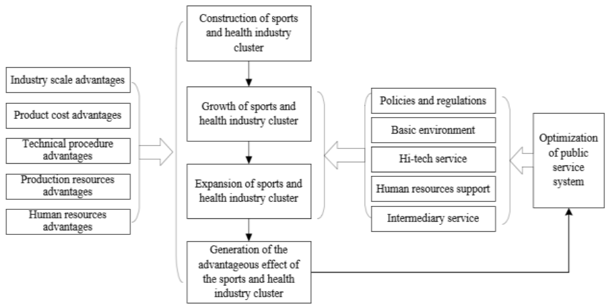

Figure 2: Production Model of Advantage Effect of Sports Health Industry Cluster.

Figure 2 displays the production model of the impact of the sports health industry cluster. From the figure, it is evident that the monetary assets associated with the sports health industry cluster bring various advantages. These advantages include scale, cost, technical, resource, and human resource advantages. They play a crucial role in promoting the benefits and advantages of the sports health industry cluster, indirectly contributing to the optimisation of the public service system. Thus, the benefits of a sports health industry cluster resulting from financial resources can be incorporated into the analysis model as an internal factor. In the context of Formula 1, the expression of the benefits of a sports health industry cluster can be represented by V. This refers to the internal production function of the advantages associated with the sports health industry cluster can be expressed as:

$$B = XG(L, K, V) \quad (6)$$

When the output of the sports health industrial cluster of unit human capital is fixed, the return of the six elements remains constant. The introduction of Vl indicates that the model places emphasis on the function and utilisation of monetary assets.

The influence of non-monetary assets on the sports health industry cluster is primarily seen in the development of a regional brand effect during the expansion of the cluster. The regional brand effect plays a crucial role in boosting the competitiveness of the industry cluster and facilitating the improvement of the public service system. Thus, it can be concluded that the controllable non-monetary assets owned by the sports health industry cluster should be directly proportional to the stock of monetary assets. It is believed that the total amount of assets in the sports and health industry cluster in the region can be divided into non-monetary assets (represented by W) and monetary assets (represented by L). The ratio of W to L, known as γ, indicates the influence of non-monetary assets on the sports health industry cluster. A higher value of γ suggests a greater proportion of non-monetary assets compared to monetary assets, resulting in a more pronounced advantage for the sports health industry cluster. The production function is *B=XG* (*L*, *K*). If *b=B/XK*, *l=L/XK*, then

$$b = \frac{B}{XK} = g\left(\frac{L}{XK}\right) = g(l) \qquad L_{p+1} = (1+\eta)L_p + DU_p + \gamma L_p \frac{L_{p+1}}{(XK)_{p+1}} - \frac{L_p}{(XK)_p} = r\frac{B_p}{(XK)_p} - \eta\frac{L_p}{(XK)_p} + \gamma\frac{L_p}{(XK)_p} = rg(L_p) - \eta L_p + \gamma l_p \frac{dL}{dp} = \frac{d\left(\frac{L}{(XK)}\right)}{dp} = \frac{1}{XK}\cdot\frac{dL}{dp} - \frac{L}{(XK)^2}\left(X\frac{dK}{dp} + K\frac{dX}{dp}\right) = \frac{1}{XK}\cdot\frac{dL}{dp} - (h_X + h_K)\cdot l_p = rg(l_p) - (\eta + h_X + h_K - \gamma)\cdot l_p \quad (7)$$

Because the production function satisfies $B=XG(L, K) = XL^{\beta}K^{1-\beta}$ and $0<\beta<1$, $b=B/XK=l^{\beta}$. In order for the sports health industry cluster to generate favourable outcomes, it is necessary for dl/dp to equal zero. This indicates that the cluster is in a state of stable advantageous effects, there is $rg(l_d) = (\eta+h_K+h_X+\gamma)\, l_p$, i.e.:

$$l^{\beta} = \left(\frac{r}{\eta+h_K+h_X-\gamma}\right)^{\frac{1}{1-\beta}}; b^{\beta} = \left(\frac{r}{\eta+h_K+h_X-\gamma}\right)^{\frac{\beta}{1-\beta}} \quad (8)$$

From the formula above, it is evident that as the sports health industry cluster grows, the proportion of non-monetary assets will gradually rise in comparison to monetary assets. This will lead to an improvement in the cluster output and optimisation of the public service system. It suggests a positive relationship between the cluster output, optimisation degree of the public service system, and the impact of the sports health industry cluster. In addition, when considering monetary and non-monetary assets, it has been confirmed that the sports health industry cluster plays a beneficial role in driving its own growth and enhancing the improvement of the public service system.

