



Digital platform empowers public sports service supply and demand to fit the efficiency improvement path

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SUMMARY: *The "Internet of Everything" and the idea of "Digital China" have brought about a turning point in the development of the public sports service system, where the development paradigm shifts to the direction of quality development. The performance prism is used to build an assessment model based on the measuring index approach for evaluating the efficacy of public sports services in terms of supply and demand matching. Additionally, the triangular fuzzy multi-criteria decision-making assessment model is built using the TOPSIS approach and the entropy weighting method to determine the weight of the indexes. More significantly, a model on the supply and demand matching efficiency of public sports services under the growth of digital platforms is constructed using a multiple linear regression model with the development of the digital platform as an independent variable. Based on the empirical findings, it is evident that for every 1% increase in the degree of development of the digital platform, there will be 0.438% increase in efficiency, and the degree of development of the digital platform explains 78.21%.*

KEYWORDS: *entropy weight method; dynamic triangular fuzzy; performance prism model; digital platform; public sports service*

1 Introduction

With the evolution of urbanization, China's public sports service products have been greatly enriched, showing a good trend of diversified supply methods and diverse supply contents [1]. However, the drastic structural changes that are taking place in both urban and rural societies have highlighted even more of the current supply-demand conflict situation in the provision of public sports services, particularly because it is extremely difficult to keep up with the quickly changing trend of urbanization due to certain historical factors [2, 3].

The current evolution of public sports services is not only associated with enhancing the overall physical well-being of a country's population but also involves the promotion of social harmony and urban civilization [4]. With the advent of the digital era and the growth of digital platforms as channels for delivering service, the sphere of public sports services has been continuously expanding, along with growing diversity and improving service quality [5, 6]. On one hand, the application of digital platforms will help improve the quality of public sports services and enhance the efficiency of supply and demand alignment [7]. The use of digital technology will enable intelligent management of sports venues and fitness centers, thus increasing the efficiency of utilization and minimizing wastage of resources [8, 9]. Moreover, digital technology can offer personalized fitness advice to the public and cultivate their fitness behavior. On the other hand, based on the support of digital platforms, public sports services

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can discover new types of innovations, such as fitness apps, online fitness classes, and virtual reality fitness programs [10, 11]. The emergence of such new service models not only adds to the variety of services provided by the sports industry but also encourages wider public engagement in sports activities [12]. In addition, digital empowerment will allow for greater integration and collaboration between the sports industry and other sectors, leading to higher value-added services in the sphere of public sports services [13, 14].

With the promotion of "National Fitness", the academic community has conducted extensive research on how digital platforms can enhance the efficiency of matching supply and demand in public sports services and related fields. Literature [15] examined the relationship between the digital industry and China's sports service sector in the context of the 5.5G era. It verified the Granger causality effect of the digital industry on information services such as sports media using the vector autoregression model, and emphasized that its interactive influence continues to reinforce over time, highlighting the enabling role of digital technology in public sports services. Literature [16] evaluated nine rural public sports service policies through a policy coherence model, and finds that most of the policies have been implemented well but still have deficiencies, points out that digital technology can provide new opportunities for them, and proposes optimization paths to strengthen incentive mechanisms, improve the adaptability of policy instruments, and establish a cross-sectoral coordination framework. Literature [17] reveals the current situation of imbalance between supply and demand in the public sports industry, demonstrates the necessity of solving the supply-demand mismatch through the analysis of supply-side reform, and puts forward a specific path to improve the matching efficiency of public sports services through digital platforms. Literature [18] builds a sports public service platform with the background of "Internet+", analyzes the communication path of the network and mobile terminals, reveals its ability to promote information sharing and accurate service, and points out that the digital platform has important practical value in enhancing supply-demand matching efficiency in public sports. Literature [19] focuses on the resource allocation of ice and snow sports venues in colleges and universities, evaluates the role of digitization in enhancing the spatial agglomeration and development potential of resources through data envelopment analysis, and proposes a targeted optimization strategy based on the efficiency results, emphasizing the value of digital platforms in supporting the promotion of the sustainable development of ice and snow sports. Literature [20] examined the enabling role of digital technologies such as 5G and blockchain on the sports service industry through case studies, pointed out their value in optimizing service structure and improving supply-demand matching, and proposed an overall strategy to promote greater efficiency in public sports service fitness at the three levels of macro-policy, meso-coordination and micro-cultivation. Literature [21] explored the role of the Integrated Management Information System (IMIS) in improving the service experience of sports facilities through a systematic review of the IMIS, pointing out that the system improves service efficiency through data-driven and personalized functions, and emphasizing the continued value of integrating artificial intelligence and Internet of Things (IoT) technologies in optimizing the fitness of public sports resources. Literature [22] describes the multi-dimensional empowerment of digital technology to the sports industry, and examines the role of wearable devices, big data and social media technologies in enhancing athletes' performance and optimizing fans' experience, points out their practical applications in event management and club operations, and emphasizes the core value of this integration in promoting the innovative development of public sports services.

In order to analyze the role of the digital platform in improving the efficacy of the supply-demand match in the public sports service sector, this paper first proposes an index assessment system and a complete assessment model using the dynamic triangular fuzzy multi-criteria decision-making approach, or TOPSIS. Second, a multiple linear regression model is built using

the degree of digital platform development as the independent variable and the performance of the supply-demand fit in the public sports services sector as the dependent variable. Finally, several suggestions are made to enhance the way that digital platforms facilitate the supply-demand fit in public sports services.

2 Evaluation of the performance of public sports services in terms of matching supply and demand

The advent of cutting-edge information technologies, such as big data, artificial intelligence, the Internet of Things, and cloud computing, has led to the current era of digitization. From the standpoint of the government as a provider of public services, offering public sports activities is a component of important social initiatives that promote social peace and enhance public health. It is crucial to use digitization and information technology to promote the growth of these social initiatives in order to guarantee their coordinated development.

