The indicator for measuring economy converting from GDP to GGDP: Is it worth? —— Research of the impact mechanism of GGDP algorithm on the global environment based on Saša Stjepanović

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Abstract. We have seen the irrationality of the global community's long-standing use of GDP as an indicator of economic health, and we have also seen new hope for our global environment and economy using the new GGDP indicator. This paper proposes a model to quantify as precisely as possible the impact of the use of GGDP on the global environment, compare it with the GDP indicator currently used, and analyze whether this transition is worthwhile from environmental, economic, and social perspectives. We test the models and results using real-world data (from WMO, UNFCCC, IEA, UNEP), striving to draw more reasonable and scientific conclusions. Based on the position that it is easy to quantify, we wanted to choose indicators with strong versatility, which can be adapted to different countries, and chose the calculation method accordingly. This paper uses stepwise regression analysis method to establish a multiple linear regression model. In our model, indicators (KtCO2, Twaste, NRD) reflecting the effect of the global measures taken after using GGDP were used as independent variables, and indicators (global average temperature, global average precipitation, air humidity) reflecting global environmental impact were used as dependent variables. We collected data from 2010-2019 models to address how to quantify their global environmental impact, and concluded: for every million tons of CO2 emissions, the average global average temperature increase was 0.09 degrees; For every 1 per cent decrease in global natural resource depletion as a percentage of gross national income, global precipitation increases by an average of 8,9.35 mm; For every million tons of carbon dioxide emissions and 100 million tons of waste, global air humidity rises by an average of 3.956%, And these are all positive impacts that the use of GGDP indicators will have on the global environment. Indeed, the process of measuring the economy's indicators from GDP to GGDP requires a significant amount of cost. To analyze whether this transformation is worthwhile, we convert all the ecological value brought by the indicator transformation into US dollars so we can account and compare it easier. We used the cost-benefit analysis method and the multiple linear regression model established above to calculate the direct benefits, indirect benefits, direct costs and indirect costs generated in the transformation from GDP to GGDP. In addition, we estimate future trends in benefits and costs. In summary, due to the high cost of building a resource accounting department, for a short time, the global benefits were much smaller than the costs consumed, but with the development of technology, it will become easier to use more clean energy, reduce carbon dioxide and waste emissions, so the cost of emission reduction will be greatly reduced. At the same time, the improvement of the global ecological environment has effectively prevented some disasters caused by environmental degradation to a certain extent, resulting in a significant increase in potential benefits. In summary, we believe that this shift is still worthwhile and necessary in the long run.

Keywords: GGDP, cost-benefit analysis, multiple linear regression model.

1. Introduction

1.1. Research Background

For a long time, Gross domestic product (GDP) has been the most commonly used indicator of the health of a nation's economy. Because it helps boost national purchasing power and increase access

to credit, nations often take various measures to boost GDP, even at the expense of the environment. In fact, a good environment promotes economic growth, while economic growth is conducive to the more efficient use of natural resources, and the economy and the environment are synergistic, not adversarial. Therefore, the credit of natural resources needs to be fully considered in order to more accurately assess the real progress and well-being of the country in the future. It is conceivable that if green GDP is used as an indicator to measure the country's economic situation, there will be a strong policy orientation, and a series of measures conducive to environmental protection and resource conservation will be introduced one after another, so as to effectively alleviate the climate crisis and a series of other global environmental problems. Admittedly, persuading all countries to use GGDP indicators will not be easy, but we believe that as long as the climate crisis is effectively mitigated, all efforts are worth it. GDP is used as the most common indicator to measure a country's economic status, but over-indicating numbers can lead to environmental and resource waste. If green GDP is used as a measurement indicator, it is more policy-oriented and conducive to the introduction of environmental protection and resource conservation measures to alleviate global environmental problems.

