An evaluation model of sustainable development of sports tourism industry based on matter-element theory

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Abstract

The sustainable development of sports tourism industry is concerned with many factors. Its evaluation is a complex system engineering. This paper studies the complexity and diversity of factors that influence the sustainable development of sports tourism industry and proposes an evaluation model of sustainable development based on matter-element theory. An indicator system is put in place. Evaluation indicators of classical field matter-elements model, section domain matter-element model and evaluation objects matter-element model are constructed based on matter-element theory. Different methods of calculating extension degree are adopted according to characteristics of the evaluation objects matter-element model to calculate the comprehensive extension degree between evaluation objects matter-element model and classical field matter-elements model. This extension degree refers to the layer of sustainable development capability of evaluation objects. It will provide strategic support for the development of sports tourism industry. Case study has proved that the model and the algorithm are effective.

Keywords: sports tourism industry; sustainable development; matter-element theory; extension degree; evaluation model

1 Introduction

With social and economic development, people have a higher requirement on life quality and their lifestyles become diversified. While enjoying a wealthy life, they are paying more attention to their health. Sports tourism industry is an emerging tourism industry. On one hand, it brings spiritual experience to tourism. On the other, it integrates sports into tourism to reach the purpose of health cultivation. Sports tourism industry is expected to have a bright future [1-4].

Limited by regions and populations, sports tourism industry needs long-term, sustainable and rapid development. And it is significant to evaluate the industry’s ability to achieve sustainable development [5-8]. However, such evaluation is complicated given that many factors have to be taken into account. Some factors can be quantified and clear while others are fuzzy and require qualitative descriptions.

Thus, this paper draws merits from previous researches and proposes an evaluation model of the sustainable development of sports tourism industry based on matter-element theory [9-14]. Then the grade of the ability to achieve sustainable development is acquired. Case study proves that the model and the algorithm are feasible and effective.

2 Indicator system of Sustainable development of sports tourism evaluation

Generally speaking, the boom of the sports tourism industry has much to do with geographical locations. Though it is one of the shining points of this industry, destruction on environment may also bear its own consequences. Therefore, many factors should be taken into consideration to evaluate the ability to achieve sustainable development of sports tourism industry. Scientific, objective and effective indicators are selected tailored to real situation. Service-oriented purpose should also be emphasized to select comprehensive, key and feasible indicators.

Therefore, this paper analyzes common indicators from five perspectives, namely, social factors, economic factors, environmental factors, sports factors and tourism factors and constructs a scientific and effective indicator system of sustainable development of sports tourism evaluation, as is shown in Table 1.

Table 1 Indicator system of Sustainable development of sports tourism evaluation

<table>
<thead>
<tr>
<th>Target layer</th>
<th>Criterion layer</th>
<th>Indicator layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator system of Sustainable development of sports tourism evaluation A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>social factors A₁</td>
<td></td>
<td></td>
</tr>
<tr>
<td>upgrading of regional social force a₁₁</td>
<td></td>
<td></td>
</tr>
<tr>
<td>government support a₁₂</td>
<td></td>
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</tr>
<tr>
<td>tourist satisfaction a₁₃</td>
<td></td>
<td></td>
</tr>
<tr>
<td>public support a₁₄</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sustainable development of related industries a₁₅</td>
<td></td>
<td></td>
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<tr>
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<td></td>
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<td>investment returns a₂₂</td>
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</tr>
<tr>
<td>market growth a₂₃</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sustainable industry scale a₂₄</td>
<td></td>
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</tr>
</tbody>
</table>

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3 Evaluation model of Sustainable development of sports tourism based on matter-element theory

3.1 MATTER-ELEMENT THEORY
As one of the pillars of Extenics, matter-element theory has a promising future. The analysis is based on matter-element design or object analysis and adopts extension qualitative and quantitative analysis with matter-element as the logic cell. A comprehensive use of extension mathematics, extension transformation and extension logic is adopted to address the problems as a part of the extension engineering.