Measurement of Overall Transformation Efficiency of Industrial Basic Capabilities

Not many studies considered the foundation of the sports industry, so this paper conducted research using theories from previous studies. The study focuses on the production bases of sports goods at the national and provincial levels, gathering relevant data to conduct research. This paper aims to thoroughly assess the overall efficiency of the newly established sports health industry cluster's industrial basic ability. Building upon existing literature, the conventional three-stage DEA model is enhanced by incorporating environmental factors and random noise. The execution of the improved three-stage DEA model is explained in detail. Upon completing the efficiency evaluation of the sports health industry cluster, we have selected the input relaxation variable and environmental variable as the dependent and explanatory variables for our model. Based on this, we have constructed the following model. It is assumed that the relaxation error value of the ith element input of the recently established sports health industry cluster in the jth research area is denoted as Rij. The environmental variable is denoted as Cj, and the coefficient of the environmental variable is denoted as γi. The mixed error term is denoted as uij+λij. The presence of a random error term is evident by $u \sim M(0, \varepsilon^2_u)$, and the management ineffectiveness rate is represented by λ, and $\lambda \sim M^{+}(0, \varepsilon^2_{\lambda})$, then:

$$R_{ij} = g(C_j; \gamma_i) + u_{ij} + \lambda_{ij}; i = 1,2,\ldots,M; j = 1,2,\ldots,N \quad (9)$$

It is supposed that the input of the sports health industry cluster after adjusting is represented by A^{X}_{ij}, the input before the adjustment is represented by A_{ij}, the adjustment of external environmental factors is represented by $[max(g(C_j;\gamma\hat{}_i) -. g(C_j;\gamma\hat{}_i)]$ and the adjustment of all decision-making units to the same environment is represented by $[max(u_{ij}) - u_{ij}]$, then

$$A^{4}_{ij} = A_{ij} + \left[max\left(g(C_j, \hat{\gamma}_i)\right) - g(C_j, \hat{\gamma}_i)\right] + \left[max(u_{ij}) - u_{ij}\right]; i = 1,2,\ldots,M; j = 1,2,\ldots,N \quad (10)$$

The substitution of Aij with AXij ensures that the output of the sports health industry cluster remains unchanged, while the efficiency of the newly formed cluster is recalculated. One can obtain the overall efficiency value of the newly formed sports health industry cluster's industrial basic capacity.

The stochastic frontier analysis method replaces technical efficiency with a conditional expectation of technical inefficiency. This allows for simultaneous testing of model parameters and the model itself, resulting in more accurate estimation results. To create a research sample, this paper examines the data from the newly established sports health industry cluster during the research years. It then calculates the cluster's industrial capacity in the research area as well as its efficiency in various production stages. The aim is to effectively manage the cluster subject.

The stochastic frontier analysis method replaces technical efficiency with the conditional expectation of the technical inefficiency term. This allows for simultaneous testing of model parameters and the model itself, resulting in more accurate estimation results. This paper examines the data of the newly established sports health industry cluster during the research years to create a research sample. It then calculates the industrial capacity of the cluster in the research area and analyses its efficiency in different production stages. The aim is to effectively manage the cluster subject.