2.1 Construction of the evaluation index system

2.1.1 The performance prism model

The Performance Prism Model is a visual performance measurement tool with five dimensions, including Stakeholder Satisfaction, Strategy, Process, Capability and Stakeholder Contribution. It is a three-dimensional framework that adopts the structure of a three-prism, with the top and bottom bottom surfaces representing stakeholder satisfaction and stakeholder contribution, and the three sides representing strategy, process, and capability in that order. The model is an enterprise performance evaluation system formed by integrating strategy, process and capability with stakeholder satisfaction as the starting point and stakeholder contribution as the end point. These five aspects are cascading and interrelated. The relationships of the five perspective dimensions of the performance prism model are shown in Figure 1, and the relationships are mutually causal, with an exchange and symbiotic relationship between the enterprise and its stakeholders.

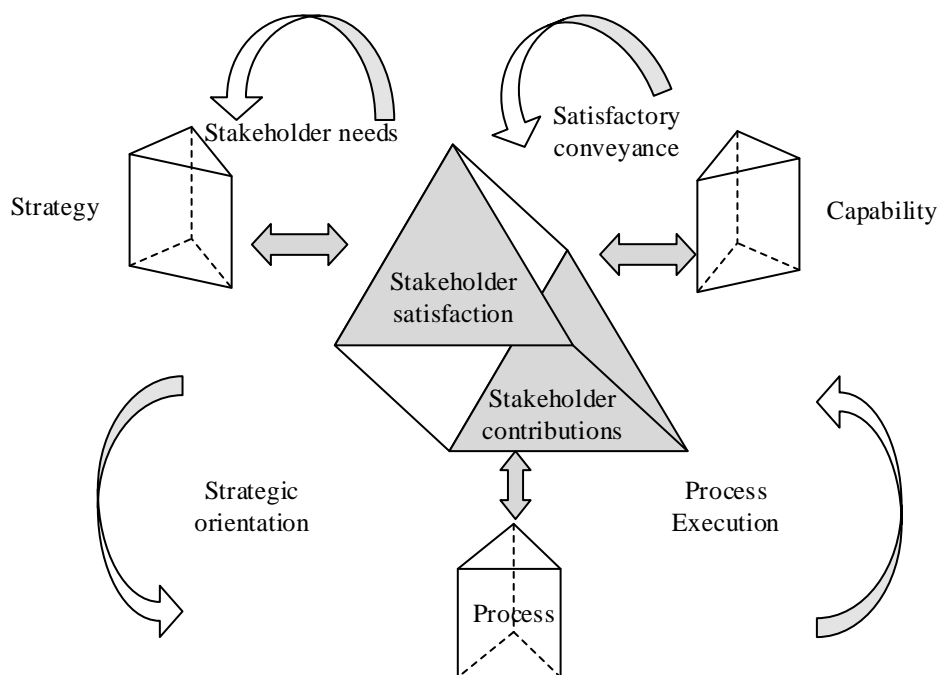


Figure 1: Perspective relation of the performance prism model

The Performance Prism Model, based on the stakeholder perspective, is a system for evaluating corporate performance centered on stakeholder value propositions. In today's business environment, companies committed to long-term growth and success must be clear about who their stakeholders are and what they want and need, and in order to meet the needs of these stakeholders, companies must nurture and develop their capabilities. These capabilities include a combination of management leadership, appropriate manpower, leading-edge technology, good practices and physical infrastructure. In order to nurture and develop their capabilities, stakeholders must contribute to the organization. The enterprise has to consider what strategy to adopt to ensure that it realizes the value assigned to its stakeholders. To ensure the effective implementation of the strategy, the organization must have well-designed processes and the ability to execute them efficiently to ensure that they run smoothly.

2.1.2 Evaluation indicator system

The following can be used to examine the performance of the supply and demand of public sports services. Based on the performance prism model and pertinent research data, this study develops an index system for assessing the effectiveness of supply-demand matching in public sports services. Table 1 below illustrates how it follows the concepts of scientificity, practicability, systematicness, and direction with specific content. Twenty secondary indices and five basic indices make up this assessment technique, which allows for a more detailed analysis of the supply-demand matching of public sports services.

Table 1: Performance evaluation index system for supply and demand matching

| Level 1 | Level 2 | Code |
|---------------------------------|--|------|
| Community members are satisfied | Government departments | CM1 |
| | Community residents' committee | CM2 |
| | Undertaking institution | CM3 |
| | Service staff | CM4 |
| | Cooperative institution | CM5 |
| Development Strategy | Based in the community. | DS1 |
| | Integrate resources | DS2 |
| | Meet the needs of public sports services | DS3 |
| Service process | Collect the service object information | SP1 |
| | Establish service availability | SP2 |
| | Establish a service monitoring mechanism | SP3 |
| | Establish service improvement mechanism | SP4 |
| Service capacity | The allocation of service personnel | SC1 |
| | Corporate strength | SC2 |
| | Facility construction | SC3 |
| Community contribution | Government departments | CC1 |
| | Community residents' committee | CC2 |
| | Undertaking institution | CC3 |
| | Service staff | CC4 |
| | Cooperative institution | CC5 |

2.2 Evaluation model of adaptation performance

2.2.1 Calculation of indicator weights

Entropy originally denotes the degree of uniform distribution of energy in space and is commonly employed to describe the level of disorder within a system. A higher entropy value indicates that the system is more disordered, contains less information, and has a lower utility value, which in turn corresponds to a smaller weight. By contrast, a lower entropy value suggests that the system is more ordered, carries more information, and possesses a higher utility value, thereby resulting in a greater weight. An objective allocation method called entropy weighting involves figuring out the criteria's entropy and assigning a weight depending on how much of an impact it has on the overall variance of the system. The effect on the evaluation as a whole increases with the system's overall relative variance or the variation of the criteria.

