The evaluation of Sustainable Development

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Abstract. Sustainable development plays a more and more important role in various countries. To determine whether a country is sustainable, we define a concept named sustainability index, which is utilized to represent the sustainable level. The **S**ustainability **I**ndex(SI) is calculated by 22 indicators, such as forest area and energy production. We use the Principal Component Analysis (PCA) to calculate the SI separately. Finally, 17 typical countries are selected to evaluate by the SI. The results presents that Norway and Japan are more sustainable, and South Africa and Sudan are less sustainable among the 17 countries.

1. Introduction

Over the past few years, “Sustainable Development” (SD) has emerged as the latest development catchphrase. A wide range of nongovernmental as well as governmental organizations have embraced it as the new paradigm of development[1].

Now, the International Conglomerate of Money (ICM) wants to use their extensive financial resources and influence to create a more sustainable world.our the evaluation method can give some advices to them to help that unsustainable development country.

2. The Model of Sustainability Evaluation

We set a model of sustainability evaluation based on Principal Component Analysis (PCA)

We defined sustainability index , which reflects the sustainable development level of a country . Through our model, as long as some data of a country, it is capable for us to calculate the sustainability index exactly. And then we can judge if the country is sustainable development or not. Moreover , we also set up environment index , resource index , economy index and society index to find out what has blocked the sustainable development of a country, which is useful for us to determine policies as well as provide assistance.

2.1 The Model Preprocessing

There are many factors related with the sustainability of a country or area. We divided all the factors into four categories. They are environment, resource, economy and society. All the factors we selected are presented in Table 2.

Table 2. The evaluation factors

Environment	GEF benefits index for biodiversity	y1
	Carbon dioxide emissions	y2
	Nitric oxide emissions	y3
	Forest area (% of land area)	y4
resource	Renewable internal freshwater resources per capita	y5
	Energy production	y6
	Alternative and nuclear energy	y7
	Fossil fuel energy consumption	y8
	GDP per unit of energy use	y9
Economy	GDP growth	y10
	Service ,etc value added	y11
	GNI per capita	y12
	Agriculture, value added (% of GDP)	y13
	GDP per capita	y14
Social development	School enrollment, tertiary	y15
	Population in urban agglomerations of more than 1 million pita	y16
	Malnutrition prevalence, weight for age	y17
	The rate of poverty	y18
	Internet users (per 100 people)	y19
	The rate of urban population	y20
	Poverty headcount ratio at national poverty lines	y21
	Population growth	y22

After determining the factors, we need to select some typical countries to ensure the criterion of sustainable development. We choose 17 countries from different continents, including developed countries and developing ones, as the samples.

Table 3. The typical countries

Developed countries	America Japan German Norway Canada Spain Australia
Developing countries (not include LDC)	Brazil Columbia Argentina China Kazakhstan South Africa Egypt Saudi Arabia
Least developed countries (LDC)	Sudan Congo

We can see that the 17 countries come from different continents and their development level are different, so we can think the results is appropriate for all countries.

2.2 Data pre-processing

Because the dimensions of each index exist, we eliminate the influence of dimension through standardization, the standardization process is as follows.

We can make standard 0-1 transformation and it can make every indicators lies between 0 and 1. To positive influence factors, the pre-processing formula is:

$$b_{ij} = \frac{a_{ij} - a_j^{\min}}{a_j^{\max} - a_j^{\min}} \tag{1}$$

To negative influence factors, the pre-processing formula is:

$$b_{ij} = \frac{a_j^{\max} - a_{ij}}{a_j^{\max} - a_j^{\min}} \tag{2}$$

Where a_{ij} is the data need to be pre-processed, $a_j^{\min}$ is the minimum data of the indicators in group j, and $a_j^{\max}$ is the maximum data of the indicators in group j. The pre-processing result is b_{ij}.

2.3 Evaluation Model

There are several indicators in every categories. To use less variables represent the most change in the data, we use the method of principal component analysis.

First, calculate the data after pre-processing and obtain the coefficient of correlation matrix R. The formula is:

$$r_{ij} = \frac{\sum_{k=1}^{n} b_{ki} \cdot b_{kj}}{n-1} \tag{5}$$

Where r_{ij} is the coefficient of correlation of indicator i and indicator j. b_{ki} and b_{kj} is the data after pre-processing.

