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Higher Education System Evaluation Model Based on Entropy Method and the Weighted Factor Ratio

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Abstract: *Higher education has a vital influence on the development of a country. But today's higher education evaluation system is not perfect. In the current pandemic, we have the opportunity to reflect on the existing higher education system and seek a more objective and effective evaluation system. For the issue of establishing a higher education evaluation system, we get 28 secondary indicators relative to the primary indicators. Next, we divided the countries of the world into three categories according to their degree of development, and evaluated them. Finally, we got the higher education evaluation system model.*

Keywords: *Higher education, Education reform, Entropy weight method*

1. Introduction

Higher Education is an optional final stage of formal learning that occurs after completion of the required level of education, also called the post-secondary education.

As we all know, students who have undergone higher education are active in cutting-edge fields and vital departments of traditional fields, and they are the fundamental driving force for social, scientific and technological development. So it is no doubt that higher education plays an important role in the development of one nation.

Accordingly, to establish a correct higher education evaluation system by considering various factors, and to verify system's effectiveness based on actual conditions have become an important national issue. And nation is being required to put forward reasonable suggestions to reach a more healthy and sustainable system of higher education.

2. The Model for Higher Education Evaluation

In our evaluation model, we measure the class of higher education at a national level from six macro indicators (first-level indicators) such as higher education foundation, higher educational academic quality, and higher education funding input. [1, 2] According to literatures, data and our researching, we concretize and quantify each of the above macro indicators, and establish a mathematical model of sub-indices (secondary indicators) based on the existing international higher education evaluation standards and the future development tendency of higher education.

After that, we use the entropy method to determine the weight values of the first-level indicators and determine the weight values of the secondary indicators varying from research objects (countries with different development levels), and finally get a comprehensive national-level higher education evaluation system model. In addition, we classified the first-level indicators to constitute the higher education health and sustainability indicators.

2.1 Indicators of Evaluation Model

This indicator is used to measure the quality of university education and research. The acquisition of honorary awards and the publication of papers are direct signs of recognition by peers, so we use the following six secondary indicators to further quantify.

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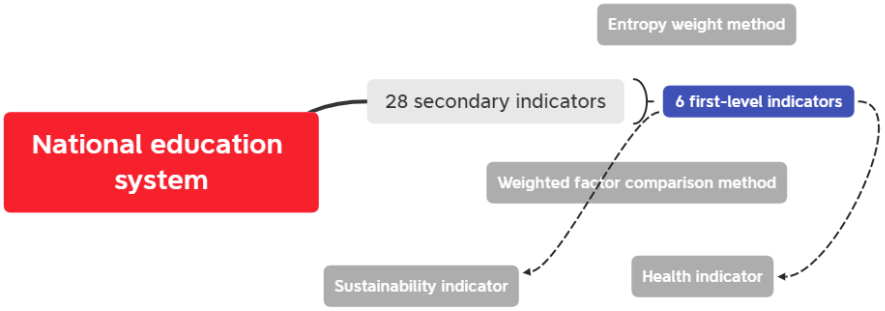

Figure 1: An Overview of Our Evaluation Model for Higher Education System

- **Number of International Award Winners (indicated as N_{pri})**
- **International University Rankings Weighted Scores (IUS)**

The international ranking of a university reflects the comprehensive strength of the university. For a country, the weighted score of its international university ranking reflects the comprehensive strength of the entire country. The US News & World Report Best Global Universities Rankings is based on the university's academic level, international reputation and other ten indicators to get the world's best university rankings, so as to provide students from all over the world in choosing the ideal university globally. The ranking is authoritative. In 2020, U.S. News has named a total of 1829 best universities. For a country, if the number of the university on the U.S. News World University Rankings is *m*, then this country's IUS is calculated by the following formula:

$$IUS = \sum_{i=1}^{m} \left(1829 - r_i^u\right)$$

Where r_i^u represents the ranking of the country's *i*-th university on the list. Universities that are not on the list will not be counted. It can be seen that the higher the university ranking, the higher the score.

