Research Article

Novel Deng’s Grey Development Relation Model Based on Information Difference and Its Application in Sanatorium Performance Evaluation

Jinxin Huang,1 Yaoguo Dang,1 Junjie Wang,1 and Qingyuan Xue1,2,3

1College of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing 211100, China
2School of Health Management, Inner Mongolia Medical University, Hohhot 010110, China
3Research Institute for Health Policy, Inner Mongolia, Hohhot 010110, China

Correspondence should be addressed to Qingyuan Xue; 4218423@qq.com

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In view of the varying amounts of information and the difference in information value in sanatorium performance evaluation, Deng’s development relation model based on information difference is proposed herein. Firstly, the definition of panel data on sanatorium performance evaluation and the construction criteria of its optimal vector are given. Simultaneously, the indicators are standardized. In order to objectively highlight the difference of effective information among indicators, the entropy weight method is introduced to determine the weight of performance evaluation indicators in sanatoriums on the basis of traditional Deng’s correlation model avoiding the limitation of subjective effects. Furthermore, the weight of the temporal index is employed to determine the weight of performance evaluation results in different years, based on the new information priority, to dynamically evaluate the development trend of annual sanatorium performance. Finally, the performances of TS, YZ, and XZ sanatoriums are dynamically evaluated by using the proposed new grey relational model. Combined with the weight of time index, the 5-year comprehensive performance value is given. It is found that the performance level of TS sanatorium is the highest followed by YZ sanatorium and XZ sanatorium, which verifies the practicability and effectiveness of the model.

1. Introduction

Performance evaluation is defined as evaluators using scientific evaluation methods to assess performance according to predetermined standards to help improve the operational efficiency of the evaluated objects. It is a formal structured system used to measure and evaluate the attributes, behaviors, and results of objects related to work [1]. Performance evaluation is generally considered to have a positive impact on the performance of the evaluated objects. However, evaluation may also have a negative impact on motivation and role cognition when the design and management are imperfect [2].

Sanatoriums are set up in specific areas suitable for convalescence based on the use of convalescent factors. They provide individuals with such services as physical enhancement, health restoration, rehabilitation, and recuperation. Sanatoriums in China can be divided into two categories: comprehensive sanatoriums and specialized sanatoriums. With the continuous improvement of living standards over the years, people’s need for treatment and recuperation services has gradually increased. On the one hand, a variety of for-profit organizations providing rehabilitation services have sprung up on a large scale. On the other hand, people’s demand for quality treatment and recuperation services is also increasing. This requires sanatoriums to constantly improve the quality of service and enhance the economic and social benefits. Therefore, it is particularly important to carry out the performance evaluation of sanatoriums.

Performance evaluation of sanatoriums is closely related to their characteristics. Sanatorium business involves a wide
range of aspects, including health recuperation, rehabilitation physiotherapy, physical examination, and business reception. Different sanatoriums have different primary and secondary businesses, depending on their nature and location. The performance evaluation of sanatoriums in China is a relatively late phenomenon. From the perspective of evaluation, it is mainly the periodic assessment by the superior management department or unit and the self-assessment by the sanatoriums. In terms of evaluation cycle, it mainly includes annual evaluation and daily evaluation. From the perspective of evaluation methods, it greatly adopts the combination of expert marking and progress evaluation. However, the results of self-evaluation often significantly differ from those of the manager performance evaluation [3]. This top-down, staged performance evaluation method is too subjective, lacking objectivity. Consequently, it is extremely necessary to make the performance evaluation through more scientific evaluation theories and methods.

Sanatoriums have existed and operated for many years, but there is little discussion in academic literature on their performance evaluation. At present, performance evaluation methods are mainly divided into three categories: qualitative, quantitative, and the combination of the two. Cundric et al. [4] proposed a DEX-based multiatribute decision expert system framework, which is particularly suitable for qualitative decision evaluation problems involving qualitative concepts and a large number of expert judgments. For heterogeneous information in the evaluation system, Espinilla et al. [5] constructed a 360-degree comprehensive performance evaluation model that can effectively process heterogeneous information.

