

# Analysis on China's Economic Development Evaluation Based on AHM-CVM Algorithm

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## ABSTRACT

When the economy is shifting from high-speed development to high-quality development, China needs to explore a new evaluation system to make a more scientific evaluation of the quality of economic development. After in-depth research on China's economic development characteristics, this paper selects six evaluation dimensions of the economic development achievements, financial development vitality, innovative development level, fiscal and taxation capacity, green development level, and open development level. It is used AHM (Attribute Hierarchical Mode) algorithm, CVM (coefficient of variation method) algorithm, and Lagrange multiplier method to establish the AHM-CVM model to evaluate China's economic development from 2010 to 2020 and conclude that the quality of China's economic development has generally continued to improve. The fiscal and green development levels fluctuate, and the open development level decreases year by year.

**Keywords:** AHM-CVM model; economic development quality; index evaluation system; Lagrange multiplier method.

## 1. INTRODUCTION

Since the 21st century, China's economy has continued to maintain a rapid development trend, and in 2010 surpassed Japan to become the world's second-largest economy. However, with the changes in the internal and external environment of the country's economic development, China is more urgently in need of an economic development evaluation system that keeps pace with the times to monitor the healthy operation of the economy, to promote the formation of a modern economic structure and achieve high-quality economic development.

At present, many experts and scholars have researched China's economic evaluation, such as Yang and Zhang<sup>[1]</sup> explored the theoretical basis of China's high-quality economic transformation, constructed relevant theoretical models, analyzed the main factors affecting the quality of China's economic development, and formed a comprehensive multi-index evaluation system to measure the quality of China's economic development. The evaluation of high-quality economic development has been explored. For example, Zhang et

al.<sup>[2]</sup> are based on the idea of "unified marginal return on capital." A "function estimation method" is proposed, which uses a time-varying elastic production function model to estimate time-varying capital-output Resilience measures the efficiency of regional capital allocation to explore the impact mechanism of China's capital allocation efficiency. Fang et al.<sup>[3]</sup> based on the drive-pressure-state-influence-response (DPSIR) framework and used the grey system theory to empirically conduct an empirical study on China's Hainan Island Research. Moreover, using relevant analysis and TOPSIS technology to perform a coupled and coordinated analysis of the sustainable development of the island's blue economy. Ren and Song<sup>[4]</sup> Construct China from the four dimensions of innovation, informatization, new industrial models, and realization. The indicator system uses the anti-entropy method to evaluate new economic development, which determines the weight of various indicators. It makes an evaluation and analysis of the overall performance of China's recent economic development; Ma et al.<sup>[5]</sup> starting with the opening of the five dimensions, the evaluation index system for high-quality development of China's economy was constructed, and the overall situation of

high-quality development of China's regional economy was compared and analyzed based on this. These papers use different methods to evaluate the Chinese and regional economies. These evaluation methods and the derived evaluation index system provided great help to the writing of this paper.

This paper uses the optimized algorithm model to combine subjectivity and objectivity in economic evaluation and conduct a good exploration. This paper collects 20 indicators from 6 aspects to construct China's national economic development evaluation system. On this basis, an AHM-CVM economic evaluation model is established, combined with 2010-2020 data, to evaluate and analyze China's economic development quality. It provides a new method for assessing the quality of China's economy.

## **2. CONSTRUCTION OF THE EVALUATION INDEX SYSTEM**

In constructing the evaluation index system, this paper absorbs the shortcomings of the existing measurement methods and uses the essential points presented in the high-quality economic development as the theoretical basis for constructing the index. And fully considering the actual needs of the high-quality development of the Chinese economy and the research done by experts and scholars around the world, this article mainly focuses on the economic development achievements ( $y_1$ ), financial development vitality ( $y_2$ ), innovative development level ( $y_3$ ), fiscal and taxation capacity ( $y_4$ ), green development level ( $y_5$ ) and open development level ( $y_6$ ). As a basis, studying the quality of China's economic development from 2010 to 2020, constructing an evaluation system for the quality of China's economic development, and conducting empirical analysis and research.<sup>[3]</sup>

**Economic development achievements:** Economic development achievements are the most crucial factor in measuring national economic development. As the country's phased economic achievement, this dimension reflects, on the one hand, the driving force of the country's economic development. On the other hand, it also represents the country's overall economic activity. Comprehensively considering economic development momentum and vitality factors, this paper selects five specific indicators: per capita GDP ( $x_1$ ), industrialization rate ( $x_2$ ), per capita consumption expenditure ( $x_3$ ), per capita disposable income ( $x_4$ ), and Gini coefficient ( $x_5$ ) to reflect the level of national economic development results.

