Transactions on Computer Science and Intelligent Systems Research
ISSN: 2960-1800, eISSN: 2960-2238 | Volume 5
AIDML 2024

Green GDP -- Research on the development of green GDP and ecological environment cost based on regression model

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Abstract. This study explores the concept of green GDP and its relationship with eco-environmental cost, aiming to study the development of green GDP and eco-environmental cost based on regression model. First, green GDP is a new type of GDP after deducting the cost of resource and environment degradation and increasing environmental profit based on traditional GDP. Then, it introduces its accounting method to realize sustainable development by calculating resource and environmental cost and environmental benefit. It is found that the cost of resources and environment has an important impact on the growth of green GDP. Based on the regression model and SPSS statistical software, the complex nonlinear relationship between green GDP and environmental cost, resource depletion cost and environmental deterioration cost is quantitatively analyzed. Through multiple regression, it is concluded that the environmental pollution loss cost has a significant impact on green GDP, and the natural resource depletion cost is also one of the important factors. The results of this study help to better understand the relationship between the development trend of green GDP and the ecological environment cost, and provide theoretical support and policy suggestions for sustainable development.

Keywords: Green GDP; Ecological Environment Cost; Regression Model.

1. Introduction

There is a close relationship between green development and economic development, in the context of today's society, green economy has become an important direction of economic development. Economic development has long been usually guided by the pursuit of economic growth and profit maximization, but this has led to problems [1] such as excessive consumption of resources, environmental pollution and ecological damage. Therefore, to achieve the sustainable development Goals, the concept of green development came into being. In this context, this study aims to explore the relationship between green GDP and ecological and environmental costs. The concept of green GDP was put forward to assess the environmental costs behind economic growth and integrate environmental factors into economic development. Green GDP is the expansion and modification of traditional GDP, which deducts the cost of resource and environment degradation and increases environmental profits, reflecting the impact [2] of economic activities on the ecological environment. By studying the development of green GDP and ecological environment cost, the relationship between environmental sustainability and economic development can be evaluated.

However, the existing researches on the relationship between green GDP and ecological environment cost mainly focus on the calculation methods [3] of green GDP, environmental protection investment [4], enterprise cost accounting [5] and so on. Some studies use regression analysis and other economic models to explore the development of green GDP in different countries and regions, and find that environmental costs have an important impact on the growth of green GDP. However, at present, the research on the specific relationship between green GDP and ecological environment cost is still limited, especially the lack of in-depth discussion on the nonlinear relationship. To solve this problem, this study will use regression model and SPSS statistical software for quantitative analysis, to explore the relationship between green GDP and environmental cost, resource depletion cost and environmental deterioration cost. We will combine the experience and methods of previous studies

to build a relatively complete analysis framework, to reveal the complex nonlinear relationship between green GDP and ecological environment cost, and further understand its impact on sustainable development, to promote the coordination between economic growth and environmental protection.

The marginal contribution of this paper is as follows: First, it has enriched the relevant research on the influencing factors of green GDP. It is very important to study the correlation between green GDP and resource and environment cost for sustainable development. Through in-depth analysis of the development trend of green GDP and the ecological environment cost, the impact of economic development on the ecological environment can be more accurately measured. Secondly, studying the development trend of green GDP can help us understand the relationship between economic growth, resource consumption and environmental pollution. By comprehensively considering the cost of resource depletion, the cost of environmental degradation and environmental profit, we can get specific data and indicators to evaluate the impact of economic development activities on resources and environment. Finally, the study of the relationship between green GDP and ecological and environmental costs can also provide theoretical support and policy suggestions for sustainable development. These research results can provide scientific basis for the government to promote new development concepts, circular economy and sustainable development.

2. Research design

2.1. Meaning of green GDP

Green GDP refers to the new GDP after the government deducts the degradation cost of resources and environment from the traditional GDP and increases the environmental profit. The cost of resources and environment mainly includes:

(1) Depletion cost of natural resources: Depletion cost of natural resources refers to the value brought by the use and consumption of certain natural resources in the economic activities of a country or region [6]

(2) The cost of environmental deterioration: the loss of all-natural environment value caused by the deterioration of ecological environment due to the decline of environmental quality caused by unreasonable **human** development [6].

