Problem Chosen	2021 MCM/ICM Summary Sheet	Team Control Number
F		0000001

Policy Formation Oriented Higher Education System Assessment

Summary

Nowadays, it seems that global education development has come to a halt. Globally, higher education is gradually becoming a commodity, inequity rising sharply, education resources being overly monopolized, unaffordable expenditures, and such. Hence, it is high time that we check the pulse and temperature of higher education.

Firstly, the data are collected and integrated into 14 main indices. We categorized the indices into 3 dimensions, which are student treatment (ST), school development (SD), and social significance (SS). Concerning the two most-weighted aspects reflecting the status and growing tendency of an education system, i.e., health and sustainability, we select Germany, India, United Kingdom and Japan.

Secondly, In the 3DVA model, we selected ST, SD, SS as the three dimensions. In the ST dimension, we selected the expenditure index and the enrollment rate as the database. In the SD dimension, we focused on five main aspects including research-level, academic level, investment, attraction, and education quality. In the SS dimension, we look forward to expressing the higher education system's social influence through gender equity, education equity, global contribution, education coverage.

Thirdly, In the Tendency Sphere model, we selected Human Development Index, Fragile States Index, Gini Coefficient as the database. Similarly, we calculate the corresponding weights using the EWM and obtained the radius of the tendency sphere.

Finally, after establishing the overall reform direction, we analyze the outcomes that the policies' implementation may bring. How to enhance the positive effects and eliminate the negative effects still need to be further discussed and evaluated. But undeniably, as the second-largest country in population, fifth-largest economy, its amelioration towards higher education is of benefit to the global average education level.

Keywords: Entropy Weight Method; 3-Dimension Vector Assessment; Inequity; Policy Formation; Higher Education; Sustainability

Content

1 Introduction

1.1 Background

The evaluation of Higher Education was chaotic and nonstandard. Although it is well-known that higher education has an irreplaceable status. Not only does it mirror the school's development, but it also affects students' treatment and unfolds social significance. What's more, under current circumstances, each student facing the college entrance examination cannot get a full picture of the concept of the university.

Fortunately, fellow researchers including Ellen Hazelkorn, the president of the European Higher Education Society, have traced the development of the university ranking system in the book published in 2015.[1] From then on, the phenomenon of commonly reporting a lack of data from colleges and universities has vanished. In regards to the rise of ranking, it can be attributed to four main drivers, which are the global pursuit of talent, transition to a knowledge-intensive economy, the importance of higher education to the economy, and consumerist student attitudes toward higher education.

In modern ages, the ranking of a university is no longer the only criterion for assessment. The outbreak of the covid-19 pandemic has exposed the inequity and deficits greatly emphasizing the need for a healthier and more sustainable pattern for the assessment of the whole education system. Especially, in this context, the higher education system.

1.2 Problem Restatement

As mentioned in the background, there's a tight connection between assessing the health as well as the sustainability of an education system and institute ranking. Currently, the ranking of the higher education system of all countries is in urgent need of updating. How to build a set of suitable models to correctly assess, make an appraisal and ameliorate a country's higher education system is the problem we are facing with. Through the models we built, we valuate the pulse and temperature of higher education systems in three aspects, which are student treatment (ST), school development (SD), and social significance (SS). Then we further screen a few representative countries as an illustration, whose higher education system needs to be enhanced and provided with rational policy suggestions, to make positive real-world impacts (e.g., on students, on faculty, on schools, on communities, on the nation) of implementing our plan both during the transition and in the final stage. Certainly, the effectiveness of the external

factors and their impact on the real world still require further evaluation.

1.3 Our work

To start, we set a boundary of higher education for future discussion. Then we reviewed literature in close relevance to the topic and summarized 11 indicators weighing most in accessing the higher education system which then categorized into 3 major aspects including school development, student treatment, social significance.

We established the 3DVA (3-Dimension Vector Assessment) model in the first place. We use the categorized three main aspects (SD, ST, SS) of education as the three axes, where the quantity determines the wellness in each aspect. Then we set up standards to make comparisons between the utopia vector and each country's education system assessment vector, which includes deviation angle and magnitude. Based on data-processing, we selected the Entropy Weight Method to calculate each factor's weight, which requires a huge amount of origin data. After obtaining data with such a method, we then can finally make the comparison. Besides, we established the Tendency Sphere model. Using the EWM to process relevant data, we gain the radius of the sphere centered at the endpoint of the assessment vector, which represents a country's development tendency in the future.

We selected Australia, Japan, Germany, and India as our final assessment countries. Among them, India is assessed by the Tendency Sphere model for future prediction and policy suggestions.

In the 3DVA model, we selected ST, SD, SS as the three dimensions. In the ST dimension, we selected the expenditure index and the enrollment rate as the database. In the SD dimension, we focused on five main aspects including research-level, academic level, investment, attraction, and education quality. In the SS dimension, we look forward to expressing the higher education system's social influence through gender equity, education equity, global contribution, education coverage.

In the Tendency Sphere model, we selected Human Development Index, Fragile States Index, Gini Coefficient as the database. Similarly, we calculate the corresponding weights using the EWM and obtained the radius of the tendency sphere.

After the 3DVA model assessment and TS model prediction targeted at India, we get a whole picture of India's status and development tendency. Following this,

we come up with elaborate analysis and policy-formulating suggestions.

The analysis of policies and policy-formulating suggestions are also separately discussed in ST, SD, SS while considering the status quo of India's economy, politics, and India's cultural background.

Regarding to student treatment, India should center at raising enrollment rate. Regarding to school development, India should introduce reform about the structure and management of academia. Regarding to social significance, the propaganda and dissemination of human rights need to be enhanced, realizing the democratize of concepts concerning equity and democracy.

After establishing the overall reform direction, we analyze the outcomes that the policies' implementation may bring. For example, regarding to the reform of higher education institutes, it cuts the unnecessary administration expenses, yet it may cause the conflict among universities. How to enhance the positive effects and eliminate the negative effects still need to be further discussed and evaluated. But undeniably, as the second-largest country in population, fifth-largest economy, its amelioration towards higher education is of benefit to the global average education level.

2 General Assumptions

1. Acknowledge that higher education systems vary among nations while there are similarities and a unified criterion evaluating the education system can be established.

2. The statistics collected online reflect the fact and relevant researches are reliable.

3. The objects of study are reasonably selected.

4. The indicators chosen are comprehensive.

5. Admit that the models established have a certain degree of distortion with the reality, while under ideal conditions can fit the reality well.

6. The focused factors, such as the amount of higher education institutes, change mildly under the influence of time and policies.