**Financial development vitality:** In modern economic development, finance plays an irreplaceable role in financial integration and promoting the rational allocation of resources. Furthermore, the high-quality development of the future economy is also inseparable

from the vitality of national finance. Therefore, this paper focuses on the selection of four indicators: per capita deposit balance ( $x_6$ ), per capita loan balance ( $x_7$ ), loan deposit ratio ( $x_8$ ), and per capita fixed asset investment ( $x_9$ ) from the three aspects of savings, loans, and investment at the national level, to take overall control of the country's financial development vitality.

**Innovative development level:** In constructing the modern economic structure in the new era, innovation has always been the primary productive force, playing a leading core role. As for the level of national scientific and technological innovation, a comprehensive investigation should be made from the two aspects of national innovation funding and national innovation achievements. Therefore, this paper selects three specific indicators of R&D expenditure ( $x_{10}$ ), the number of patent applications granted ( $x_{11}$ ) and the number of registrations of scientific and technological achievements ( $x_{12}$ ) to reflect the level of national innovation and development.

**Fiscal and taxation capacity:** The role of finance in providing national investment, improving social security, promoting fair distribution, and providing public services is a necessary prerequisite and guarantee for achieving high-quality economic development. Especially for China, the fiscal and tax expenditure capacity is directly related to all aspects of the country's overall economic operation. Therefore, this paper starts from the per capita level of taxation and finance and selects three indicators: per capita tax revenue ( $x_{13}$ ), per capita fiscal revenue ( $x_{14}$ ), and per capita fiscal expenditure ( $x_{15}$ ), which comprehensively reflect the country's fiscal revenue and expenditure capacity.

**Green development level:** Greening is an inevitable requirement for today's economical, high-quality, and sustainable development. From the perspective of its connotation, economic greening, on the one hand, it represents the national greening level and environmental protection investment status. On the other hand, it also reflects the energy consumption of economic output. Therefore, this paper selects three indicators of ecological protection expenditure ( $x_{16}$ ), total afforestation area ( $x_{17}$ ), and energy consumption per unit of GDP ( $x_{18}$ ) to measure the comprehensive level of national green development.

**Open development level:** Since the 21st century, the contribution of exchanges between countries to their economy has gradually increased. In evaluating the economy in the new era, more attention should be paid to the quality of imports and exports and foreign investment utilization. Therefore, in this dimension, this paper selects two indicators, the degree of dependence on foreign trade ( $x_{19}$ ) and the proportion of foreign direct investment in GDP ( $x_{20}$ ) to reflect the level of national economic openness.

In summary, this paper focuses on selecting 20 specific indicators from the above six dimensions to

establish an indicator system for China's economic development evaluation, as shown in Table 1.

**Table 1** China's economic development evaluation index system

First level indicator	Secondary indicators	Three-level indicators	Indicator type
Quality of China's economic development (L)	Economic development achievements( $y_1$ )	Per capita GDP ( $x_1$ )	Positive
		Industrialization rate ( $x_2$ )	Positive
		Per capita consumption expenditure ( $x_3$ )	Positive
		Per capita disposable income ( $x_4$ )	Positive
		Gini coefficient ( $x_5$ )	Negative
	Financial development vitality( $y_2$ )	Per capita deposit balance ( $x_6$ )	Positive
		Per capita loan balance ( $x_7$ )	Positive
		Loan deposit ratio ( $x_8$ )	Positive
		Per capita fixed asset investment ( $x_9$ )	Positive
	Innovative development level( $y_3$ )	R&D expenditure ( $x_{10}$ )	Positive
		Number of patent applications granted ( $x_{11}$ )	Positive
		Number of registrations of scientific and technological achievements ( $x_{12}$ )	Positive
	Fiscal and taxation capacity( $y_4$ )	Per capita tax revenue ( $x_{13}$ )	Positive
		Per capita fiscal revenue ( $x_{14}$ )	Positive
		Per capita fiscal expenditure ( $x_{15}$ )	Positive
	Green development level( $y_5$ )	Ecological protection expenditure ( $x_{16}$ )	Positive
		Total afforestation area ( $x_{17}$ )	Positive
		Energy consumption per unit of GDP ( $x_{18}$ )	Negative
	Open development level( $y_6$ )	Degree of dependence on foreign trade ( $x_{19}$ )	Positive
		The proportion of foreign direct investment in GDP ( $x_{20}$ )	Positive

