Scientific Training Model of Sports Tourism Based on Nonlinear Differential Equation

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Abstract

This paper establishes a scientific training model for sports tourism based on the nonlinear differential equation. This paper takes sports tourism as the research object. Then the nonlinear differential equation method is used to model communication, access, risk assessment and transparency. Then this paper analyzes and discusses how to improve residents’ participation in sports tourism sports projects. Finally, this paper finds that the method has a good application prospect in the analysis and modeling sports tourism basketball projects by experimental simulation.

Keywords: Nonlinear differential equation; Sports tourism projects; Factor analysis; Participation; Risk assessment

AMS 2020 codes: 34A34
Introduction

Sports tourism is a new industry that sports and tourism developed together. It has quietly become the unique hot consumption point. Foreign sports tourism is mainly divided into ornamental and participation markets. Ornamental sports tourism specifically refers to tourists leaving their usual residences. Through visual and auditory appreciation and experience of sports activities, stadiums, sports art and sports culture, they can obtain pleasant sensory feelings and soul reverberation [1]. It is mainly completed by watching sports events and participating in festivals. The bigger the event, the greater its tourism value. For example, every Olympic Games, World Cup, NBA and other major events are the most significant sports tourism market. The host country of the Olympic Games makes use of the opportunity of holding the Olympic Games to continuously improve the level of its sports tourism industry [2]. It has a profound influence on the economic and social development of the country. According to data, during the 2000 Sydney Olympic Games, the number of inbound tourists to Australia reached about 500,000. Tourism generated about $3.7 billion in revenue. Unlike ornamental sports tourism, participative sports tourism pays more attention to tourists' participation rather than their sensory experience. A participative sports tourism sports project is a project with a particular difficulty. It needs to pay for specific physical strength under the help and guidance of a sports tourism manager and coach. Participative sports tourism is not based on competition but on the experience and entertainment of sports tourists [3]. Developing participatory sports tourism in developed countries is much better than in developing countries. In the United States, Britain, France and other developed countries, modern social life's high speed and fast pace bring people psychological pressure. People are eager to get out of the house for leisure and fitness to relieve psychological stress. Therefore, participation in sports tourism has been well-developed in these countries. By participating in popular participatory sports such as mountain biking, mountaineering and golf, tourists can not only achieve the purpose of fitness and health but also let tourists close to nature [4]. This allows them to completely relax their body and mind and release the pressure of life.

For example, Switzerland, the "roof of Europe," has five peaks above 4,000 meters. This is the world's mountaineering paradise. According to the Swiss Tourism Board, the country's tourism revenues have reached 21.6 billion Swiss francs. Sports tourism accounts for nearly 5 percent of the gross domestic product. In terms of skiing events, a large number of skiers are involved every year [5]. As of 2015, there are more than 6,000 ski resorts worldwide. The resort attracts about 100 million skiers. Skiers bring considerable economic benefits to the countries where these resorts are located. Compared with developed countries, developing countries natural resources and human environment are better preserved because of their less rapid development. This has become a beautiful sports tourism mecca. Sports tourism is also growing extremely fast in developing countries [6]. Asia has great potential for sports tourism development. According to relevant statistics, the annual growth rate of its sports tourism market will reach 6.8%. It's a huge emerging market.

Compared with overseas sports, tourism development started late. The domestic sports tourism industry began to develop in the 1980s. In 1985, Tibet Sports Commission established the Tibet International Sports Tourism Company to meet the needs of more domestic and foreign mountaineers to climb Mount Qomolangma [7]. This became the origin of Chinese sports tourism. In the 1990s, all parts of China combined with their reality to develop many sports tourism products under market demand guidance and great push by the government [8]. Sports tourism products are increasingly abundant. By 2012, the China Sports Tourism Expo, led by the General Administration of Sport and the National Tourism Administration, had launched 198 sports tourism quality projects. One of the more famous is Shennongjia Savage's five outdoor experience routes, Zhengzhou International Shaolin Martial Arts Festival, Yellow River rafting, Tour of Qinghai Lake International road cycling race, etc. These sports tourism products have contributed a lot to local economic growth. Our government attaches more and more importance to the development of sports tourism [9]. Currently,
in developing sports tourism poverty alleviation projects in some regions, the main problem of low participation of residents has been exposed. Through the review and analysis of the literature on value co-creation at home and abroad, this paper finds out how to improve the participation of residents in sports tourism projects by constructing a nonlinear differential equation model with four elements: dialogue, acquisition, risk assessment and transparency.