7. The quantity of higher education institute sets the foundation of quality while it serves as a minor element.

8. The external factors such as tsunami and COVID-19 pandemic are taken no account.

9. The boundary of higher education is drawn about UNESCO, which is an optional stage of formal learning that occurs after completion of the required level of education.[2]

3 Notation Table

Table 1

Symbol	Description
SD	The student development dimension.
ST	The school development dimension.
SI	The social influence dimension.
A	The original data matrix.
Y	Matrix after data-processing.
P	Probability matrix.
$I(x)$	The information function.
$p(x)$	The probability of event x.
$C(x)$	The information quantity contained in incident x.
e_j	The information entropy of the j-th indicator.
v_j	The entropy redundant of information.
w_j	The entropy weight of the j-th indicator.
V_B	The utopia vector in our 3DVA model.
V'	The differential vector.
R	The rate of an education system.
θ	The deviation angle between a given vector and the utopia vector.
A_I	The angle indicator.
R_I	The rate indicator.
H_i	The Human Development Index of country i.
F_i	The Fragile Country Index of country i.
G_i	The Gini Coefficient of country i.
K	The administration vector.
r	The radius of the administration sphere.
k	The unification coefficient.

4 Data Obtaining, Pre-processing And Factor Categorization

4.1 Data Obtaining

To build an elaborated system of assessment, we extract the data from websites and governmental records. From Times Higher Education, we obtained the education quality indexes[3]. Moreover, we go through the United Nations Educational Scientific and Cultural Organization Institute for Statistics[4], World Bank Data[5]. Through these, we summarized the following 11 indicators.

4.2 Data Pre-processing

4.2.1 Data Missing

Assume the set of data $\boldsymbol{A_i}$, three continuous data $\boldsymbol{r_1, r_2, r_3}$.

1. If a few amounts of data is missing (e.g. $\boldsymbol{r_2}$) while adjacent data is intact, then replace the missing one with the arithmetic average of the adjacent two, i.e.

$$\boldsymbol{r_2 = \frac{r_1 + r_3}{2}} \quad (\mathbf{1})$$

2. If the data strongly showing correlation with the year indicator, then employ the regression interpolation method to calculate the missing data.

3. If a nation's data is missing in huge amount (e.g. $\boldsymbol{A_m}$), then use the arithmetic average of all other valid countries instead, i.e.

$$\boldsymbol{A_m = \frac{\sum_{i=1}^{n} A_i}{n-1}} \quad (\mathbf{2})$$

4.2.2 Outlier Occurrence

1. For data with a significant level of $\boldsymbol{\alpha < 0.01}$, we regard it as invalid so that they are discarded.

2. For data that obviously deviated from the actual meaning, we discard them.

4.3 Data Normalization

Assume the original data matrix $\boldsymbol{A(ij)}$, to calculate the weight, we need to make sure that each entry in the matrix falls in the region **[0,1]**, which is called the normalization of matrix.

Create a matrix $\boldsymbol{Y}$ that shares the same size with matrix $\boldsymbol{A}$, for an entry $\boldsymbol{y_{ij}}$ in $\boldsymbol{Y}$, let

$$y_{ij} = \frac{a_{ij} - a_{min}}{a_{max} - a_{min}} \quad (3)$$

Repeat the same process for each entry.

4.4 Factor Categorization

To access the health status and sustainability of a higher education system, we categorized the 11 indicators (as shown in Table 2) into 3 dimensions, which are student treatment, school development, and social influence.[6]

Table 2

STUDENT TREATMENT	The expenditure index for student to receive higher education.
	The enrollment rate of students who received secondary education.
SCHOOL DEVELOPMENT	The scientific research level of higher education institute.
	The academic level of higher education institute.
	The investment from government and organizations.
	The attraction of investment as well as researchers and students.
	The education quality, including teaching and infrastructure.
SOCIAL SIGNIFICANCE	The gender equity issue.
	The education equity among social statuses.
	The global contribution made.
	The education coverage in society.

5 Establish Model

5.1 Weight Calculation

After data pre-processing, we obtain a matrix $\boldsymbol{Y}$.

To calculate the weight in each indicator, we introduce the Entropy Weight Method (EWM). Firstly, we calculate the probability matrix $\boldsymbol{P}$. For the component $\boldsymbol{p_{ij}}$, it can be calculated using equation (4) as below:

$$p_{ij} = \frac{y_{ij}}{\sum_{i=1}^{11} y_{ij}} \quad (4)$$

Assume event $\boldsymbol{M}$ has $\boldsymbol{m}$ kinds of possible outcomes, $\boldsymbol{p(m_i)}$ is the probability For the $\boldsymbol{i}$-th outcome. We define the information quantity included in $\boldsymbol{i}$ can be

represented by the information function:

$$\boldsymbol{I(m_i) = -\ln\big(p(m_i)\big)} \tag{5}$$

Define the expected information quantity contained in incident $\boldsymbol{M}$ as:

$$\boldsymbol{C(M) = -\sum_{i=1}^{m}\big[p(m_i) * ln\big(p(m_i)\big)\big]} \tag{6}$$

When all possible outcomes share the same probability, $\boldsymbol{C(M)}$ obtains its maximum $\boldsymbol{\ln(m)}$.

After using the equation (4) to get the probability matrix $\boldsymbol{P}$, we then use formula (7) to calculate each indicator's information entropy $\boldsymbol{e_j}$. To get $\boldsymbol{e_j}$ falls into the region $\boldsymbol{[0,\ 1]}$, we divide the equation (6) by the constant $\boldsymbol{\ln(m)}$. For the $\boldsymbol{j}$-th indicators' information entropy:

$$\boldsymbol{e_j = -\frac{1}{\ln(m)}\sum_{i=1}^{10}\big[p_{ij} * \ln\big(p_{ij}\big)\big]} \tag{7}$$

Since the quantity of information entropy is negatively correlated with the information amount, we define the entropy redundant of information:

$$\boldsymbol{v_j = 1 - e_j} \tag{8}$$

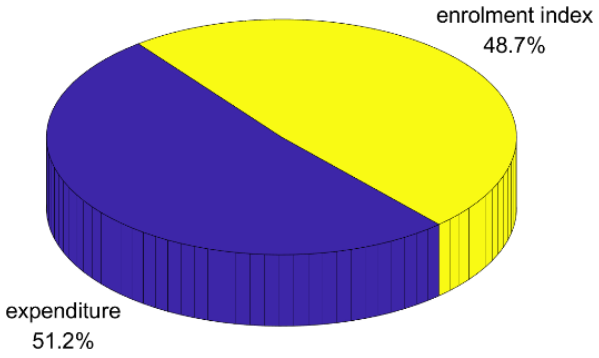
The information entropy redundant is positively correlated with the information quantity.

