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Empirical Research on the Development of EU Green Economy and Its Influencing Factors

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ABSTRACT

Based on the research of green economy, this paper recalculates the green GDP of 24 EU countries from 2005 to 2019, and analyzes the influencing factors of green GDP through a fixed-effect panel regression model. The results show that industrial structure (IS), energy intensity (EI), per capita gross domestic product (RGDP), technological progress (TDL), environmental regulation (ER) and new energy vehicle sales (INC) all have a significant impact on green GDP.

Keywords: *Green Economy, EU, Green GDP, Panel data model, Influencing Factors*

1. CALCULATION OF EU GREEN GDP

1.1. Calculation method of green GDP

For the development of the green economy in the EU, the calculated green GDP value is used. Because GDP is a general concept, it has certain explanatory significance. Green GDP, also known as GGDP (Green Gross Domestic Product), refers to the consideration of natural resources (mainly including land, forests, minerals, water and ocean) and environmental factors (including ecological environment, natural environment, etc.) in a country or region. , human environment, etc.) affect the final results of economic activities, that is, the cost of resource consumption and environmental degradation in economic activities will be deducted from GDP. GDP is the total value added of all resident producers in an economy plus any taxes on products minus any subsidies not included in the value of products. It is calculated without deducting the depreciation of manufactured assets or the depletion and degradation of natural resources.

Zhao Ying and Wang Min (2021) established a green GDP accounting system from four aspects: the depletion value of resources, the ecological degradation loss of natural resources, the cost of environmental pollution, and the improvement of resource and environmental benefits. Entropy weight method to model accounting.[1] Guo Chengli (2013)[2] suggested that the basic theories and principles of SEEA (Comprehensive Environmental and Economic Accounting Manual) should be adopted with reference to Canadian practices. It consists of three parts: environmental pressures, environmental conditions and environmental responses[3]. Each part consists of different accounts, indicators, and data to reflect various economic The relationship between activity and environment. Peng Tao, Wu Wenliang (2010), based on the expansion and accounting difficulties from SNA (System of National Economic Accounts) to SEEA, proposed a simplified green GDP accounting method, the reduction of GDP plus natural resource consumption, and the reduction of environmental quality degradation. , Accounting for the value of recycled products [4]. Jiang Ya, Li Xiaoyan, and Zhang Shuochen started by sorting out the current status of international green GDP accounting, reviewed the death of green GDP in the United States and the process of green GDP accounting in Japan, and put forward suggestions on the necessity of compiling a national balance sheet[5] This paper mainly adopts the international mainstream SEEN method to calculate the green GDP. From GNP, the first deduction represents the cost of CO_2 pollution; the second deducts the opportunity cost of one ton of waste that could be used to produce electricity; and the third deducts the percentage of natural resource depletion-adjusted savings. See the following formula for details:

$$GGDP = GDP - (CO_2 * CDM) -(TWASTE * 74KWH * PELECT) - (GNI / 100 * NRD)$$

The first deduction from green GDP is the cost of carbon dioxide pollution abatement. The cost of carbon dioxide abatement is related to two variables, namely the

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total carbon dioxide emission equivalent (CO_2) and the corresponding treatment price. Among them, the carbon dioxide emission CO_2 can be obtained by direct query. This article uses the authoritative World Bank data. The governance price is relatively difficult to measure, and current unified cognition adopts the corresponding CO_2 price in carbon trading (ETS), that is, CDM. The data comes from the World Bank.

Table1. The 2005-2019 green GDP in different regions of the European Union, unit, USD 100 million