The stochastic frontier model constructed is represented by b_v=g (a_v,p) exp (u_v-v_v), which obeys $M(0,r^2_q)$ semi-normal distribution. It is assumed that the input of the sports health industry cluster newly formed in the study area i in Year p is expressed by a_{ip}, the output is expressed by b_{ip}, the input coefficient is expressed by γ, and the transformation efficiency of the basic industrial capacity of the newly formed sports and health industry cluster in the study area i in different production links in Year p is indicated by the PO_{ip}. u_i and v_i are mutually independent, then:

$$ln\, b_{ip} = \gamma_0 + \sum_m \gamma_m\, ln\, a_{ip} + u_{ip} - v_{ip} \tag{11}$$

$$PO_{ip} = \frac{O[g(a)exp(u-v)]}{O[g(a)exp(u-v)]v=0} = O\left[exp\left(-v_{ip}\right)\middle|\sigma_{ip}\right] = o^{-v_{ip}} \tag{12}$$

The newly established sports health industry cluster has a notable spillover effect of cutting-edge technology, creating a technology chain that enhances the quality of scientific and technological services in the public service system. It is assumed that ST represents the number of highly qualified skilled personnel, EN represents the number of high-tech R&D projects, RE represents the number of public science and technology service institutions, and PA represents the number of effective high-tech transformations and applications. Input variables ST, EN, and RE are defined, while the output variable PA is also defined. The stochastic frontier model constructed is represented by the following formula:

$$ln\, P\, A_{ip} = \gamma_0 + \gamma_1\, ln\, S\, T_{it} + \gamma_2\, ln\, E\, N_{ip} + \gamma_3 RE_{ip} + +u_{ip} - v_{ip} \tag{13}$$

The calculation of the formula mentioned above can provide the overall efficiency of the fundamental capacities of the recently established sports health industry cluster.

Experimental Results and Analysis

Table 1 provides an overview of the scores for various clusters in the sports health industry, such as sports health products, advertising, tourism, competition, and training services. The benefits of a sports health industry cluster include the advantage of scale, cost, technology, resources, and human resources.

Table 1

Scores of Advantages of Different Sports and Health Industry Clusters.

Type	Product Category	Advertising Category	Tourism Category	Competition Category	Training and Service Category
scale advantage	0.215849	0.026537	0.048512	0.062593	0.252485
cost advantage	-0.415286	-0.162538	-0.174851	-0.132652	-0.195861
technology advantage	0.518428	0.315296	0.142533	0.261294	0.219586
resources advantage	0.625384	1.362592	0.341528	0.415823	0.514201
human resources advantage	0.341174	0.541028	0.457252	0.613307	0.416785

Table 2

Effect Value and Regional Output Value of Sports Health Industry Cluster.

Year	2009	2010	2011	2012	2013	2014
Cluster effect value	0.062142	0.052958	0.162538	0.174852	0.116253	0.148752
Logarithmic value of cluster effect	-2.3265274	-2.6352858	-1.6958321	-1.4152832	-2.6259347	-1.3026595
Regional output	3151.18	4625.47	5584.62	6478.51	7536.95	8475.02
Logarithmic value of regional output	8.4152362	8.4152362	8.4157268	8.6235315	8.0236259	9.4152277
Year	2015	2016	2017	2018	2019	2020
Cluster effect value	0.1958625	0.162538	0.147854	0.139586	0.123528	0.104185
Logarithmic value of cluster effect	-1.6958657	-1.295865	-1.329586	-1.8415243	-1.6258536	-1.5847631
regional output	11252.36	19586.25	1302.46	12485.73	19586.52	17458.68
Logarithmic value of regional output	9.3265934	9.6253547	9.6253145	9.5263145	9.4781513	9.4785129

In order to further investigate the relationship between the advantage effect of regional sports health industrial cluster and the industrial output value, this study quantifies the advantage effect and analyses the cluster advantage expansion index and regional output value index. Table 2 presents the pertinent data regarding the impact of the sports health industry cluster on regional output value.

Figure 3 illustrates the rate at which cluster advantages expand across various values of γ, representing the ratio of total non-monetary assets to total monetary assets. Based on the derivation of formulas in Chapter 3, the speed of expansion for the cluster advantage is determined by the overall efficiency measurement of the basic industrial ability of the sports and health industry cluster. From the figure, we can observe that in the simulation test of measuring the overall efficiency of the basic capabilities of the cluster industry, there is a noticeable pattern. When γ is large, the expansion speed of cluster advantages initially increases and then decreases over time, resulting in a curve that follows an inverted "U" shape. When the value of γ is small, the expansion speed of cluster advantages will stabilise after it reaches a certain value.