### 3. CONSTRUCTION OF AHM-CVM EVALUATION MODEL

$$x^* = \frac{\max(x) - x}{\max(x) - \min(x)} \quad (2)$$

#### 3.1. Positive and negative index processing

When performing model analysis on economic indicator data, the measurement units of different indicators are different, which seriously hinders subsequent data analysis. To eliminate the dimensional effect of the indicators and make each variable have the same expressive power in the entire indicator system, this paper makes the following positive and negative treatments for the positive and negative indicators:

Positive processing :

$$x^* = \frac{x - \min(x)}{\max(x) - \min(x)} \quad (1)$$

Negative processing :

#### 3.2 AHM algorithm

AHM algorithm is a new unstructured decision-making hierarchy analysis method. As a representative method of subjective weight determination, the AHM algorithm is relatively simple, and at the same time, it does not need to do the consistency check of the judgment matrix, which makes decision-making and analysis easier to implement [6]. Therefore, due to the coexistence of reasonable subjective weight determination and simple calculation, this paper determines it as a method of subjective weight determination in economic evaluation. The specific method steps are as follows.

Step1: Define the index as the element  $u$ , then the ratio of the elements  $u_i$  and  $u_j$  can be expressed by

the relative ratio scale  $\rho_{ij}$ , and determined as  $u_{ij}$ , and  $\beta \geq 1, u_{ij} \geq 0, u_{ji} \geq 0, u_{ij} + u_{ji} = 1, u_{ii} = 0$ , the calculation formula is:

$$u_{ij} = \begin{cases} \beta_k / (\beta_k + 1), & a_{ij} = k \\ 0.5 & a_{ij} = k, i \neq j \\ \beta_k / (\beta_k + 1), & a_{ij} = 1/k \end{cases} \quad (3)$$

Simultaneously construct the judgment matrix of the AHM model:  $P = (u_{ij})_{n \times n}$

Step2: Find the sum of the elements in each row of the judgment matrix P:

$$w_i = \sum_{j=1}^n u_{ij} \quad (4)$$

Step3: Find the relative weight vector under a single criterion:

$$w^{c_i} = \frac{2}{n(n-1)} \sum_{j=1}^n u_{ij} \quad (5)$$

Step4: Calculate the composite weight vector of each indicator to the target as follows:

$$w^c = (w^{(c_1)}, w^{(c_2)}, w^{(c_3)}, \dots, w^{(c_j)}) \quad (6)$$

### 3.3 CVM algorithm

The CVM algorithm is a representative method of objective weight determination. Its basic principle is: the more significant the difference in the indicator's value, the more information the indicator contains, and the greater the weight it occupies. [7] In the field of economic management evaluation, the CVM algorithm is still an excellent objective weighting method. Therefore, because of its objective information preservation and strong reflection algorithm characteristics, this paper determines it as an objective method of determining weight in economic evaluation. The specific method steps are as follows.

Step1: There are n samples and p evaluation indicators,  $x_{ij}$  represents the value of the j-th evaluation index of the i-th sample, and the mean and standard deviation of the j-th evaluation index is calculated:

$$\begin{cases} \bar{x}_j = \frac{1}{n} \sum_{i=1}^n x_{ij} \\ S_j = \sqrt{\frac{\sum_{i=1}^n (x_{ij} - \bar{x}_j)^2}{n-1}} \end{cases} \quad (7)$$

Step2: Calculate the coefficient of variation of the j-th evaluation index:

$$v_j = \frac{S_j}{x_j}, j = 1, 2, \dots, p \quad (8)$$

Step3: Normalize the coefficient of variation to obtain the weight of each indicator:

$$w_j = \frac{v_j}{\sum_{j=1}^p v_j} \quad (9)$$

Step4: Get the final weight:

$$W = \{w_1, w_2, \dots, w_p\} \quad (10)$$

### 3.4 Lagrange multiplier method

In economic evaluation, this paper uses two algorithms, AHM and CVM, to determine the index weights in the evaluation system. In the comprehensive evaluation, to make the final weights as close as possible to the original subjective and objective weights, according to the principle of minimum relative information entropy, the final evaluation weights can be obtained after optimization by the Lagrange multiplier method [8], the specific method as follows.