The steps for solving the weight of indicators by entropy weight method are as follows:

(1) Construct the original matrix. If there are n evaluated objects and they contain m indicators respectively, these indicators constitute the original matrix. That is:

$$A = a_{ij} (i = 1, 2, 3, \dots, m; j = 1, 2, 3, \dots, n) \quad (1)$$

$$A = (a_{ij})_{m \times n} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} \quad (2)$$

(2) Dimensionless processing. Through the dimensionless data processing, the standard matrix is obtained as:

$$X = (x_{ij})_{m \times n} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (3)$$

(3) Calculate the characteristic weight. The weight conversion of standardized data to obtain the characteristic weight P_{ij} of each indicator by the following formula, i.e.:

$$P_{ij} = \frac{x_{ij}}{\sum_{j=1}^n x_{ij}} \quad (4)$$

According to the definition of entropy, the entropy e_i of the i th indicator is calculated as using the following formula:

$$e_i = -\frac{1}{\ln n} \sum_{j=1}^n p_{ij} \ln(p_{ij}), 0 \leq e_i \leq 1 \quad (5)$$

(4) Calculate the indicator redundancy g_i as:

$$g_i = 1 - e_i (i = 1, 2, 3, \dots, m) \quad (6)$$

(5) Determine the indicator weights ω_i as:

$$\omega_i = \frac{g_i}{\sum_{j=1}^n g_i} \quad (7)$$

2.2.2 Triangular fuzzy decision making

The idea of multi-attribute decision-making entails optimizing a set of limited options containing several attributes in a certain way utilizing the information available for decision-making. Based on the conventional TOPSIS methodology for solving problems involving dynamic multi-attribute decision-making where the time period weights are known and the attribute values are described by interval triangular fuzzy numbers, we will create a model for dynamic triangular fuzzy multi-attribute decision-making using the TOPSIS principle in this article.

In order to facilitate the integration of information in the later paper, this paper defines an integration operator-Dynamic Interval Triangular Fuzzy Weighted Average (DITFWA) operator. Let $\tilde{a}(t_1), \tilde{a}(t_2), \dots, \tilde{a}(t_p)$, where $\tilde{a}(t_k) = [(a_1(t_k), a_1'(t_k)); a_2(t_k); (a_3'(t_k), a_3(t_k))]$ is the number of interval triangular fuzzy numbers for p different time periods $t_k (k = 1, 2, \dots, p)$, and $v(t) = (v(t_1), v(t_2), \dots, v(t_p))$ is the weight vector of the time series $t_k (k = 1, 2, \dots, p)$,

$v(t_k) > 0 (k = 1, 2, \dots, p)$, $\sum_{k=1}^p v(t_k) = 1$, is called:

$$\begin{aligned} DITFWAA_{v(t)}(\tilde{a}(t_1), \tilde{a}(t_2), \dots, \tilde{a}(t_p)) &= \sum_{k=1}^p v(t_k) \tilde{a}(t_k) \\ &= \left[\left(\sum_{k=1}^p v(t_k) a_1(t_k), \sum_{k=1}^p v(t_k) a_1'(t_k) \right); \sum_{k=1}^p v(t_k) a_2(t_k); \left(\sum_{k=1}^p v(t_k) a_3'(t_k), \sum_{k=1}^p v(t_k) a_3(t_k) \right) \right] \end{aligned} \quad (8)$$

is the dynamic interval triangular fuzzy weighted average operator.

The steps of the dynamic triangular fuzzy multi-attribute decision-making method based on TOPSIS are as follows:

(1) The interval triangular fuzzy decision matrix $\tilde{D}(t_k) = (\tilde{a}_{ij}(t_k))_{m \times n}$ ($k = 1, 2, \dots, p$) at each time period is set into a composite interval triangular fuzzy decision matrix by using the DITFWA operator. set into a comprehensive interval triangular fuzzy decision matrix $\tilde{D} = (\tilde{a}_{ij})_{m \times n}$. Where:

$$\begin{aligned} \tilde{a}_{ij}(t_k) &= \left[\left(a_{ij1}(t_k), a'_{ij1}(t_k) \right), a_{ij2}(t_k), \left(a'_{ij3}(t_k), a_{ij3}(t_k) \right) \right], \\ \tilde{a}_{ij} &= \left[\left(a_{ij1}, a'_{ij1} \right), a_{ij2}, \left(a'_{ij3}, a_{ij3} \right) \right], i = 1, 2, \dots, m, j = 1, 2, \dots, n. \end{aligned} \quad (9)$$

(2) Construct a normalized interval triangular fuzzy decision matrix $\tilde{R} = (\tilde{r}_{ij})_{m \times n}$.

For the benefit attribute $j \in \Omega_b$, there are:

$$\tilde{r}_{ij} = \left[\left(\frac{a_{ij1}}{a_{j3}^+}, \frac{a'_{ij1}}{a_{j3}^+} \right); \frac{a_{ij2}}{a_{j3}^+}; \left(\frac{a'_{ij3}}{a_{j3}^+}, \frac{a_{ij3}}{a_{j3}^+} \right) \right], i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (10)$$

For the costly property $j \in \Omega_c$, there is:

$$\tilde{r}_{ij} = \left[\left(\frac{a_{ij1}^-}{a_{ij3}^-}, \frac{a_{ij1}^-}{a_{ij3}^-} \right); \frac{a_{ij2}^-}{a_{ij2}^-}; \left(\frac{a_{ij1}^-}{a_{ij1}^-}, \frac{a_{ij1}^-}{a_{ij1}^-} \right) \right], i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (11)$$

where $a_{j3}^+ = \max \{ a_{ij3}, i = 1, 2, \dots, m \}$, $a_{j1}^- = \max \{ a_{ij1}, i = 1, 2, \dots, m \}$. For convenience, we can abbreviate \tilde{r}_{ij} as $\tilde{r}_{ij} = \left[(g_{ij}, g'_{ij}); g_{ij}; (l_{ij}, l'_{ij}) \right]$.

(3) Determine the positive ideal scheme r^+ and the negative ideal scheme r^- , i.e:

$$r^+ = \{r_1^+, r_2^+, \dots, r_n^+\} \quad (12)$$

$$r^- = \{r_1^-, r_2^-, \dots, r_n^-\} \quad (13)$$

where $r_j^+ = [(1, 1), 1, (1, 1)]$, $r_j^- = [(0, 0), 0, (0, 0)]$. For ease of description, denote the scheme $x_i (i = 1, 2, \dots, m)$ as $x_i = \tilde{x}_{i1}, \tilde{x}_{i2}, \dots, \tilde{x}_{im} (i = 1, 2, \dots, m)$.

