A method of Assessing Country's Sustainable Development Capacity

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Abstract. This paper use PCA and DEA to establish a sustainable development model. First, Principal Component Analysis (PCA) method is used to cluster the twelve factors which have selected. Then extract four indexes from all the factors, which are environmental pollution, resource consumption, economic and technology development. More importantly, by innovatively using the Data Envelopment Analysis (DEA) method. It is a new statistical analysis method that can apply in sustainability evaluation. Based on PCA and DEA, the evaluation model can be formulated successfully. Then choose seven high sustainable countries' data as samples, use the value of validity coefficient to determine the sustainable standard.

1. Introduction

Nowadays, sustainable development has become a goal for international aid agencies, planners, governments, and non-profit organizations. We are egger to strive towards a sustainable future. So it's significant to give a method of assessing country's sustainable development capacity.

2. Model Preparation

Before constructing the model, the most important thing is the selection of impact factors. Some factors may include human health, food security, and access to clean water, local environmental quality, energy access, livelihoods, community vulnerability, and equitable sustainable development. Due to these different kinds of factors, it is difficult for us to determine the key factors as well as the relationship between factor and sustainable development.

In this paper, DEA is used to build a sustainable development model. Basing on the indexes what have been selected by PCA, the model succeed in assessing a country's sustainable development capacity.

3. Assumption

For the sustainable development model , some reasonable assumptions are as follows：

The countries which are used as a standard all considered to be sustainable development;

The data which have been collected is enough and accurate.

4. Symbols and Definitions

In the section, some symbols which are used for constructing the model as follows.

Symbols	Definitions
θ	DEA validity coefficient
V_D	Optimal value of Linear Program
$\boldsymbol{\lambda}$	Weights
n	The number of DMU
x_0	Input of DMU_{j0}
y_0	Output of DMU_{j0}

5. Model Building

5.1 Select factors and represented countries.

Sustainable development problem is very complex with many impact factors. After constant compare and calculate, 12 factors which been regarded as have greater impact on sustainable development are determined to use in the model. In order to assess a country's sustainable development capacity, selecting 7 sustainable development countries as specimens. Each country's data we needed about 12 factors can be get from World Bank. In this paper, we use the data in 2010.

Table 1. Twelve factors of seven countries' date in 2010

	A	B	C	D	E	F	G	H	I	J	K	L
Australia	16.93	95.07	0.66	2.39	51800.9	70.58	27.05	10740.4	37530	11.88	2409	0.74
Canada	14.68	74.33	0.05	1.86	47465.4	70.79	27.69	16211.4	39200	14.05	4550	2.94
Switzerland	4.95	51.57	0.03	2.87	74276.7	73.01	26.26	8174.7	54430	25.42	1622	1.49
France	5.56	49.85	0.02	2.24	40706.1	78.62	19.60	7736.2	36610	24.92	14748	3.03
Britain	7.86	88.34	0.12	1.77	38363.4	78.68	20.65	5700.1	36320	20.88	15490	0.99
Japan	9.19	80.84	0.06	3.25	43117.8	71.28	27.54	8377.7	34830	17.97	290081	2.86
USA	17.56	84.15	0.09	2.74	48377.4	78.44	20.39	13394.9	49040	19.93	241977	0.60

(A, B, C, L represent the twelve factors, we give it in Figure 1)

5.2 Use PCA to put the 12 factors into four indicators.

Using the seven country's data to reduce dimensions base on Principal Component Analysis. Then, calculate coefficient of each factor in the corresponding principal component. Finally to get the classification of total factors from principal component coefficient, the result as shown in the Figure 1.

By calculation we obtain four principal component: x_1(resource consumption), x_2 (environmental pollution), y_1 (economic development) and y_2 (technology development).