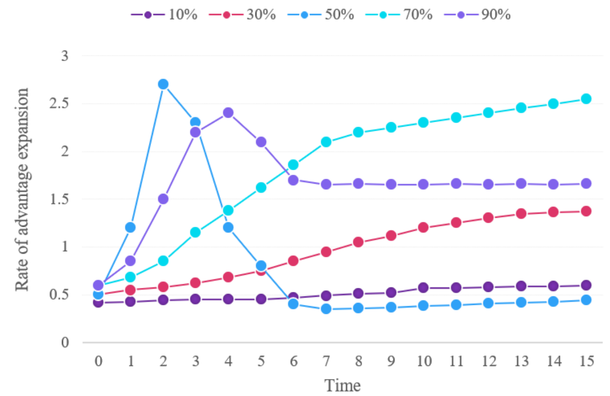

Figure 3: Expansion Speed of Cluster Advantages Under Different γ.

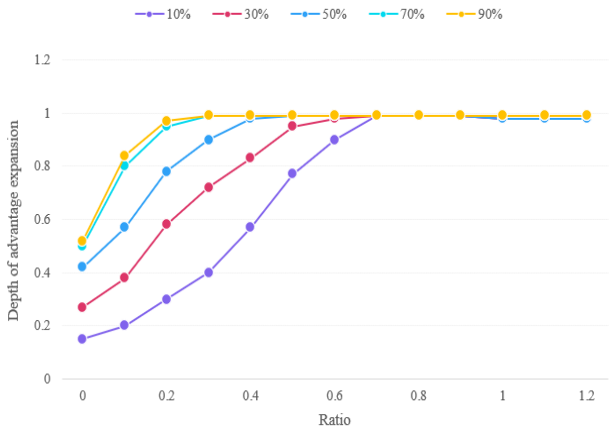

Figure 4: Depth of Cluster Advantage Expansion Under The Dual Mechanism.

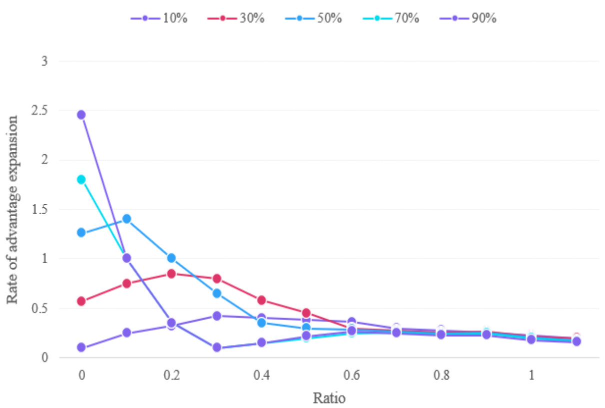

Figure 5: Expansion Speed of Cluster Advantages Under The Dual Mechanism.

Figure 4 illustrates the extent to which the cluster advantage expands with varying levels of optimisation in the public service system and γ. From the figure, it is evident that as the public service system is optimised to a certain extent, the expansion depth of cluster advantages will increase with the growth of γ. The higher the value of γ, the greater the stability of the expansion depth of the cluster advantages.

Figure 5 illustrates the variations in the speed of cluster advantage expansion, influenced by γ and the optimisation degree of the public service system. Looking at the situation from a scholarly perspective, when the optimisation of the public service system is minimal, there is a direct correlation between the value of γ and the rate at which cluster advantages expand. As the public service system becomes increasingly optimised, the growth of γ leads to a rise in the expansion speed of cluster advantages, which eventually levels off. When the public service system's optimisation level is small, we observe that the rate of cluster advantage expansion initially increases and then gradually decreases to 0. When γ is large, the impact of the optimisation degree of the public service system on the expansion speed of cluster advantages becomes less apparent. Eventually, the expansion speed of cluster advantages plateaus, and then gradually declines to zero. In general, when it comes to the level of optimisation of the public service system, the impact of γ on the rate at which cluster advantages expand is quite significant.