(4) Calculate the distances D_i^+ and D_i^- between each scenario x_i and the positive and negative ideal scenarios, respectively, i.e:

$$D_i^+ = \sum_{j=1}^n d(\tilde{x}_{ij}, r_j^+) \quad (14)$$

$$D_i^- = \sum_{j=1}^n d(\tilde{x}_{ij}, r_j^-) \quad (15)$$

(5) Calculate the closeness c_i of each scheme, i.e:

$$c_i = \frac{\tilde{D}_i^-}{\tilde{D}_i^+ + \tilde{D}_i^-} \quad (16)$$

(6) Sort and optimize all the schemes according to the size of the closeness c_i , the larger the closeness c_i , the better the scheme x_i .

2.3 Evaluation and analysis of adaptation performance

2.3.1 Evaluation sample selection

The chosen cities have rather strong public sport services systems and comparatively advanced digital technologies. The statistical yearbook of the corresponding cities, the statistical bulletin of the nation's economic and social development, the annual report of the government websites, and the websites of the respective cities' governments, among other sources, provided the data for each index in accordance with the assessment index system for the supply and demand of public sport services, which was established in section 2.1.2. For cases where there are multiple sources of the same index, the data from the higher level is preferred. For cases where there are multiple sources of the same indicator, priority is given to the data source at the higher level, e.g., if there is a slight difference between the indicators in the city statistical yearbook and the provincial statistical yearbook, priority is given to the provincial statistical yearbook or the national statistical yearbook.

In addition, for missing values in the data, this study finds the corresponding data from the province to which the specific city belongs and replaces the missing values with the average value. Objective data are usually based on generally accepted measurement standards and methods and are easier to quantify. That is, the transformation into specific numbers or statistical values reduces the influence of subjective interpretation and individual differences in the data, thus reducing the possibility of data being misinterpreted or misused, which makes the indicator data easier to analyze, compare, and manipulate, thus supporting more in-depth research and decision-making.

2.3.2 Indicator weighting analysis

Based on the sample data obtained, the calculation formula is used to normalize it, and then the corresponding indicators are included in the relevant formula to obtain the evaluation matrix, and then combined with the entropy weighting method of solving steps to deal with the matrix data to calculate the weights of the indicators and sorting. Table 2 shows the results of the entropy weighting method for each indicator.

Analyzing the data from the results of indicator weights, it can be seen that in the hierarchical index system of public sports service supply and demand fit performance calculated by entropy weight method, the results of weight coefficients of each secondary indicator range from 0.0447 to 0.0601, of which the relative weights of 9 secondary indicators are more than 0.05, and the relative weights of 11 secondary indicators are lower than 0.05. In the first-level indicators, the Community team satisfied the highest proportion of weights (24.0%). weight is the highest (24.38%), Community team contribution is the second highest (24.14%), while the weight of service capacity is relatively the lowest (16.51%), but the two secondary indicators under it are in the top three. As a result, it is evident that the indicators have their own directions for assessing the performance of the public sports service supply and demand fitness. However, it is also crucial that the indicators be arranged in a way that enhances the performance of the public sports service supply and demand fitness and better meets the needs of the public in this regard.

Table 2: The entropy weight method weight results of the indicators

| Level 1 | Level 2 | e_i | g_i | w_i | Sorting |
|---|---------|--------|--------|--------|---------|
| Community members are satisfied (0.2438) | CM1 | 0.9171 | 0.0829 | 0.0492 | 11 |
| | CM2 | 0.9469 | 0.0531 | 0.0521 | 6 |
| | CM3 | 0.9088 | 0.0912 | 0.0501 | 9 |
| | CM4 | 0.9653 | 0.0347 | 0.0464 | 15 |
| | CM5 | 0.9207 | 0.0793 | 0.0461 | 16 |
| Development Strategy (0.1673) | DS1 | 0.8442 | 0.1558 | 0.0527 | 5 |
| | DS2 | 0.7685 | 0.2315 | 0.0545 | 4 |
| | DS3 | 0.9091 | 0.0909 | 0.0601 | 1 |
| Service process (0.1824) | SP1 | 0.9786 | 0.0214 | 0.0453 | 19 |
| | SP2 | 0.9012 | 0.0988 | 0.0468 | 14 |
| | SP3 | 0.9398 | 0.0602 | 0.0456 | 18 |
| | SP4 | 0.9261 | 0.0739 | 0.0447 | 20 |
| Service capacity (0.1651) | SC1 | 0.9674 | 0.0326 | 0.0572 | 2 |
| | SC2 | 0.9125 | 0.0875 | 0.0561 | 3 |
| | SC3 | 0.9068 | 0.0932 | 0.0519 | 8 |
| Community contribution (0.2414) | CC1 | 0.9569 | 0.0431 | 0.0494 | 10 |
| | CC2 | 0.8475 | 0.1525 | 0.0520 | 7 |
| | CC3 | 0.8702 | 0.1298 | 0.0460 | 17 |
| | CC4 | 0.9063 | 0.0937 | 0.0471 | 12 |
| | CC5 | 0.9478 | 0.0522 | 0.0469 | 13 |

2.3.3 Fuzzy evaluation results

The model is used to assess the performance of supply and demand fitness of public sports services for the dynamic triangular fuzzy multiple attribute decision making method using the TOPSIS method presented in this paper. This allows the public to choose the city that provides the best public sports services. Despite the first screening procedure, four cities remain to be considered for the city that chooses the best public sports service supply and demand capacity: A, B, C, and D. The decision makers set five first-level indicators according to their own preferences in combination with the evaluation indexes, i.e., satisfaction of the community members, development strategy, service process, service capacity and the contribution of the community members. Experts evaluate the four cities according to the five indicators respectively, and the evaluation value of each city is given in the form of triangular fuzzy

number, which is organized to get the initial triangular fuzzy decision matrix, and its specific results are shown in Table 3.