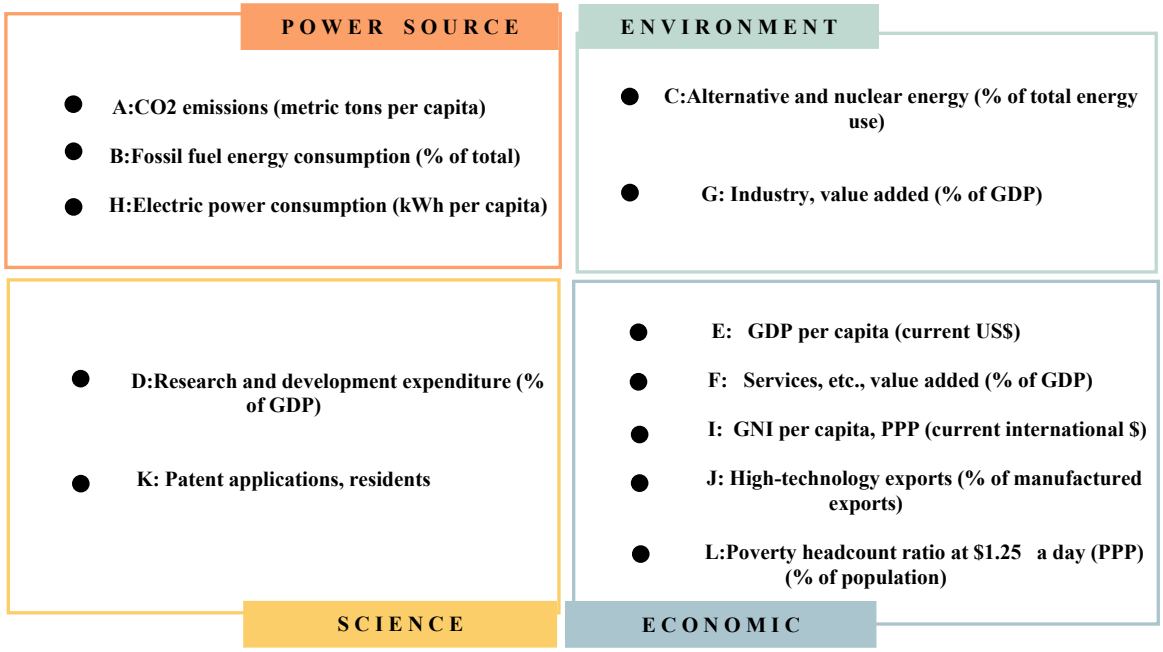

Figure 1. Classification of total twelve factors

5.3 Build the sustainable development model base on DEA.

Step 1: Using different countries' data as decision-making unit (DMU), seven countries as specimen of sustainable development country. Each decision-making unit (DMU_j) has two kinds of input as well as output, then we have:

$$x_j = (x_{1j}, x_{2j})^T, y_j = (y_{1j}, y_{2j})^T, j = 1,2,\cdots,n \quad (1)$$

In the formula, x_{1j} is the input of environmental pollution; x_{2j} is the input of resource consumption; y_{1j} is the output of economic development; y_{2j} is the output of technology development.

Therefore, construct the C^2R model with scale efficiency and technical effectiveness of DMU_{j0}[2].The necessary and sufficient conditions for DEA (C^2R) effective of DMU_{j0} is $V_D = \lambda$.

Step 2: Calculate the relative effectiveness of the country that we need, the result can be used to judge a country's sustainable development capacity. The degree of each index's impact on the sustainable development capacity can also be concluded.

5.4 Substituting the data from seven countries into the model.

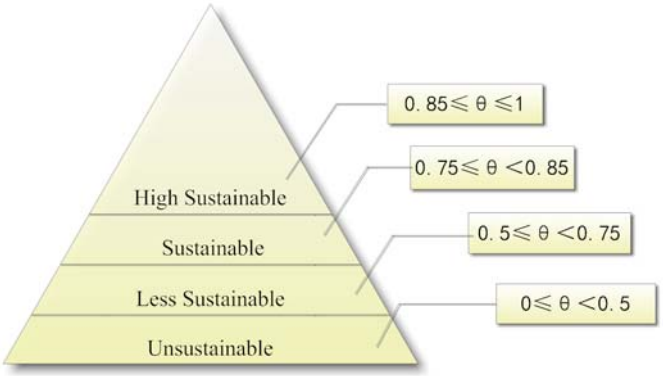

Figure 2. Standard for sustainable development

Using the data from seven countries, we have each country's value of DEA validity coefficient (θ). The result shows that the value of θ all come to 1, means the seven countries all have high sustainable development capacity, which exactly in line with our assumption. Considering all the factors, we can conclude a standard for sustainable development country. The result shows in Figure 2.

6. Conclusion

Principal Component Analysis (PCA) can reduce the dimension of too many factors, which can reduce the number of variables. Thus each factors' weight in their principal component that we get is objective and reliable. Data Envelopment Analysis (DEA) has been perfectly used in the model. The θ can successfully evaluate a country's capacity for sustainable development. By using the actual data of inputs and outputs to determine weight which could remove a lot of subjective factors and make the model more objective. Through all the analysis and research of the models, the method can assess a country's sustainable development perfectly.

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