Environmentally friendly economic growth: an analysis of the role of green GDP in national development

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ABSTRACT

In recent years, the protection of the ecological environment has gradually become one of the important aspects of our country to achieve all aspects of the development of one of the important bearings, join the ecological factors of the green GDP (GGDP) is undoubtedly in line with the construction of our country's ecological civilisation in the new era of the strategic line, the use of GGDP on the promotion of green development, and to promote the harmonious coexistence of human beings and nature can produce a certain role in promoting. the accounting methods of the GGDP are also a lot in analysing the problems. This paper explores them in the following ways.

By reviewing the literature, according to the methods in different literatures, we choose the accounting formula of GGDP (see Equation 1 for details), and use TOPSIS to solve the environmental loss index and resource consumption index in the formula, and finally get China's GGDP. the solution method is shown in the main text.

The indicators of forest area and fossil fuel energy consumption are selected. The calculated GGDP data and collected GDP data were respectively subjected to grey correlation analysis with the standardized data of the selected indicators in the current year. The grey correlation of forest area with GDP was 0.73 and with GGDP was 0.817. The analysis of variance showed that with the use of GGDP, forest land was affected to the extent of about 45% of the entire population. The rest of the data is shown in Table 7. However, the use of GGDP favours the national economy and the ability to feed future generations, as shown in Figure 13.

Keywords: TOPSIS; Accounting for GGDP; Grey correlation

1 INTRODUCTION

If countries change the way they assess and compare their economies, Governments may change their behaviour and promote policies and projects that benefit the environmental health of the planet. Is "green" GDP (GGDP), where "green" refers to the inclusion of environmental and sustainability perspectives and factors, better than current conventional GDP?

2 TOPSIS-BASED ACCOUNTING MODEL FOR GGDP

2.1 Modelling background

In the SEEA accounting matrix, the environmentally adjusted net production (EDP) is at the centre of the total net green value indicator. It calculates the value of net value added after deducting environmental costs, called "environmentally adjusted net value added", emphasising that future generations should have a natural environment that is at least as good as the one we have now [1].

2.2 GGDP accounting concepts

The research process needs to choose a method of calculating GGDP to replace GDP as the main measure of economic health, we chose Ecological Gross Domestic Product (EDP) as GGDP, Ecological Gross Domestic Product (EDP) is an assessment of the total value of an economic activity taking into account the environmental and resource factors [2]. The EDP can be calculated by multiplying the GDP by the ecological loss index and the difference of resource consumption index to calculate it. The specific formula is:

EDP = GDP * (1 - Ecosystem loss index) * (1 - Resource consumption index) (1)

Among them, the environmental loss index and the resource depletion index are two commonly used indicators for measuring environmental impacts. The environmental loss index can be calculated by calculating indicators such as pollutant emissions and ecological damage. In this paper, indicators such as carbon dioxide emissions, total water resources, and nitrous oxide emissions are calculated and measured by converting them into an environmental loss index [3]. The resource consumption index, on the other hand, can be measured by calculating the consumption of resources such as energy, water resources, land and the level of sustainable use. In general, indicators such as energy use, forest area, and fossil fuel energy consumption can be converted into resource depletion indices and compared with the corresponding sustainable utilisation levels.

To convert these two indicators into an ecological loss index and resource consumption, the TOPSIS method is used in this paper. The indicators constituting the environmental loss index and the indicators constituting the resource consumption index are evaluated comprehensively with TOPSIS, and the final normalised scores are used as the environmental loss index and the resource consumption index, respectively.