Table 3: Initial triangular fuzzy decision information

| City | A | B | C | D |
|------|------------------|------------------|------------------|------------------|
| CM | [0.79,0.81,0.86] | [0.93,0.94,1.00] | [0.72,0.75,0.78] | [0.86,0.89,0.91] |
| DS | [0.51,0.57,0.58] | [0.92,0.98,0.94] | [0.73,0.78,0.81] | [0.64,0.68,0.71] |
| SP | [0.91,0.96,0.96] | [0.87,0.88,0.82] | [0.93,0.94,0.99] | [0.92,0.96,0.98] |
| SC | [0.81,0.83,0.86] | [0.67,0.68,0.72] | [0.93,0.97,1.00] | [0.86,0.92,0.93] |
| CC | [0.93,0.91,0.98] | [0.46,0.52,0.57] | [0.81,0.87,0.91] | [0.52,0.57,0.58] |

Triangular fuzzy multi-attribute decision making based on the dynamic triangular fuzzy TOPSIS method is used in the above example using the following process:

(1) The normalized triangular fuzzy decision data is shown in Table 4 after the triangle fuzzy decision matrix has been normalized.

Table 4: Normalized triangular fuzzy decision information

| City | A | B | C | D |
|------|---------------------|---------------------|---------------------|---------------------|
| CM | [4.471,5.515,5.589] | [4.401,4.438,4.479] | [5.518,5.557,6.623] | [4.447,4.469,5.517] |
| DS | [2.163,2.205,3.238] | [5.581,6.624,6.694] | [3.342,3.369,3.389] | [2.276,2.298,3.383] |
| SP | [4.426,4.483,5.511] | [3.382,3.396,4.431] | [4.476,5.512,5.553] | [4.431,4.489,5.514] |
| SC | [3.368,3.395,4.447] | [2.214,2.295,3.314] | [5.514,5.538,5.624] | [4.412,4.476,5.531] |
| CC | [5.512,6.623,6.687] | [1.148,1.482,2.219] | [4.431,4.475,5.538] | [1.158,1.176,1.198] |

(2) Based on the entropy weight method to solve the obtained weights of each level of indicators [0.2438, 0.1673, 0.1824, 0.165, 0.2414], which will be brought into the triangular fuzzy decision-making information.

(3) Construct the weighted canonical triangular fuzzy decision matrix, the specific content of which is shown in Table 5.

Table 5: Weighted normalized triangular fuzzy decision information

| City | A | B | C | D |
|------|---------------------|---------------------|---------------------|---------------------|
| CM | [0.471,0.515,0.589] | [0.401,0.438,0.479] | [0.518,0.557,0.623] | [0.447,0.469,0.517] |
| DS | [0.163,0.205,0.238] | [0.581,0.624,0.694] | [0.342,0.369,0.389] | [0.276,0.298,0.383] |
| SP | [0.426,0.483,0.511] | [0.382,0.396,0.431] | [0.476,0.512,0.553] | [0.431,0.489,0.514] |
| SC | [0.368,0.395,0.447] | [0.214,0.295,0.314] | [0.514,0.538,0.624] | [0.412,0.476,0.531] |
| CC | [0.512,0.623,0.687] | [0.148,0.482,0.219] | [0.431,0.475,0.538] | [0.158,0.176,0.198] |

(4) Determine the distances D_i^+ and D_i^- for the positive and negative ideal schemes, i.e:

$$\begin{aligned}
 D_i^+ &= \{[0.1043,0.1158,0.1268],[0.0851,0.0948,0.1052],[0.0953,0.1048,0.1161], \\
 &\quad [0.0503,0.0538,0.0619],[0.0831,0.0921,0.1048]\} \\
 D_i^- &= \{[0.0814,0.0824,0.0951],[0.0253,0.0318,0.0332],[0.0751,0.0748,0.0815], \\
 &\quad [0.0214,0.0282,0.0306],[0.0038,0.0056,0.0074]\}
 \end{aligned} \tag{17}$$

(5) Calculate to obtain the relative affixing progress of each alternative city to the positive and negative ideal scenarios D_i^+ and D_i^- , i.e:

$$\begin{aligned} c_i(A, D_i^+) &= 0.8125, c_i(B, D_i^+) = 0.6543, c_i(C, D_i^+) = 0.8872, c_i(D, D_i^+) = 0.6402 \\ c_i(A, D_i^-) &= 0.6638, c_i(B, D_i^-) = 0.8158, c_i(C, D_i^-) = 0.6041, c_i(D, D_i^-) = 0.8218 \end{aligned} \quad (18)$$

(6) Calculate the overall relative posting schedule, then:

$$C_i(A) = -0.2038, C_i(B) = -0.6342, C_i(C) = 0.0016, C_i(D) = -0.6836 \quad (19)$$

(7) From the results of the overall relative posting progress, it can be seen that the ranking scheme of the four cities' public sports service supply and demand fitness performance is $C > A > B > D$. Therefore, the city with the optimal performance of public sports service supply and demand fitness is City C, which means that City C is optimal for decision makers and can provide more comprehensive public sports services for users.

3 Factors affecting the matching of supply and demand for public sports services

The public sports service's digital governance is becoming more widely acknowledged as a key indicator of the sports management industry's modernization. It is essential to use the digital approach to determine the actual sports needs of the populace in order to build a solid public sports service system for carrying out fitness activities across the nation. The concept of "digital governance of public sports service demand" originated in this setting. Emerging technology trends like big data, artificial intelligence, and the Internet of Things play a critical role at this point.

3.1 Variable Definition and Modeling

3.1.1 Multiple linear regression

Using statistics and mathematical functions, Multiple Linear Regression Analysis analyzes, interprets, and describes the content, characteristics, and laws of change related to the interdependency between the random or dependent variable and multiple independent variables. It has the advantages of simple method and strong ability to explain the relationship between variables, and is widely used in social, economic and many natural science fields.

The formal description of the multiple linear regression analysis model with n independent variables is:

$$y = b + a_1x_1 + a_2x_2 + \dots + a_mx_m \quad (20)$$

where b is the constant term (intercept), i.e., the value of y when all the independent variables are zero, and $a_1 \sim a_m$ is the m regression coefficient, there are standardized regression coefficients and non-standardized regression coefficients. Standardized regression coefficients are used to investigate the degree of influence of the independent variable and the dependent variable in the equation, as the units of the variables are not affected. Unstandardized regression coefficients vary with the units of the independent variables and are generally not used to determine the influence of the independent variables. a_1 indicates the amount of change in y caused by each change in the value of x_1 when the independent variables except x_1 remain unchanged, and $a_2 \sim a_m$ indicates the same meaning as a_1 .