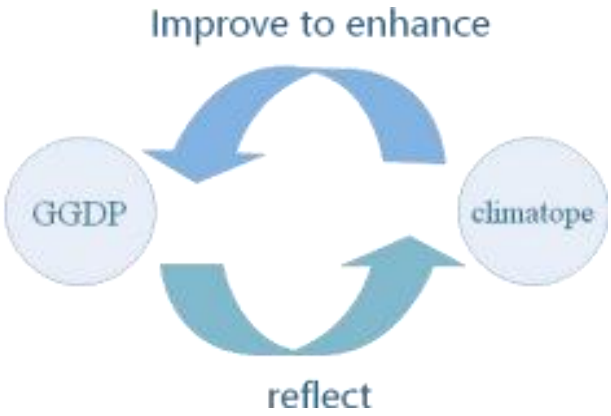

Figure 1. GGDP &.climate

1.2. Research Framework

We quantify whether GGDP should be used instead of GDP as the primary indicator of the health of a nation's economy. We build scalable, multi-layered and dynamic models, run simulations and present visualizations and predict how the global community will change after the adoption of the GGDP indicator, and what impact these changes will have on the environment. Here are the issues our team reported as having been resolved

Choose a suitable GGDP calculation method to ensure that its impact on climate change is quantifiable.

Model the impact of using the GGDP as a measure of economic health.

Determine whether our models suggest that this shift in indicators is worth it globally, comparing the potential climate benefits of the transition against the costs of the transition.

In order to estimate the impact of the transition from GDP to GGDP indicators on mitigating the climate crisis, our team chose a simpler and measurable one from many existing GGDP calculation methods, and collected GDP and climate indicators data from 25 European countries from 2010 to 2019 from Eurostat, the World Meteorological Organization and the World Bank's World Indicator Database, calculated their GGDP value and growth rate, and compared it with the GDP growth rate. The relative size found to be divided into three cases. Then we analyze the aspects from which countries need to consolidate or improve their GGDP values after the indicator transformation, and these actions will have an important impact on the global climate and even the entire ecological environment, and we combine the entropy weight method and multiple linear regression analysis to establish a simple model to quantify the impact of improved indicators on mitigating the climate crisis to prove that they will indeed contribute to the mitigation of the climate crisis. However, the change of multilateral factors is extremely challenging, and it will take great efforts for countries to fully

realize the potential advantages of GGDP in mitigating the climate crisis, and we quantify the direct benefits, indirect benefits, direct costs, and indirect costs that will be generated by the indicator switch, and conduct a cost- benefit analysis by analyzing its future trends, proving that the transition from GDP to GGDP is indeed worthwhile in the long run.

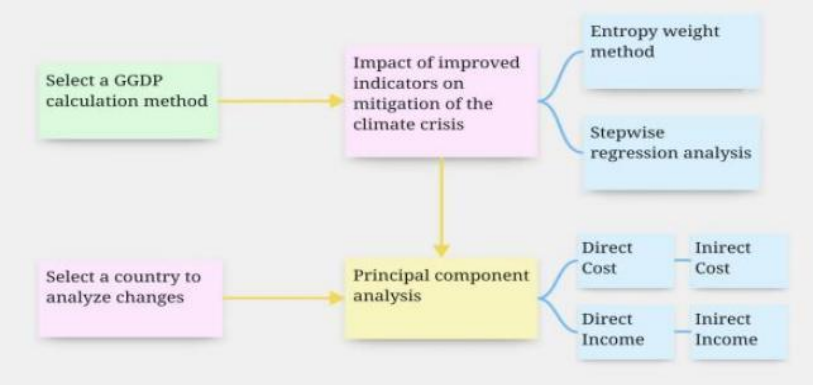

Figure 2. Our Framework

2. Assumptions and Notations

The key mathematical notations used in this paper are listed in Table1.