Matter-element, as one of the logic cells of Extenics, describes the design objects by constructing a sequence groups with three elements \( R = (N, C, V) \). \( N \) refers to the name of the design object. \( C \) refers to matter-element characteristics of the design object and \( V \) refers to the value of a quantity of the design object \( N \) about matter-element characteristic \( C \). If the design object has only one characteristic, then \( R = (N, C, V) \) is the matter-element extension model with one dimension, which is called the basic element; In particular, if the object has multiple characteristics, \( R = (N, C, V) \) is the matter-element extension model with multiple dimensions. At this moment,

\[
C = (c_1, \cdots, c_i, \cdots, c_n)^T,
\]

\[
V = (v_1, \cdots, v_i, \cdots, v_n)^T,
\]

\( n \) refers to the number of dimensions of \( R = (N, C, V) \). Extension distance can be used to measure the extension correlation degree between matter-element models or matter-element characteristics. Suppose the matter-element characteristics of the reference object is \( X = [x_1, x_2] \), that of the target object is \( V \), then the extension distance \( \rho \) between the two is:

\[
\rho = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (v_i - x_i)^2}.
\]

3.2 CONSTRUCTING THE MATTER-ELEMENT MODEL OF THE SUSTAINABLE DEVELOPMENT OF SPORTS TOURISM INDUSTRY

Definition 1 Matter-element in classic field for sustainable development evaluation the sustainable development of the sports tourism industry is in different states or has different evaluation grade. Every state or grade corresponds to a characteristic value of the matter-element model.

Thus, suppose there are \( n \) characteristics \( c_1, c_2, \cdots, c_n \) and their corresponding values of a quantity are \( v_1, v_2, \cdots, v_n \). Construct the evaluation matter-element model \( R_n^C(i) \), which is the matter-element in classic field for sustainable development evaluation.

\[
R_n^C = \begin{bmatrix}
N_c & c_1 & v_1(i) \\
& c_2 & v_2(i) \\
& \vdots & \vdots \\
& c_n & v_n(i)
\end{bmatrix}
\begin{bmatrix}
N_c & c_1 & [v_1^l(i), v_1^r(i)] \\
& c_2 & [v_2^l(i), v_2^r(i)] \\
& \vdots & \vdots \\
& c_n & [v_n^l(i), v_n^r(i)]
\end{bmatrix}.
\]

(2)

Definition 2 Matter-element in section field for sustainable development evaluation Section field is defined as the collection of the development state or evaluation grade of sustainable development of the sports tourism industry.
\[ R^O_n = \begin{bmatrix} N_O & c_1 & v_1 \\ c_2 & v_2 \\ \vdots \\ c_n & v_n \end{bmatrix} = \begin{bmatrix} N_O & c_1 & v^L_{O1}, v^R_{O1} \\ c_2 & v^L_{O2}, v^R_{O2} \\ \vdots \\ c_n & v^L_{On}, v^R_{On} \end{bmatrix}. \]  

(3)

Where, \( v^L_{Oj} = \min_{1 \leq i \leq m} \left( v^L_j (i) \right) \), \( v^R_{Oj} = \max_{1 \leq i \leq m} \left( v^R_j (i) \right) \). \( m \) refers to the number of development state or evaluation grade of sustainable development of sports tourism industry.

### 3.2.1 EXTENSION degree evaluation model of sustainable development of sports tourism industry

Suppose the matter-element model for evaluation is \( R_d \):

\[ R_d = \begin{bmatrix} N_d & c_{d1} & v^L_{d1} \\ c_{d2} & v^L_{d2} \\ \vdots \\ c_{dn} & v^L_{dn} \end{bmatrix} = \begin{bmatrix} N_d & c_{d1} & v^L_{d1}, v^R_{d1} \\ c_{d2} & v^L_{d2}, v^R_{d2} \\ \vdots \\ c_{dn} & v^L_{dn}, v^R_{dn} \end{bmatrix}. \]  

(4)

To effectively calculate the extension degree between the matter-element model \( R_d \) and matter-element in classic field of different state or evaluation degree, this paper discusses the followings:

1. If the characteristic value of a quantity of the matter-element model for evaluating \( R_d \) is a point value for qualitative description, then the extension distance \( \rho \left( R^d_j \ | \ R^C_n (i) \right) \) between \( R_d \) and the matter-element model \( R^C_n (i) \) about characteristics \( j \) is:

\[ \rho \left( R^d_j \ | \ R^C_n (i) \right) = \left| \frac{v^L_j (i) + v^R_j (i)}{2} - v^D_j (i) \right| \left| \frac{v^L_j (i) - v^R_j (i)}{2} \right|. \]  

(5)

Similarly, the extension distance \( \rho \left( R^d_j \ | \ R^C_n (i) \right) \) between

\[ \rho \left( R^d_j \ | \ R^C_n (i) \right) = \frac{1}{2} \left( \rho \left( v^L_{d1}, v^R_{d1} \ | \ R^C_n (i) \right) + \rho \left( v^L_{d2}, v^R_{d2} \ | \ R^C_n (i) \right) \right). \]  