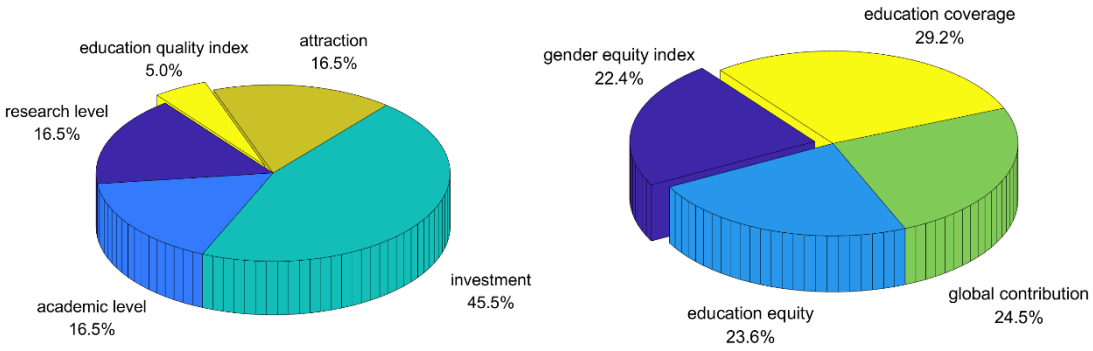
Each indicator's entropy weight:

$$\boldsymbol{w_i = \frac{1 - E_i}{k - \sum E_i}, i = 1, 2, \cdots, k} \tag{9}$$

After calculating the weight in each dimension, we obtain the result as shown in table 3.

Table 3





5.2 Three Dimensional Vector Assessment Model

With the established weight data and summarized three main aspects, we build the 3-dimension vector assessment model. The essence of the 3DVA model, is that we consider the three major aspects as irrelevant in our research scale. We meticulously adjusted the score scale so that the magnitude in each dimension could represent the wellness of the education system in the corresponding dimension.

The final evaluation score in each dimension can be calculated using the following equation:

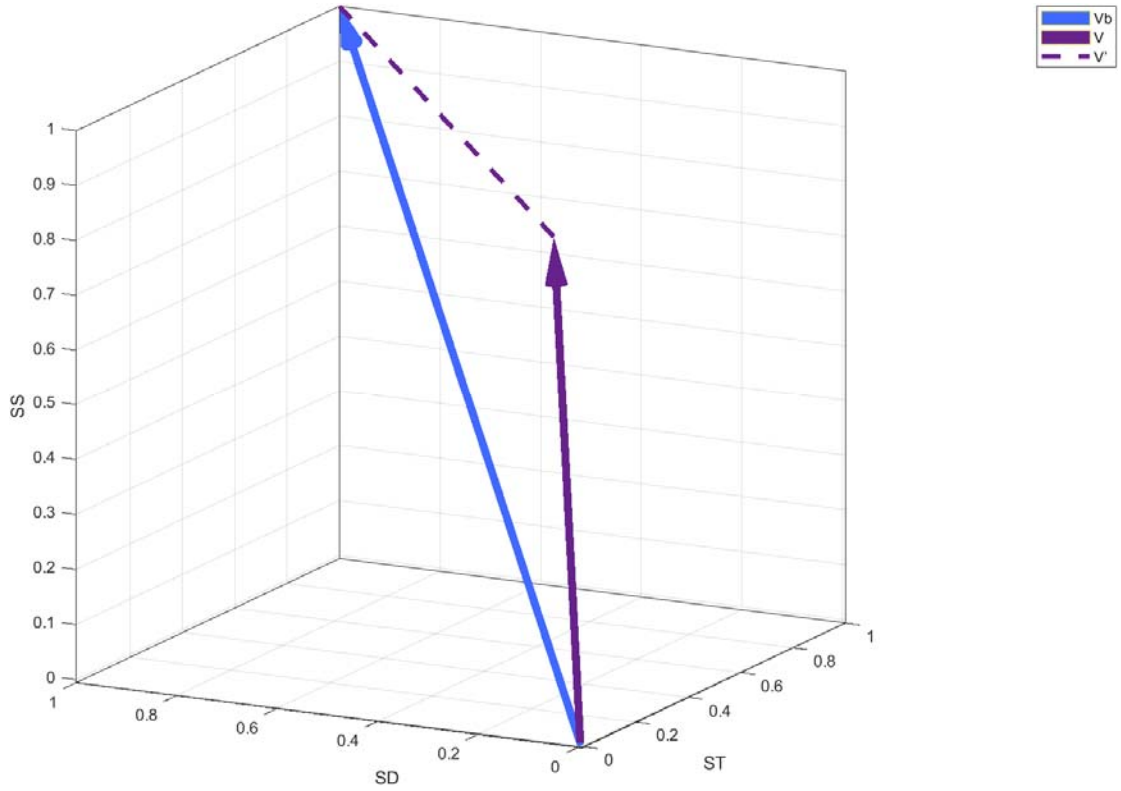
$$\begin{cases} \boldsymbol{SD} = \boldsymbol{X_1} \cdot \boldsymbol{W_1}\% \\ \boldsymbol{ST} = \boldsymbol{X_2} \cdot \boldsymbol{W_2}\% \\ \boldsymbol{SS} = \boldsymbol{X_3} \cdot \boldsymbol{W_3}\% \end{cases} \tag{10}$$

Let the vector combining three dimensions in the assessment model be assessment vector. As discussed above, since the magnitude is positively correlated to wellness, then take all dimensions into account, the best status of an education system can be represented by the utopia vector $\boldsymbol{V_B}$,

$$\boldsymbol{V_B} = \begin{bmatrix} \boldsymbol{1} \\ \boldsymbol{1} \\ \boldsymbol{1} \end{bmatrix}$$

For a given assessment vector $\boldsymbol{V} = \begin{bmatrix} \boldsymbol{ST} \\ \boldsymbol{SD} \\ \boldsymbol{SS} \end{bmatrix} = \begin{bmatrix} \boldsymbol{t} \\ \boldsymbol{d} \\ \boldsymbol{s} \end{bmatrix}$, we judge the corresponding education system by its relationship with $\boldsymbol{V_B}$.

Figure 1



The differential vector $\boldsymbol{V' = V_B - V}$ as shown in the figure 1 can be interpreted as the disparity between the status and the ideal status, which contributes to recognizing the most urgent development aspect when it comes to policy formulation.

We define the status rate of an education system as:

$$\boldsymbol{R = \frac{|V|}{|V_B|}} \tag{11}$$

This rate portrays the overall performance of an education system combining both health and sustainability. The higher this rate is, the better the education system performances.