Nikpeyma et al. [6] conducted a qualitative survey on clinical nurses in a large teaching hospital in Tehran, analyzed the data through the framework analysis method, and summarized the four major problems existing in the performance appraisal system of clinical nurses in terms of contextual problems, performance appraisal structure, performance appraisal process, and performance appraisal results. The representative quantitative methods include the analytic hierarchy process (AHP) and balanced scorecard (BSC). Kaplan and Norton [7] first proposed the performance evaluation system framework of balanced scorecard (BSC), which comprehensively evaluates the performance from four aspects: finance, customer evaluation, internal process feedback, and learning and growth, thus overcoming the defects brought by single financial evaluation. Shaout and Al-shammari [8] proposed two kinds of personnel performance evaluation models, which employ fuzzy processing of their variables and applied the fuzzy set theory to the personnel performance evaluation system. Don et al. [9] developed a new network DEA model for three-stage performance evaluation of American fund managers. Cook et al. [10] extended data envelopment analysis (DEA) to the performance evaluation of the compensation performance incentive plan and incorporated the incentive remuneration into the benchmark model of target information. Based on the four aspects of BSC, Kuo and Chen [11] used the fuzzy Delphi method to construct the key performance evaluation index system of service industry liquidity, which can provide references for the service industry to establish applicable performance evaluation indexes according to the characteristics of each industry after the introduction of liquidity. Ma et al. [12] used Fuzzy Delphi and Grey Delphi to quantify the attitudes of regional road safety, urban road safety, and highway safety and obtained the final safety performance evaluation results through the nexus of the results of the two methods.

These methods enriched the theoretic evaluating system. However, due to the insufficient attention paid to performance evaluation of sanatoriums in China, the statistics show the feature of less effective data and incomplete information. Besides, it is difficult for conventional evaluation methods to solve the multifactor and multilevel dynamic uncertainty problems involved in the complex system evaluation [13]. Grey system theory shows superior performance in modeling the uncertain system [14, 15]. In comparison with the conventional methods, the grey comprehensive evaluation method possesses a clear superiority of accessing the scarce information systems. In virtue of the outstanding performance of the grey comprehensive evaluation method, Yang et al. [16] constructed an improved grey incidence approach to evaluate the planning schemes of distributed energy supply systems. Based on a novel grey periodic relational model, Yin et al. [17] evaluated the relevance of marine and land economy. Through an improved grey dynamic trend incidence model, Jin et al. [18] dynamically analyzed factors connected to smog weather. These research studies indicate that the grey comprehensive evaluation method is a simple and practical tool. Thus, it is necessary to adopt the grey comprehensive evaluation method to make the performance appraisal of sanatoriums.

Grey correlation analysis is the basis of grey evaluation. Grey relational models can be divided into three categories. The main idea of the first category of model is to calculate the point correlation coefficient of the two sequences point by point and take the average value of each point correlation coefficient as the correlation degree, such as Deng’s correlation degree [19], slope correlation degree [20], and t-type correlation degree [21]. The main idea of the second category of the model is based on the overall or global perspective of the sequence to measure the geometric relationships between sequence curves, such as the grey generalized relational degree [22], similar relational degree, close relational degree [23], and grey spline relational degree [24]. The main idea of the third category of the model is based on the geometric relationships of the three-dimensional spatial sequence. It is mainly used to process data of higher dimensions, such as the grey index correlation clustering model [25] and the new grey index correlation model of panel data [26].

There are two shortcomings in these grey relational models. The first drawback is that the analysis results of the existing grey relational models cannot dynamically reflect the relationship between the development trends of the two sequences. Secondly, the model is limited to the equal weight processing of time and objects and cannot effectively reflect the difference in importance between different information.
According to their different main business and development stages, the performance evaluation of sanatoriums requires a grey comprehensive evaluation method which can effectively represent different time and index weights and reveal the dynamic development of sanatoriums.