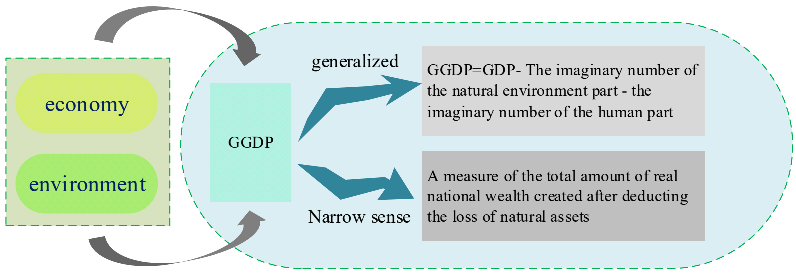

Figure 1: GDDP accounting concepts

2.3 Environmental loss index and resource depletion index solved by Topsis integrated analysis

Step 1: Firstly normalise and normalise the original matrix

The original matrix undergoes the operation of normalisation, which is essentially the conversion of all indicator types into very large indicators (benefit type). Among them, per capita food production, per capita GDP, per capita disposable income and happiness index are already very large indicators and do not need to be converted [4]. On the other hand, unemployment rate, Engel's coefficient, Gini coefficient of income and external environmental rating are very small indicators (cost type) and need to be converted to very large indicators. In order to eliminate the effect of different indicator scales, it is necessary to normalise the matrix that has been normalised [5]. The conversion process is described below:

$$min = max - x \tag{2}$$

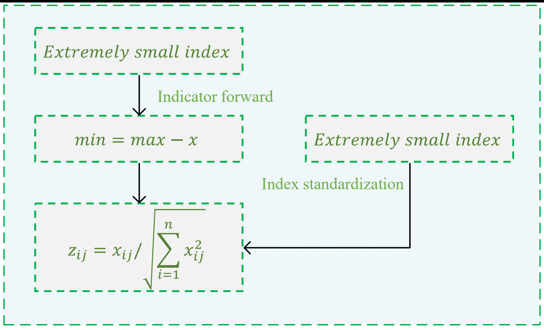

Figure 2 : Indicator normalisation and standardisation process

Note: Its normalised matrix is denoted Z

Step 2: Use entropy weighting method to solve the weights

Calculate the weight of the ith sample under the jth indicator and regard it as the probability used in the relative entropy calculation, we calculate the matrix P, where the formula for each element p_{ij} in P is as follows:

$$p_{ij} = \frac{\tilde{z}_{ij}}{\sum_{i=1}^{n} \tilde{z}_{ij}} \tag{3}$$

For the jth indicator, its information entropy is calculated by the formula:

$$e_j = -\frac{1}{\ln n}\sum_{i=1}^{n} p_{ij}\ln(p_{ij})(j = 1,2,\dots,m) \tag{4}$$

Definition of information utility value:

$$d_j = 1 - e_j \tag{5}$$

Then the larger the value of information utility, the more information it corresponds to. Get the entropy weight of each indicator: $W_j = d_j / \sum_{j=1}^{m} d_j (j = 1,2,\dots,m)$

Step 3: Calculate Composite Score

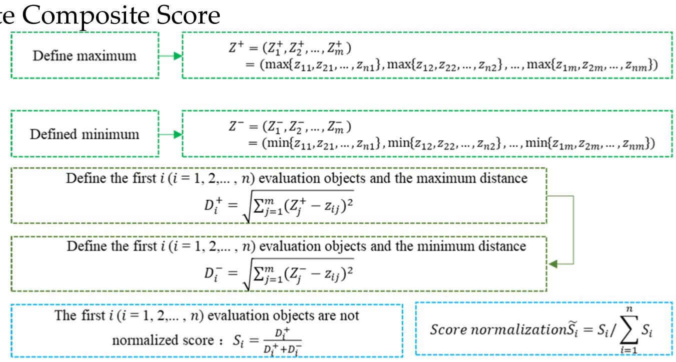

Figure 3: Process for calculating the composite score

2.3 model solution

Using entropy weighting method through MATLAB to solve the weight of each Chinese factor as:

Table 5: Table of weights for each indicator

Indicators	Total water resources (billion cubic meters)	Nitrogen monoxide emissions (thousand metric tons of CO2 equivalent)	Carbon dioxide emissions (thousand tons)
Weights	0.7123	0.0165	0.2712

Indicators	Forest area (km2)	Fossil fuel energy consumption (% of total)	Energy use (kg oil equivalent per capita)
Weights	0.8514	0.0021	0.1465

Preprocessing data into the above model, this paper China, for example, through the Matlab software using TOPSIS plus entropy weighting method to get the environmental loss index and resource consumption index of the indicators of the integrated score results were:

Table 6: Environmental damage index composite score

Year	Positive ideal solution distance (D+)	Negative ideal distance (D-)	Overall Score	Score Ranking
2014	0.1951	0.2167	0.1217	4
2013	0.2286	0.19	0.1066	6
2012	0.3051	0.1343	0.0968	11
2011	0.0148	0.3882	0.0904	8
2010	0.373	0.0964	0.0879	9
2009	0.0623	0.3371	0.0665	1
2008	0.2098	0.1837	0.0601	14
2007	0.1125	0.2832	0.059	7
2006	0.1211	0.2773	0.0573	2
2005	0.246	0.1465	0.053	12
2004	0.101	0.3312	0.0486	15
2003	0.2315	0.167	0.0471	10
2002	0.2714	0.1272	0.0403	13
2001	0.2149	0.1949	0.0386	3
2000	0.2496	0.1561	0.0259	5

Table 7: Resource Consumption Index composite score

Year	Positive ideal solution distance (D+)	Negative ideal distance (D-)	Overall Score	Score Ranking
2014	0.4146	0.0793	0.1152	15
2013	0.389	0.0822	0.1127	14
2012	0.3634	0.0907	0.1076	13
2011	0.3379	0.1046	0.1011	12
2010	0.3126	0.1203	0.0932	11
2009	0.2822	0.1436	0.0842	10
2008	0.2519	0.1712	0.0748	9
2007	0.2214	0.2009	0.0653	8
2006	0.192	0.2303	0.0555	7
2005	0.1638	0.2602	0.0463	6
2004	0.1373	0.2906	0.0381	5

2003	0.1146	0.3212	0.0324	4
2002	0.0969	0.3522	0.0274	3
2001	0.0835	0.3834	0.0239	2
2000	0.0793	0.4146	0.022	1

Note: D+ and D- values: represent the Euclidean distance between the evaluation object and the optimal solution or the worst solution, respectively, and their practical significance is the distance between the evaluation object and the optimal solution or the worst solution. Among them, the larger the D+ value of the research object is, the farther it is from the optimal solution; the larger the D- value is, the farther it is from the worst solution.

According to TOPSIS plus entropy weight method, we can get the environmental loss index and resource consumption index.

According to the formula of EDP

EDP = GDP * (1 - Ecosystem loss index) * (1 - Resource consumption index)

We can get China's EDP for that:

Table 8: China EDP data

Year	EDP in China
2014	13781491925521.00
2013	11643122078540.80
2012	11509853534908.80
2011	11360950839972.50
2010	10181844554305.10
2009	9603320247963.05
2008	9619076560040.60
2007	9213915197152.78
2006	8521299739667.57
2005	7705916788450.26
2004	6910767874154.91
2003	5612523602047.55
2002	4761951177605.48
2001	4311401275129.40
2000	3382304305199.57

3 STUDY ON THE IMPACT OF THE USE OF GGDP ON NATIONAL DEVELOPMENT

3.1Description of grey correlation analysis

Grey correlation analysis (GRA) is a quantitative method for describing and comparing the trend of development and change of a system, and its basic idea is to judge whether the connection between the sequence curves is strong or not based on the degree of similarity of their geometrical shapes. The method can reflect the degree of correlation between the curves, if the closer the curves are, the greater the correlation between the corresponding sequences, and vice versa.

The steps of its analysis are shown below:

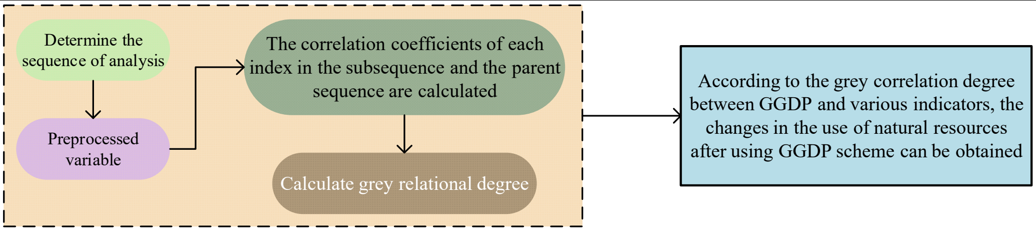

Figure 4: Route of analysis

3.2 Grey correlation analysis modeling

According to the requirements of the topic, the four aspects of forest area, carbon dioxide emissions, energy consumption of fossil fuels, and energy use are considered comprehensively, and the grey correlation analysis model is selected for analysis [6]. The specific steps are as follows:

Firstly, data pre-processing:

For different indicators, we need to unify their direction, that is, some very small indicators (the smaller the better indicators) through the following formula into very large indicators:

$$X_{max} - X \tag{6}$$

X_{max} is the maximum value in the current metric and the normalisation process is as follows:

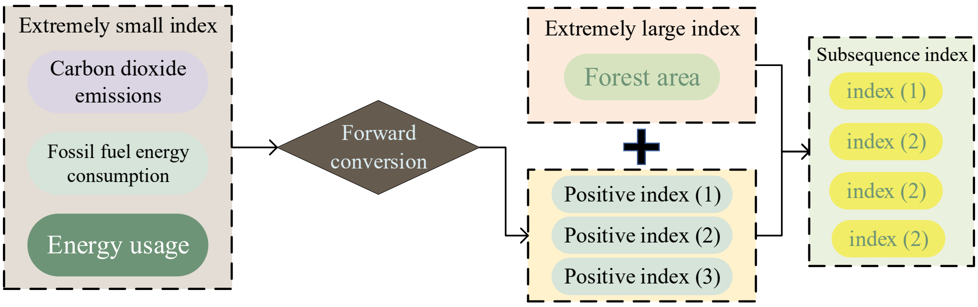

Figure 5: normalisation process

Since the units of each indicator are different, we need to standardise them and the standardisation formula is as follows:

$$z_{ij} = {x_{ij}} \Big/ \sqrt{\sum_{i=1}^{n} {x_{ij}}^2} \tag{7}$$

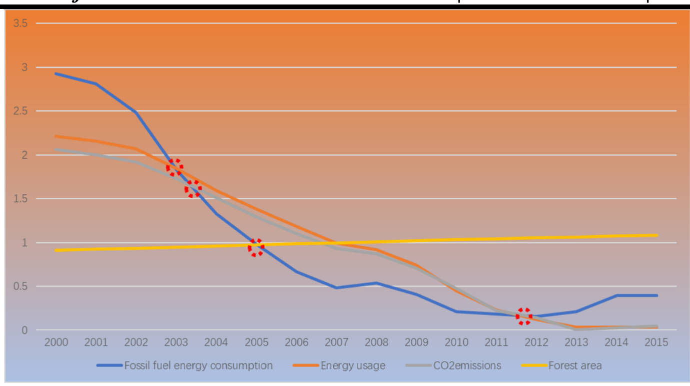

Figure 6 : Normalised data plot

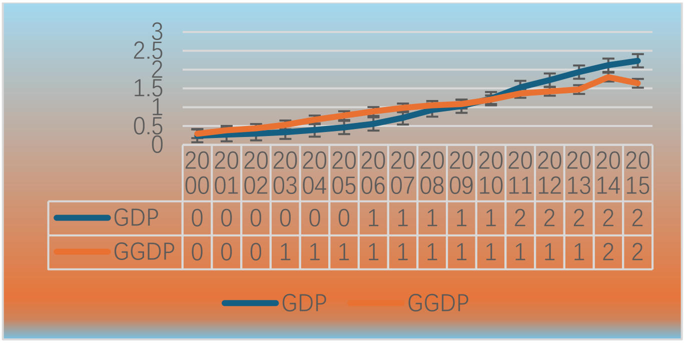

Figure 7: Standardised data maps

Subsequently, the parent and subsequence sequences were constructed.