2.2. Calculation method of green GDP

The accounting method aims to determine various resource and environmental costs through calculation, and obtain sustainable development benefits from them, to achieve sustainable development [7] of green GDP. It is expressed by the formula as follows:

$$Green\ GDP = traditional\ GDP - resource\ and\ environmenttal\ costs + environmental\ benefits \quad (1)$$

The cost of resources and environment can be calculated by reducing the cost of natural consumption, pollution and natural destruction, to achieve the sustainability of environmental protection.

(1) Accounting of the cost of depletion of natural resources

① Accounting of the cost of depletion of renewable resources: Replacement cost method is an important cost accounting method, including all the costs of restoring the natural environment and resources.

(2) Non-renewable resource depletion cost accounting: To accurately estimate the consumption cost of non-renewable resources, it is necessary to obtain their actual consumption and unit value indicator data. However, at present, only their fair market price can be obtained, and their true value cannot be determined. So, we can choose opportunity cost method or alternative cost method to estimate.

(2) Accounting of the cost of environmental degradation

① Accounting of environmental pollution loss: due to human industrialization, urbanization and the development of other industries, the consumption of natural resources has far exceeded the load of nature, which has brought huge economic losses to society, so: environmental pollution loss cost: [8]E_nD_c

$$E_nD_c = E_nDC_a + E_nDC_w + E_nDC_s \quad (2)$$

Where: E_nD_c is the cost of environmental pollution loss, E_nDC_a is the cost of air pollution environmental pollution loss, E_nDC_w is the cost of water pollution environmental pollution loss,$E_nDC_s$is the cost of soil pollution environmental pollution loss

② Accounting of ecological damage loss: this accounting considers how to reduce the economic impact caused by human activities. Combining the total input of these resources with the proportion of this input by the maximum value obtained, the cost of ecological damage loss is:E_eDC

$$E_eDC = E_eDC_f + E_eDC_g + E_eDC_w + E_eDC_a \quad (3)$$

Where: E_eDC_f represents the destruction of forest ecosystems, E_eDC_g refers to the destruction of grassland, wetland and farmland ecosystems, and E_eDC_a refers to the damage loss of these systems.

③ Accounting of environmental benefits: With the continuous advancement of environmental protection, enterprises can not only get more benefits from disposing of waste, but also drive the green development of industry, which can be reflected by traditional GDP measurement.

3. Study on the relationship between green GDP and resource and environmental cost

The research finds that the cost of resources and environment has an important impact [9] on the growth of green GDP. Since it is impossible to assess this impact, a quantitative method is chosen to analyze the relationship between green GDP and resources and environment cost by constructing a regression model and using SPSS statistical software.

3.1. Correlation analysis -- scatter chart

When exploring the mathematical connection between green GDP and resource and environment cost in China from 20013 to 2021, green GDP is taken as the dependent variable and resource and environment cost as the independent variable, and the characteristics between them are found by drawing scatter plots. Excel tool is used to process the data and it is found that green GDP, resource and environment cost, natural resource consumption and environmental pollution all have certain mutual influence. By comparing the scatterplot, the variation trend is non-linear. In Figure 1 and Figure 3, the change of green GDP tends to be consistent, that is, with the intensification of resource and environment consumption and pollution, GDP also shows an upward trend. However, in Figure 2, the change is more obvious, indicating that the change of green GDP tends to be consistent.