- **Number of Papers in "Nature", "Science", and "Cell" (indicated as N_{NSC})**
- **Number of SCI and SSCI Papers Per Teacher (indicated as N_{SCI})**
- **Number of EI Papers Per Teacher (indicated as N_{EI})**
- **Number of Highly Cited Papers (indicated as N_{FI})**

2.2 The Evaluation Model for System of Higher Education

After completing the division of national levels, we can use the entropy method to calculate the value of the primary indicator based on the collected specific data of the secondary indicator.

Entropy is a measure of uncertainty. The greater the amount of information, the smaller the uncertainty and entropy. According to the characteristics of entropy, the randomness and disorder of events can be judged by calculating the entropy value, or the degree of dispersion of a certain index, that is, the greater the degree of dispersion of the index, the greater the influence of the index on the comprehensive evaluation. The entropy method mainly includes the following seven steps:

- **Construct Data Matrix**

$$A = \begin{pmatrix} X_{11} \cdots X_{1m} \\ \vdots \quad \vdots \quad \vdots \\ X_{n1} \cdots X_{nm} \end{pmatrix}_{n \times m} \tag{1}$$

Where X_{ij} is the value of the *j*-th indicator of the *i*-th scheme.

- **Data Non-negative Processing**

The entropy weight method uses the ratio of each index to the total of the same index, so it does not need to be normalized. However, when there are negative numbers in the data, it needs to be non-negative, which is generally realized by translation.

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For the indicators which are the bigger the better:

$$\tilde{X}_{ij} = \frac{X_{ij} - min(X_{1j}, X_{2j}, \Lambda, X_{nj})}{max(X_{1j}, X_{2j}, \Lambda, X_{nj}) - min(X_{1j}, X_{2j}, \Lambda, X_{nj})} + 1 \quad (2)$$

For the indicators which are the smaller the better:

$$\tilde{X}_{ij} = \frac{max(X_{1j}, X_{2j}, \Lambda, X_{nj}) - X_{ij}}{max(X_{1j}, X_{2j}, \Lambda, X_{nj}) - min(X_{1j}, X_{2j}, \Lambda, X_{nj})} + 1 \quad (3)$$

- **Calculate the Proportion of Each Indicator in the Total Indicators**

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}}, \quad (j = 1,2, \cdots m) \quad (4)$$

- **Calculate the Indicator Entropy Values**

$$e_j = -k \times \sum_{i=1}^{n} P_{ij}\, ln(P_{ij}) \quad (5)$$

Where $k>0$, ln(...) is the natural logarithm, and $e_j \geq 0$. Generally, let k be $1/\ln(m)$, then $0 \leq e \leq 1$.

- **Calculate the Coefficient of Variance of the Indicators**

$$g_j = 1 - e_j \quad (6)$$

For the i-th index, the greater the difference of the index value X_{ij}, the greater the effect on program evaluation and the smaller the entropy value.

- **Calculation Weight**

$$W_j = \frac{g_j}{\sum_{j=1}^{m} g_j}, \quad j = 1,2, \cdots m \quad (7)$$

- **Calculate the Comprehensive Score of the First-level Indicator Evaluation**

$$S_i = \sum_{j=1}^{m} W_j \cdot P_{ij}, \quad (i = 1,2, \cdots n) \quad (8)$$

Here, we take the calculation of first-level indicator (education foundation) of one nation from type A as an example, and introduce in detail how to use the above entropy method. First, we need to collect all the data of the secondary indicators included in the education foundation from all of the country from type A (the gross enrollment rate of higher education, the proportion of graduate students in the school, the proportion of doctoral students in the school), which constitutes a data matrix A, where X_{ij} is the value of the j-th secondary indicator of the i-th country. Then through the above-mentioned data non-negative processing, calculate the proportion of each index in the total index, calculate the index entropy value, calculate the difference coefficient of the index, calculate the weight, and finally obtain the national first-level indicator-the comprehensive score of the education foundation.

The same method can be used to calculate the comprehensive scores of other first-level indicators, but it must be noted that when constructing the data matrix, the data used comes from the data of the same level of countries, not the data of all sovereign countries in the world.