Multiple linear regression prediction model is mainly to select some independent variables that have a greater impact on the dependent variable, and to find the relationship between the variables for model construction. For the selection of independent variables, either all independent variables or variables with higher degree of correlation can be used to construct the equation. After the construction of the equation is completed, the equation needs to be tested to determine whether the equation is accurate or not, and the common tests are the test of coefficient of determination (R^2 test), the test of significance of the equation (F test) and the test of significance of the regression coefficient (T test).

3.1.2 Definition of research variables

This study uses a two-way fixed-effects model to experimentally examine how digital platforms affect the effectiveness of supply-demand matching for public sports services. The research variables are defined as follows:

(1) Dependent variables. The entropy value method and dynamic triangular fuzzy number multi-attribute decision-making method were used to determine the efficiency of the fit between supply and demand in public sports services (GGTY) from five perspectives: community residents' satisfaction, strategic level, service process, service capability, and co-production of community residents.

(2) Independent variables. Level of digital platform development (DIG). Three dimensions of digital infrastructure development, degree of digital technology application, and degree of digital technology innovation were established in this study, and the entropy weight technique was used to determine the variable's value.

(3) Control variables. Other external factors may have an impact on the effectiveness of supply and demand fit in public sports services, in addition to the effect of digital platforms. Thus, marketization (MAR), industrial structure upgrade (STR), openness (OPEN), economic development (ECO), and population density (DEN) were selected as control variables.

3.1.3 Research model design

In order to examine the direct relationship between the degree of digital platform development and the supply and demand fitness of public sports services, this study builds a stepwise regression model. The model looks like this:

$$GGTY_{i,t} = \alpha_0 + \alpha_1 DIG_{i,t} + \alpha_2 \sum Control_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \quad (21)$$

where, $GGTY_{i,t}$ is the explanatory variable, representing the performance level of supply and demand fitness of public sports services in the i city in the t year. $DIG_{i,t}$ is the core explanatory variable representing the level of development of digital platforms in year t in city i , and $Control_{i,t}$ is a series of control variables. α_0 is a constant term, α_1 is the regression coefficient of the explanatory variables, α_2 is the regression coefficient of the control variables μ_i, γ_t represent the region fixed effect and year fixed effect, respectively, and $\varepsilon_{i,t}$ is the randomized disturbance term.

3.2 Econometric evidence of impact factors

3.2.1 Stepwise regression analysis

The next part uses benchmark regression analysis to assess the effectiveness of supply-demand

fitness for public sports services in the context of digital platforms, based on the study methodology described in the previous section. The degree of development of the digital platform was the primary independent variable in the benchmark regression, and the effectiveness of the supply-demand match for the public sports service was the dependent variable. The lengthy panel data were used as the data sample for the analysis of the effects of the level of development of digital platforms on the effectiveness of supply-demand fit of public sports services. Panel regression techniques including feasible GLS, panel-corrected standard errors, and LSDV are commonly employed. Table 6 displays the model's stepwise regression findings.

The degree of development of digital platforms and the effectiveness of supply-demand adaptation of public sports services are clearly positively correlated, as shown in the above table. The regression coefficient of the degree of development of digital platforms on the effectiveness of supply-demand adaptation of public sports services is 0.438 without the addition of any other variables, while the coefficient of determination, R², reaches 0.7821 with a significant value at 1%. In other words, for every 1 percentage point increase in digital platform development, the efficiency of supply-demand adaptation in public sports services rises by 0.438 percentage points, and 78.21% of this improvement can be attributed to digital platform development. At the 1% level, the effect coefficient of the degree of digital platform development consistently exhibits positive association, although progressively declining after gradually adding control variables. This suggests that reliance on digital platforms can improve the efficiency of supply-demand matching in public sports services, reduce inequality in public sports service provision, and encourage more balanced growth between supply and demand within the industry.

Table 6: The stepwise regression results of the model

| Variable | (1) | (2) | (3) | (4) | (5) | (6) |
|----------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| DIG | 0.438*** (4.263) | 0.412*** (3.357) | 0.386*** (4.932) | 0.369*** (5.148) | 0.332*** (4.773) | 0.316*** (5.278) |
| DEN | - | 6.238*** (4.015) | 4.386*** (3.795) | 3.275** (3.063) | 2.551*** (4.158) | 1.763** (3.274) |
| ECO | - | - | 0.578*** (6.824) | 0.432*** (5.759) | 0.328*** (4.935) | 0.301*** (3.875) |
| OPEN | - | - | - | 0.378*** (3.274) | 0.316*** (3.591) | 0.284*** (2.548) |
| STR | - | - | - | - | 0.514** (4.795) | 0.432*** (3.851) |
| MAR | - | - | - | - | - | 0.216** (3.278) |
| (Con_) | 0.216*** (3.748) | 0.293*** (3.792) | 0.314*** (5.763) | 0.358*** (7.243) | 0.361*** (7.526) | 0.376*** (7.835) |
| Time | YES | YES | YES | YES | YES | YES |
| Region | YES | YES | YES | YES | YES | YES |
| R ² | 0.7821 | 0.7837 | 0.8028 | 0.8359 | 0.8394 | 0.8527 |

Note: Values in parentheses are t-statistics. ***, **, * indicate significant at 1%, 5% and 10% confidence levels, respectively, as below.

3.2.2 Robust test analysis

This study investigates the resilience of the empirical findings using three methods: decreasing the key explanatory factors, lagging the explanatory variables, and re-estimating them using the GMM model in order to demonstrate the robustness of the stepwise regression results. The robustness test's regression findings are displayed in Table 7.

(1) Tailoring to handle core explanatory variables. In light of the potential problems

associated with outliers and non-randomness in data, the core explanatory variables are adapted to a 1% shrinkage process. The development level of the digital platform is coded as Dig-w after being subjected to a 1% shrinkage process. According to the estimation results in Model (1) The sign and significance of the primary independent variables are same, as Table 7 makes clear. Therefore, it can be said that the process of shrinking the level of development of digital platforms is very important for the effectiveness of supply and demand fitness of public sports services.

(2) The lag of one period in terms of the effectiveness of supply-demand matching for public sports services is a novel explanatory factor used to assess the robustness of empirical findings. The results in Table 7 under model (2) show that the impact of digital platform development on the efficiency of supply-demand matching for public sports services is still valid even in the context of the baseline regression model. This demonstrates the continued high robustness of empirical results employing novel explanatory factors.