Table 3

Statistics of Public Service System Scores

	Number of samples		Average value	Standard deviation
	Effectiveness	Deficiency		
A1	125	0.2	3.85	0.22
A2	148	0.6	4.15	0.26
A3	195	0.1	3.74	0.25
A4	126	0.5	3.95	0.23
A5	152	0.3	3.75	0.24

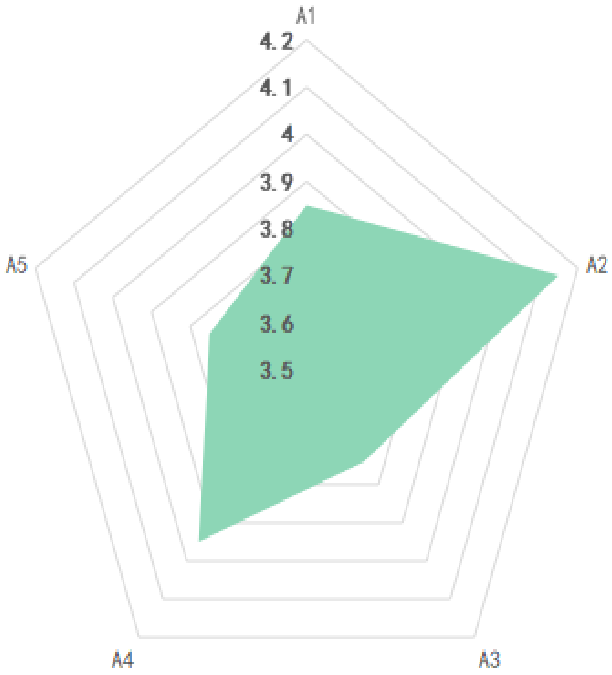

Figure 6: Scoring of Public Service System.

Table 3 shows the statistical results of public service system scores, which are based on five evaluation indicators: the quality of scientific and technological services, the level of talent support, the strength of policies and regulations, and the range of intermediary services (A1, A2, A3, A4, and A5). This paper presents the scoring situation in a more intuitive manner using a radar chart, as shown in Table 3. The data in Figure 6 indicates that all five evaluation indicators have achieved a "good" level. The score for basic environmental performance is exceptionally high, reaching the level of "excellent." The quality of scientific and technological services and the diversification of intermediary services are at a moderate level. Based on the analysis provided, it is evident that the sports health industry cluster in the study area has achieved satisfactory results in optimising the public service system. However, there is a need for greater focus on the spillover effect of innovative technology to enhance the quality of scientific and technological services.

Conclusion

This paper examines the impact of sports health industry clusters and the improvement of public service systems using complex network theory. Using complex network theory, we have constructed a network for the expansion of the sports health industry cluster. This network serves as a foundation for further analysis and research. An extensive public service system was established for the sports health industry cluster, and a quantitative analysis was conducted to assess its impact. A new three-stage mathematical envelope analysis model was developed to assess the overall efficiency of the newly established basic industrial capacity of the sports health industry cluster. The experiment's findings provided a summary of the advantage scores for various clusters in the sports and health industries. The measured cluster advantage expansion index and the regional output value index underwent analysis. We provided data on the impact value of the sports health industry cluster and the regional output value. Under various circumstances, the paper examines the rate and extent of growth in the sports health industry cluster. It concludes by assessing the effectiveness of the public service system and offering recommendations, such as emphasizing the impact of innovative technology and enhancing the quality of scientific and technological services.

This paper conducted a comprehensive analysis of the industrial cluster of sports goods production, including measuring its clustering features, identifying the challenges it faces, and suggesting specific solutions to address them. Focusing on the empirical findings, this paper argues that as leading companies strengthen their capabilities, they will stimulate the growth of other companies within the cluster network, fostering the creation and development of new businesses. This injection of fresh energy will ensure that the cluster network grows robustly. We should actively foster a strong sense of trust within institutions to contribute to a positive social production environment. This will allow for the effective collaboration of both interpersonal and institutional trust mechanisms.