Then, calculate the eigenvalues and the eigenvectors. λ_i is the eigenvalue of the coefficient of correlation matrix R and $\lambda_1 \geq \lambda_2 \geq \cdots\cdots \geq \lambda_n \geq 0$. The eigenvectors of the matrix are $u_1, u_2 \cdots u_n$, where $u_j = \left[u_{1j}, u_{2j}, \cdots, u_{nj}\right]^{\mathrm{T}}$. We can get new values consisted of the eigenvectors.

$$\begin{aligned} y_1 &= u_{11} \cdot b_1 + u_{21} \cdot b_2 + \cdots + u_{n1} \cdot b_n \\ y_2 &= u_{12} \cdot b_1 + u_{22} \cdot b_2 + \cdots + u_{n2} \cdot b_n \\ &\cdots \\ y_n &= u_{1n} \cdot b_1 + u_{2n} \cdot b_2 + \cdots + u_{nn} \cdot b_n \end{aligned} \tag{6}$$

Where y_1 is the number 1 principal component, y_2 is the number 2 principal component $\cdots$

Select p principal components, and calculate the rate of contribution of each principal components.

$$w_i = \frac{\lambda_i}{\sum_{k=1}^{p} \lambda_k} \tag{7}$$

Where w_i is the rate of contribution of each principal components.

And the accumulated rate of contribution.

$$\alpha_p = \frac{\sum_{k=1}^{p} \lambda_k}{\sum_{k=1}^{n} \lambda_k} \tag{8}$$

Where α_p is the accumulated rate of contribution. n is the number of indicators.

Calculate the comprehensive evaluation value of each categories.

$$X_k = \sum_{k=1}^{p} w_i y_i \tag{9}$$

Where X_k is environment index, resource index, economy index or society index. w_i is the rate of contribution of each principal components, y_i is the principal component.

After getting the four indexes of the four categories, we can obtain the sustainability indexes of the 17 countries.

$$Z_1 = \sum_{i=1}^{4} e_i \cdot X_i \tag{10}$$

Where Z_1 is the sustainability index I.

3 The Results

The result of sustainability index is as follow.

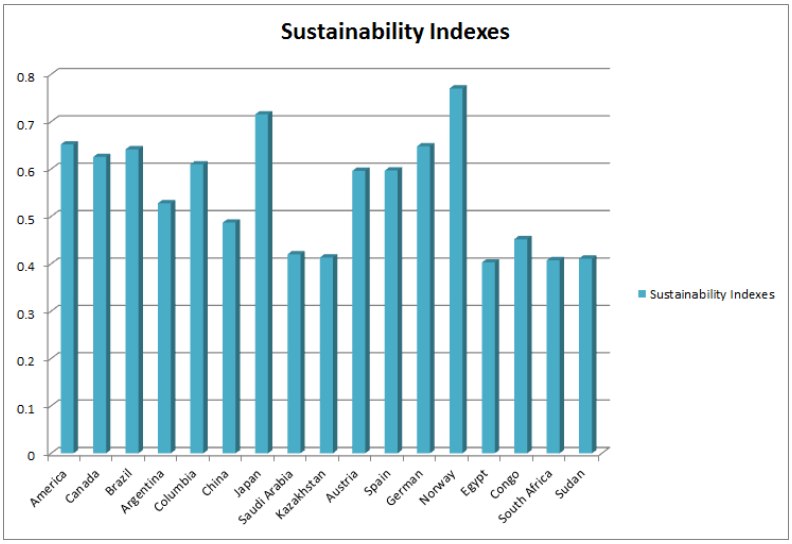

Figure 2. The sustainability indexes of 17 countries

We can draw some conclusions from the results.

Table 6. Some conclusions of sustainability index

The Average of 17 countries	0.50
The Highest (Norway)	0.81
The lowest (Saudi Arabia)	0.27
America	0.66
China	0.41

For environment index, resource index, economy index and society index, we can also get the highest value, the lowest value and the average value. We can calculate the Environment index, Resource index, Economy index and Society index:

$$z_i = W \times X_i + (1-W) \times r_i \tag{15}$$

Where z_i (i=1,2,3,4) is the value of environment index, resource index, economy index and society index.

All results are shown in Table 7.

Table 7. The index results

Sustainability index	The highest (Norway)	0.81
	The lowest (Saudi Arabia)	0.27
	The average	0.50
Environment index	The highest (Brazil)	0.71
	The lowest (Saudi Arabia)	-0.08
	The average	0.28
resource index	The highest (Norway)	0.93
	The lowest (Kazakhstan)	0.03
	The average	0.34

Economy index	The highest (Norway)	0.72
	The lowest (Congo)	-0.23
	The average	0.25
Society index	The highest (German)	1.60
	The lowest (Japan)	0.09
	The average	1.15

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