(7)

Substitute (1) to (7) and get:

\[ \rho \left( R^d_j \ | \ R^C_n (i) \right) = \frac{1}{2} \left( \left| v^L_{d1} - v^R_{d1} \right| + \left| v^L_{d2} - v^R_{d2} \right| \right) \left| v^D_j (i) \right| \left( v^L_j (i) + v^R_j (i) \right) + \left| v^L_j (i) - v^R_j (i) \right| \right). \]  

(8)

Similarly, the extension distance \( \rho \left( R^d_j \ | \ R^O_n (i) \right) \) between \( R_d \) and the matter-element model \( R^O_n (i) \) about characteristic \( j \) is:

\[ \rho \left( R^d_j \ | \ R^O_n (i) \right) = \frac{1}{2} \left( \rho \left( v^L_{d1}, v^R_{d1} \ | \ R^O_n (i) \right) + \rho \left( v^L_{d2}, v^R_{d2} \ | \ R^O_n (i) \right) \right). \]  

(9)

Substitute (1) to (7) and get:

\[ \rho \left( R^d_j \ | \ R^O_n (i) \right) = \frac{1}{2} \left( \left| v^L_{d1} - v^R_{d1} \right| + \left| v^L_{d2} - v^R_{d2} \right| \right) \left| v^O_j (i) \right| \left( v^L_j (i) + v^R_j (i) \right) + \left| v^L_j (i) - v^R_j (i) \right| \right). \]  

(10)
(3) If the characteristic value of a quantity of the matter-element model for evaluation $R_d$ is a fuzzy interval value of quantity and if the optimal value of a quantity of the matter-element in classic field is

$$v^j_i(i) \in \left[ v^L_j(i), v^R_j(i) \right],$$

the extension distance $\rho(R^j_d | R^c_n(i))$ between $R_d$ and the matter-element model $R^c_n(i)$ about characteristic $j$ is:

$$\rho(R^j_d | R^c_n(i)) = \frac{1}{2} \left( \rho(v^j_d | R^c_n(i)) + \rho(v^j_d | R^c_n(i)) \right)$$

$$\rho(v^j_d | R^c_n(i)) = v^L_j(i) - v^s_d$$

$$v^s_d \leq v^0_j(i)$$

$$\rho(v^j_d | R^c_n(i)) = v^R_j(i) - v^s_d$$

$$v^s_d \geq v^0_j(i).$$

$$\rho(v^j_d | R^c_n(i)) = (v^R_j(i) - v^L_j(i))(v^s_d - v^s_d)/(v^L_j(i) - v^0_j(i))$$

$$v^s_d \in (v^0_j(i), v^0_j(i)).$$

If the optimal value of a quantity of matter-element in classic field is $v^0_j(i) \in \left[ v^L_j(i), v^R_j(i), v^R_j(i) \right]$, the extension distance $\rho(R^j_d | R^c_n(i))$ between $R_d$ and the matter-element model $R^c_n(i)$ about characteristic $j$ is:

$$\rho(R^j_d | R^c_n(i)) = \frac{1}{2} \left( \rho(v^j_d | R^c_n(i)) + \rho(v^j_d | R^c_n(i)) \right)$$

$$\rho(v^j_d | R^c_n(i)) = v^L_j(i) - v^s_d$$

$$v^s_d \leq v^0_j(i)$$

$$\rho(v^j_d | R^c_n(i)) = v^R_j(i) - v^s_d$$

$$v^s_d \geq v^0_j(i).$$

$$\rho(v^j_d | R^c_n(i)) = (v^R_j(i) - v^L_j(i))(v^s_d - v^s_d)/(v^L_j(i) - v^0_j(i))$$

$$v^s_d \in (v^0_j(i), v^0_j(i)).$$

Similarly, the extension distance $\rho(R^j_d | R^o_n(i))$ between $R_d$ and the matter-element model $R^o_n(i)$ about characteristics $j$ has two forms. If there is $v^0_j(i) \in \left[ v^L_j(i), v^L_j(i), v^R_j(i) \right], then:

$$\rho(R^j_d | R^o_n(i)) = \frac{1}{2} \left( \rho(v^j_d | R^o_n(i)) + \rho(v^j_d | R^o_n(i)) \right)$$