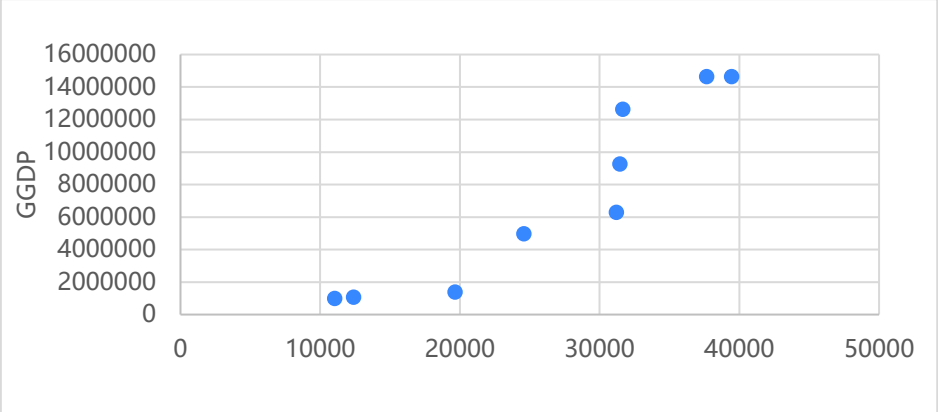

Figure 1. Scatter chart of green GDP and resource and environmental costs

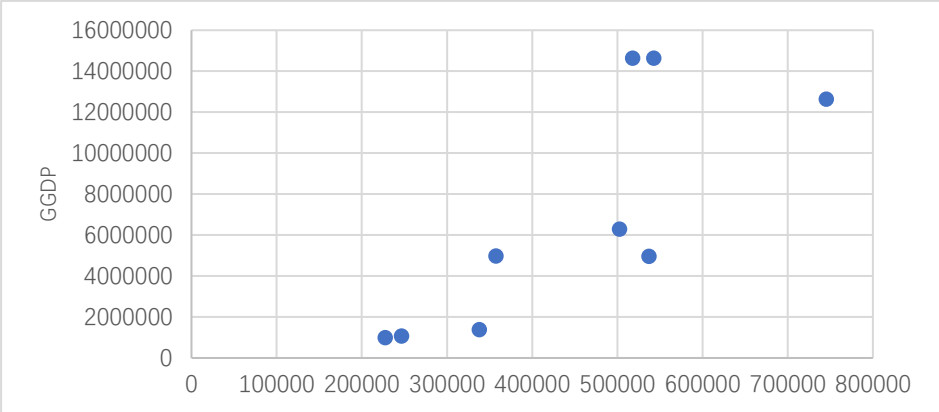

Figure 2. Distribution diagram of green GDP and resource consumption cost

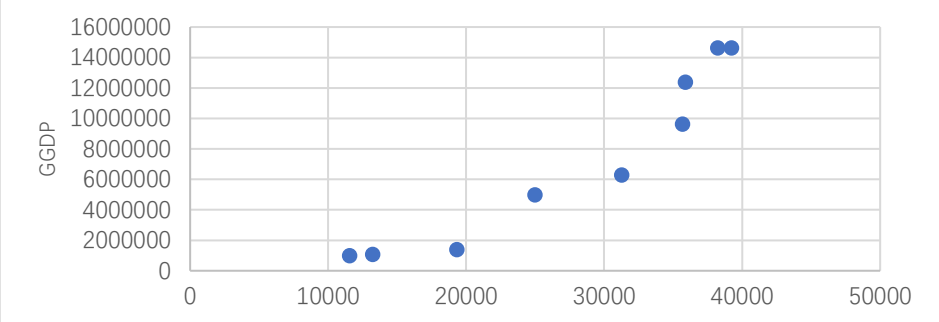

Figure 3. Scatter plot of green GDP and cost of environmental degradation

3.2. Model Construction

Through the analysis of scatter plot, there is a curvy relationship between green GDP and environmental cost, natural resource consumption cost and environmental deterioration cost. To better fit this relationship, the final model is determined, in which the determinability coefficient (R^2) and significance test value (F) are important reference indicators. Therefore, this paper constructs 5 different function curve estimation models to obtain better results.

Quadratic function curve:

$$Y = \alpha_0 + \alpha_1 x + \alpha_2 x^2 \quad (4)$$

Cubic function curve:

$$\Upsilon = \alpha_0 + \alpha_1 x + \alpha_2 x^2 + \alpha_3 x^3 \quad (5)$$

Growth function curve:

$$\Upsilon = e^{\alpha_0 + \alpha_1 x} \quad (6)$$

S function curve:

$$\Upsilon = e^{\alpha_0 + \frac{\alpha_1}{x}} \quad (7)$$

Power function curve:

$$\Upsilon = \alpha_0 (x^{\alpha_1}) \quad (8)$$

Where is green GDP, is the environmental cost index, including the total environmental cost, environmental degradation cost and natural resource depletion cost, is the model coefficient.$\Upsilon\chi\alpha o, \alpha_1, \alpha_2, \alpha_3$

The F-test can be used to measure the match between the regression equation and the actual data, to evaluate the similarity of two parameters and to judge their importance. The F-test can be used to determine the importance of two parameters more accurately. Depending on the chosen measure of significance (usually 0.05 or 0.01), the degrees of freedom for n21 and n are determined. If F is greater than F>Fa (n1, n2), the regression model is statistically significant and worthy of recognition.