It is defined as a total of p evaluation indicators. The combined weight is  $w_i$ , the subjective weight is  $w_{1i}$  and the objective weight is  $w_{2i}$ , the formula is:

$$w_i = \frac{(w_{1i} w_{2i})^{0.5}}{\sum_{i=1}^p (w_{1i} w_{2i})^{0.5}} \quad (11)$$

## 4. EMPIRICAL ANALYSIS RESULTS

### 4.1. Data collection and processing

The indicator data in this article comes from the 2010-2020 public data of the National Bureau of Statistics of China, the Ministry of Finance, and the People's Bank of China, and has undergone positive and negative processing as described above. The data display is shown in Figure 1:

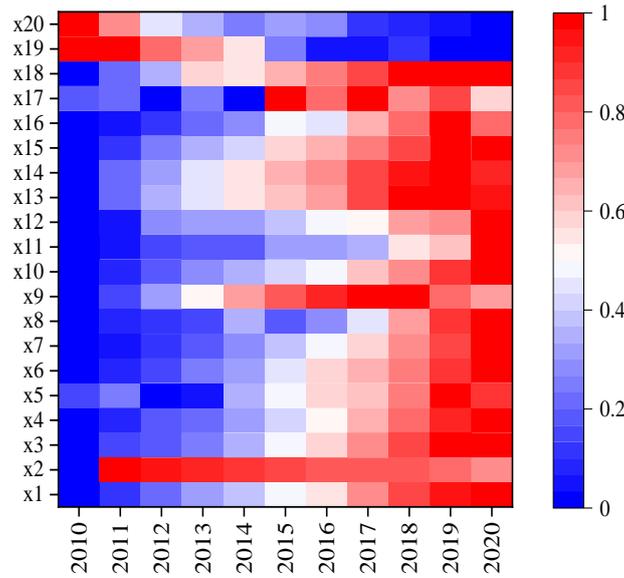


Figure 1 Index data heat map

At the same time, the Saaty 9-level scaling method is used to process the relative proportional scale data under the AHM algorithm, and the judgment matrix is shown below. Among them, L is the judgment matrix of China's economic development quality,  $y_1$  is the judgment matrix of economic development achievements,  $y_2$  is

the judgment matrix of financial development vitality,  $y_3$  is the judgment matrix of innovative development level,  $y_4$  is the judgment matrix of fiscal and taxation capacity, and  $y_5$  is the judgment matrix of green development level,  $y_6$  is the judgment matrix of open development level.

$$L = \begin{pmatrix} 1 & 3 & 1 & 3 & 1 & 5 \\ \frac{1}{3} & 1 & 0.5 & 1 & \frac{1}{3} & 3 \\ 1 & 2 & 1 & 2 & 1 & 3 \\ \frac{1}{3} & 1 & 0.5 & 1 & \frac{1}{3} & 1 \\ 1 & 3 & 1 & 3 & 1 & 3 \\ 0.2 & \frac{1}{3} & \frac{1}{3} & 1 & \frac{1}{3} & 1 \end{pmatrix}$$

$$y_1 = \begin{pmatrix} 1 & 3 & 3 & 3 & 3 \\ \frac{1}{3} & 1 & 0.5 & 0.5 & 1 \\ \frac{1}{3} & 2 & 1 & 1 & 2 \\ \frac{1}{3} & 2 & 1 & 1 & 2 \\ \frac{1}{3} & 1 & 0.5 & 0.5 & 1 \end{pmatrix}$$

$$y_2 = \begin{pmatrix} 1 & 1 & 3 & 3 \\ 1 & 1 & 3 & 3 \\ \frac{1}{3} & \frac{1}{3} & 1 & 1 \\ \frac{1}{3} & \frac{1}{3} & 1 & 1 \end{pmatrix}$$

$$y_3 = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$

$$y_4 = \begin{pmatrix} 1 & 0.5 & 0.5 \\ 2 & 1 & 1 \\ 2 & 1 & 1 \end{pmatrix}$$

$$y_5 = \begin{pmatrix} 1 & 5 & 3 \\ 0.2 & 1 & 0.5 \\ \frac{1}{3} & 2 & 1 \end{pmatrix}$$

$$y_6 = \begin{pmatrix} 1 & 3 \\ \frac{1}{3} & 1 \end{pmatrix}$$

in the evaluation system, the calculated index data and weights are shown in Table 2.