Table 1. The key mathematical notations

Symbol	Definition	Unit
GDP	The final result of the productive activities of all the resident units in a country (or region) within a certain period.	dollar
CO_2	The average greenhouse gas emissions from the production, transportation, use and recycling of a product	100 million tons
CDM	The average volume-weighted price for carbon (in PPP)	dollar
Twaste	The total amount of waste that can be used to generate electricity	100 million tons
74 kWh	Kilowatts of energy in one tonne of waste present an amount of electrical energy that can be obtained from a waste.	kWh
Pelect	Electricity prices	dollar
GNI	A country's total national income Adjusted savings of natural resource	dollar
NRD	depletion as a percentage of the GNI per country	percentage
Temperature	Global annual average temperature	millimeter
Precipitation	Global average annual precipitation	Celsius
Humidity	Global annual average humidity	percentage

We assume that the data collected in all databases is authentic and consistent with each other. Since our data sources come from the websites of official international organizations, there is a high probability that their data will be of good quality

In each model, we assume that the state is a holistic concept, without taking into account possible differences between regions within the country.

In the model, the metric values that we ignore have little effect on the model.

We ignore the possibility of other dramatic shifts in the world beyond changes in the indicators of the national economic system

3. Data Statistics and Algorithm Selection of GGDP

3.1. The Definition of GGDP

Green GDP is a much-used but undefined term designed to take into account and correct for the environmental impact of economic activity. However, in the current research and practice of green GDP, there are differences in the expression of green GDP, lacking a unified and standardized definition. Since the 1970s, the United Nations, the World Bank and other international organizations have done a lot of work on the research and promotion of green GDP. In 1993, SEEA (Sino-Australia Educational Exchange Association) officially proposed the concept of green GDP, which included the adjustment of resource consumption, environmental degradation and the total economic volume of environmental protection expenditure into green GDP accounting.

In essence, green GDP, which considers environmental cost and resource cost, represents the net positive effect of national economic growth. It can reflect the level of economic growth and the degree of harmony and unity between economic growth and natural environment.

3.2. GGDP calculation method Selection

For the various calculation methods of GGDP in 4.2, we comprehensively consider the difficulty of data collection and calculation, and choose a more traditional green GDP definition and accounting method, that is, green GDP = GDP - environmental pollution loss - ecological resource loss.

After determining the GGDP calculation method, we finally decided to quantitatively calculate the GGDP value, drawing on the methods of Juraj Dobrila and Mijo mirkovic of Pula University, that is, the cost of converting environmental pollution loss and ecological resource loss into CO_2 pollution (CO emissions multiplied by carbon market price), opportunity cost of waste that can be used for power generation, and saving natural resource consumption. Its specific calculation formula is as follows:

$$GGDP = GDP - (KtCD_2 \times PCDM) - (Twaste \times 74kWh \times Pelect) - \left(\frac{GNI}{100}\right) \times \%NRD \quad (1)$$

The first deduction is the cost of CO pollution (CO emissions multiplied by the carbon market price), the second deduction is the opportunity cost per ton of waste available for power generation, and the third deduction is the percentage of adjusted natural resource consumption savings in each country's gross national income.

4. GGDP: Models and Impact Analysis

4.1. Model Indicators

Clearly, after the indicator shift, countries must take steps to improve their GGDP scores. Therefore, we selected three indicators that reflect their measures (carbon dioxide emissions, waste emissions, and natural resource depletion), further quantified the impact of these three indicators on the global environment, and reflected them through these three environmental indicators (global average temperature, global average precipitation, air humidity). The specific idea is as follows:

Figure 3. Indicator System

4.2. GGDP calculation and analysis

The regression equations were obtained by multiple linear analysis with global average temperature, global average precipitation and air humidity as dependent variables, and carbon dioxide emissions, global natural resources depletion as a percentage of gross national income and waste emissions as independent variables.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon \tag{2}$$

$$\varepsilon \sim N(0, \sigma^2) \tag{3}$$

Where the dependent variable, independent variables and coefficients are all third-order matrices, Ɛ is a perturbation factor.

In the BP test, the p-value is greater than 0.05, It means that the original hypothesis of no heteroskedasticity is accepted.