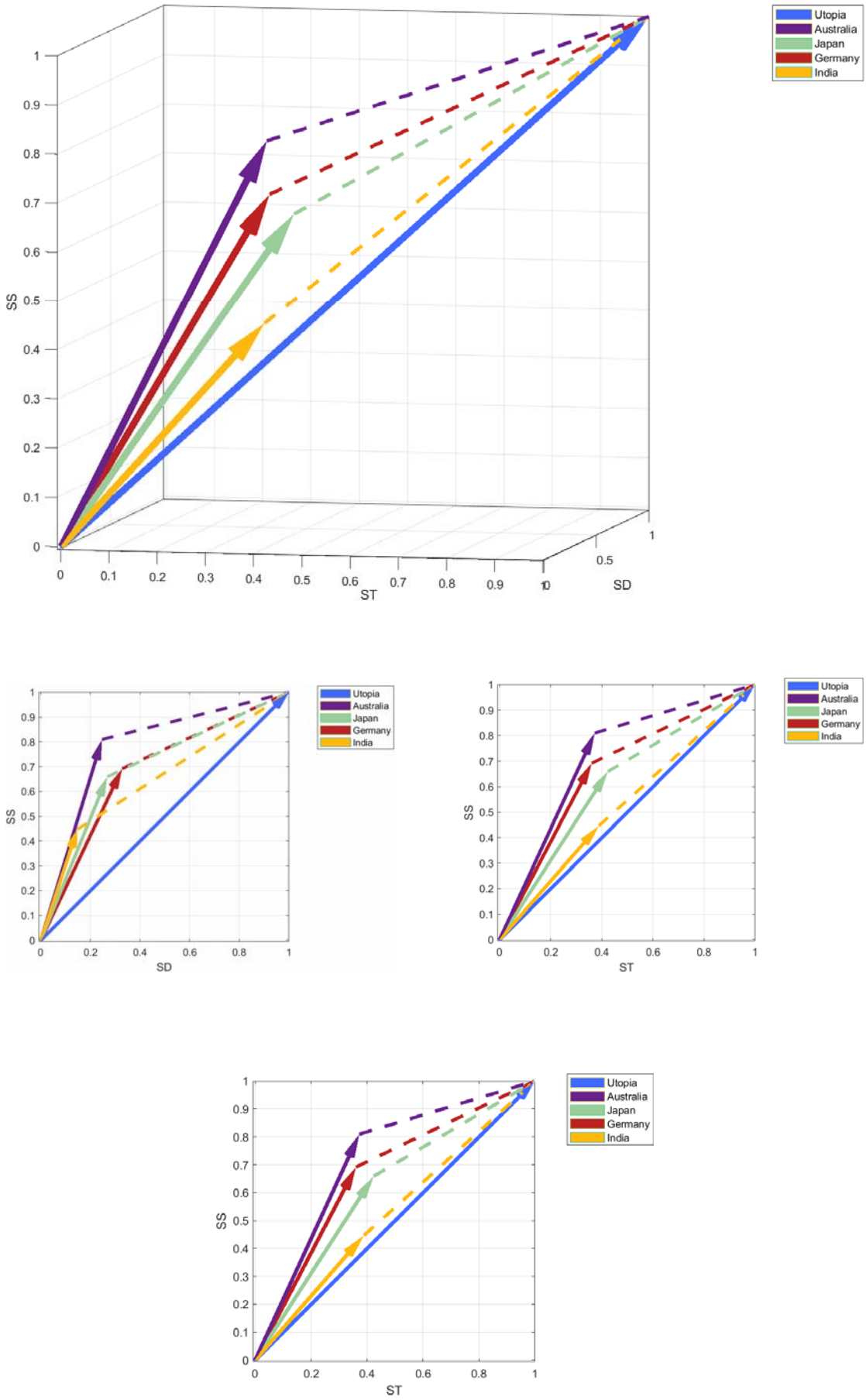
Consider the angle $\boldsymbol{\theta}$ between $\boldsymbol{V}$ and $\boldsymbol{V_B}$.

$$\boldsymbol{\theta = \cos^{-1}\left(\frac{V \cdot V_B}{|V| \cdot |V_B|}\right)} \tag{12}$$

Through observation, Cannikin's law can be applied here. I.e., the deviation scale is accumulated in three dimensions rather than compensated. The magnitude of $\boldsymbol{\theta}$ represents the total deviation scale, which illustrates the imbalance of an education system.

To check the validity of our assessment model, we select 4 representative countries for examination, which are Germany, India, Japan, and Australia. Their assessment vectors are depicted in figure 2.

Figure 2



The calculated results are listed in table 4.

Table 4

	R	θ(rad)
Germany	0.4883	0.3436
India	0.3522	0.3769
Japan	0.4780	0.3429
Australia	0.5336	0.4690

Through the figure 2 and table 4, we discover that India shows the largest scale of imbalance and unsustainability. Therefore, we select India for later policy-related discussion.

6 Tendency Sphere Model

Based on the discussion above, we need to establish a model to describe the future development tendency and analyze the possible effects of raised policies.

6.1 The Establishment of TS Model

Based on the result shown by the 3DVA model, we establish the tendency sphere model. The tendency sphere model mainly focuses on how the education system evolves from the basis of its current education system status. The purpose is clear: decrease the deviation angel $\boldsymbol{\theta}$ and increase the magnitude of the status rate $\boldsymbol{R}$. To illustrate the details and functions of this model, we correspondingly define the angle indicator $\boldsymbol{A_I}$ and the rate indicator $\boldsymbol{R_I}$.

After reading relevant materials, we discover that the education systems' development is affected by much wider fields including economy, politics, diplomacy, etc. To build a complete model, we select 3 indexes as indicators for determining a nation's education developing speed and tendency, which are Human Development Index (HDI), Fragile States Index (FSI), and Gini Coefficient (Gini).

The Human Development Index is a statistic composite index of life expectancy, education, and per capita income indicators, which are used to rank countries into four tiers of human development. A country's HDI score is positively correlated with lifespan longevity, education level, and gross national income.

The Fragile States Index aims to assess states' vulnerability to conflict or collapse, ranking all sovereign states with membership in the United Nations where there is enough data available for analysis. The ranking is based on the sum of scores for 12

indicators categorized into cohesion, economic, political, social.

The Gini coefficient is a measure of statistical dispersion intended to represent the income inequality or wealth inequality within a nation or any other group of people. [7]

For country $\boldsymbol{i}$, let its Human Development Index be $\boldsymbol{H_i}$, accordingly, its Fragile States Index is $\boldsymbol{F_i}$ and Gini coefficient is $\boldsymbol{G_i}$. Based on the correlations and collected data, we use the Entropy Weight Method to calculate each term's weight. Using the same method, we obtain the result shown in table 5.

Table 5

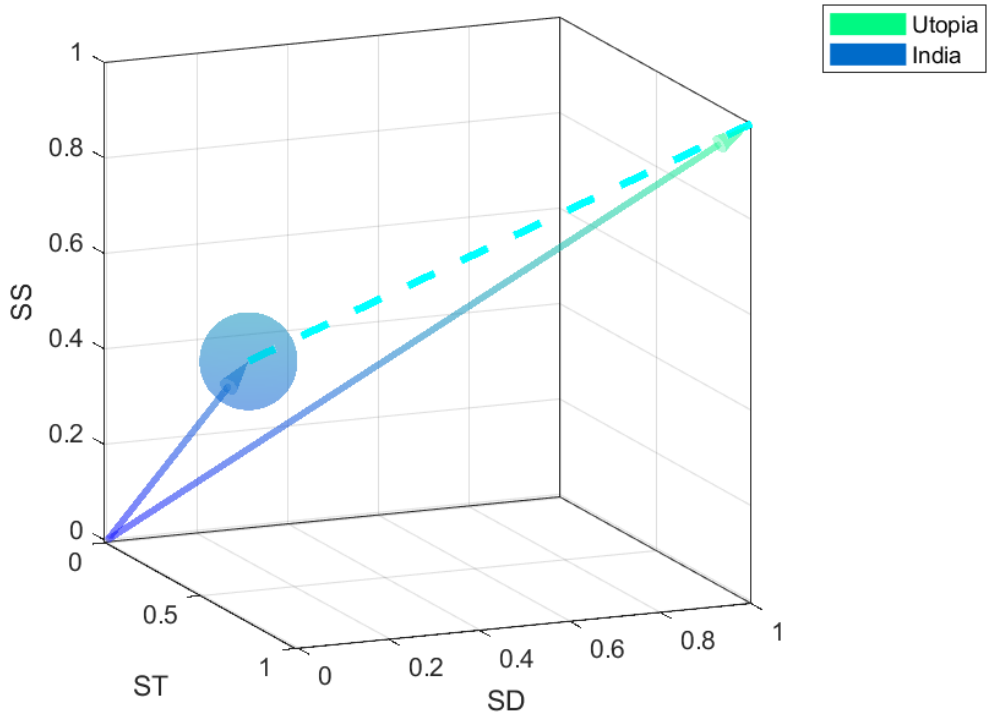
	$\boldsymbol{W_H}$	$\boldsymbol{W_F}$	$\boldsymbol{W_G}$
Weight	0.0290	0.8557	0.1152