(3) Estimation of the System GMM model. It is also possible to think of the effectiveness of supply-demand matching in public sports services as a dynamic process. In other words, the effectiveness of supply-demand matching is influenced not only by the public sports service's present state of growth but also by its worth in the past. As a result, the model incorporates a lagged term of the growth of public sports services, and the system GMM technique is used to estimate the entire model once more. The system GMM estimation method compensates for the disadvantage of differential GMM by simultaneously taking into account the effect caused by a level equation, with the independent variable of the level equation (Ln.Ser) serving as the differenced lagged dependent variable, even though the differential GMM method already has a difference equation. The impact of the growth of digital platforms on the effectiveness of supply-demand matching in public sports services likewise shows comparable outcomes to those in the benchmark test, as shown in the model (3) in Table 7.

Table 7: The regression results of the robustness test

| Variable | (1) | (2) | (3) |
|----------|-----------------|-----------------|-----------------|
| DIG | - | 0.383***(4.135) | 0.263***(4.478) |
| DIG-w | 0.352***(3.612) | - | - |
| Ln.Ser | - | - | 0.513***(5.818) |
| DEN | 0.172**(4.029) | 0.183**(3.276) | 0.172**(3.434) |
| ECO | 0.051***(3.174) | 0.076***(4.258) | 0.089***(4.126) |
| OPEN | 0.239***(2.785) | 0.179**(3.043) | 0.153***(2.765) |
| STR | 0.323*(3.579) | 0.249***(4.056) | 0.316***(3.243) |
| MAR | 0.517***(2.538) | 0.438***(3.539) | 0.503***(2.951) |
| (Con_) | 0.243***(2.514) | 0.318***(3.897) | 0.369***(4.236) |
| Time | YES | YES | YES |
| Region | YES | YES | YES |

3.2.3 Subgroup Heterogeneity Analysis

For testing the heterogeneity in the matching process of demand and supply for public sport facilities enabled by digital technologies, this study looks into two categories: region and city size. For each dimension, the studied area has been divided into the eastern region versus central western region and small cities vs medium to large cities, respectively. Table 8 presents the outcomes of the heterogeneity test.

(1) Heterogeneity across geographic regions. The influence of digital platforms on the supply-demand matching efficiency of public sports services differs by region. Owing to its

economic strengths, the eastern region has established a clear advantage over many other parts of the country. As indicated in the table, in the eastern region, the regression coefficient of digital platform development on the supply-demand matching efficiency of public sports services reaches 0.576 and is significant at the 1% level; by contrast, in the central and western regions, the corresponding coefficient is 0.275 and is also significant at the 1% level. This pattern reveals clear regional heterogeneity in how digital platform development affects the supply-demand matching efficiency of public sports services. One possible reason is that the eastern region benefits from stronger economic growth and clear advantages in digital technology, culture, sports, and entertainment. Consequently, digital platforms exert a stronger enabling effect on public sports services. In comparison, because the central and western regions adopted digital technology relatively late, the sports sector there still trails behind and plays a limited role, thereby reinforcing regional differences.

(2) Heterogeneity by city size. Urban scale shapes the sources of regional economic growth and therefore affects regional development trajectories. In smaller cities, the effect of digital platforms on the supply-demand fitness of public sports services is not statistically significant. In contrast, in medium-sized and large cities, digital platforms significantly improve the supply-demand fitness of public sports services, with a coefficient of 0.358 at the 1% significance level. This suggests that digital platforms are more effective in enhancing the supply-demand fitness of public sports services in medium and large cities. A possible explanation is that small cities possess relatively limited internal resources, and their economic growth depends mainly on science and technology as well as the tertiary sector, which means digital platform development has already approached a bottleneck, while digital platform construction in service industries represented by public sports services remains comparatively insufficient. By comparison, medium and large cities have achieved more advanced science- and technology-oriented digital platform development, and their economic expansion relies more heavily on the resource economy. Moreover, the elasticity generated by improvements in digital platform development is greater in these cities, making its contribution to strengthening the matching efficiency of public sports service supply and demand more evident than in small cities.

Table 8: The results of the heterogeneity of the group

| Variable | Region | | City scale | |
|---------------------|-----------------|-----------------|-----------------|-----------------|
| | Eastern (1) | Midwest (2) | Small (3) | Medium-Big (4) |
| DIG | 0.576***(4.249) | 0.275***(2.243) | 0.175(2.316) | 0.358***(4.762) |
| Control | YES | YES | YES | YES |
| (Con ₁) | 0.538***(3.268) | 0.467***(3.534) | 0.316***(4.128) | 0.404***(3.296) |
| Time | YES | YES | YES | |
| Region | YES | YES | YES | |
| R^2 | 0.2834 | 0.3568 | 0.3602 | 0.2837 |

4 Paths to improving the matching of supply and demand for public sports services

One of the best ways to guarantee that "Healthy China" and "Strong Country of Sports" can be fully implemented is to provide high-quality public sports services. Additionally, it will allow us to address people's higher-level needs in order to make their lives better. By empowering digital platform technology and fully utilizing its capabilities in "digitalization" and "intelligence," we may achieve the balance of overall equality in terms of sports services and address the problem of public sports services. Enhancing the efficacy and efficiency of public

sports services would satisfy people's desire for a better living while also enhancing their emotional experiences of participation in public sports.

4.1 Facility Development and Institutionalization

4.1.1 Advancement of facilities

The growth of digitization of public sports services is greatly aided by digital infrastructure, which serves as the basis for connecting the digital and physical worlds and is crucial for enhancing the effectiveness of supply-demand matching. Comparatively speaking, the new technology infrastructure and arithmetic infrastructure in public sports services have a relatively short starting time, and the overall development is characterized by insufficient investment scale, uneven regional distribution, and problems such as fast development of “hard infrastructure” and lagging behind of “soft infrastructure”. Therefore, with the new development concept as the lead, and driven by technological innovation, the construction of digital infrastructure should be comprehensively strengthened, so as to provide a guarantee for the digital transformation, intelligent upgrading and integration and innovation of public sports services.

