Analysis of contribution to climate based on DEA and AHP

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Abstract. With the increasing shortage of resources and energy, the traditional GDP cannot reflect the comprehensive economic strength of the country, so the GGDP has attracted great attention from the governments of all countries and the international community. This paper developed an evaluation model for the impact of human activity on climate change. The human activities affecting climate are summarized as industrial production activities, agricultural production activities, human reproduction, transportation and man-made disasters, and the index system was established from these five aspects. The objective weight of the index is calculated by DEA, the subjective weight of the index is calculated by AHP, the comprehensive weight is calculated by game theory empowerment, and finally the score of the impact of human activities on climate change is calculated by TOPSIS. Mining GGDP model indicators and the common influencing factors of human activities, to improve the influencing factors as a decision variable, establish linear planning model, update the calculation results of the price model index data, get new national scores and previous policy implementation, through paired sample t test proved that the climate change before and after the implementation of the significant differences.

Keywords: GGDP, DEA, AHP,game theory empowerment method.

1. Introduction

After the 1960s, with the progress of science and technology, the productivity has been greatly improved. The simple pursuit of rapid GDP growth has brought great benefits to mankind, but it also pays a considerable price for resources and the environment. In order to make up for the neglect of energy efficiency and environmental pollution loss in traditional GDP evaluation, the concept of green GDP has received wide attention to promote the transformation and upgrading of industrial structure and the transformation of economic and social development mode [1].

In 1972, Nordhaus and Tobin developed MEW based on NNP, and the social cost of economic activities such as urban pollution should be deducted from GDP. Daly and Cobb, further elaborated this concept and constructed the sustainable economic welfare index. GGDP, released by the United Nations in SEEA in 1993, takes the use of economic activities to the environment as an investment and is constantly updated in several versions, including SEEA-2000 and SEEA-2003. There are several important systems of international green national accounting, including SEEA developed by the United Nations, ENRAP developed by Professor Peskin and applied in the Philippines, SERIEE developed by the European Union, and NAMEA developed by Statistics Netherlands. Among these, SEEA is the most mature and accepted framework for [2].

Green GDP is based on the traditional GDP, considering the consumption of natural resources and environmental costs in the process of economic activities, and reflecting the relationship between the actual economic level of a country or region and the environment. According to the United Nations Department of Economic and Social Affairs, green GDP is an important economic growth measure to make the traditional GDP adapt to the changing value of environmental resources on the basis of sustainable development theory, and reduce the resource consumption and environmental cost in the traditional GDP calculation. It shows that the development of a country or region must be the harmonious and sustainable development of environmental resources and economic society, and emphasizes that economic development should not be at the expense of environmental resources.

2. Materials and Methods

2.1. GGDP computational method

GGDP, there are many mature calculation methods, including SEEA accounting framework as part of the national economic accounting framework is widely accepted and applied at home and abroad, in the SEEA accounting framework has energy value analysis, material flow analysis, fuzzy value evaluation and resource value loss method, is based on the human capital method, resource environment value loss method is the highest degree, the effect of the most practical method. Meanwhile, in order to better reflect the impact of GGDP on climate, this paper selects the resource and environmental value loss method as the GGDP accounting model based on the SEEA accounting framework, the model is used to calculate the global GGDP and compare with GDP.

2.2. The AHP-DEA combined model

AHP is a multi-criterion decision method combining qualitative and quantitative analysis proposed by Satty et al. in the 1970s. It is a decision analysis method combining qualitative and quantitative analysis [3]. Judging the relative importance of the measure based on the experience of the decision maker and reasonably give the weight of each criterion for each decision scheme, which is highly subjective [4]. However, due to the excessive reliance on its subjective judgment, it is difficult to eliminate the bias caused by human factors. DEA is a systematic analysis method for evaluating the relative effectiveness of the same type of units based on the concept of "relative efficiency". DEA is to establish the most favorable mathematical model for each decision unit, and calculate the weight by finding the optimal solution. Assuming m decision units, n evaluation measures, each decision unit has an input of the type p and an output of the q type, p + q=n. Establish a planning model to solve the weights. The evaluation results are not affected by human factors, but do not reflect the preferences of decision makers [5]. The AHP-DEA model combines the advantages of the former two and comprehensively considers the subjective and objective factors, significantly increasing the scientificity and smoothness of the model [6].

3. Based on the establishment of the DEA-AHP combination model

This article reviews human activities affecting climate, such as industrial production activities, agricultural production activities, human reproduction, transportation, and man-made disasters[7]. From these five aspects, the index system of the evaluation model of the influence degree of human activities on climate change was established [8]. The established index system of evaluating the degree of climate change caused by human activities is shown in Table 1.