In this study, the industrial cluster has not been subdivided. However, there is potential for further subdivision in the future to analyse the basic capacities of clusters in different industries. This would allow for more detailed evaluations. Additionally, it is recommended to select more reasonable and precise evaluation index systems to construct comprehensive and effective models for analysing the influencing factors of the basic capacities in different industries.

Funding

The research is supported by the Natural Science Foundation Joint Fund of Jilin Province (Grant No.: YDZJ202201ZYTS303).

References

Alvaro, C. (2021). God and Kant's Suicide Maxim. *Cultura, 18*(2), 27-53. https://doi.org/10.3726/CUL022021.0002

Atalay, A. (2022). An evaluation of the carbon footprint problem in winter sports: carbon footprint of Sarikamis Ski Facilities. *Journal of Corporate Governance, Insurance, and Risk Management, 9*(1), 229-242. https://doi.org/10.51410/jcgirm.9.1.15

Atat, R., Liu, L., Ashdown, J., Medley, M. J., Matyjas, J. D., & Yi, Y. (2017). A physical layer security scheme for mobile health cyber-physical systems. *IEEE Internet of Things Journal, 5*(1), 295-309. https://doi.org/10.1109/JIOT.2017.2780263

Bhatia, M. (2020). Iot-inspired framework for athlete performance assessment in smart sport industry. *IEEE Internet of Things Journal, 8*(12), 9523-9530. https://doi.org/10.1109/JIOT.2020.3012440

Chen, J., Chen, H., Wu, Z., Hu, D., & Pan, J. Z. (2017). Forecasting smog-related health hazard based on social media and physical sensor. *Information Systems, 64*, 281-291. https://doi.org/10.1016/j.is.2016.03.011

Colucci, F. (2015). Testing the digital gearbox: computational testing pools promise to save designers of rotorcraft transmissions physical testing time and money, and make Health and Usage Monitoring Systems more reliable. *Verti-flite*. https://trid.trb.org/View/1397122

Deng, C., Guo, R., Liu, C., Zhong, R. Y., & Xu, X. (2018). Data cleansing for energy-saving: a case of Cyber-Physical Machine Tools health monitoring system. *International Journal of Production Research, 56*(1-2), 1000-1015. https://doi.org/10.1080/00207543.2017.1394596

Ditizio, A. A. (2018). Nature and characteristics of the sport industry and its current trends impacting the industry. In *Sports Media, Marketing, and Management: Breakthroughs in Research and Practice* (pp. 284-300). IGI Global. https://doi.org/10.4018/978-1-5225-5475-2.ch016

Dong, B. (2022). Dynamic Modeling of High-Quality Development of Sports Industry Driven by Big Data Digital Economy. *Mobile Information Systems, 2022*. https://doi.org/10.1155/2022/9131081

Dong, Y. (2017). Research into the main factors influencing the layout of regional leisure sport industry. *Agro Food Industry Hi-Tech, 28*(3), 1579-1582. https://www.researchgate.net/publication/319091148

Doraiswami, R., & Cheded, L. (2015). A novel identification scheme for physical systems with applications to system health monitoring. *IFAC-PapersOnLine, 48*(3), 1768-1772. https://doi.org/10.1016/j.ifacol.2015.06.342

Ebrahimi, J., Phan, N., Dou, D., Piniewski, B., & Kil, D. (2016). Characterizing physical activity in a health social network. In *Proceedings of the 6th International Conference on Digital Health Conference* (pp. 123-129). https://doi.org/10.1145/2896338.2896349

Gou, T. (2021). Big Data Technology and "Internet+ Sports Health" Industry Development. In *2020 International Conference on Applications and Techniques in Cyber Intelligence: Applications and Techniques in Cyber Intelligence (ATCI 2020)* (pp. 527-534). Springer. https://doi.org/10.1007/978-3-030-53980-1_78