2.3 The Summary of the Six Indicators

After collecting, calculating, and sorting out all the above secondary indicators, we use the entropy method introduced above to calculate the scores of each country's six first-level indicators. Due to paper limitations, in the process of using the entropy method, the specific weight values will not be repeated. Here we give the scores of these six national level indicators as follows:

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Table 1: The Summary of the Total Scores of First-level Indicators

	Type A		Type B		Type C	
	America	**Germany**	**China**	**India**	**Laos**	**Afghanistan**
Education Basic	0.98	0.86	0.92	0.93	0.84	0.85
Education Quality	0.96	0.91	0.87	0.64	0.59	0.67
Funding Inputs	0.98	0.89	0.91	0.71	0.61	0.84
Education Social Benefits	0.91	0.93	0.64	0.71	0.31	0.4
Education Informatization	0.93	0.95	0.59	0.37	0.72	0.63
Education Internationalization	0.79	0.69	0.94	0.42	0.61	0.59

Regarding the data in Tab.1 above, we need to pay special attention to the fact that the scores of the first-level indicators of each country are compared in the same category of countries, and the scores of the same indicator of different categories of countries have no significance for comparison. For example, the United States' educational base score is 0.98, while Germany's educational base score is 0.86, which shows that the United States' educational base is better than Germany's. However, India's educational foundation score is 0.93, which is also higher than Germany's score. This does not mean that India's educational foundation is better than Germany, because when calculating their respective scores, the data used are the data of the Type A and B Countries, which is in the same category.

Through calculation, we get the health indicator scores and sustainability indicator scores of these six countries as follows:

Table 2: The Score of Health Indicator and Sustainability Indicator

	Type A		Type B		Type C	
	America	**Germany**	**China**	**America**	**Germany**	**China**
Health Indicator	0.4581	0.4587	0.5268	0.4194	0.4671	0.5241
Sustainability Indicator	0.6197	0.6034	0.3814	0.2748	0.1924	0.2107

As the data in Tab.2 above, the scores of the health indicator and sustainability indicator of each country are compared in the same category of countries. And the scores of the same indicator of different categories of countries have no significance for comparison.

It can be seen from Tab.2 that in the same category of countries, the United States and Germany have almost the same scores, Laos and Afghanistan have similar scores, but China and India have significant differences in scores. Compared with China, India's score on health indicator is only 78% of China's, while sustainability indicator is only 71% of China. This shows that there is still a lot of room for improvement in higher education in India, especially in terms of sustainability, which needs to be improved urgently.

3. Conclusions

We believe that the period 2031-2050 is the final stage of India's higher education reform. This stage mainly greatly improves the internationalization and social benefits of the higher education system. However, considering practical factors, we have found that for students, the arrival of more international students can enhance students' world vision, but the educational benefits of domestic students may decrease due to the increase in foreign students. At the same time, if education pays more attention to social benefits, it will pay more attention to the cooperation between universities and enterprises, which is not conducive to the development of disciplines with difficult employment. As far as teachers are concerned, an increase in the proportion of teachers with overseas study experience will increase the barriers to employment for teachers and make teachers more competitive with each other. For the government, the further deepening of internationalization requires a good relationship between the Indian government and other countries in the world, and a lot of effort is needed in this regard.

To sum up, the advancement of higher education reform is challenging at the student, teacher, or national level and will face many difficulties.

Comprehensive Indicators. We have detailed analysis from education foundation, funding investment, etc. We have not only the first-level indicators, but also secondary indicators for each first-level indicator. But data dependence is strong, requiring a large amount of data collection and sorting work.

In the future, dynamic factors are to add to the considerations in order to make the model have time-varying characteristics.

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References

[1] Rui Zhou. Research on Evaluation Model and System of Education System Oriented to Higher Vocational Education. 2020, 9(6)
[2] A Schellekens, F Paas, A Verbraeck, et al. Designing a flexible approach for higher professional education by means of simulation modelling. 2010, 61(2): 202-210.
[3] Xiaoqi Hu. Comparison of Higher Education Funding Systems between China and the United States. 2019, 7(4): 150-159.
[4] Feitosa de Moura Valéria, Alexandre de Souza Cesar, Noronha Viana Adriana Backx. The use of Massive Open Online Courses (MOOCs) in blended learning courses and the functional value perceived by students. 2021, 161: 104077.
[5] Kiyoko Saito, Kim SoungHee. The Internationalization of Higher Education in Japan: Effective Organization for a Sustainable Internationally Cooperative Higher Education Program. 2019, 9(1)