area	nation	2005	2007	2009	2011	2013	2015	2017	2019
Western Europe	Germany	26009.1	29753.7	30004.5	33912.3	36191.5	38802.8	43694.0	46240.1
	France	19170.2	21787.1	22378.6	24359.7	26041.3	27143.3	29792.6	33120.0
	Netherlands	6078.7	7141.6	7288.9	7668.6	8177.7	8471.2	9397.9	10251.3
	Czech	2225.1	2693.5	2876.5	3005.9	3228.8	3564.0	4102.3	4556.7
	Luxembourg	314.0	401.8	406.8	473.2	518.0	589.5	668.6	747.5
Central and Eastern Europe	Poland	5215.0	6352.7	7264.5	8554.8	9284.0	10150.3	11363.2	12864.9
	Austria	2858.0	3257.0	3398.5	3704.6	4050.7	4299.2	4755.9	5188.5
	Belgium	3448.7	3897.2	4057.3	4490.8	4862.5	5196.9	5726.8	6259.7
	Hungary	1704.4	1905.7	2056.4	2270.4	2411.4	2627.2	2875.5	3299.7
	Greece	2786.0	3222.6	3351.4	2820.2	2832.0	2879.5	3071.0	3292.5
	Cyprus	203.2	251.5	272.5	281.2	261.0	268.9	326.3	364.4
	Slovakia	883.8	1136.0	1236.2	1396.9	1511.5	1618.0	1631.9	1765.6
	Slovenia	473.4	554.8	559.0	589.4	616.1	651.3	753.1	856.7
	Bulgaria	764.8	947.3	1036.4	1118.2	1183.3	1301.8	1498.0	1698.3
	Malta	88.9	101.3	109.3	119.7	137.2	166.3	198.1	231.7
Southern Europe	Portugal	2369.8	2704.0	2788.1	2812.3	2916.9	3067.3	3398.0	3767.9
	Spain	11970.2	14648.3	14833.6	14817.3	15093.4	16181.7	18390.1	19814.7
	Italy	17339.6	19883.5	20371.4	21594.7	21812.6	22361.6	25130.9	26691.7
Nordic	Denmark	1812.9	2096.0	2197.7	2424.3	2592.3	2771.2	3174.3	3486.8
	Sweden	3070.9	3722.6	3732.0	4183.5	4427.7	4797.9	5208.3	5637.1
	Finland	1664.8	1990.8	2013.6	2182.5	2245.9	2319.0	2605.4	2835.7
	Latvia	309.0	399.9	362.3	407.4	458.5	492.9	555.9	611.5
	Lithuania	478.1	614.8	570.8	688.9	788.7	836.2	953.7	1079.6
	Estonia	220.4	294.9	270.2	319.0	359.0	383.1	442.5	509.2

The second deduction is the opportunity cost of a ton of waste for the user to produce electricity. We think from three dimensions. First, the total amount of waste generated by economic activities (TWASTE) should be obtained by direct query. Second, the electric energy obtained from one meal of waste. According to relevant experimental data, one meal of waste can extract approximately 74KWH of electric energy. The variable is 74KWH, and the last is the industrial and commercial average electricity price, which can be directly inquired through Eurostat.

The third indicator is the adjusted percentage of natural resource depletion savings. This variable actually accounts for the depletion and degradation of natural resources. We express it by GNI of gross domestic product and the ratio of savings after adjusting for natural resource consumption to GNI.

1.2. Green GDP measurement results

After sorting out the underlying data of green GDP, use R language software for econometric analysis, and the results show on Table1.

Judging from the results of green GDP measurement, the overall equivalent of green GGDP is already leading in Western Europe, followed by Southern Europe, then Central and Eastern Europe and Northern Europe. The gap with GDP has remained basically the same. At the national level, the absolute value of France and Germany increased more, especially Germany.Germany, France, Italy, and Spain rank among the top five in the EU in terms of absolute green GDP, all showing a positive growth trend.

2. ANALYSIS OF INFLUENCING FACTORS OF GREEN ECONOMY

The policies that affect the development of green economy are systematically sorted out, and the mechanisms are coordinated with influencing factors, which leads to country and regional differences in the development of green economy. According to the literature review, the system of influencing factors affecting the green economy can be divided into three categories, as social development, industries and supporting policies.

2.1. Social and economy development

2.1.1. The level of economic development (RGDP)

The level of economic development can be transmitted to the environment as well as to the efficiency of resource utilization, which in turn directly affects the level of green economic development. The environmental Kuznets curve shows that economic development and environmental quality have a U-shaped relationship, that is, in the early stage of economic development, with the development of the economy, the environmental quality is getting worse and worse, and when the economic development reaches an inflection point, people begin to pay more attention to the ecological environment. Environmental protection, from ideology to practice, will pay attention to the ecological environment. With this concept, along with the sustainable development of the economy, the environmental quality will gradually improve[6]. We can regard environmental protection and green development as the superstructure, and the level of economic development at this time has an immeasurable impact on it. [7]In view of the convenience of quantitative analysis, this paper uses per capita RGDP to represent the level of social and economic development.