The effect combining each aspect can be quantified as the administration vector $\boldsymbol{K}$ in the education space. Its module reflects a country's development potential regarding education. In the 3DVA graph, its geometric interpretation is a sphere centered at the endpoint of the assessment vector $\boldsymbol{V}$. Its radius $\boldsymbol{r}$ is determined by the formula (13):

$$\boldsymbol{r = k(W_H \cdot H_i + W_F \cdot F_i + W_G \cdot G_i)} \qquad \textbf{(13)}$$

where $\boldsymbol{k}$ is the unification coefficient used for uniting the score with the 3DVA model. Now that the sphere with radius $\boldsymbol{r}$ represents a country's administration ability of reform and govern in the assessment space, as figure 3 depicts.

Figure 3



Assume the assessment vector lands on the point $\boldsymbol{P_0(D_0, T_0, S_0)}$, the point set formed by all possible $\boldsymbol{K}$s satisfies:

$$\boldsymbol{(D - D_0)^2 + (T - T_0)^2 + (S - S_0)^2 \leq r^2} \quad \textbf{(14)}$$

Since each point contained in the sphere has a corresponding point on the sphere, sharing the same deviation angle but larger in module, then we can limit the discussion on the surface only.

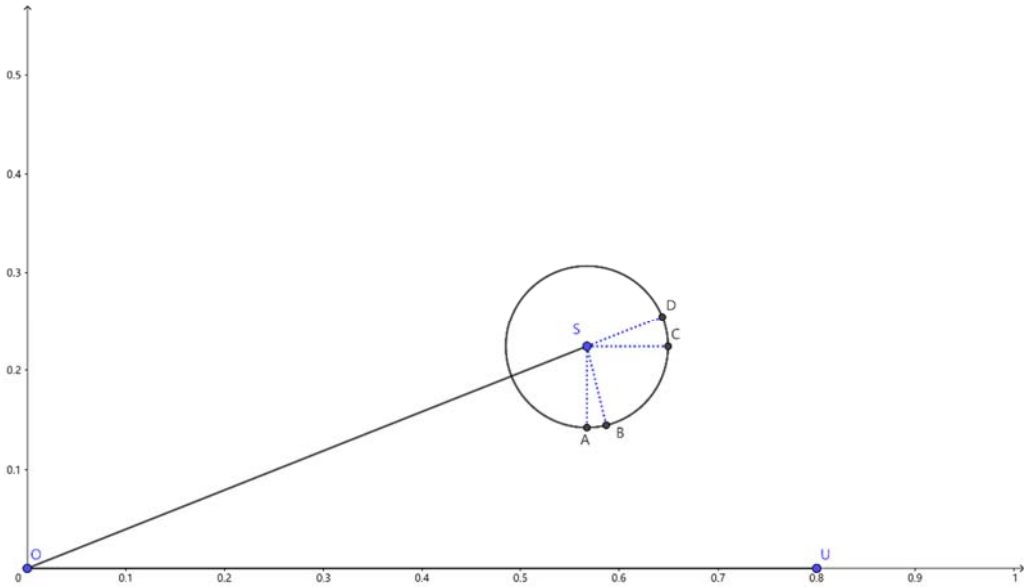
We rotate the plane so that the assessment vector $\boldsymbol{V_0}$ and the utopia vector $\boldsymbol{V_B}$ are coplanar. Now the angle reflects its true value. For each non- coplanar point, there's a corresponding planar point that share the same module but smaller in deviation angle. Now we achieve the dimension reduction. Only the planar calculation is required.

When the synthesized vector is tangent to the circle, the deviation angle reaches its minimum while when the synthesized vector is collinear with the assessment vector, the module reaches maximum. Since we cannot reach the optimal goal at the same time, we must make a trade-off between module enlargement and deviation angle diminution. Furthermore, this trade-off reflects that in real-world, balancing a system and advancing a system may not necessarily be in the same direction.

To determine the weight of angle-magnitude compensating, we introduce the angle indicator $\boldsymbol{A_I}$ and the rate indicator $\boldsymbol{R_I}$ as mentioned above. We study India's alteration in a decade and assume its administration capacity only has a minor scale of change, which is negligible. Still, the upper discussion of domain holds. Only the magnitude of the administration vector's magnitude is changed.

We now use the polar coordinate system for further discussion. As figure 4 depicts.

Figure 4



Note that the radius is enlarged for illustration.

The magnitude reaches maximum when $\boldsymbol{K}$ is in the direction of $\boldsymbol{OC}$ while the deviation angle reaches minimum when $\boldsymbol{K}$ is in the direction of $\boldsymbol{SA}$. However, since we cannot develop advancement at the cost of expanding inequity and vice versa, we limit the discussion on the arc $\widehat{\boldsymbol{AC}}$. Since $\boldsymbol{OB}$ is the circle $\boldsymbol{S}$'s secant, also any point on arc $\widehat{\boldsymbol{BC}}$ has a larger corresponding magnitude than any point on arc $\widehat{\boldsymbol{AB}}$, then we can eliminate the arc $\widehat{\boldsymbol{AB}}$ out of discussion.

The final impact of policies' implementation vector falls on the region of arc $\widehat{\boldsymbol{BC}}$ is considered as the optimal situation.

7 Policies in Accordance

7.1 Student Treatment

In respect to student treatment, the higher education expense and admission rate are of approximate weight. However, India only has a higher education admission rate of 13.0%. There's a huge gap between India and other developed countries such as Japan as well as Australia.

To increase the total enrollment number of higher education in India, the core problem is that the students in India are short of aids and the schools are in poor condition. Consider the extreme class division phenomenon in India, the discrimination on campus cannot be ignored. However, since this problem is not representative enough, we skip this topic during later discussion.

Our corresponding policy advice is:

1. Increase the fund of higher education nationwide, for infrastructure building, raising teaching quality, provide the students with more opportunities of the internship.