Table 1. Model for evaluating the degree of climate change induced by human activities

First level index	Second level index	Index quantification
agricultural production	lumbering	Average annual temperature growth rate
	overstocking	Deserated area
Human reproduction	Human reproduction	density of population
industrial production	Industrial soot emissions	air pollution index
	Industrial soot emissions	PH of rainwater
	oil spill	Oil contaminated area
	Urbanization construction	The proportion of urban surface
man-power disaster	Non-standard incineration	Forest fire frequency
transportation	Vehicle exhaust emissions	Car traffic

The objective and subjective weights were determined by using data envelope analysis and hierarchical analysis respectively, then the game theory empowerment method was used to calculate the optimized comprehensive weights, and finally TOPSIS was used to calculate the score.

3.1. Determination of the objective weights and the subjective weights

DEA is to build the most favorable mathematical model for each decision unit and calculate the weight by finding the optimal solution. Assuming m decision units, n evaluation measures, each decision unit has an input of the type p and an output of the q type, p + q=n. The planning model was established as follows:

$$\max h_i = \sum_{t=1}^{q} u_t y_{ti} \tag{1}$$

$$s.t. \sum_{s=1}^{p} u_s x_{si} - \sum_{t=1}^{q} u_t y_{ti} \geq 0, i = 1,2,...,m \tag{2}$$

$$\sum_{s=1}^{p} v_s x_{si} = 1 \tag{3}$$

$$V = (v_1, v_2, ..., v_s, ..., v_p)^T \geq 0 \tag{4}$$

$$U = (u_1, u_2, ..., u_t, ... u_q)^T \geq 0 \tag{5}$$

$$W = (v_1, v_2, ..., v_p, u_1, u_2, ..., u_q) \tag{6}$$

Hierarchical analysis is a decision analysis method combining qualitative analysis and quantitative analysis. It is highly subjective to judge the relative importance of the measures from the experience of the decision makers and to reasonably give the weight of each criterion for each decision scheme.The hierarchical analysis structure diagram constructed in this paper is Figure 1:

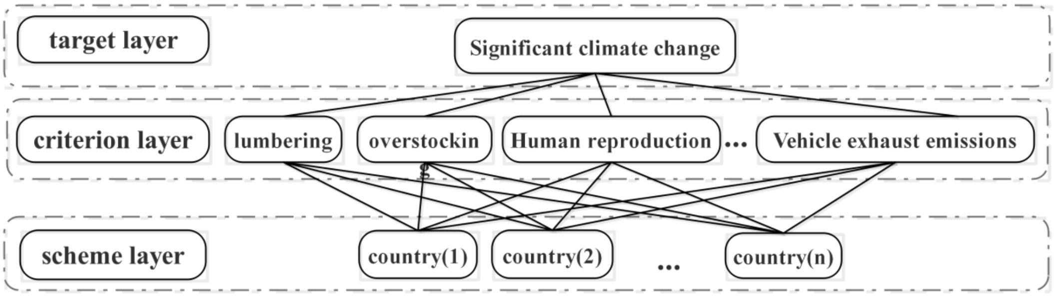

Figure 1. Structural diagram of the hierarchical analysis

3.2. Determine the composite weight

This paper uses the game theory combinatorial allocation method to comprehensively optimize the weights obtained by data envelope analysis and hierarchical analysis to fully consider the influence of subjective and objective factors. The game theory combinatorial authorization model reduces the deviation between different methods and various basic weights to minimize the difference between different methods [9].

Step1:Establish the portfolio weights. The formula for calculating the combined weight W is constructed in an arbitrary linear combination.

$$W = \sum_{i=1}^{n} a_i W_i \tag{7}$$

$$W_i = \{w_{i1}, w_{i2}, ..., w_{im}\}^T \tag{8}$$

In the equation: Wi represents the set of weights obtained by the i method.

Step2:Optimize the weight. According to the basic principles of game theory, the weights are optimized to minimize the deviation between the combined weights and the weights involved in the optimization.

$$\min\left\|\sum_{i=1}^{n}(a_iW_i - W_j)\right\|_2 \tag{9}$$

Step3:normative approach. To ensure the consistency of the results, the weight coefficients were normalized.

$$a_i^* = a_i / \sum_{i=1}^{n} a_i, i = 1,2,...,n \tag{10}$$

In formula a, i * means the normalized parameter i corresponding to the coefficient a.

Step4:Determine the weight of the portfolio. Based on the calculation results, the optimized combined weight of W * is obtained.

$$W^* = \sum_{i=1}^{n} a_i^* W_i \tag{11}$$

The original and optimized datasets were transferred into the optimized weighted model for calculation, resulting in Figure 2.