Based on the characteristics of sanatoriums in China, this paper utilizes the entropy weight method to determine the weight of the sample index. Considering the structural difference of index data of different objects of sanatoriums, this paper applies the entropy weight method to determine the weight of the sample index. On the basis of new information priority, time weight is introduced to construct the weight of the sample index. Considering the structural differences in the nature of indicators, and differences in positive and negative data. In order to improve the operability, comparability, and reliability of performance evaluation, the following differential standardization is proposed.

**Definition 1.** Assuming that there are \( i (i = 1, 2, \ldots, m) \) indicators, \( s (s = 1, 2, \ldots, N) \) objects, and \( k (k = 1, 2, \ldots, n) \) continuous observation time points in the system, then \( y_s(i, k) \) is called the observation value of the \( i \) indicator at time \( k \). Then, \( Y_s(i) = (y_s(i, 1), y_s(i, 2), \ldots, y_s(i, n)) \), \( Y_s(k) = (y_s(1, k), y_s(2, k), \ldots, y_s(m, k)) \) is called the section data of the \( s \) object.

In the performance evaluation of sanatoriums, there are different orders of magnitude between indicators, differences in the nature of indicators, and differences in positive and negative data. In order to improve the operability, comparability, and reliability of performance evaluation, the following differential standardization is proposed.

**Definition 2.** Let the panel data be \( Y = \{Y_1(i, k), \ldots, Y_s(i, k), \ldots, Y_N(i, k)\} \). \( Y_s(i, k) \) is the cross-sectional data of the object \( s \). If the indicator \( i \) is a beneficial indicator for the object, the standardized result of \( y_s(i, k) \) is as follows:

\[
x_s(i, k) = \begin{cases} 
\frac{\max_{k} \left[ y_s(i, k) \right] - \min_{k} \left[ y_s(i, k) \right]}{2}, & y_s(i, k) < q, \\
1 - \frac{q - y_s(i, k)}{\max_{k} \left[ y_s(i, k) \right] - \min_{k} \left[ y_s(i, k) \right]}, & y_s(i, k) = q,
\end{cases}
\]

If the indicator \( i \) is a cost-type indicator for the object, the standardized result of \( y_s(i, k) \) is given as follows:

\[
x_s(i, k) = \begin{cases} 
1 - \frac{q - \min_{k} \left[ y_s(i, k) \right]}{\max_{k} \left[ y_s(i, k) \right] - q}, & y_s(i, k) < q, \\
\frac{y_s(i, k) - q}{\max_{k} \left[ y_s(i, k) \right] - \min_{k} \left[ y_s(i, k) \right]}, & y_s(i, k) = q,
\end{cases}
\]
X = \{X_1(i, k), \ldots, X_j(i, k), \ldots, X_N(i, k)\} is called the
standardized panel data, where

\[
X_s(i, k) = \begin{bmatrix}
x_1(1, 1) & x_1(1, 2) & \cdots & x_1(1, n) \\
x_2(1, 1) & x_2(1, 2) & \cdots & x_2(1, n) \\
\vdots & \vdots & \ddots & \vdots \\
x_j(m, 1) & x_j(m, 2) & \cdots & x_j(m, n)
\end{bmatrix}
\] (4)

In the performance evaluation comparison of sanatoria, in order to unify the comparison standard, the optimal ideal value should be selected uniformly from N objects when the comprehensive performances of different

objects are compared. If an optimal ideal set is set for each object in the same way as the section data, the comparison results among objects will be invalid. Therefore, the optimal ideal vector of panel data is defined as follows.

**Theorem 1.** Let the panel data be \( Y = \{Y_1(i, k), \ldots, Y_j(i, k), \ldots, Y_N(i, k)\} \), \( Y_s(i, k) \) is the cross-sectional data of the object \( s \). If the standardized result of the indicator \( i \) in time \( k \) is \( x_s(i, k) \), \( x_s(i, k) \in (0, 1) \).