2.1.2. Technological Progress (TDL)

Table 2. Overview of Mixed, Fixed, and Random Effects Models

	mixed effects		fixed effects		random effects	
	Estimate	t-value	Estimate	t-value	Estimate	z-value
RGDP	-0.131416.	-1.7982	-0.1613*	-1.9815	-0.1367	-1.8556
IS	-371.0782*	-2.5718	-380.5521**	-2.6259	143.8522 **	-2.5825
UI	-277.6417 ***	-5.6044	-299.9295 ***	-6.1454	-279.1876 **	-5.6700
EI	-2411.6716 ***	-16.8241	-2674.4889 ***	-17.1793	-2431.6685 ***	-16.9378
TDL	4198.5112 ***	3.8799	4382.1635 ***	3.8949	4235.0062 ***	3.9115
ER	-78.7143	-0.0825	-90.4534	-0.0953	-64.6636	-0.0681
FDI	13.2259	0.1184	13.3726	0.1199	13.6437	0.1226
INC	0.0895***	6.4378	0.0478*	2.3471	0.0873***	6.1038
R-Squared	0.8285		0.8483		0.8302	
Adj. R^2	0.8173		0.8223		0.8192	
F-statistic	74.4083 on 10 and 154 DF, p-value: < 0.0001		78.2896 on 10 and 140 DF, p-value: < 0.0001		NA	
Chisq	NA		NA		753.211 on 10 DF, p-value: <0.0001	

Technological and technological progress will bring great changes to both production and way of life. First of all, technological progress and iteration will improve labor productivity and thus improve resource utilization efficiency, which means that the same resource and energy consumption will bring more ode unit output. Secondly, scientific and technological progress will change the form of resource utilization, such as switching from traditional energy to new energy, from primary energy to renewable energy, from extensive to intensive, all of which have contributed to the development of a green economy. In addition to improving labor efficiency and changing the form of resource utilization, scientific and technological progress has also improved the technology and ability level of workers and prompted them to use more efficient, economical and environmentally friendly methods and technologies. In this paper, TDL adopts the internationally accepted indicator for comparing the human input of science and technology, that is, the full-time equivalent of R&D.

2.1.3. Urbanization level (UI)

The level of urbanization, as another variable of the level of social and economic development, reflects the agglomeration effect and scale effect of social resources from another aspect. The urbanization level index can be used as an important correction variable. This paper uses the proportion of urban population to total population at the end of the year to represent the level of urbanization (UI)[8].

2.2. Industry development

2.2.1. Industrial Structure (IS)

From an industrial point of view, the primary and tertiary industries almost do not emit greenhouse gases, and they are basically green and environmentally friendly industries, and the development and high proportion of the tertiary industry will promote social progress. The industrial manufacturing industry, which belongs to the secondary industry, is the main source of emission of the three wastes in the world. Therefore, the industrial structure of an economy and society will greatly affect the development of green economy. In this paper, the industrial structure (IS) adopts the proportion of GDP of the secondary industry.

2.2.2. Energy Intensity (EI)

One of the core paths of the Eu's green economy development is green energy. The level of energy intensity has a great impact on emissions and energy consumption per unit of output value. Energy intensity directly affects the development of low-carbon and green economy. In this paper, energy intensity (EI) is represented by the energy consumption per unit of GDP (energy consumption per unit of output value), that is, the proportion of total domestic primary energy use or final energy use in GDP.[9].

2.2.3. New Energy Vehicles (INC)

Policy incentives have an obvious positive effect on the development of green economy. The transportation field is an important scenario for energy conservation and emission reduction, and it is also the core industry direction of policy incentives. As an application field, the new energy of transportation has a great impact on carbon peaking and carbon neutralization. This paper uses the sales volume of new energy vehicles (INC) to replace the impact of policy incentives on the development of green economy.

2.3. Factors of policy

2.3.1. Degree of opening to the outside world (FDI)

The degree of economic openness is generally expressed by foreign direct investment (FDI). The degree of economic openness represents the development level of advanced production technology and management technology. From the actual situation, the degree of openness to the outside world has the phenomenon of inhibiting the development of green economy efficiency, that is, the hypothesis of "pollutant refuge effect". Most of the industries with a high proportion of foreign investment in various countries belong to the industries that make full use of the stock

resources of each country. Generally, the output value is large but the growth rate is small. A large proportion of foreign investment in the market may cause market and resources to crowd out and inhibit the growth of the green economy.