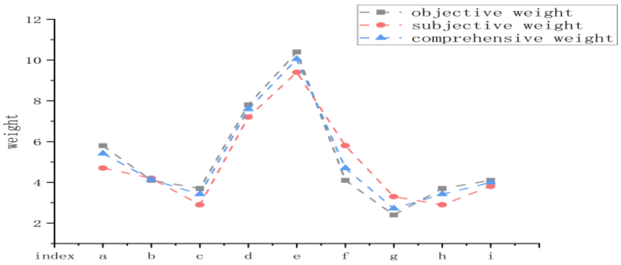

Figure 2. Weight contrast plot

Through the comprehensive effect of the weight, the volatility of the weight coefficient is reduced and makes the information reflected by the weight more convincing.

3.3. Implementation simulation based on linear programming GGDP

According to the definition of GGDP, its determinants include GDP, resource consumption value, environmental pollution value, and ecological environment improvement benefit. The indicators in the GGDP accounting model and the index evaluation model of human activity impact on climate were extracted respectively to find the same influencing factors in each index. By observing relevant indicators, the natural resource loss and environmental pollution value of GGDP can be linked to the industrial production activities of the human climate activity evaluation model of fossil fuels and quantified by the emission of industrial dust and industrial exhaust gas; the value of natural resource loss can also link the reduction of forest area to the agricultural production activities of human activities. To this end, with the goal of maximizing production benefit, the improvement degree of the common influencing factors of GGDP accounting model and the influence degree of human activities on the climate evaluation model as the decision variables, and the proportion of governance environmental cost to production benefit is less than the absolute change rate of GDP as the constraint, the planning model is established as follows:

Step1:Determine the decision variables:

$$x_{ij}, (j = 1,2,3,4) \tag{12}$$

It represents the percentage of the resolution of the j-th measure in the i-th country, such as j=1 is the percentage of the decision to treat the total amount of industrial soot, and so on.

Step2:Select the policy input:

$$C_i = \sum_{j=1}^{m} x_{ij} k_j V_j \tag{13}$$

The k represents the cost per unit processing capacity, the V represents the total amount to be treated; for example, j=1 represents the treatment cost per unit volume dust and the total emission of industrial dust, and so on.

Step3:Calculate the environmental management cost:

$$B_i = V_j * (1 - x_{ij}) * b_j, (j = 1,2) \tag{14}$$

b is industrial waste gas, and industrial soot is directly discharged into the atmosphere. In the future, the cost of pollution sources per unit volume needs to be treated. b=1 is the cost of soot emission, and b=2 is the cost of emitting harmful gas per unit volume.

Step4:Select the objective function

$$\max W_i = \sum_{i=1}^{n} (S_i - C_i - B_i) \tag{15}$$

Step5:Set the constraints:

$$0 \le x_{ij} \le 1 \tag{16}$$

$$\frac{C_i}{S_i} \le \frac{GDP_i - GGDP_i}{GDP_i} \tag{17}$$

The indicator data of the evaluation model of human activity impact on climate were updated using the solved decision variables.

4. Results and analysis

4.1. Comparative analysis of results

On the basis of the previous model construction and solution, the index data of each country were input into the model to obtain the climate influence degree score of human activity in each country. In order to enhance the comparison, the score visualization results are shown in Figure 3. With the solved decision variable. The index data of the evaluation model of human activity is updated, and the scoring visualization is shown in Figure 4.