**Proof.** (1) For the efficiency indicators:

\[
x_s(i, k) = \frac{\max_{k_s} \{y_s(i, k)\} - \min_{k_s} \{y_s(i, k)\} + y_s(i, k) - \min_{k_s} \{y_s(i, k)\}}{2 \left( \max_{k_s} \{y_s(i, k)\} - \min_{k_s} \{y_s(i, k)\} \right)}.
\] (5)

Since \( \max_{k_s} \{y_s(i, k)\} > y_s(i, k) > \min_{k_s} \{y_s(i, k)\} \),
the following equalities can be obtained:

\[
\begin{align*}
\max_{k_s} \{y_s(i, k)\} - \min_{k_s} \{y_s(i, k)\} &> 0, \\
\max_{k_s} \{y_s(i, k)\} - \min_{k_s} \{y_s(i, k)\} &> 0, \\
\max_{k_s} \{y_s(i, k)\} - \min_{k_s} \{y_s(i, k)\} &\geq y_s(i, k) - \min_{k_s} \{y_s(i, k)\} > 0.
\end{align*}
\] (6)

Meantime, the cost-type index and moderate-type index can be proved by the same logic.

**Definition 3.** \( X = \{X_1(i, k), \ldots, X_j(i, k), \ldots, X_N(i, k)\} \) is set
as panel data after system standardization. The optimal ideal value of indicator \( i \) is \( x_s^* = \max_{k_s} \{x_s(i, k)\} \). Then, \( X_s^* = (x_1^*, x_2^*, \ldots, x_m^*)^T \) is called the index optimal ideal

vector, where \( T \) is the transpose. After that, \( X_s^* = \begin{bmatrix} x_1^* \\ x_2^* \\ \vdots \\ x_m^* \end{bmatrix} \)

\[
\begin{bmatrix}
\max_{k_s} \{x_1(i, k)\} \\
\max_{k_s} \{x_2(i, k)\} \\
\vdots \\
\max_{k_s} \{x_j(i, k)\}
\end{bmatrix}
\] is available.

**Definition 4.** From Definition 3, suppose that \( X_s^* \), \( X_s^* = (x_1^*, x_2^*, \ldots, x_m^*)^T \), is the optimal ideal vector of indicator. Then,

\[
\gamma_{ik}(x_s^*, x_s(i, k)) = \frac{\mu_s + \xi U_i^*}{2 (x_s^* - x_s(i, k)) + \xi U_i^*}
\] (7)

is called the correlation coefficient of Deng’s point between the observed value \( x_s(i, k) \) of the object \( s \), index \( i \) at the

moment \( k \) and the optimal ideal value of \( x_s^* \), where \( U_i^* = \max_{k_s} \{x_s^* - x_s(i, k)\} \) and \( \mu_s = \min_{k_s} \{x_s^* - x_s(i, k)\} \).

**Definition 5.** Let \( \gamma_{ik}(x_s^*, x_s(i, k)) \) be the correlation coefficient of Deng’s point between the observed value \( x_s(i, k) \) and
the optimal ideal value of \( x_s^* \). Then, Deng’s panel correlation degree is defined as

\[
\gamma_{ik}(X_s^*, x_s(i, k)) = \sum_{i=1}^{m} \eta_i \gamma_{ik}(x_s^*, x_s(i, k)),
\] (8)

where \( \eta_i \) is the weight of the index \( i \) and \( \sum_{i=1}^{m} \eta_i = 1 \).