The linear regression equations between different dependent variables and independent variables were finally obtained by stepwise regression to filter the factors.

$$\begin{cases} Tem = 11.412 + 0.095 lnCO_2 \\ Per = 1177.48 + 8935.48 NRD \\ Hum = 0.656 + 0.0349 lnCO_2 + 0.047 Twase \end{cases} \tag{4}$$

Tem, Per, and Hum denote average temperature, average precipitation, and average humidity, respectively; NRD and Twase denote global natural resource depletion as a percentage of gross national income and waste emissions, respectively.

The above system of equations shows that for every million tons of CO2 emissions, the average global temperature rises by an average of 0.09 degrees; For every 1% decrease in global natural resources loss as a percentage of GNI, global precipitation increases by an average of 89.35 mm; For every million tons of CO2 emissions and 100 million tons of waste, global air humidity rises by an average of 3.956%.

The model can demonstrate that there are significant positive correlations between global CO2 emissions, natural resources depletion rate, total waste emissions and global average temperature, precipitation and humidity, and the impact of GGDP on global climate change can be explained by these independent variables.

5. Is it worth it to switch from GDP to GGDP?

5.1. Idea analysis

Previously, we conclude that the climate crisis can indeed be mitigated by reducing carbon dioxide emissions, natural resource depletion and waste emissions under the GGDP calculation method by Saša Stjepanović, but we do not consider the cost of changing the value of these factors, so we need to compare the two to determine whether the conversion of GGDP is beneficial to global sustainable development (including economic, social and environmental aspects).

To solve this problem, we use a cost-benefit analysis, combining the GGDP calculation method by Saša Stjepanović and the climate impact of the use of GGDP in our model, respectively, to analyze the direct benefits, indirect benefits, direct costs and indirect costs that will be generated by converting GDP to GGDP, quantify them in monetary terms, estimate the future trend of benefits and costs, and then judge whether the conversion is worth it by their differences.

5.2. Cost-benefit analysis

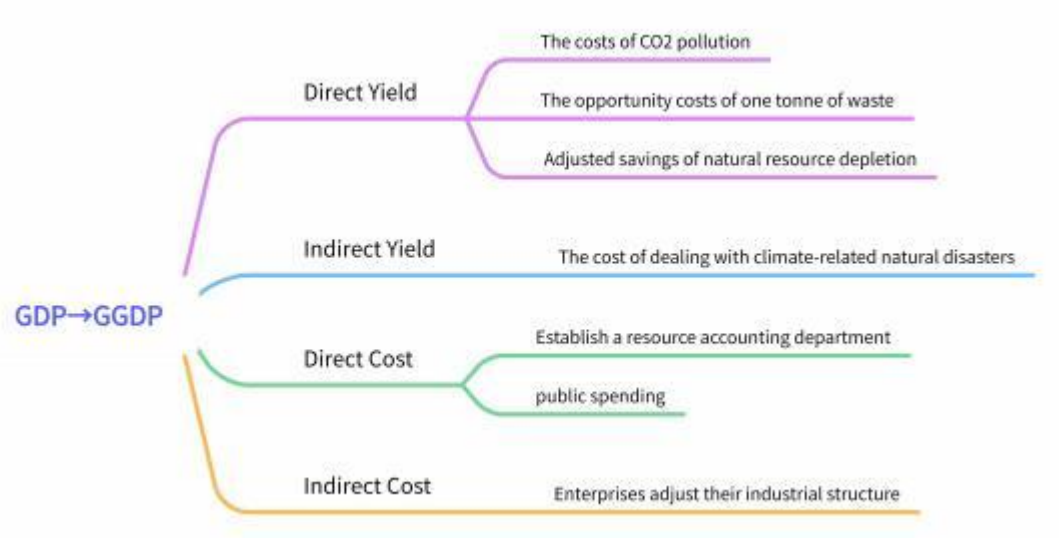

Figure 4. Cost-benefit analysis

The cost-benefit analysis formula is:

$$CBA = \sum(DB + \mathrm{IE}) - (\mathrm{DC} - \mathrm{IC}) \tag{5}$$

Where DB denotes direct benefits, IE denotes indirect benefits, DC denotes direct costs, and IC denotes indirect costs.