2 Training model based on nonlinear differential equation

To obtain the error analysis, we first give the following essential inequalities:

**Lemma 1.** Let's say \( r \geq 0 \), then, we have \( 1 - e^{-r} \leq r \)

*Proof.* Take \( g(r) = 1 - e^{-r} - r \), then \( g'(s) = e^{-r} - 1 \leq 0 \), so \( g(r) \) is the monotonically decreasing function. So when \( r \) is 0, \( g(r) \) is the maximum. \( g(r) \leq 0 \) lemma is proved.

**Lemma 2.** If \( r \geq 0, x \geq 0 \), and \( \gamma > 0 \), then there is \( r^\gamma \cdot e^{-sx} \leq \left( \frac{\gamma}{ex} \right)^\gamma \).

*Proof.* Take \( g(r) = r^\gamma \cdot e^{-sx} \),

\[
g'(r) = \gamma \cdot r^{\gamma-1} \cdot e^{-sx} + r^\gamma \cdot (-x) \cdot e^{-sx} = r^{\gamma-1} \cdot e^{-sx} (\gamma - rx).
\]

Let's say \( g'(r) = 0, s = 0 \) or \( \frac{\gamma}{x} \).

When \( r = 0 \) is \( g(r) = 0 \); When \( r = \frac{\gamma}{x} \) is \( g(r) = \left( \frac{\gamma}{ex} \right)^\gamma > 0 \).

\[
g'(r) > 0 \text{ when } r < \frac{\gamma}{x} \text{; When } r > \frac{\gamma}{x} \text{ is } g'(r) < 0.
\]

So the maximum of \( g(r) \) is \( \left( \frac{\gamma}{ex} \right)^\gamma \), and the lemma proves it.

The convergence estimation between the exact solution of the problem and its regular approximate solution is established as follows:

**Theorem 3.** Suppose \( u(x,t) \) is an exact solution to the equation given by theorem (1). \( v(x,t) \) is a quasi-inverse regular approximation of the original problem given by theorem (2). So when the regularization parameter is \( \eta = \frac{T}{\ln \frac{E}{\varphi}} \), \( 0 < t < T \), the regularization solution converges to the exact solution \([10]\). When \( \varphi \to 0 \), the following stability estimation is valid:

\[
\|v(x,t) - u(x,t)\| \leq 2T^2CE \left( \frac{1}{\ln \frac{E}{\varphi}} \right) + \max \left\{ e^{T^2} \cdot \phi, E^{1-T} \cdot \phi^T \right\}
\]

(1)
Where \( C = \left( \frac{1 + \frac{a}{2}}{e^{\alpha t} \cos \frac{2\alpha t}{2}} \right)^{\frac{1}{2}} \).

**Proof.** From Parseval equation, triangle inequality

\[
\|v(x, t) - u(x, t)\| = \|\hat{v}(\lambda, t) - \hat{u}(\lambda, t)\|
\leq \left\| e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} \cdot (\hat{f}^a(\lambda) - \hat{f}(\lambda)) \right\|
+ \left\| \left( e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} - e^{-\iota \alpha t} \right) \cdot \hat{f}(\lambda) \right\|
= \left\| e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} \cdot (\hat{f}^a(\lambda) - \hat{f}(\lambda)) \right\|
+ \left\| \left( e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} - e^{-\iota \alpha t} \right) \cdot e^{-\iota \alpha \mu \lambda^2} \cdot \hat{u}(0, t) \right\|
\]

Using the property \( \|k\| = |k| \cdot \|g\| \) of norm and related conditions, the following formula can be obtained:

\[
\leq \sup_{\lambda \in R} A(\lambda) \cdot \varphi + \sup_{\lambda \in R} B(\lambda) \cdot E
\]

\[
A(\lambda) = \left( e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} \right), \quad B(\lambda) = \left( e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} - e^{-\iota \alpha t} \right) \cdot e^{-\iota \alpha \mu \lambda^2}
\]

(4)

So let's estimate \( A(\lambda) \) and \( B(\lambda) \). The point is to show that as \( \varphi \to 0 \), \( \sup_{\lambda \in R} A(\lambda) \cdot \varphi \) and \( \sup_{\lambda \in R} B(\lambda) \cdot E \) theta both approach 0.

i) For \( A(\lambda) \)

\[
A(\lambda) = \left( e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} \right) = \left( e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} \right) \leq e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}}
\]

(5)

Then according to the triangle inequality \( \cos x \leq x \) and \( \alpha \) value range: 0 < \( \alpha < 1 \) can be obtained

ii) For \( B(\omega) \)

\[
B(\lambda) = \left( e^{\frac{\iota \alpha t}{1 + \mu \lambda^2}} - e^{-\iota \alpha t} \right) \cdot e^{-\iota \alpha \mu \lambda^2}
\]