3.3. Regression Analysis

3.3.1. Regression analysis of green GDP and environmental cost.

With the support of SPSS software, there is a close relationship between green GDP and environmental cost. The functional relationship between them is listed through the connection. Please refer to Table 1 for details. We find that its R-2value is beyond the significance of 0.05, which means that the quadratic and cubic curves do not meet the requirements of F. According to the requirements of the best fitting procedure, the R^2 and F values of the S-curve significantly exceed those of other curve models, which makes it considered to be the best curve for green GDP and environmental costs, expressed as follows: $Y = e^{12.682 - 49873.092/x}$

Table 1. Regression results of green GDP and resource and environment cost

Equation	Model summary					Parameter estimates			
	R^2	F	df1	df2	Sig	a_0	a_1	a_2	a_3
Quadratic function	.702	7.067	2	6	.026	-124460304.30	60.133	3.741 E-005	-
Cubic function	.704	3997	3	5	.085	-2609423.403	4.832	000.	-
Growth function	.754	21.234	1	7	.002	12.827	-	-	-
s function	.989	45232	1	7	.000	12.682	49873.09	-	-
Power function	.829	33074	1	7	.001	8.66 E-002	-	-	-

According to the data of regression analysis, it is found that with the continuous increase of environmental costs, the growth rate of green GDP slows down, forming an S-shaped trend. This

indicates that with the continuous rise of environmental costs, the development of green GDP is limited to some extent.

3.3.2. Regression analysis of green GDP and resource depletion cost.

After analysis, the regression results of green GDP and resource depletion cost are shown in Table 2. The R^2 of the fitted model is more than 0.5, and the highest is 0.982. However, the significance levels of the quadratic and cubic curves are lower than the F-value respectively. After considering the influence of R^2 and F value comprehensively, S function curve is finally selected to fit the relationship between them: $Y = e^{12.682-49873.092/x}$

Table 2. Regression results of green GDP and resource consumption cost

Equation	Model summary					Parameter estimates			
	R2	F	df1	df2	Sig	Alpha 0	Alpha 1	Alpha 2	Alpha 3
Quadratic function	.965	87369	2	6	.000	6923376.286	-677.265	.023	-
Cubic function	.969	92716	2	6	.000	1186283.933	.000	-.009	3.840 E-001
Growth function	.982	397.936	1	7	.000	12.382	.000	-	-
S function	.963	182.329	1	7	.000	17.292	-57435.054	-	-
Power function	.987	543.932	1	7	.000	8.557	2.659	-	-

3.3.3. Regression analysis of green GDP and environmental degradation cost.

According to the data in Table 3, the R2 value of the fitting curve of the power function of R^2 and F value reaches 0.987, which means that 98.7% of the total sum of squares of deviation can be accurately described by the sample regression curve. The relationship between green GDP and environmental pollution is similar, where Y=8.557 is Y=8.557 (χ2.659).

Table 3. Regression results of green GDP and environmental degradation cost

Equation	Model summary					Parameter estimates			
	R^2	F	df1	df2	Sig	a_0	a_1	a_2	a_3
Quadratic function	.687	6.595	2	6	.006	1758570011.307	107617665.7	-	-
Cubic function	.688	3.675	3	5	.098	- 834513463237	39.288		-
Growth function	.722	18515	1	7	.004	1.885E-009			-
s function	.893	40585	1	7	.000	17.728	895167.694	-	-
Power function	.807	28367	1	7	.001	12.896	2.878	-	-

