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Grain System Model Based on Weight Change

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Abstract: In order to establish an efficient model to represent the current global food system, considering that the current global food system is affected by different factors, and different factors have different degrees of comprehensive influence, this paper choose Entropy Weight Method to judge the influence of each factor on the system. The results calculated by the entropy method will change with the samples, which can be corrected by AHP. The results are processed by entropy method and then combined with analytic hierarchy process (AHP). Two vectors representing efficiency and profitability and fairness and sustainability respectively are obtained, which are represented by EPES1 and EPES2.EPES2 will change the weight of the four influencing factors through AHP to build a model that is biased towards fairness and sustainability.

1. Introduction

Hunger is the global enemy of mankind. Even though great progress has been made in the fight against hunger, a vast majority of the world's population still suffers from hunger because of lack of food. All of our current food systems focus on efficiency and profitability, which leads to a neglect of equity and sustainability. As we expand food production, we are also damaging the environment and affecting biodiversity. In order to form a sound grain system for the development of the next generation, it is necessary to continue to optimize the existing grain system.

Based on the above problems, we established a model, in which we converted the factors affecting grain production into weights, and quantified the influence of factors changes on grain returns and social ecological environment through weights, thus solving the problems required by the question.

2. The model about Efficiency-profit-equity-sustainability

2.1 Selection of food system indicators

The current food system prioritizes efficiency and profitability (hereafter referred to as (EPES 1). Therefore, equity and sustainability (EPES 2) need to be reconsidered in order to optimize the current food system. Therefore, our model needs to consider two different premises respectively. At the same time, since the indexes such as efficiency, fairness and sustainability involved cannot be directly represented by some relevant data, we choose to use multiple data collocation to represent these indexes. The indicators we have chosen are not only easy to obtain, but also convenient to use as indirect indicators of what is needed. In order to make a more intuitive explanation, we need to continue to classify multiple data more accurately. The world food system is divided into three layers:

the target layer, the indicator layer and the sub-indicator layer. Individual data in the index layer is represented using the indirection mentioned above. The EPES table to list the other indicators related to the required data is shown in table 1.

Table 1: Introduction to indicators

Target Layer	**Indicator layer**	**Sub-indicator layer**	**Direction**
The model about Efficiency-profit-equity-sustainability ($EPES$)	Efficiency indicators ($EPES_1$)	Annual grain capacity	+
		Government expenditures	+
		Energy consumption	+
	Profitability indicators ($EPES_2$)	Export volume	+
		The proportion of grain in GDP	+
	Equity indicator ($EPES_3$)	The proportion of under-nourished people in the national population	-
		Calorie Intake	+
	Sustainability indicator ($EPES_4$)	Arable land per capita	+
		Average temperature	+
		Carbon dioxide emissions	-
		Population size	-
		The proportion of land biological reserves	+

2.2 A model that focuses on efficiency and profitability ——EPES1

In this kind of EPES model, the index weight plays a crucial role in the model and directly affects the accuracy of the evaluation results. Entropy Weight Method (EWM) is an objective weighting method. So we use it to determine the weight of the index. We tested the model by collecting relevant data from six different countries. The we use the Entropy Weight Method, using Entropy Weight Method, due to the magnitude of each data and measurement is different, we need the data normalization processing, individual data into decimal (0, 1), to facilitate the later data processing, we to a certain degree of modified formula, make its in some premise, has more scalability.

The 12 indicators mentioned above have positive correlation and negative correlation on efficiency and profitability. Therefore, we need to normalize the data in the case of positive correlation and in the case of negative correlation.

In the positive correlation case:

$$\boldsymbol{r_{ij} = \frac{y_{ij} - r_{min}}{r_{max} - r_{min}} + 1}$$

In the negative correlation case:

$$\boldsymbol{r_{ij} = \frac{r_{min} - y_{ij}}{r_{max} - r_{min}} - 1}$$

r_{min}, r_{max} represents the minimum and maximum values of a set of data, respectively. y_{ij} is the row. r_{ij} is the normalized value.

Next, we calculate the proportion of i country in the j factor:

$$\boldsymbol{p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{n} r_{ij}}}$$

Then, calculate the entropy weight "e_j" of the j-th index:

$$\boldsymbol{e_j = -\ (ln\frac{1}{n})\ \sum_{i=1}^{n} p_{ij} ln\ \ (p_{ij})}$$

And, calculate the difference coefficient "g_j" of the j-th index

$$\boldsymbol{g_j = \frac{1 - e_j}{n - \sum_j e_j} j = 1, 2, 3, \ldots, n}$$

And, calculating weight “w_j”

$$\boldsymbol{w_j = \frac{g_j}{\sum_j g_j}}$$

Finally, an overall score of “S” was calculated for each country.

$$S = w * p$$

In this formula, we use w to represent the weight vector, and P is the vector composed of the proportion of the j-th factor of the i-th country.

According to the comprehensive score of S, the country's food production capacity is high or low.