2. Establish special aids and scholarships for qualified applicants.

3. Set up special programs such as book-trading, open-access online courses.

Comment: In a short period of time, the higher education enrollment rate can increase drastically. However, if the funding scale is overly large, it may cause stagnation in other areas. This may bring imbalance to the whole system. So, keep the pace of funding slowly but continuously, also identify the qualification of each applicant carefully. In the same process, relevant authorities should partner with National Statistics Bureau to build a filing system to increase the sustainability of the whole funding system.[8]

7.2 School Development

Regarding school development, we can see from the table 3 that the investment takes up the most weight, research level, academic level, and attraction are of the equal weight of 16.5%.

Research is “creative and systematic work undertaken to increase the stock of knowledge” by definition. Therefore, a nation’s academic level and research level are of vital significance. India’s research and academic level are of low rank. Undoubtfully, this factor contributes to the current horrible education level in India on a very large scale. To improve the education status of India, the task of enhancing the research level is unavoidable.

1. Introduce resolute reform and erase the formalism from the current research regulations. For there’s no regulatory institutions nor supervision system over academic as well as research misconducts. What’s more, no relevant legal regulation has ever been established. Hence the vitality of a resolute reform.

2. Increase the governmental fund to universities and research institutes. For the recent 20 years, India’s expense on scientific research converges to 0.65% of the total GDP, far lag than the average standard of the United States and Europe.

3. Follow the global development trend, encourage cooperation between enterprises and academia.

Commentary: As Mukhtar Ahmad mentioned, the higher education teaching quality is in close relevance to teachers’ quality. High-quality teachers take up a very little portion of the whole teaching industry. While the common phenomenon is that most teachers are ignorant of teaching standards, teaching off a blackboard becomes the norm. In addition, temporary teachers and visiting professors take up a large part of Indian universities’ faculty. The faculty lacks continuity, hence ameliorating the whole university faculty structure is the way to go.

Now India is extremely lack in high-technology research talents. We can establish a set of policies such as Germany’s “green card” program to solve the foreign talents’ worries. Reference China’s “1,000 Talents Plan” to provide funds and support in other forms.

Although India’s higher education expenditure’s portion in GDP is of leading rank, its higher education’s outcome is unsatisfying. With the existence of a college-university affiliation system, there’s a huge administration cost. We can also introduce the cooperate projects between universities and enterprises. Proving universities with abundant funds and energize the enterprises.

7.3 Social Significance

As a result of the higher education system in India, there're very few formal universities around India. The college-university affiliation system, as mentioned above, leads to a limited capacitance of the higher education system. To raise the education penetration rate, Indian government has to enlarge the enrollment scale of universities and rationalize the higher education system for the long run.

Note that India is a religious country, the deep-rooted caste system, and social-economic imbalance gave rise to the occurrence of multiply disadvantaged groups. To realize education equity, we have to make sure that the disadvantaged groups' rights are safeguarded in the first place.

1. Implement an enrollment quota system, promote higher education equity. Guarantee class mobility.

2. Set up multiple school or government funds to subsidize the impecunious groups.

3. Start the reform with elementary education. The disadvantaged groups suffer from low admittance, high drop rate, and poor education quality since elementary education.

4. Reserve quota especially for the female group, establish laws in accordance to protect women's rights to receive an education. Promote propaganda to reinforce the perception shift about gender equity.

Commentary: Realize gender equity in higher education. As the Times Higher Education data points out, India's top universities' gender diversity ranked first in the world, which gives us a glance at inequality in India. Because of the patriarchal society's mainstream culture, in some regions, the females are treated as the "second class citizen". Many females dropped out since high school. Though the reserved quota can guarantee the equity issue the Indian government is facing, it may intensify the conflict among advantaged groups and disadvantaged groups.[9][10]

8 Analysis on The Impact of Policy Implementation

8.1 Student Treatment

The target policies mentioned above focus mainly on the expansion of the higher education enrollment scale, providing aids for qualified applicants, safeguard the disadvantaged groups. Therefore, on the personal scale, the implementation of these policies would bring life-altering chances to the individuals.

The undesirable impacts would arise at the same time. Such as the involution occurrence. Under the background of the student enrollment index rising, the education quality may not be ensured. Moreover, due to the existence of the Caste system and social prejudice, the equity issue related policies may face huge resistance.[11]

8.2 School Development

The advancement of higher education institutes is positively correlated with the government's capital investment. The governmental funds would bring alterations in financial structure, unnecessary administration expenses could be cut. Universities may function more smoothly and rationally. In the gradual enhancement of higher education reform, more foreign talents and investments would be attracted.

Nevertheless, the investment of government funds would cause conflict among universities, even different departments within one university. The imbalanced distribution of funding may increase inequity in research.[12]

8.3 Social Significance

8.3.1 Nationwide Impact

The reform in education brings vitality to the whole nation's development. Not only a solid academic foundation is built, but also more talents of science and engineering background are trained. The cultivation of talents is the basis of a country's advancement. Innovation relies heavily on talents. With their presence, more knowledge-intensive, commercial valuable enterprises would be attracted. Undoubtfully, India's economic growth tendency is positively influenced, which forms a benign circulation.

The reform of education couldn't be realized in a flash. India's education status has severe problems in many aspects. Because of the lengthy influence of the Caste system and religious culture, many concepts are ingrained, which inject huge obstruction to the implementation of multiple policies. In consideration of India's current financial status, we can no longer urge the India government to add investment to higher education. India's higher education development still has a long way to go.[10][9]

8.3.2 Worldwide Impact

India has the second-largest population in the world, occupies the position of the fifth largest economy, whereas India's average GDP takes up the 137^{th} of the world.

The implement of these policies would bring economic growth, which contributes to the world population's poverty liberating. Based on India's experiences, other developing countries could also draft policies of their own status.

9 Strengths and Weaknesses

9.1 Strengths

1. Intuitive

We used the combination of the 3DVA model and the Tendency Sphere model, which uses graphical interpretation of the meaning of data. The problems and the development pace of a country's higher education system are visualized.

2. Rigorous Categorization

The dimensions and indicators are established after reviewing massive relevant materials, they span the whole education research focuses. Moreover, we considered the affect of other areas and introduced indicators such as Gini Coefficient and Human Development Index for a more thorough discussion.

3. Universal

The model we built are based on the data collected all over the world, thus, the model is universal for usage. Once the input data is determined, the output can approximately reflect a country's higher education system's status and tendency for growth.

9.2 Weaknesses

1. Data-dependent

The Entropy Weight Method relies on quantity of data heavily. This caused the whole model's data dependence. When it comes to data missing and fake data, the error is unavoidable.

2. The consideration of change in administration ability is incomplete

A country's administration ability is dynamic instead of fixed. So, the administration vector in the Tendency Sphere model is inaccurate. The precision of the Tendency Sphere model is not high. Only a rough prediction can be made.

3. Disjoined

Our model doesn't include exceptional events such as wars, natural disasters, which is observable in the real world. For countries that suffer from relevant factors' effect, this model may not be applicable.