(6)

I'm going to put \( \theta = \frac{\eta_2^2}{1 + \eta \lambda^4} \left( T - t \right) \cdot |\xi| \cdot \text{sign}(\lambda) \cdot \sin \frac{\alpha \pi}{2} \) in function

\[
1 - e^{-\frac{\eta_2^2}{1 + \eta \lambda^4} \left( T - t \right) \cdot |\xi| \cdot \text{sign}(\lambda) \cdot \sin \frac{\alpha \pi}{2}}
\]
And because of 

\[ |1 - e^{i\theta/2}| = |1 - (\cos \theta - i \sin \theta)| \]

\[ = \sqrt{2 \cdot 2 \sin^2 \frac{\theta}{2}} = 2 \cdot |\sin \frac{\theta}{2}| \leq 2 \cdot \frac{|\theta|}{2} = |\theta| \]  

(7)

Note that the reduction of \( \eta \lambda^2 \) preserves the regularized parameter \( \eta \),

So \( B(\lambda) \leq e^{-\eta \lambda^2 (T-t) \cdot |\lambda|^\alpha} \).

Let \( r = |\lambda|^\alpha \), \( x = t \cdot \cos \frac{\alpha \pi}{2} \) in function \( e^{-\eta \lambda^2 (T-t) \cdot |\lambda|^\alpha} \), then

\[ e^{-\eta \lambda^2 (T-t) \cdot |\lambda|^\alpha} \cdot 2T \cdot \eta |\lambda|^{\alpha+2} = e^{-rx} \cdot 2T \mu s^{\alpha+2} \]  

from lemma 2:

\[ s^y \cdot e^{-rx} \leq \left( \frac{\gamma}{ex} \right)^y, (r \geq 0, x \geq 0, \gamma > 0) \]  

(9)

\[ e^{-\eta \lambda^2 (T-t) \cdot |\lambda|^\alpha} \cdot 2T \cdot \eta |\lambda|^{\alpha+2} = e^{-rx} \cdot 2T \mu s^{\alpha+2} \leq 2T \eta \cdot \frac{\alpha + 2}{\alpha} \] 

(10)

So

\[ B(\lambda) \leq 2T \eta \cdot \left( \frac{1 + \frac{\alpha}{2}}{et \cdot \cos \frac{\alpha \pi}{2}} \right)^{\frac{\alpha}{2}} = 2T \eta \cdot C \]  

(11)
After $C = \left( \frac{1+\frac{a}{e \cdot \cos(\frac{\pi}{2})}}{\frac{1+a}{2}} \right)$ gets the estimation of $A(\lambda)$ and $B(\lambda)$, it comes back to the convergence estimation of the regular solution and the exact solution. So

$$\left\| v(x,t) - u(x,t) \right\| \leq \sup_{\lambda \in \mathbb{R}} A(\lambda) \cdot \delta + \sup_{\lambda \in \mathbb{R}} B(\lambda) \cdot E$$

$$\leq \max \left\{ e^{T-t} \cdot \frac{T-t}{\eta}, e^{T} \cdot \eta \right\} \cdot \delta + 2T\eta \cdot C \cdot E$$

(12)

Select the regularization parameter $\eta = \frac{T}{\ln \varphi}$, so

$$\left\| v(x,t) - u(x,t) \right\| \leq \max \left\{ e^{T-t} \cdot \varphi, e^{T} \cdot \varphi \right\} + 2T^2 CE \cdot \frac{1}{\ln \varphi}$$

(13)

So we see that when $\varphi \to 0$ is $\left\| v(x,t) - u(x,t) \right\| \to 0$. The theorem is proved, and the regular solution converges to the exact answer.

3 Experimental verification

Based on the original GEM model, the initial index is determined after literature research and expert interview [11]. Then, through the "Delphi" method, experts are invited to screen the sports complex's competitiveness index system based on the sports complex's characteristics to reflect the sports complex's competitiveness and finally determine the final index. The mean value and coefficient of variation were used to measure the degree of concentration and coordination of expert opinions [12]. Through two rounds of expert consultation, the results show that the experts have a high degree of recognition of the structural division of the index system and think that the index setting is reasonable [13]. Generally speaking, in the first and second rounds of expert consultation, the degree of concentration and coordination of the expert's opinions on the first and second indexes reached $M_i > 4.0$ and $V_i < 0.2$, respectively [14]. It can be concluded that experts have a high degree of recognition for the first and second indexes (Table 1).
Table 1. Primary and secondary index analysis parameters