China's fossil fuel energy consumption, China's energy use, CO2 emissions and forest area were analysed as subsequences, and GGDP and GDP were analysed as parent sequences, respectively:

Parent sequence: $x_0 = \left(x_0(1), x_0(2), \ldots, x_0(n)\right)^T$

$$x_1 = \left(x_1(1), x_1(2), \ldots, x_1(n)\right)^T$$

Subsequence: ...

$$x_0 = \left(x_m(1), x_m(2), \ldots, x_m(n)\right)^T$$

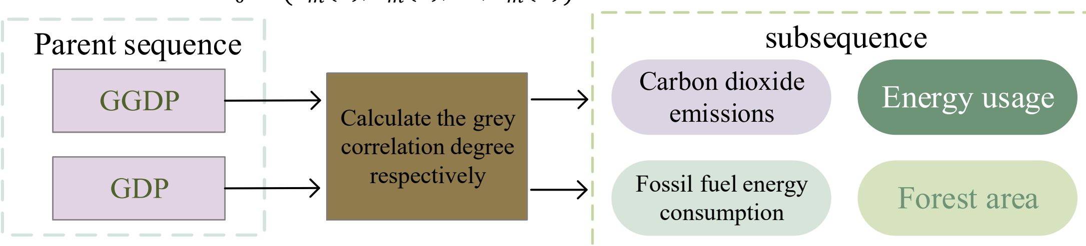

Figure 8: Grey correlation solving

The formula for calculating the grey correlation is as follows:

$$\gamma\left(x_0(k), x_i(k)\right) = \frac{a + \rho b}{|x_0(k) - x_i(k)| + \rho b} \tag{8}$$

where ϱ is the resolution factor (generally taken as 0.5) $i = 1,2, \ldots, m, k = 1,2, \ldots, n.$

The analysis was carried out using SPSSPRO software to obtain correlation coefficient plots of GDP against the subseries:

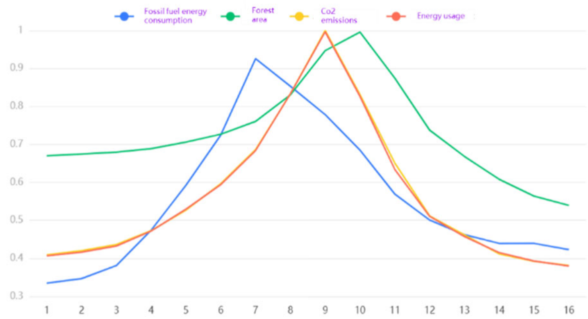

Figure 9: Graph of correlation coefficients between GDP and subseries

GDDP is plotted against the subsequence:

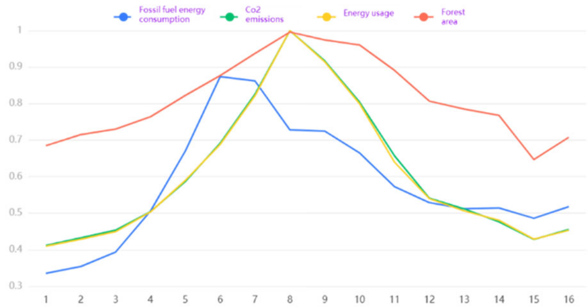

Figure 10: Plot of GDDP against subsequences

3.3 Grey correlation analysis modeling

The grey correlation results were obtained using SPSSPRO software analysis:
GDP and subseries correlation results:

Table 9: GDP and subseries correlation results

Evaluation items	Relevance	Ranking
Forest area	0.73	1
Carbon dioxide emissions	0.564	2
Energy use in China	0.561	3
Fossil fuel energy consumption in China	0.558	4

Correlation results of GGDP with sub-sequences:

Table 10: Correlation results of GGDP with subseries

Evaluation items	Relevance	Ranking
Forest area	0.817	1
Carbon dioxide emissions	0.606	2
Energy use in China	0.603	3
Fossil fuel energy consumption in China	0.578	4

From the above table, it is clear that forest area has the highest grey correlation with GDP, and the difference in the correlation of the subseries is observed by plotting a histogram using MATLAB software:

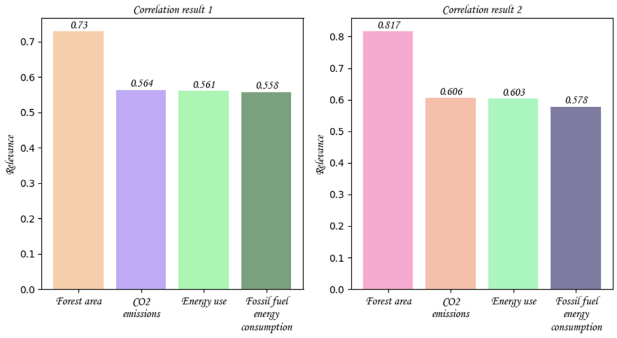

Figure 11: Differences in correlation of sub-series

From the above results we can observe that GDP has a different correlation with GGDP and the subseries indicators, and the difference between them is the impact of using GGDP, so the grey correlation can be differenced to determine the impact:

Table 11: Results data

Sub-series indicators	Correlation with GDP	Correlation with GGDP	Difference	Normalized Data
Forest area	0.73	0.817	0.087	0.455497382
Carbon dioxide emissions	0.564	0.606	0.042	0.219895288
Energy use	0.561	0.603	0.042	0.219895288
Fossil fuel energy consumption	0.558	0.578	0.02	0.104712042

From the normalised data we can get that the most impact of natural resource use or conservation with GGDP is the forest area, which means that the forest area will improve the most, and the rest of the impact levels can be seen in the data in the table above or in the graph below:

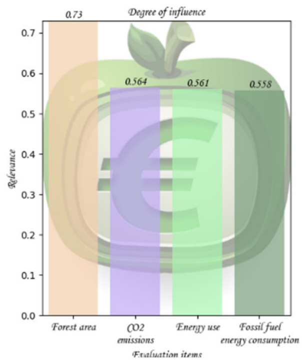

Figure 12: Degree of impact

According to the impact degree, after the use of GGDP in China, the forest area will increase a lot, carbon dioxide emissions and energy consumption will be reduced moderately, and fossil fuel energy consumption will be reduced a little [7].

Based on the above data, MATLAB software was used to draw the Line chart of GDP, GGDP and the difference between them from 2000 to 2014,The analysis chart is obtained by combining various indexes:

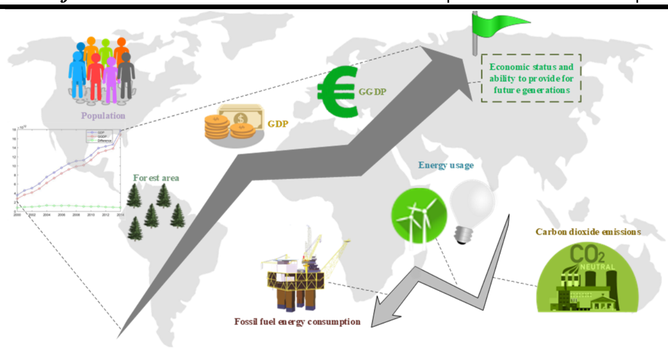

Figure 13: Analysis result

It can be seen from the figure that China's economy is in a good form, and the difference value can reflect that it is less affected by environment and resources and is very stable. Therefore, if GGDP is used in China in the future, the economic form will still be very favorable [8-10]. However, according to the analysis of the ability to support future generations, since China's population is on the rise, and the consumption index is on the decline and the storage index is on the rise, we can conclude from the model. It is good for the country's ability to provide for future generations.

4 CONCLUSION

This paper selected a specific GGDP accounting formula and innovatively applied the TOPSIS method to solve the environmental loss index and resource consumption index to calculate China's GGDP. Further, the article selected indicators such as forest area and fossil fuel energy consumption, and used grey correlation analysis to compare the correlation between GGDP and traditional GDP with the selected indicators, and the results of the study showed that the GGDP has a higher correlation with forest area, indicating that GGDP is more sensitive in reflecting ecological impacts. In addition, the analysis of variance shows that GGDP contributes to a more accurate measure of the national economy and the ability to feed future generations. In summary, the introduction and application of GGDP has a positive role in promoting green development and harmonious coexistence between human beings and nature.

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