Reference

[1] M. Davis, “Can College Rankings Be Believed?,” *She Ji*, vol. 2, no. 3, pp. 215–230, 2016, doi: 10.1016/j.sheji.2016.11.002.

[2] “https://en.m.wikipedia.org/wiki/Higher_education.” .

[3] “Impact rankings 2020: quality education,” *https://www.timeshighereducation.com/rankings/impact/2020/quality-education#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/undefined*. .

[4] U. I. for Statistics, “Education System Characteristics and Education Expenditure.”

[5] W. B. Data, “Government Expenditure on Education.” .

[6] “Higher Education Expence,” *https://collegescorecard.ed.gov/ QS*. .

[7] “Gini Coefficient,” *https://knoema.com/atlas/topics/Poverty/Income-Inequality/GINI-index?baseRegion=IN*. .

[8] “Population Receiving HE,” *https://data.oecd.org/eduatt/population-with-tertiary-education.htm*. .

[9] “Justice,” *https://www.timeshighereducation.com/rankings/impact/2020/peace-justice-and-strong-institutions#!/page/1/length/25/sort_by/rank/sort_order/asc/cols/undefined*. .

[10] “Gender Equity,” *https://www.oecd-ilibrary.org/education/education-atglance19991487*. .

[11] “Education Quality,” *https://www.timeshighereducation.com/rankings/impact/2020/qualityeducation#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/undefined*.

[12] “Governmental Expenses,” *https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?end=2019&start=1970*. .

Appendix

Code1: 3DVA Model

```
start_point1=[0,0,0];%设定理想向量（即 Utopia 向量）的初始点
stop_point1=[0.95,0.95,0.95];%设定理想向量的终点，这里由于在建立 arrow3 函数时箭头圆锥的高度并不容易考虑，所以在作图设定箭头高度为（√3）/20 时，向量的模长要相应减少同样的长度

a=xlsread('data.xlsx','Sheet1')/100;%导入国家数据，并使数据的值控制在 0~1 之间。

AU=a(1,:);%Australia
JP=a(2,:);%Japan
DE=a(3,:);%Germany
IN=a(4,:);%India

mA=sqrt(sum(AU.*AU,2))%计算向量模长
mJ=sqrt(sum(JP.*JP,2))
mG=sqrt(sum(DE.*DE,2))
mI=sqrt(sum(IN.*IN,2))

aA=acos((dot([1,1,1],AU))/(mA*sqrt(3)))%计算向量与 Utopia 向量的夹角
aJ=acos((dot([1,1,1],JP))/(mJ*sqrt(3)))
aG=acos((dot([1,1,1],DE))/(mG*sqrt(3)))
aI=acos((dot([1,1,1],IN))/(mI*sqrt(3)))

pA=AU*(mA-sqrt(3)/20)/mA%设定向量终点，同本代码数据第二条
pJ=JP*(mJ-sqrt(3)/20)/mJ
pG=DE*(mG-sqrt(3)/20)/mG
pI=IN*(mI-sqrt(3)/20)/mI

p1=arrow3(start_point1,stop_point1,0.007,sqrt(3)/20,0.02,[65/255 105/255 1]);%绘制箭头向量
p2=arrow3(start_point1,pA,0.007,sqrt(3)/20,0.02,[104/255 34/255 139/255]);
p3=arrow3(start_point1,pJ,0.007,sqrt(3)/20,0.02,[155/255 205/255 155/255]);
p4=arrow3(start_point1,pG,0.007,sqrt(3)/20,0.02,[188/255 34/255 34/255]);
p5=arrow3(start_point1,pI,0.007,sqrt(3)/20,0.02,[1 185/255 15/255]);

h1=plot3([AU(:,1) 1],[AU(:,2) 1],[AU(:,3) 1],'--
','color','#68228B','linewidth',3)%将四个国家的向量终点用虚线连接至 Utopia 向量终点
h2=plot3([JP(:,1) 1],[JP(:,2) 1],[JP(:,3) 1],'--
','color','#9BCD9B','linewidth',3)
h3=plot3([DE(:,1) 1],[DE(:,2) 1],[DE(:,3) 1],'--
','color','#BC2222','linewidth',3)
h4=plot3([IN(:,1) 1],[IN(:,2) 1],[IN(:,3) 1],'--
```

```
','color','#FFB90F','linewidth',3)

legend([p1 p2 p3 p4 p5],'Utopia','Australia','Japan','Germany','India');%设置图例 start_point1=[0,0,0];%设定理想向量（即 Utopia 向量）的初始点
stop_point1=[0.95,0.95,0.95];%设定理想向量的终点，这里由于在建立 arrow3 函数时箭头圆锥的高度并不容易考虑，所以在作图设定箭头高度为（√3）/20 时，向量的模长要相应减少同样的长度

a=xlsread('data.xlsx','Sheet1')/100;%导入国家数据，并使数据的值控制在 0~1 之间。

AU=a(1,:);%Australia
JP=a(2,:);%Japan
DE=a(3,:);%Germany
IN=a(4,:);%India

mA=sqrt(sum(AU.*AU,2))%计算向量模长
mJ=sqrt(sum(JP.*JP,2))
mG=sqrt(sum(DE.*DE,2))
mI=sqrt(sum(IN.*IN,2))

aA=acos((dot([1,1,1],AU))/(mA*sqrt(3)))%计算向量与 Utopia 向量的夹角
aJ=acos((dot([1,1,1],JP))/(mJ*sqrt(3)))
aG=acos((dot([1,1,1],DE))/(mG*sqrt(3)))
aI=acos((dot([1,1,1],IN))/(mI*sqrt(3)))

pA=AU*(mA-sqrt(3)/20)/mA%设定向量终点，同本代码数据第二条
pJ=JP*(mJ-sqrt(3)/20)/mJ
pG=DE*(mG-sqrt(3)/20)/mG
pI=IN*(mI-sqrt(3)/20)/mI

p1=arrow3(start_point1,stop_point1,0.007,sqrt(3)/20,0.02,[65/255 105/255 1]);%绘制箭头向量
p2=arrow3(start_point1,pA,0.007,sqrt(3)/20,0.02,[104/255 34/255 139/255]);
p3=arrow3(start_point1,pJ,0.007,sqrt(3)/20,0.02,[155/255 205/255 155/255]);
p4=arrow3(start_point1,pG,0.007,sqrt(3)/20,0.02,[188/255 34/255 34/255]);
p5=arrow3(start_point1,pI,0.007,sqrt(3)/20,0.02,[1 185/255 15/255]);

h1=plot3([AU(:,1) 1],[AU(:,2) 1],[AU(:,3) 1],'--
','color','#68228B','linewidth',3)%将四个国家的向量终点用虚线连接至 Utopia 向量终点
h2=plot3([JP(:,1) 1],[JP(:,2) 1],[JP(:,3) 1],'--
','color','#9BCD9B','linewidth',3)
h3=plot3([DE(:,1) 1],[DE(:,2) 1],[DE(:,3) 1],'--
','color','#BC2222','linewidth',3)
h4=plot3([IN(:,1) 1],[IN(:,2) 1],[IN(:,3) 1],'--
','color','#FFB90F','linewidth',3)
```

```
legend([p1 p2 p3 p4 p5],'Utopia','Australia','Japan','Germany','India');%设置图例
```