2.3.2Green Finance (GB)

Green Finance (GB) directly acts on the development of green economy, and will form a spiral of green finance-green economy development. However, since 2007, the practice of green finance in the EU has achieved rapid development since 2014. From the perspective of quantitative analysis, this part of the data has poor continuity and cannot be used for panel data model analysis for the time being.

2.3.3Environmental Regulation (ER)

Environmental regulation clearly defines the path and direction of the development of the green economy from an institutional perspective, imposes additional green burdens on social and economic entities, and promotes the development of the green economy. This paper adopts the environmental regulation RE1, which represents the proportion of national environmental protection expenditure in GDP, and measures the resources invested by resident units to protect the natural environment[10].

3. MODEL ESTABLISHMENT AND PARAMETER ESTIMATION

3.1The basic model

According to the dimensions of the collected data and the basic logical judgment of qualitative analysis, the panel data regression model is indeed used. Panel data are represented by double-subscript variables. For example, N means that the panel data contains N individuals. T represents the maximum length of the time series. If t is fixed, yi.(i = 1, 2, …, N) is N random variables in the cross section; if i is fixed, y.t(t = 1, 2, …, T) is A time series (individual) on a longitudinal section.

Let y_{it} be the value of the explained variable at cross section i and time t, x_{jit} be the value of the j explanatory variable at cross section i and time t, and u_{it} be the random error term of cross section i and time t; b_{ji} is the model parameter of the j explanatory variable on the i section; a_i is the constant term or intercept term, representing the i cross section (the influence of the i individual); the number of explanatory variables is j=l, 2, ..., k; the number of sections is i=1, 2, …, N; the time length is t=1, 2, …, T. Among them, N is the number of individual cross-section members, T is the total number of observation periods for each cross-section member, and k is the number of explanatory variables. The general form of the single-equation panel data model can be written as:

$$\mathbf{y}_{it} = \mathbf{a}_i + b_{1i}x_{1it} + b_{2i}x_{2it} + \cdots + b_{ki}x_{kit} + u_{it}$$
$$i = 1,2,\cdots,N$$
$$\mathbf{t} = 1,2,\cdots,T$$

where u_{it} is a random error term that satisfies the assumptions of independence, zero mean, and homoscedasticity.

According to the above analysis, using R language software, three models of fixed effect, random effect and mixed effect were established respectively. The main results of the model are shown in Table2.

From the results of the three models, the overall significance test of the model has passed. The R-square of the three models is around 0.81, with no significant difference. From the parameter estimation results, the differences in the coefficient terms of IS and ERI are obvious, among which IS is positively correlated in the random effect model, which is significantly different from the other two models. Therefore, it is necessary to further test the fixed effects of the model to determine a more accurate model form.

3.2The fixed effect and random effect test

The random effects model, which assumes that the individual effects, residuals, and explanatory variables are statistically independent, can also be considered as a way of testing for endogeneity. There is no clear criterion for whether the panel regression model uses random effects or fixed effects, and the Hausman test is generally used. Aiming at the test efficiency of the general Hausman test in the case of heteroscedasticity and serial correlation, this paper also conducts the document Hausman test. The P value was less than 0.05, rejecting the null hypothesis. That is, it is considered that the estimation formula of random effects is inconsistent, and the parameters considered in the fixed effect setting are consistent.

In addition, using an F test, it is tested whether the individual and time dimensions need to be fixed. The p-value< 0.0001. With a two-factor F test, the null hypothesis cannot be rejected. Therefore, a two-way fixed-effects model is required.

3.3Estimation of the model

Two-way fixed-effects models were estimated using the least squares method of dummy variables (LSDV). The least squares dummy variable method LSDV estimation, using dummy variables, treats individual effects as intercept terms.

4. MODEL CHECKING AND CORRECTION

4.1Serial correlation test

Serial correlation can greatly affect the quality of the model. In this paper, the Woodridge test is used to test whether the above models have serial correlation.The F value was 5.08, and the P value was 0.0256, which was less than 0.05. Therefore, the null hypothesis is rejected, and it is believed that there is a correlation in the series, which needs to be corrected.

4.2. Modification of the coefficient estimation formula

According to Wooldridge (2010), the time period in this example is short and can be corrected directly using AR(1). Calculated by R language software.The transformation matrix used in the correction process.

4.3Modification of variance estimation formula

Heteroskedasticity robust covariance correction for panel data mainly includes White type correction, panel correction standard error correction (PCSE) and parent-less method correction. Use software to calculate them separately, and the results in Table3 and Table4.