<table>
<thead>
<tr>
<th>First and second-level indicators</th>
<th>Mean value (Mi)</th>
<th>Standard deviation (Si)</th>
<th>Coefficient of variation (Vi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic (Level 1 indicator)</td>
<td>4.958</td>
<td>0.639</td>
<td>0.126</td>
</tr>
<tr>
<td>Enterprise (first level indicator)</td>
<td>5.042</td>
<td>0.578</td>
<td>0.117</td>
</tr>
<tr>
<td>Market (first level indicator)</td>
<td>4.844</td>
<td>0.784</td>
<td>0.157</td>
</tr>
<tr>
<td>Resources (secondary indicators)</td>
<td>4.781</td>
<td>0.751</td>
<td>0.156</td>
</tr>
<tr>
<td>Facilities (Level 2 indicators)</td>
<td>4.958</td>
<td>0.716</td>
<td>0.141</td>
</tr>
<tr>
<td>Suppliers and ancillary Industries (Level 2 Index)</td>
<td>4.760</td>
<td>0.764</td>
<td>0.159</td>
</tr>
<tr>
<td>Corporate Structure, Strategy and Competition (secondary indicators)</td>
<td>4.740</td>
<td>0.662</td>
<td>0.143</td>
</tr>
<tr>
<td>Local Market (secondary indicator)</td>
<td>4.802</td>
<td>0.763</td>
<td>0.158</td>
</tr>
<tr>
<td>External Market (secondary indicator)</td>
<td>5.010</td>
<td>0.819</td>
<td>0.164</td>
</tr>
</tbody>
</table>

According to the evaluation results of the experts, they have a high degree of agreement on setting the three first-level indicators of the competitiveness of the sports complex, namely, the foundation, the enterprise and the market [15]. After selecting experts, the competitiveness evaluation index system of the sports complex, composed of 3 first-level indicators, 6 second-level indicators and 30 third-level indicators, was finally determined (Table 2).
Table 2. Index system and weight of competitiveness evaluation of sports complex

<table>
<thead>
<tr>
<th>First-level index and weight coefficient</th>
<th>Secondary index and weight coefficient</th>
<th>Three-level index and weight coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base (0.617)</td>
<td>A Resource (0.381)</td>
<td>A1 Geographical Location (0.573)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A2 Capital strength (0.213)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A3 Unique Sports products (0.157)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A4 Labor Force Level (0.057)</td>
</tr>
<tr>
<td></td>
<td>B Facilities (0.236)</td>
<td>B1 Traffic Facilities (0.461)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B2 Network Environment (0.174)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B3 Special Sports Facilities (0.161)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B4 Supporting Facilities (0.098)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B5 Policy Support (0.070)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B6 Industry Association assistance level (0.036)</td>
</tr>
<tr>
<td></td>
<td>Enterprise (0.274)</td>
<td>C Suppliers and related ancillary industries (0.167)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C1 number and level of suppliers (0.521)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2 supplier product price (0.292)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3 Number of R&amp;D institutions (0.187)</td>
</tr>
<tr>
<td></td>
<td>D Corporate structure, Strategy and competition (0.107)</td>
<td>D1 number of similar enterprises (0.408)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D2 Similar enterprise size (0.267)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D3 Benefits of similar Enterprises (0.175)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D4 Professional Degree in Enterprise Management (0.091)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D5 Property Rights Structure (0.059)</td>
</tr>
<tr>
<td></td>
<td>The Market (0.109)</td>
<td>E Local Market (0.069)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E1 market size (0.413)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E2 market share (0.241)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E3 Growth and Outlook (0.145)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E4 Product Standard and Quality Assessment (0.084)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E5 Customer Recognition (0.073)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E6 Customer Loyalty (0.043)</td>
</tr>
<tr>
<td></td>
<td>F External market (0.040)</td>
<td>F1 geographical distance (0.337)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2 Geographical Accessibility (0.270)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F3 External market size and growth rate (0.166)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F4 External Customer Cognition (0.124)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F5 External market popularity and reputation (0.067)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F6 Barriers to access to external markets (0.035)</td>
</tr>
</tbody>
</table>

4 Conclusion

This paper establishes a scientific training model of sports tourism based on a nonlinear differential equation. Then this paper constructs the data model of sports tourism information based on extensive data analysis. This will lay the foundation for further research of sports tourism information systems based on big data. The purpose of the index construction of this study is to find out the overall gap and deficiency in the development of sports tourism projects through horizontal and vertical comparison to help improve the influence level of sports tourism projects. The validity of the measurement in this study remains to be further tested in subsequent studies.
References