Code 2:Tendency Sphere Model

```
start_point1=[0,0,0];
stop_point1=[0.95,0.95,0.95];

a=xlsread('data4.xlsx','Sheet1')/100;

IN=a(4,:);

mI=sqrt(sum(IN.*IN,2))

pI=IN*(mI-sqrt(3)/20)/mI

p1=arrow3(start_point1,stop_point1,0.007,sqrt(3)/20,0.02,[65/255 105/255 1]);
p5=arrow3(start_point1,pI,0.007,sqrt(3)/20,0.02,[1 185/255 15/255]);

h4=plot3([IN(:,1) 1],[IN(:,2) 1],[IN(:,3) 1],'--','color','c','linewidth',3)% 以 上代码引用自‘main’文件

ellipsoid(IN(:,1),IN(:,2),IN(:,3),0.1,0.1,0.1,60)%在 India 向量末端绘制 r=0.1 的球体

legend([p1 p5],'Utopia','India');%设置图例

shading interp
alpha(0.3)%将图像设置成透明，便于看出球体内包含的向量箭头
colormap(winter)%给图像上色
```

Code3:Arrow Plot

```
function p=arrow3(X1,X2,r1,h,r2,color)
%一个简单的实例：arrow3([1 2 3],[7 8 9],0.25,1,0.6,'b');
%箭头由圆柱体和圆锥体组成:包括圆柱体的起点和终点位置，以及半径，圆锥的半径和高度
hold on;
box on;
grid on;
cylinder3(X1,X2,r1,color)
X3=(X2-X1)/norm(X2-X1)*h+X2;
p=cone3(X2,X3,r2,color)
end
```

```
function cylinder3(X1,X2,r,color)
%一个简单的例子：cylinder3([1 2 3],[7 8 9],1,'b')
length_cyl=norm(X2-X1);
[x,y,z]=cylinder(r,100);
z=z*length_cyl;
%绘制两个底面
hold on;
EndPlate1=fill3(x(1,:),y(1,:),z(1,:),'r');
EndPlate2=fill3(x(2,:),y(2,:),z(2,:),'r');
Cylinder=mesh(x,y,z);
%计算圆柱体旋转的角度
unit_V=[0 0 1];
angle_X1X2=acos(dot( unit_V,(X2-X1) )/( norm(unit_V)*norm(X2-X1)) )*180/pi;
%计算旋转轴
axis_rot=cross(unit_V,(X2-X1));
%将圆柱体旋转到期望方向
if angle_X1X2~=0 % Rotation is not needed if required direction is along X
    rotate(Cylinder,axis_rot,angle_X1X2,[0 0 0])
    rotate(EndPlate1,axis_rot,angle_X1X2,[0 0 0])
    rotate(EndPlate2,axis_rot,angle_X1X2,[0 0 0])
end
%将圆柱体和平面挪到期望的位置
set(EndPlate1,'XData',get(EndPlate1,'XData')+X1(1))
set(EndPlate1,'YData',get(EndPlate1,'YData')+X1(2))
set(EndPlate1,'ZData',get(EndPlate1,'ZData')+X1(3))
set(EndPlate2,'XData',get(EndPlate2,'XData')+X1(1))
set(EndPlate2,'YData',get(EndPlate2,'YData')+X1(2))
set(EndPlate2,'ZData',get(EndPlate2,'ZData')+X1(3))
set(Cylinder,'XData',get(Cylinder,'XData')+X1(1))
set(Cylinder,'YData',get(Cylinder,'YData')+X1(2))
set(Cylinder,'ZData',get(Cylinder,'ZData')+X1(3))
% 设置圆柱体的颜色
set(Cylinder,'FaceColor',color)
set([EndPlate1 EndPlate2],'FaceColor',color)
set(Cylinder,'EdgeAlpha',0)
set([EndPlate1 EndPlate2],'EdgeAlpha',0)
axis equal;
xlabel('ST');
ylabel('SD');
zlabel('SS');
view(3)
end

function p=cone3(X1,X2,r,color)
```

```
%一个简单的例子：cone3([1 2 3],[7 8 9],1,'b');%两个空间点位置，圆锥底面半径，颜色
% 圆锥的高度
length_cyl=norm(X2-X1);
[x,y,z]=cylinder(linspace(r,0,50),100);
z=z*length_cyl;
%绘制圆锥底面
hold on;
EndPlate1=fill3(x(1,:),y(1,:),z(1,:),'r');
Cylinder=mesh(x,y,z);
p=Cylinder;
%计算圆锥体旋转的角度
unit_V=[0 0 1];
angle_X1X2=acos(dot( unit_V,(X2-X1) )/( norm(unit_V)*norm(X2-X1)) )*180/pi;
%计算旋转轴
axis_rot=cross(unit_V,(X2-X1));
%将圆锥体旋转到期望方向
if angle_X1X2~=0 % Rotation is not needed if required direction is along X
    rotate(Cylinder,axis_rot,angle_X1X2,[0 0 0])
    rotate(EndPlate1,axis_rot,angle_X1X2,[0 0 0])
end
%将圆锥体和底面挪到期望的位置
set(EndPlate1,'XData',get(EndPlate1,'XData')+X1(1))
set(EndPlate1,'YData',get(EndPlate1,'YData')+X1(2))
set(EndPlate1,'ZData',get(EndPlate1,'ZData')+X1(3))
set(Cylinder,'XData',get(Cylinder,'XData')+X1(1))
set(Cylinder,'YData',get(Cylinder,'YData')+X1(2))
set(Cylinder,'ZData',get(Cylinder,'ZData')+X1(3))
% 设置圆锥体的颜色
set(Cylinder,'FaceColor',color)
set(EndPlate1,'FaceColor',color)
set(Cylinder,'EdgeAlpha',0)
set(EndPlate1,'EdgeAlpha',0)
axis equal;
view(3)
end
```

Code4:Entropy Weight Method

```
x=xlsread('data.xlsx','Sheet1');%导入数据

[rows,cols]=size(x);%确定数据的行列
k=1/log(rows);%计算不确定性函数的数值

f=zeros(rows,cols);
```

```
sumBycols=sum(x,1);

for i=1:rows
for j=1:cols
f(i,j)=x(i,j)./sumBycols(1,j);%计算第 i 个国家第 j 个指标的比重
end
end

lnfij=zeros(rows,cols);
for i=1:rows
for j=1:cols
if f(i,j)==0
lnfij(i,j)=0;
else
lnfij(i,j)=log(f(i,j));%计算不确定性
end
end
end

Hj=-k*(sum(f.*lnfij,1));%计算信息熵
weights=(1-Hj)/(cols-sum(Hj))%计算出权重
```