In view of the fact that the performance assessment of sanatoriums carried out is transient, different indicators are particularly important for the effective results of information provided by the system. In addition, structural differences of index data on different objects should be comprehensively considered. The greater the difference between the information provided by the index and other indices, the greater the contribution to system cognition. The less information the index provides, the stronger the homogeneity, which shows that the index has less effect on the system research. Since this principle coincides with the entropy weight method, the entropy weight method was selected here to determine the index weight. In Definition 2, the original data were standardized to ensure that all the standardized data are positive; the specific steps are shown as follows [16].
Step 1. The entropy of the indicator \( i \) at time \( k \) is defined as follows:

\[
H_i(k) = -p \sum_{i=1}^{N} f_s(i,k) \ln f_s(i,k), \quad i = 1, 2, \ldots, m,
\]

where \( f_s(i,k) = (x_s(i,k)) / \sum_{i=1}^{N} x_s(i,k) \), \( p = (1/\ln N) \).

Step 2. The entropy weight of the indicator \( i \) at time \( k \) is defined as

\[
\eta_i(k) = \frac{1 - H_i(k)}{m - \sum_{i=1}^{n} H_i(k)}.
\]

Step 3. The entropy weight of the \( i \)-th indicator is defined as

\[
\eta_i = \frac{1}{n} \sum_{k=1}^{n} \eta_i(k).
\]

The entropy value of the index has a characteristic of “larger means the smaller the difference of the index among the objects and the smaller the entropy weight.” The maximum entropy value is 1, while the entropy weight is 0, indicating that this index does not provide any effective information to the evaluator. According to the definition of entropy weight, \( 0 \leq \eta_i \leq 1 \) and \( \sum_{i=1}^{m} \eta_i(k) = 1 \) can be obtained. Therefore, formula (8) is called the correlation degree of Deng’s development model based on information difference.

According to Definition 5, by combining the information difference perspective, the performance of an object in different time points can be objectively evaluated. However, the shortcomings of comprehensive ordering multiple objects from the angle of development between the performance advantages and disadvantages still exist. Therefore, based on the perspective of new information priority, this paper introduces time weight and builds Deng’s relation model based on information difference. A detailed illustration is shown in Definition 5.

Definition 6. From Definition 4, the optimal ideal vector of indicator is \( X_s^* = (x_s^1, x_s^2, \ldots, x_s^m)^T \), and \( y_k(X_i^*, x_s(i,k)) \) is Deng’s correlation degree based on information difference. Then, Deng’s development relation model based on information difference is defined as

\[
y(X_s^*, X_s(i,k)) = \sum_{k=1}^{m} \lambda^{n-k+1} y_k(X_i^*, x_s(i,k)),
\]

where \( \lambda^{n-k+1} \) is the time weight of performance at time \( k \), \( \lambda \in (0, 1) \).

Theorem 2 (see [27]). Let \( X_s^* = (x_s^1, x_s^2, \ldots, x_s^m)^T \) be the optimal ideal vector of indicator and \( y(X_i^*, X_s(i,k)) = \sum_{k=1}^{m} \lambda^{n-k+1} y_k(X_i^*, x_s(i,k)) \) be the correlation degree of Deng’s development model. Suppose that \( \sum_{k=1}^{n} \lambda^{n-k+1} = 1 \), \( \lambda^1 + \lambda^2 + \cdots + \lambda^n = \sum_{k=1}^{n} \lambda^k = 1 \), then \( n = (\ln (2\lambda - 1)/\ln \lambda) - 1 \).

Proof. When \( \sum_{k=1}^{n} \lambda^{n-k+1} = 1, \lambda^1 + \lambda^2 + \cdots + \lambda^n = \sum_{k=1}^{n} \lambda^k = 1 \), from the formula for the sum of geometric sequences, \( (\lambda(1 - \lambda^n))/(1 - \lambda) = 1 \) can be obtained.

After being simplified, \( n = (\ln (2\lambda - 1)/\ln \lambda) - 1 \).

It is worth noting that \( n = (\ln (2\lambda - 1)/\ln \lambda) - 1 \) should be meaningful under the condition of \( 0.5 < \lambda < 1 \).