$$\rho(v^j_d | R^o_n(i)) = v^L_j(i) - v^s_d$$

$$v^s_d \leq v^0_j(i)$$

$$\rho(v^j_d | R^o_n(i)) = v^R_j(i) - v^s_d$$

$$v^s_d \geq v^0_j(i).$$

$$\rho(v^j_d | R^o_n(i)) = (v^R_j(i) - v^L_j(i))(v^s_d - v^s_d)/(v^L_j(i) - v^0_j(i))$$

$$v^s_d \in (v^0_j(i), v^0_j(i)).$$

If there is $v^0_j(i) \in \left[ v^L_j(i), v^L_j(i), v^R_j(i) \right], then:

$$\rho(R^j_d | R^o_n(i)) = \frac{1}{2} \left( \rho(v^j_d | R^o_n(i)) + \rho(v^j_d | R^o_n(i)) \right)$$

$$\rho(v^j_d | R^o_n(i)) = v^L_j(i) - v^s_d$$

$$v^s_d \leq v^0_j(i)$$

$$\rho(v^j_d | R^o_n(i)) = v^R_j(i) - v^s_d$$

$$v^s_d \geq v^0_j(i).$$

$$\rho(v^j_d | R^o_n(i)) = (v^R_j(i) - v^L_j(i))(v^s_d - v^s_d)/(v^L_j(i) - v^0_j(i))$$

$$v^s_d \in (v^0_j(i), v^0_j(i)).$$
Thus, we can get the extension degree $K(R_i | R_n(C) (i))$ between $R_i$ and the matter-element model $R_n(C) (i)$ about characteristics $j$:

$$K(R_i | R_n(C) (i)) = \begin{cases} \frac{\rho(R_i | R_n(C) (i))}{|v_j(i)|} & \text{if } v^L_j(i), v^R_j(i) \in [v^L_j(i), v^R_j(i)] \\ \frac{\rho(R_i | R_n(C) (i))}{\rho(R_i | R_n(C) (i)) - \rho(R_i | R_n(C) (i))} & \text{if } v^L_j(i), v^R_j(i) \notin [v^L_j(i), v^R_j(i)] \end{cases}.$$  \hspace{1cm} (15)

If weight of the matter-element characteristic is considered, the weighted extension degree $\phi(R_i | R_n(C) (i))$ is:

$$\phi(R_i | R_n(C) (i)) = \sum_{j=1}^{n} (w_j \ast K(R_i | R_n(C) (i))).$$  \hspace{1cm} (16)

 Normalize the weighted extension degree $\phi(R_i | R_n(C) (i))$ and get:

$$\bar{\phi}(R_i | R_n(C) (i)) = \frac{\phi(R_i | R_n(C) (i)) - \min_{1 \leq i \leq m} \phi(R_i | R_n(C) (i))}{\max_{1 \leq i \leq m} \phi(R_i | R_n(C) (i)) - \min_{1 \leq i \leq m} \phi(R_i | R_n(C) (i))}.$$  \hspace{1cm} (17)

If there is

$$\bar{\phi}(R_i | R_n(C) (k)) = \max \left( \bar{\phi}(R_i | R_n(C) (1)), \bar{\phi}(R_i | R_n(C) (2)), \ldots, \bar{\phi}(R_i | R_n(C) (m)) \right).$$  \hspace{1cm} (18)

Then it indicates that the evaluation grade of sustainable development of sports tourism industry is of grade $k$.

4 Case study and test

This paper intends to combine forest areas’ geographical features and regional advantage to do the analysis of the sustainable development assessment of sports tourism industry. And based on the above to do the verification and instructions for models and algorithms. The forest yard, their geographic environment is superior, the river in the forest area of diverse, both gentle rapids of the river there are rapids, relatively abundant rainfall in summer, while winter snow sources are abundant, therefore, based on the existing strengths suited to carry out forest skiing and rafting sports tourism projects. To this end, by seeking expert advice on the basis of the forest to carry out skiing, rafting and other sports tourism industry sustainability assessment into force excellent, good, fair, poor four levels, namely the force corresponding to the four sustainability assessment Classic domain matter element, the specific results is as shown in Table 2.