According to Saša Stjepanović 's GGDP calculation methodology, assuming that GDP and GNI remain unchanged, since it is difficult for the CDM and Pelect indicator values to change significantly in the short term, most countries will turn their attention to carbon dioxide emissions, waste emissions, and natural resource depletion, and increase the GGDP value by reducing their indicator values.

Thus, according to the calculation method of Saša Stjepanović, we can convert the natural resource benefits saved into monetary form, namely:

$$Direct\ benefits = CO_2 \times PCDM + Twaster \times 74kWh \times Pelect + \frac{GNI}{100} \times \%NRD \tag{6}$$

For example, based on the formula and carbon market prices, it can be concluded that for every 10,000 tones of emissions reduced by other indicators, generating about $21,000. And According to our model, it'll also reduces carbon dioxide emissions and natural resource.

Also, consumption can effectively curb global warming and increase global humidity and precipitation, which will bring another part of the benefits.

In China, for example, after having improvd air quality in 2015, about 1.2 million people avoided dying from pollution, which is worth a total of about US $169 billion assuming that the value of a person's life is measurable. By enhancing resource conservation and recycling, China could save 4.4% of China's GDP in 2019 each year, or about US $640 billion). However, the introduction of the policy of converting GDP to GGDP will also force countries to pay certain economic costs, including the direct costs of establishing resource accounting departments (including labor costs, equipment costs, publicity costs, data collection and processing costs, etc.) and the indirect costs of industrial restructuring, but these costs are relatively stable and can be regarded as a constant.

Therefore, we can estimate the economic cost of converting GGDP to GDP in relation to the economic benefits obtained as follows:

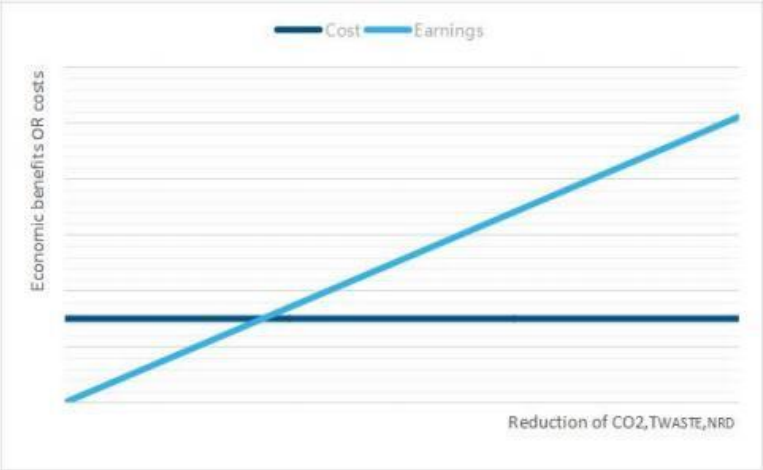

Figure 5. GDP-GGDP economic efficiency relationship

It can be seen that according to our hypothesis, after the conversion from GDP to GGDP, for a long time, the global benefits are much smaller than the cost of consumption due to the high cost of building the resource accounting department. But with the development of science and technology, it will be easier and easier to use more clean energy, reduce carbon dioxide and waste emissions, and thus save the future large opportunity cost. In addition, the improvement of environmental quality is also conducive to improving people's happiness in life and promoting comprehensive sustainable development worldwide. Therefore, we believe that the transition from GDP to GGDP is very worthwhile, even if it will initially destabilize the economic systems of some countries, but we believe that with reasonable adjustment of our policies and institutions, we can successfully survive this Changes in the global economic system and truly benefit mankind.

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