3. Case Analysis

3.1. Establishment of Appraisal Indices. In this team’s study, the appraisal index system was determined by three main steps. Firstly, the authors of this paper form the initial appraisal index system by considering the nature of sanatorium in terms of public welfare and basic recuperation business. Then, we surveyed the current systems and methods of sanatorium evaluation. Finally, we refined the appraisal index system through discussions with industrial experts and academic experts. Consequently, the performance evaluation index of the sanatorium system is determined. It includes five aspects: financial index, industry index, social benefit index, internal management index, and satisfaction index.

(1) Financial Index. In the selection process of financial indicators, the profit and capital operation management of the unit are taken into consideration. Indices such as total income, income and expenditure surplus, working capital turnover rate, asset preservation rate, and growth rate of employee income are chosen.

(2) Industry Index. The industry indicators include some commonly used indicators in the existing performance assessment guidelines for trade union enterprises, which reflect the hardware facilities and operational capacity of the unit.

(3) Social Benefit Index. The indicators include the number of patients receiving treatment and recuperation, the number of beds in the ward, and the utilization rate of the ward. In addition, the number of employed people is employed as the social benefit index to reflect the positive effect on the society.

(4) Internal Management Index. The internal management indicators mainly focus on the investment and attention of the directly affiliated units in human resources.

(5) Satisfaction Index. In terms of the satisfaction index, questionnaires are designed from five aspects: rehabilitation, guest room, catering, environment, and landscape treatment, respectively, for comprehensive examination.