After analysis, the total amount of green GDP and the loss cost of environmental pollution show a consistent increasing trend, and the growth shows no sign of decreasing during the study sample period, which indicates that the development of green GDP is based on [10] serious environmental pollution. Secondly, through multiple regression analysis, we can better understand how green GDP reduces the cost of resource consumption and environmental deterioration. Through the binary linear regression model, two regression methods, namely univariate regression method, can be compared to evaluate the relationship between environmental pollution, resource consumption, GDP and other economic indicators, to obtain accurate conclusions. According to the analysis of the correlation coefficient, the growth of green GDP will lead to more energy consumption, but also increase the damage to the natural environment, which is supported by the binary regression analysis.

Based on the above analysis, the relationship model between green GDP and resource depletion cost and environmental deterioration cost is preliminarily established:$\Upsilon = \beta + \alpha_1\chi_1 + \alpha_2\chi_2$

After SPSS analysis, it is found that there is a close relationship between green GDP and resource depletion cost and environmental pollution loss. Table 4 summarizes such associations and provides the statistics used to assess them. In addition, the correlation coefficient of this association is 0.991, indicating that there is a close correlation between environmental GDP and various resource depletion efficiency and pollution risk. The adjustment of R^2 is very important for the fitting effect of the model; the higher its value, the higher the accuracy of the model. It can be seen from Table 4 that the adjusted R^2 reaches 0.991, which indicates that the fitting ability of the modeling is excellent.

Table 4. Summary of the model

Model	R	R square	R square after adjustment	Errors in standard estimates	Durbin-Watson
1	.991	.982	.979	9223.372036854777000	1.751

According to the data in Table 5, the statistic of F reaches 327.358, and the value of P is lower than 0.05, all of which indicate that this model has strong statistical significance, thus drawing an important conclusion: there is a significant positive correlation between resource consumption, environmental pollution and GDP.

Table 5. Analysis of Variance Table

Models		Sum of Squares	Degrees of Freedom	Mean square	F	Salience
1	Regression	1194568107323101.200	5	238913621464620.250	327.358	000.
	Residual	21894726655283.508	30	729824221842.784		
	In total	1216462833978384.800	35			

From the data in Table 6, it can be inferred that y=69934.727, where the values of 4.223x1+279.943x2 are the values of y, and these values can be used to describe the regression coefficients of the independent variables.

Table 6. Table of regression coefficients

Models		Unstandardized coefficients		Standardized coefficient	t	Salience
		B	Standard error	Beta		
1	(Constant)	67934.583	184375.338		379.	707.
	Depletion of natural resources	4.223	78.810	- 008.	- 335.	740.
	Environmental pollution losses	279.943	252.264	011.	4.441	663.

Through T-test, it is found that environmental pollution loss has a significant impact on green GDP, and its regression coefficient is between $Y = 67934.583 - 4.223x_1 + 279.943x_2$, which is higher than the standard value. In contrast, the depletion cost of natural resources has a smaller impact, but it is still an important factor.

4. Conclusion

Green development is a development concept that strikes a balance between economic development and environmental protection. In recent years, with the increasing prominence of global environmental problems and the advocacy of sustainable development, green development has become an important topic for governments and international organizations. In this context, this study explores the concept of green GDP and its relationship with ecological and environmental costs, aiming to study the development of green GDP and ecological and environmental costs based on a regression model. First, green GDP is a new type of GDP after deducting the cost of resource and environment degradation and increasing environmental profit because of traditional GDP. Then, it introduces its accounting

method to realize sustainable development by calculating resource and environmental cost and environmental benefit. It is found that the cost of resources and environment has an important impact on the growth of green GDP. Based on the regression model and SPSS statistical software, the complex nonlinear relationship between green GDP and environmental cost, resource depletion cost and environmental deterioration cost is quantitatively analyzed. Through multiple regression, it is concluded that the environmental pollution loss cost has a significant impact on green GDP, and the natural resource depletion cost is also one of the important factors. The results of this study are helpful to better understand the relationship between the development trend of green GDP and the cost of ecological environment, to promote sustainable economic growth and sustainable environmental protection. To provide theoretical support and policy suggestions for sustainable development, to promote the realization of sustainable development.

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