2.3 A model that focuses on efficiency and profitability ——EPES2

In order to get a model focusing on fairness and sustainability, we changed the evaluation matrix of AHP to increase the weight of fairness and sustainability, so that the model was more inclined to focus on fairness and sustainability, thus changing the priority of the food system. The modeling process is similar to that of EPES1.

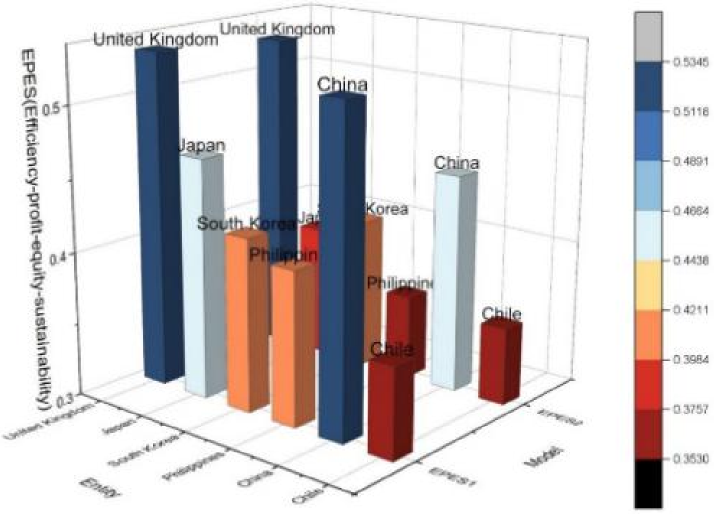

Figure 1: Comparison of EPES1 and EPES2 in different countries

Then, we assign weight to model EPES2 through AHP algorithm, and the assigned results are as follows: Energy use (0.075), annual production capacity of grain (0.0937), the government agricultural expenditure (0.0768), grain consumption index (0.0684), (0.0602), years food exports, food accounts for (0.0524), total GDP per capita calorie intake (0.0948), the per capita arable land area (0.0997), biological reserve covers an area of land ratio (0.0969), the annual CO2 emissions (0.0979), the national total population (0.0898), malnutrition accounts for the proportion of the population (0.0944).Therefore, we can verify the model by selecting three developed countries and three developing countries, and the results are shown in Figure 1.

We can see that after the change of weights, countries with larger grain exports and more government spending on agriculture, such as Japan and China, will have greater changes, while countries with larger grain exports and less government spending on agriculture, such as South Korea and Chile, will have smaller changes. This shows that the more a country gains from agriculture, the more likely it is to suffer from the benefit when investing in equity and sustainability, regardless of whether it is a developed country or a developing country. The agricultural level of Britain is relatively high, but it is not completely self-sufficient. Its export volume is small, and the income from grain is small, so it can be relatively stable under the change of weight. The Philippines has a relatively weak agriculture sector, with large grain exports and low government spending on agriculture compared to other countries. However, agriculture accounts for a relatively high proportion of GDP, so the national grain production capacity changes greatly under the change of its weight. In general, the greater the benefits obtained in agriculture, the more likely the benefits will be damaged after the change of factor priority, that is, the decrease of food production capacity.

We selected the grain export volume as the index of food production and distribution, and the per capita cultivated land area as the index of environmental potential of food production. The least square method was used to correlate the results of EPES1 and EPES2 with the two, respectively. The correlation coefficient, formula and results were calculated as follows:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

Table 2: The EPES1 and EPES2 values of 6 countries

National model	United Kingdom	Japan	South Korea	Philippines	China	Chile
EPES1	0.5314	0.4658	0.4198	0.4198	0.5215	0.3623
EPES2	0.5239	0.3910	0.4036	0.3579	0.4510	0.3534

As we can be seen from Table 2, the correlation coefficient between the EPES model and the indicators of food production and distribution and production environmental potential shows that, compared with the EPES1 model, the EPES2 model decreases by 0.1525 in the aspects of food production and distribution, but increases by 0.1716 in the aspects of food production environmental potential. From this, we can conclude that when the fairness and sustainability are optimized, there will be the following changes: although the establishment of EPES2 model may cause the contraction of grain circulation to a certain extent, it is more practical in terms of sustainability.

3. Conclusion

When we are on the basis of the global food system, increase the consideration of fairness and sustainability problem, we found that the world food system will appear a certain degree of grain circulation of contraction, but that does not affect our judgment fairness and sustainability, on the contrary, as a result of our global food system at this stage because of the large national and international food producers and distributors has led to its instability. If allowed to continue, it will put enormous pressure on the future. The reduction of food trade between countries indirectly means that domestic food supply and demand are similar, which corrects and prevents trade restrictions and distortions in the world agricultural market. At the same time, it maximizes the utilization of food resources, doubles agricultural productivity and doubles the income of small-scale food producers, which is conducive to future sustainable development. Therefore, we can see the importance of optimizing the current global food system so that the optimized system has a stronger performance in terms of sustainability.

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