3.2. Original Data. TS, YZ, and XZ sanatoriums are members of the Chinese sanatorium directory, which offers concentration of multifunctional conference reception services for the integration of public welfare institutions, including health recuperation, rehabilitation, medical care, and tourism. Affiliated to the all-China federation of trade unions, it has been designated as the national “labor model rehabilitation base.” They are the best and most representative sanatoriums for workers from south to north in Jiangsu.
| Sanatorium | First class index | Second class index | 2012       | 2013       | 2014       | 2015       | 2016       | 2017       |
|------------|------------------|--------------------|------------|------------|------------|------------|------------|------------|
| TS sanatorium | Financial index | Total revenue (ten thousand yuan) | 5156.47 | 3957.93 | 5108.04 | 5295.13 | 5906.72 | 5609.21 |
|            |                  | Balance of income and expenditure (ten thousand yuan) | 326.87 | –314.45 | 349.65 | 401.54 | 403.23 | –169.14 |
|            |                  | Working capital turnover (%) | 20.21 | 11.96 | 12.27 | 10.52 | 11.32 | 10.71 |
|            |                  | Value preservation and appreciation rate of assets (%) | 174.79 | 103.95 | 146.84 | 103.29 | 103.97 | 96.83 |
|            |                  | Growth rate of employee income (%) | 38.40 | 19.94 | 15.14 | 33.54 | 24.90 | 34.80 |
|            |                  | Perception and recuperation person-time (ten thousand) | 4.20 | 4.50 | 4.80 | 4.90 | 5.10 | 5.20 |
|            | Industry index | Number of beds in the ward (piece) | 120 | 120 | 120 | 120 | 165 | 165 |
|            |                  | Utilization rate of wards (%) | 45.00 | 35.00 | 50.00 | 75.00 | 80.00 | 30.00 |
|            | Social benefit index | Number of persons employed (piece) | 103 | 108 | 110 | 113 | 115 | 118 |
|            | Internal management index | Proportion of professional and technical personnel (%) | 63.00 | 63.00 | 65.00 | 65.00 | 65.00 | 64.00 |
|            |                | Rehabilitation satisfaction (%) | 80.2 | 79.95 | 79.65 | 80.26 | 81.62 | 80.96 |
|            |                | Room satisfaction (%) | 79.62 | 78.40 | 78.46 | 78.52 | 78.95 | 78.62 |
|            |                | Catering satisfaction (%) | 80.62 | 78.65 | 79.62 | 81.62 | 82.65 | 82.32 |
|            |                | Environmental satisfaction (%) | 79.61 | 77.86 | 78.62 | 79.32 | 79.61 | 79.10 |
|            |                | Landscape satisfaction (%) | 79.62 | 78.61 | 78.65 | 79.32 | 79.98 | 78.69 |
| YZ sanatorium | Financial index | Total revenue (ten thousand yuan) | 626.37 | 788.75 | 982.40 | 1774.20 | 1140.08 | 2965.70 |
|            |                  | Balance of income and expenditure (ten thousand yuan) | –50.40 | –33.16 | –15.00 | 855.50 | 276.44 | 656.86 |
|            |                  | Working capital turnover (%) | 39.43 | 25.52 | 33.15 | 24.05 | 49.69 | 55.95 |
|            |                  | Value preservation and appreciation rate of assets (%) | 94.71 | 97.55 | 98.94 | 137.55 | 108.53 | 104.49 |
|            |                  | Growth rate of employee income (%) | 3.91 | 4.52 | 4.81 | 11.47 | 10.87 | 10.82 |
|            |                  | Perception and recuperation person-time (ten thousand) | 0.5480 | 0.6551 | 1.4928 | 2.3203 | 1.5186 | 1.8430 |
|            | Industry index | Number of beds in the ward (piece) | 160 | 160 | 195 | 195 | 195 | 195 |
|            |                  | Utilization rate of wards (%) | 32.30 | 33.50 | 65.20 | 75.80 | 68.20 | 72.70 |
|            | Social benefit index | Number of persons employed (piece) | 91 | 60 | 60 | 64 | 62 | 59 |
|            | Internal management index | Proportion of professional and technical personnel (%) | 29.70 | 43.30 | 48.30 | 53.10 | 51.60 | 55.90 |
|            |                | Rehabilitation satisfaction (%) | 77.01 | 77.03 | 77.1 | 78.02 | 78.93 | 79.62 |
|            |                | Room satisfaction (%) | 77.96 | 78.02 | 79.21 | 80.34 | 80.96 | 81.69 |
|            |                | Catering satisfaction (%) | 78.03 | 78.05 | 78.96 | 79.63 | 80.65 | 81.32 |
|            |                | Environmental satisfaction (%) | 75.32 | 75.63 | 76.56 | 76.98 | 77.32 | 77.63 |
|            |                | Landscape satisfaction (%) | 77.96 | 78.03 | 78.69 | 79.6 | 80.20 | 80.69 |
| XZ sanatorium | Financial index | Total revenue (ten thousand yuan) | 1609.03 | 774.73 | 566.99 | 1098.23 | 1597.33 | 2095.94 |
|            |                  | Balance of income and expenditure (ten thousand yuan) | –453.01 | 34.65 | 29.12 | –78.46 | 89.38 | 129.94 |
|            |                  | Working capital turnover (%) | 64.00 | 30.00 | 22.00 | 43.00 | 93.00 | 109.00 |
|            |                  | Value preservation and appreciation rate of assets (%) | 102.11 | 105.38 | 105.80 | 105.13 | 100.06 | 108.87 |
|            |                  | Growth rate of employee income (%) | 2.09 | 3.70 | 5.05 | 77.11 | 48.32 | 3.22 |
|            |                  | Perception and recuperation person-time (ten thousand) | 0.7886 | 0.8714 | 0.5916 | 0.4822 | 0.6076 | 0.6512 |
|            | Industry index | Number of beds in the ward (piece) | 154.36 | 62.10 | 42.15 | 37.89 | 30.89 | 85.37 |
|            |                  | Utilization rate of wards (%) | 100.00 | 383.00 | 249.00 | 236.00 | 100.00 | 100.00 |
|            | Social benefit index | Number of persons employed (piece) | 54 | 54 | 53 | 50 | 49 | 43 |
|            | Internal management index | Proportion of professional and technical personnel (%) | 31.48 | 31.48 | 32.08 | 28.00 | 25.57 | 39.53 |
|            |                | Rehabilitation satisfaction (%) | 77.20 | 77.12 | 78.21 | 78.96 | 79.10 | 79.65 |
|            |                | Room satisfaction (%) | 77.01 | 77.03 | 77.23 | 77.36 | 77.89 | 78.21 |
|            |                | Catering satisfaction (%) | 78.56 | 78.62 | 79.69 | 79.98 | 80.96 | 81.69 |
|            |                | Environmental satisfaction (%) | 77.12 | 77.69 | 78.02 | 78.36 | 78.56 | 78.69 |
|            |                | Landscape satisfaction (%) | 77.63 | 77.96 | 78.96 | 81.94 | 82.31 | 82.63 |
province. In this paper, these three sanatoriums were selected to validate the effectiveness of our model.