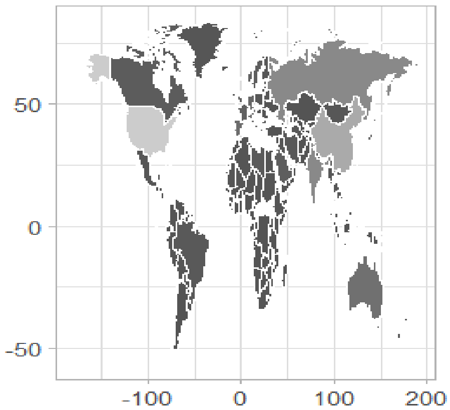

Figure 3. World score heat map

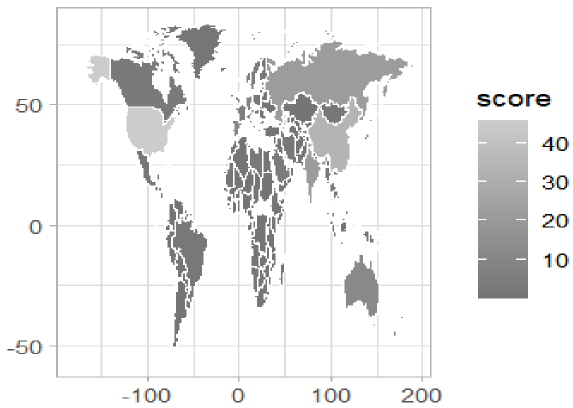

Figure 4. Heat map after the policy implementation

As observed in Figure 3, the higher the degree of national development, the lower the degree of human activity on climate, that is, the less the damage of production and living activities to the environment. On the contrary, the relatively less developed countries, the higher the degree of environmental damage. Comparing Figure 3 with Figure 4, the impact of human activities on climate is significantly reduced due to the implementation of the GGDP policy. Demonstrate that the GGDP policy has a significant positive effect on the global climate improvement.

Differential analysis of the impact degree scores of human activity before and after policy implementation on climate was performed using the paired sample T-test. The paired-sample t-test was used to test whether two related samples were from a population with the same mean, a t-test comparing the difference mean used in the paired design with the population mean 0.The degree of climate influence was analyzed before and after the implementation of GGDP.Analysis results are as shown in Table 2:

Table 2. Table of cluster results

The number of cases	relativity	conspicuousness
186	1.000	0.000

According to the table, the P value is less than 0.05, the null hypothesis is rejected, and the scoring data before and after the implementation of the strategy are significantly different. That is, the implementation of GGDP can significantly reduce the impact of human activities on climate in the short term, and promote the transformation and upgrading of industrial structure and the transformation of economic and social development mode.

4.2. GGDP implementation impact analysis

The short-term climate influence of GGDP is quantified above from the perspective of climate. In order to fully reflect the impact and value of GGDP implementation, this paper expounds it from three aspects: economic development, industrial development and ecological development.

Impact of adopting Green GDP on economic development

- **Reflect the real situation of economic development**:Statistics from the State Environmental Protection Administration show that at least 18% of China's GDP in terms of economic growth is obtained by over-exploitation of resources and ecological environment. With the adoption of the Green GDP statistical system, the country has a clearer grasp of the data, which helps to provide more reliable data for the country[10].
- **Speed up the development of efficient and ecological agriculture:**At present, most agricultural products are produced under the condition of energy and resource consumption. By including green GDP in the statistics, high quality, efficient and ecological agricultural products will be consciously chosen to bring our agriculture, forestry and livestock farming into a virtuous circle of development.

Impact of adopting green GDP on industrial development

- **Improving the production system of green, low-carbon and circular development: t**he adoption of green GDP accounting system can promote the transformation of economic growth mode from extensive to intensive, and help promote the industrial green upgrading[11]. The government will accelerate the green transformation of the steel, petrochemical, chemical, non-ferrous, building materials, textile, paper, leather and other industries. Will expand the green and environmental protection industries. Will build a number of national green industry demonstration bases, and promote the formation of an open, collaborative and efficient innovation ecosystem.
- **Improving the circulation system of green, low-carbon and circular development:** the adoption of green GDP accounting system can strengthen the development and utilization of renewable resources and help to build green logistics. Actively adjust the transport structure. The government will promote garbage sorting and renewable resources recycling, accelerate the establishment of a system for recycling waste materials, and improve the output rate and recycling

rate of resources. It will help to establish a green trading system.

The effect of adopting green GDP on the ecological environment

- The deterioration of the global ecological environment has become a global crisis that has attracted global attention. At present, the unhealthy economic development models in many areas are increasing the pressure on the ecological environment. The adoption of green GDP accounting system is conducive to improving the importance of relevant departments to formulate ecological and environmental policies, and has far-reaching theoretical and practical significance for sustainable economic growth.

5. Conclusion and discussion

5.1. Advantages of the model

In this paper, the subjective and objective weights are determined by data envelope analysis and hierarchical analysis respectively, and the game theory enabling method is used to calculate the comprehensive weight, neutralize the subjective and objective factors, and finally the score is calculated by TOPSIS. This integration method belongs to the non-homogeneous evaluation, which has a rigorous logical reasoning and mathematical basis, improves the discriminability between the bidding schemes, and its evaluation results are more accurate and reasonable.

In this paper, we mined the common index model of the GGDP accounting model and evaluation index, established a linear planning model, simulated policy implementation, and quantified the impact of policy on climate.

5.2. Lack and improvement of the model

The data volume of the training sample of the model needs to be improved, and only for the short-term GGDP policy deduction, regardless of the long-term impact. In the later process of model construction, the number of training samples should be increased to fully consider the medium and long-term effects.

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