Hu, Q., Chen, L., Lv, P., & Yang, M. (2018). Promotion of College Students' Physical Health: A Case Study on Physical Education Intervention. In *2018 9th International Conference on Information Technology in Medicine and Education (ITME)* (pp. 540-544). IEEE. https://doi.org/10.1109/ITME.2018.00125

Hugues Hernandorena, B., Alvarez Alvarez, A. M., Elias-Calles, L. C., Ledon Llanes, L., Mendoza Trujillo, M., & Dominguez Alonso, E. (2018). Dog's ownership. Benefits for the physical health of middle-aged patients with type 2 diabetes mellitus. *Revista de Investigaciones Veterinarias del Perú, 29*(4), 1213-1221. https://www.cabidigitallibrary.org/doi/full/10.5555/20193016697

Hwang, S., & Lee, S. (2017). Wristband-type wearable health devices to measure construction workers' physical demands. *Automation in Construction, 83*, 330-340. https://doi.org/10.1016/j.autcon.2017.06.003

Kong, D., & Sun, J. (2022). Study on the countermeasures of integrating outdoor sports into the development of health service industry in China. *Journal of Healthcare Engineering, 2022*. https://doi.org/10.1155/2022/1889519

Li, G. (2022). From Society to Shehui: The Early Configuration of a Basic Concept in Modern China. *Cultura, 19*(1), 11-28. https://doi.org/10.3726/CUL012022.0002

Li, G., Liu, M., Fu, Y., & Feng, B. (2020). A comparative study on the system and scale of sport industry between China and Canada. In *Journal of Physics: Conference Series* (Vol. 1624, pp. 042070). IOP Publishing. https://doi.org/10.1088/1742-6596/1624/4/042070

Li, X., & Tong, Y. (2017). Selection analysis of Chinese sport industry structure and industry layout policy. *Agro Food Industry Hi-Tech, 28*(3), 2948-2951. https://www.researchgate.net/publication/319091329

Sawan, N., Eltweri, A., De Lucia, C., Pio Leonardo Cavaliere, L., Faccia, A., & Roxana Moşteanu, N. (2020). Mixed and augmented reality applications in the sport industry. In *Proceedings of the 2020 2nd International Conference on E-Business and E-commerce Engineering* (pp. 55-59). https://doi.org/10.1145/3446922.3446932

Shan, S., Meng, T., & Cao, L. (2016). The Physical Health Condition of Civil Servants Based On Analytic Hierarchy Process Research. *Revista Ibérica de Sistemas e Tecnologias de Informação,* (E11), 322. https://www.proquest.com/openview/2a19e444c47dadad9eaf84bc73f7d523/1?pq-origsite=gscholar&cbl=1006393

Sultoni, K., & Fitri, M. (2017). Health-related fitness knowledge and its relation to college student physical activity. In *IOP Conference Series: Materials Science and Engineering* (Vol. 180, pp. 012212). IOP Publishing. https://doi.org/10.1088/1757-899X/180/1/012212

Yu, S. (2021). Application of blockchain-based sports health data collection system in the development of sports industry. *Mobile Information Systems, 2021*, 1-6. https://doi.org/10.1155/2021/4663147

Yu, A. P., & Xu, Z. (2024). The Fusion of Tradition and Modernity: The Development Challenges of Villages in China's Ethnic Areas from The Perspective of Cultural Philosophy. *Cultura, 21*(1), 253-274. https://culturajournal.com/submissions/index.php/ijpca/article/view/445

Yun, B., & Gao, J. (2018). Study on Health and Physical Exercise of Urban Workers in Gansu Tibetan Area under the Plateau Environment. In *IOP Conference Series: Earth and Environmental Science* (Vol. 170, pp. 032160). IOP Publishing. https://doi.org/10.1088/1755-1315/170/3/032160

Zeng, C., & Liang, J. (2021). An empirical study on the agglomeration effect of sports industry on Chinese economy. In *2021 International Conference on Health Big Data and Smart Sports (HBDSS)* (pp. 202-205). IEEE. https://doi.org/10.1109/HBDSS54392.2021.00046