The relevant data from 2012 to 2017 are collected, shown in Table 1. Among them, the data of economic benefit, industry comparison, social benefit, and internal management are derived from the statistics of the sanatoriums, and customer satisfaction data are obtained by the survey.

3.3. Result Analysis. First, all the original data were standardized according to Definition 2, and the optimal ideal vector was selected. In terms of index weight, according to the standardized statistical and survey data of each sanatorium, the second-level index was weighted by the entropy weight method. The specific calculation results are shown in Table 2.

Based on the second-level index weight of sanatorium performance evaluation in Table 2, the correlation degree of Deng’s panel data based on information difference was calculated. The correlation degrees of Deng’s panel in three sanatoriums in south Jiangsu, middle Jiangsu, and north Jiangsu from 2012 to 2017 are shown in Table 3.

In terms of time weight, the weight determination method based on the new information priority perspective proposed in this paper was used to obtain the difference in time level. The specific calculation results are shown in Table 4.

Based on the correlation degree of Deng’s panel of the three sanatoriums in Table 3 from 2012 to 2017 and the performance time weight of six years in Table 4, the correlation degree of Deng’s development of the three sanatoriums was obtained to reflect their comprehensive performance level, as shown in Table 5.

As can be seen from Table 5, the performances of the three sanatoriums are ranked as TS > YZ > XZ, among which TS sanatorium has the highest performance level among the three nursing homes.

3.4. Results of Comparing the New Model with Traditional Models. As discussed in the introduction, a number of grey incidence models have been proposed for determining the connections between two sequences from different perspectives. Then, two traditional grey incidence models, whose perspective of calculating the relationships is similar to the model in this paper, are chosen to compare the performances. The two traditional models are the Deng degree of grey incidence model [19] and grey incidences for panel data [28] as shown in the first column in Table 6.

From the aspect of model improvement, compared with literature [13] which is the classical Deng’s degree of relation, the relation of this paper is scientifically determined by the entropy weight method, the degree of relation has higher
resolution, and the degree of relation is less uncertain or unstable situation. From the perspective of model results, the results of [22] are opposite to those in this paper, but the model in literature [22] has the disadvantage that the index order transformation will affect the correlation order, and the results are not comparable. It can be visually seen that the order of relation of the model is more in line with the reality through the original data and has a high degree of matching and consistency with the actual statistical results. It also has a high reference value.

4. Conclusions

Owing to the lack of industry unified standards and the individual characteristics of each object, the optimal value of the evaluation index is often difficult to determine, which makes it difficult to measure the performance evaluation level. Aiming at solving the problem, this paper utilizes reference values as the standard, establishes the grey relational development evaluation model, and carries out dynamic evaluation on the performance of evaluation objects. According to the change in the overall performance level, this paper analyzes the advantages and disadvantages of the evaluation objects in financial management, industry indicators, internal control, and other management aspects in recent years and explores the main reasons for the transformation of advantages and disadvantages. Then, feasible countermeasures and effective suggestions are put forward for the future performance management of evaluation objects.

Data Availability

The authors declare that the data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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