#### 4.2 Determination of indicator weights

After analyzing the positive and negative index data

Table 2 Index data and weight

Indicator code	CVM algorithm				AHM algorithm	Lagrange Multiplier Method
	average value	Standard deviation	Coefficient of Variation	Weight ( $w_1$ )	Weight ( $w_2$ )	Combination weight ( $w$ )
$x_1$	0.511	0.323	0.632	0.208	0.419	0.305
$x_2$	0.776	0.259	0.334	0.110	0.106	0.112

x <sub>3</sub>	0.502	0.330	0.658	0.216	0.184	0.206
x <sub>4</sub>	0.458	0.327	0.714	0.235	0.184	0.215
x <sub>5</sub>	0.464	0.326	0.703	0.231	0.106	0.162
x <sub>6</sub>	0.462	0.322	0.696	0.248	0.375	0.315
x <sub>7</sub>	0.424	0.317	0.749	0.266	0.375	0.327
x <sub>8</sub>	0.378	0.322	0.851	0.303	0.125	0.201
x <sub>9</sub>	0.622	0.321	0.516	0.183	0.125	0.157
x <sub>10</sub>	0.455	0.305	0.670	0.314	0.333	0.324
x <sub>11</sub>	0.340	0.277	0.816	0.383	0.333	0.358
x <sub>12</sub>	0.431	0.278	0.646	0.303	0.333	0.318
x <sub>13</sub>	0.603	0.316	0.524	0.318	0.200	0.255
x <sub>14</sub>	0.600	0.311	0.518	0.315	0.400	0.358
x <sub>15</sub>	0.536	0.323	0.603	0.367	0.400	0.387
x <sub>16</sub>	0.435	0.323	0.743	0.376	0.648	0.520
x <sub>17</sub>	0.507	0.368	0.725	0.367	0.122	0.223
x <sub>18</sub>	0.624	0.317	0.509	0.257	0.230	0.256
x <sub>19</sub>	0.405	0.382	0.942	0.522	0.750	0.644
x <sub>20</sub>	0.333	0.287	0.861	0.478	0.250	0.356

As shown in Table 2, through the AHM-CVM evaluation model method, it can be seen that  $y_1$  has the largest proportion, while  $y_4$  and  $y_6$  have the smallest proportions. This paper uses the subjective and objective determination of power, which can better integrate the advantages of the two and achieve the purpose of coexisting scientific and practical evaluation.

### 4.3 Calculation of score results

Based on the evaluation index system of China's economic development constructed in this paper and the combined weight data under the Lagrange multiplier method, the annual score calculation formula for the quality of China's economic development can be obtained as shown below:

$$\begin{cases}
 y_1 = 0.305x_1 + 0.112x_2 + 0.206x_3 + 0.215x_4 + 0.162x_5 \\
 y_2 = 0.315x_6 + 0.327x_7 + 0.201x_8 + 0.157x_9 \\
 y_3 = 0.324x_{10} + 0.358x_{11} + 0.318x_{12} \\
 y_4 = 0.255x_{13} + 0.358x_{14} + 0.387x_{15} \\
 y_5 = 0.520x_{16} + 0.223x_{17} + 0.257x_{18} \\
 y_6 = 0.644x_{19} + 0.356x_{20} \\
 L = 0.253y_1 + 0.156y_2 + 0.191y_3 + 0.107y_4 + 0.196y_5 + 0.097y_6
 \end{cases} \tag{12}$$

From the formula, the annual score of China's economic development from 2010 to 2020 can be calculated as shown in Table 3.