First, the standardized coordination of digital infrastructure construction should be strengthened. The digitalized operation of public sports services requires further strengthening the scientific layout of digital infrastructure construction from a long-term, systematic and global perspective. Second, promote the coordinated regional development of digital infrastructure construction. Formulate regional development strategies based on the overall layout of the digital economy, and gradually improve the situation where the east is strong and the west is weak, and towns are strong and rural areas are weak. For more perfect regions, accelerate the construction of digital city cluster networks and improve the overall operation and maintenance level. For underdeveloped regions, innovative infrastructure will be deployed ahead of time, and the upgrading of traditional infrastructure in the form of “digital+” and “smart+” will be steadily promoted, so as to expand coverage and quantity and enhance the efficiency of resource allocation. Thirdly, the development of digital “soft” infrastructure should be accelerated. Hardware systems can provide support for the realization of data value by digital technology, and continuously updated software systems can meet the growing demand for computing power in application systems. Through pilot demonstrations and compliance guidelines, we will increase capital investment in core technical areas, improve the operation and management of “soft resources”, and promote the parallel development of “soft and hard” digital infrastructure.

4.1.2 Building governance mechanisms

Deep integration of digital frequency stations is crucial to improving the efficiency of the supply and demand of public sport services. As a result, it should be encouraged to innovate the way public sport services are built so they can be sufficiently efficient and to fully utilize the role of digital technology through effective integration. Through content and mode innovation, the relevant departments should make use of network technology to strengthen the information contact between “points and points” and “blocks and blocks” among regions. An inter-block sports service management platform can be established, and the maintenance of sports facilities can also be accurately corresponded to by means of this platform. It can not only make the patrol and maintenance of sports facilities routine but also establish a supervisory mechanism to detect problems, report and maintain them in a timely manner.

Set up a cell phone APP to establish an information exchange and sharing platform. This is the medium to form a human-machine linkage and reality dissemination situation. On the cell

phone the people can also watch some instructive fitness videos in time, as well as communicate with each other and upload their own fitness tips, promoting a virtuous cycle in a certain area. The APP program is used to monitor the health index of the residents in real time, so as to better formulate their own exercise program for the residents. Setting up a government message board in the APP enables residents to provide countermeasure suggestions to the government in a better and faster way, and the government and other departments can also deal with the situation appropriately according to the people's reflections in a timely manner.

4.2 Value transformation and platform optimization

4.2.1 Enhanced value conversion

Through the creation of rich, personalized and interactive digital experiences, the potential value of digital sports facilities or services can be effectively communicated to residents and motivate them to take proactive action to realize value transformation. Through digital experiences, richer, interactive and personalized interactions can be provided to allow residents to directly engage and better experience the functions, features and benefits of digital sports or digital services. Enhancement of the digital experience can be achieved in a variety of ways. For example, through virtual reality (VR) or augmented reality (AR) technology, an immersive digital experience environment can be created for residents to experience first-hand the features and advantages of digital sports services. At the same time, digital user interface design and personalized recommendation systems can provide customized sports programs and sports experiences according to residents' preferences and needs, enhancing the interactivity between residents and digital services. Through digital experience interactivity and personalized recommendation, residents can be guided to actively participate in exercise, generate the will for physical fitness, and motivate them to take action to achieve relevant value transformation. Digital lifestyle can significantly increase the frequency of residents' exercise, enrich residents' learning channels and content, and enhance the national fitness willingness through the learning effect. Improving residents' sports informatization literacy is crucial for promoting healthy living and sports service development.

4.2.2 Digital platform optimization

In the cooperation of public sports service providers, a networked governance platform consisting of government-led participation mechanisms, support mechanisms, cooperation mechanisms, benefit integration mechanisms and supervision and evaluation mechanisms for multiple providers has been constructed to realize a multiple synergistic and linked supply system in which the government, the market, social organizations and residents of villages and towns cooperate effectively. In this collaborative network model, the external is the external macro-environment in which the public sports service supply is located, which mainly includes national policies and regulations, systems, socio-economic and cultural development level, natural conditions, technical environment, as well as the level of economic development, the development of sports, etc. These environmental conditions directly affect the collaborative and joint supply system, which is the most important factor in the development of sports. These environmental conditions have a direct impact on the relationship between the supplying bodies in the cooperative joint supply network, the formation of supply objectives and the choice of operation mode. The internal environment is the internal environment of cooperation, in which the government is in a central position, actively integrating multiple subjects to supply and play their respective advantages to cope with the complex impact of the external environment.

At the same time, the residents' demand for sports, changes in the scope of basic public services in sports and dynamic adjustments within the cooperative internal environment all

affect the supply behavior of each supplying body. Through the construction of the cooperative network, the government can play its leading role and functions of coordination, allocation and service, give full play to its own financial, intellectual and material resources, integrate the non-government supplying entities, and stimulate their potential strengths (such as flexibility and grass-roots connection, etc.) in order to enhance the ability to withstand the impacts and pressures of the external environment. At the same time, in this platform, the government can not only deal well with the horizontal relationship with the market and social organizations, but also deal with the vertical relationship between different levels of government. As well as better improve the participation of residents in the decision-making of public sports service provision, thus realizing three-dimensional synergistic linkage and promoting the enhancement of the effectiveness of public sports service provision.

5 Conclusion

The performance prism was used in the construction of the index system for assessing the performance of the supply and demand of public sports services. Additionally, the performance of the supply and demand for public sports services was evaluated using the dynamic triangular fuzzy multi-criteria decision-making approach based on the order preference by similarity to ideal solution methodology. Using the aforementioned presumptions, it was possible to build the framework for investigating the effectiveness of supply-demand matching for public sports services via the digital platform by creating a multiple linear regression model. A specific improvement approach was then put out in order to further enhance the efficacy of matching public sports service supply and demand made possible by digital platforms. Additionally, the efficacy of matching the supply and demand of public sports services was shown to be influenced by the degree of development of digital platforms, with a coefficient of influence of 0.438. This suggests that there is a strong reliance between the two elements at the 1% level. As a result, it is essential to encourage the growth of digital infrastructure and expand its function in the process of digital platform optimization and value transformation.

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