**TABLE 2** Analysis on evaluation of sustainable development of forest sports tourism industry

<table>
<thead>
<tr>
<th>Indicator layer</th>
<th>Characteristics value of quantity of matter-element</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classic field I</td>
</tr>
<tr>
<td>upgrading of regional social force $a_{11}$</td>
<td>0-0.20</td>
</tr>
<tr>
<td>government support $a_{12}$</td>
<td>0-0.20</td>
</tr>
<tr>
<td>tourist satisfaction $a_{13}$</td>
<td>0-0.20</td>
</tr>
<tr>
<td>public support $a_{14}$</td>
<td>0-0.20</td>
</tr>
<tr>
<td>sustainable development of related industries $a_{15}$</td>
<td>0-0.20</td>
</tr>
<tr>
<td>input cost $a_{21}$</td>
<td>80-100</td>
</tr>
<tr>
<td>investment returns $a_{22}$</td>
<td>0-0.10</td>
</tr>
<tr>
<td>market growth $a_{23}$</td>
<td>0-0.10</td>
</tr>
<tr>
<td>sustainable industry scale $a_{24}$</td>
<td>0-20</td>
</tr>
<tr>
<td>ecological environment protection $a_{31}$</td>
<td>0-0.60</td>
</tr>
</tbody>
</table>
According to the proposed model and algorithm, we can get the extension distance and extension degree of forest sports tourism, such as skiing, rafting, as are shown in Table 3 and Table 4.

### Table 3

<table>
<thead>
<tr>
<th>Indicator layer</th>
<th>Classic field I</th>
<th>Classic field II</th>
<th>Classic field III</th>
<th>Classic field IV</th>
<th>Section field</th>
</tr>
</thead>
<tbody>
<tr>
<td>upgrading of regional social force $a_{11}$</td>
<td>0.30</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.20</td>
<td>-0.50</td>
</tr>
<tr>
<td>government support $a_{12}$</td>
<td>0.40</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.20</td>
<td>-0.40</td>
</tr>
<tr>
<td>tourist satisfaction $a_{13}$</td>
<td>0.55</td>
<td>0.25</td>
<td>-0.015</td>
<td>0.05</td>
<td>-0.25</td>
</tr>
<tr>
<td>public support $a_{14}$</td>
<td>0.45</td>
<td>0.15</td>
<td>-0.10</td>
<td>0.15</td>
<td>-0.35</td>
</tr>
<tr>
<td>sustainable development of related industries $a_{15}$</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.30</td>
<td>-0.30</td>
</tr>
<tr>
<td>input cost $a_{21}$</td>
<td>0.10</td>
<td>20</td>
<td>0</td>
<td>0.30</td>
<td>-0.30</td>
</tr>
<tr>
<td>investment returns $a_{22}$</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>market growth $a_{23}$</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.40</td>
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<td>20</td>
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<td>0</td>
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<td>-0.40</td>
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<tr>
<td>ecological environment protection $a_{31}$</td>
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<td>0</td>
<td>0.10</td>
<td>-0.20</td>
</tr>
<tr>
<td>influence on residents $a_{32}$</td>
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<td>0.15</td>
<td>-0.10</td>
<td>0.15</td>
<td>-0.45</td>
</tr>
<tr>
<td>sustainable environment protection efforts $a_{33}$</td>
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<td>0</td>
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<td>-0.20</td>
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<tr>
<td>green life $a_{41}$</td>
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<td>0.10</td>
<td>-0.10</td>
<td>-0.30</td>
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<tr>
<td>sports event brand $a_{42}$</td>
<td>0.60</td>
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<td>0.20</td>
<td>-0.20</td>
<td>-0.20</td>
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<td>sports event appeal $a_{43}$</td>
<td>0.40</td>
<td>0.20</td>
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<td>-0.40</td>
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<tr>
<td>sports event competitiveness $a_{44}$</td>
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<td>0.20</td>
<td>0</td>
<td>0</td>
<td>-0.40</td>
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<tr>
<td>low-carbon tourism $a_{51}$</td>
<td>0.70</td>
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<td>0.20</td>
<td>-0.20</td>
<td>-0.20</td>
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<tr>
<td>tourism event brand $a_{52}$</td>
<td>0.20</td>
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<td>0</td>
<td>0.20</td>
<td>-0.40</td>
</tr>
<tr>
<td>tourism event appeal $a_{53}$</td>
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<td>0.20</td>
<td>0</td>
<td>0</td>
<td>-0.40</td>
</tr>
<tr>
<td>tourism event competitiveness $a_{54}$</td>
<td>0.40</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
<td>-0.40</td>
</tr>
</tbody>
</table>

### Table 4

Extension degree of sustainable development of forest sports tourism industry
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- **Publications:** 4 papers