**Table 3** 2010~2020 China Economic Development Quality Score

Year	$y_1$	$y_2$	$y_3$	$y_4$	$y_5$	$y_6$	L
2010	0.02	0.00	0.00	0.00	0.04	1.00	0.11
2011	0.24	0.08	0.07	0.18	0.12	0.88	0.21
2012	0.25	0.16	0.21	0.30	0.15	0.67	0.25
2013	0.30	0.25	0.25	0.41	0.31	0.57	0.32
2014	0.42	0.36	0.28	0.50	0.28	0.44	0.37
2015	0.50	0.43	0.37	0.62	0.64	0.26	0.48
2016	0.59	0.54	0.43	0.68	0.60	0.14	0.52
2017	0.69	0.65	0.49	0.80	0.78	0.08	0.62
2018	0.81	0.77	0.64	0.92	0.82	0.10	0.72
2019	0.95	0.86	0.73	0.99	0.97	0.03	0.81
2020	0.95	0.95	1.00	0.95	0.79	0.00	0.84

In order to more intuitively show the scores of China's economic development quality in various

aspects, this paper draws a 3D stacked bar graph, as shown in Figure 2.

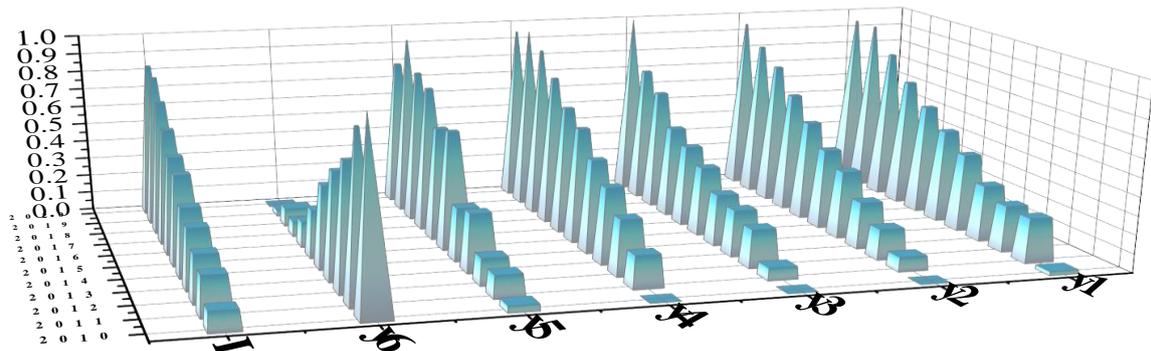


Figure 2 3D display of scores

Overall, China's economic development quality score has increased year by year from 2010 to 2020, representing that China's economic development has been on a continuous upward trend in the past 11 years. Specifically, the scores have achieved 11 consecutive years of growth in three aspects: economic development achievements, financial development vitality, and innovative development level. It represents that China's achievements in expanding economic aggregates, improving people's living standards, building a modern financial system, and leading the country's innovation trend has withstood the test of the economic crisis, the Sino-US trade war, the large-scale public health crisis, and other emergencies, and has been prosperous forever. Second, the fiscal and taxation capacity ratings and green development levels have maintained an overall upward trend while decreasing to varying degrees in 2014, 2016, 2020, and 2020, which shows that China still needs to progress green development. Moreover, make more efforts in fiscal revenue and expenditure to ensure sustainable development under volatility. Finally, except for 2018, the scores of the level of open development have shown a negative growth trend, which means that the contribution rate of foreign investment and import and export volume to China's economy has been decreasing year by year.

## 5. CONCLUSIONS

This paper uses the optimized AHM-CVM economic evaluation model to evaluate and analyze the quality of China's economic development based on the constructed evaluation index system.

This paper finds that the overall quality of China's economic development has continued to improve from 2010 to 2020, and the economic development has achieved remarkable results. However, there are still problems such as fluctuations in fiscal and taxation, the level of green development, and the decline in the level of open development year by year. Because of the volatility of fiscal and taxation capacity and the level of green development, China must prepare a long-term fiscal budget and optimize the balance structure of budgetary revenue and expenditure on the one hand. Otherwise, it must vigorously promote carbon neutrality,

improve energy efficiency, and strengthen its green construction. In response to the continued decline in open development, China needs to improve the quality of foreign capital and give full play to import and export in promoting China's economy. This paper's evaluation of the quality of China's economic development conforms to the actual development characteristics. It verifies the feasibility and practicability of the AHM-CVM model, which can be extended to other economic evaluations.

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