From the three revised results, no significant changes were found in the significance results of the main variables. Among them, the results of White correction and panel correction standard error correction have high coincidence.

4.4 Analysis of Empirical Results

Using LSDV to estimate a two-way fixed-effects model, using AR(1) to correct the parameter estimates, and using PESC to correct the variance estimator, the results can be summarized as:

Energy intensity (EI) significantly affects green GDP, with an influence coefficient of -1256.4, which means that energy use intensity has a significant reverse effect on green GDP, and a decrease in energy use intensity significantly increases the level of green GDP, and vice versa. Therefore, one of the core strategies for the development of a green and low-carbon economy is energy conservation. The implementation of energy conservation has an obvious effect on the emission reduction of the whole society.

This is also an important starting point of the national energy conservation strategy. Supporting energy conservation and emission reduction includes a series of policy support and carbon reduction. The original design of emission finance and carbon emissions trading. The national policy is committed to reducing energy consumption per unit of GDP, which will greatly promote the development of green economy.

Table 3. AR(1) Method Parameter Estimation Correction results

	Estimate	Std.Error	t-value	Pr(>|t|)
Intercept	-26754	11489	-2.329	0.0212
RGDP	0.066	0.015	4.5241	0.0000
IS	163.08	86.645	1.8822	0.0617
UI	429.78	138.56	3.1019	0.0023
EI	-246.1	147.39	-1.67	0.0970
TDL	1396.3	533.35	2.618	0.0097
ER	-189.9	767.13	-0.248	0.8048
FDI	-2.056	5.115	-0.402	0.6882
INC	0.032	0.004	7.7132	0.0000

The sales volume of new energy vehicles (INC) has a significant impact on green GDP, with an impact coefficient of 0.04. This has a certain impact on the small proportion of new energy in its infancy. From the perspective of the implementation of policies in EU countries, we are vigorously supporting the development of new energy vehicles to promote the structural transformation of the automotive industry. Therefore, when it is obvious that new energy vehicles are significantly related to the development of green economy, the next chapter we will affect the impact of new energy vehicles. Factors and then do a second analysis.

Table 4. PESC method correction results

	Estimate	Std.Error	t value	Pr(>|t|)
RGDP	0.10	0.0335	3.0616	0.0027**
IS	912.71	200.5300	4.5515	0.0000***
UI	-123.04	93.1050	-1.3216	0.1886
EI	-1256.40	153.9400	-8.1620	0.0000***
TDL	939.88	517.4800	1.8162	0.0716·
ER	978.12	884.4700	1.1059	0.2708
FDI	11.30	9.2588	1.2205	0.2244
INC	0.04	0.0067	5.7734	0.0000***

Industrial structure (IS) significantly affects green GDP with an impact coefficient of 912.71. This is contrary to our preliminary conclusion that the secondary industry is negatively correlated with the development of green economy. However, the form of the secondary industry is obviously higher than that of the primary industry. During the development of the secondary industry, the extensive development of the secondary industry should be restricted. Instead, improving the efficiency of resource utilization by optimizing the industrial structure can effectively promote the development of the green economy. On the other hand, it is necessary to moderately control the scale of the secondary industry and promote the transition of the primary industry to the secondary and tertiary industries, which will have a positive impact on the development of green GDP. From the perspective of national policy, while promoting the process of industrialization, it is necessary to ensure the upgrading and optimization of the industrial structure.

Per capita gross domestic product (RGDP) and technological progress (TDL) are both factors that affect the level of social development. The green economy will also be promoted when it promotes socioeconomic development, including increased incomes and strong support for R&D and technological innovation.Per capita gross domestic product (RGDP) significantly affects green GDP with an impact coefficient of 0.1. That is, with the improvement of the level of social development, there is a certain degree of positive impact on the environment, and this impact refers to the Kuznets curve of the environment.

5. CONCLUSION

As the empirical research chapter of this paper, this chapter starts with the green GDP measurement of the EU green economy measurement, and forms the green GDP data by fitting. Then, according to the panel regression model, the fixed effect model with two-way effect was confirmed, and then the important influencing factors of the EU core countries were modeled and analyzed through the panel regression model. It can be seen that industrial structure, energy intensity and sales of new energy vehicles have a significant impact on the development of green economy, of which energy intensity has a significant negative impact, while industrial structure and sales of new energy vehicles have a positive impact.

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