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Empirical Analysis of Factors Influencing the Development of Green Economy in Zhejiang Province

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Abstract: In the background of global warming and energy consumption, the development of green economy in Zhejiang Province has significant importance. The paper uses data from Zhejiang Provincial Statistical Yearbook between 2007 and 2022. This paper selects 11 social and environmental indicators and then applies the entropy weight method to establish a multi-indicator measurement framework of the green economy in Zhejiang Province. Initially, a multivariate linear regression model is constructed by using the ordinary least squares (OLS) method. However, due to the multicollinearity inherent in the OLS method, ridge regression is subsequently adopted to address the multicollinearity and optimize the model. The model reveals that innovation level, openness to the world and the development of economy has a significant positive impact on the development of Zhejiang's green economy, while the industrial structure has a constraining effect. Based on above conclusions derived by ridge regression, the paper offers relevant recommendations for making policies.

Keywords: Ridge regression, ordinary least squares, green economy.

1. Introduction

With the rapid development of China's economy, the environmental pollution becomes increasingly serious and the problem of energy depletion is emerging [1]. After decades of wild economic growth, China urgently needs to explore a way of economic development that harmonizes with the nature. The green economy is a safe and sustainable mode of economic development and its core concept is to achieve more economic benefits with less carbon emission [2]. Against the current backdrop of prominent environmental issues, the green economy is receiving attention in China. Zhejiang Province, as one of the most important eastern provinces, has important advantages for green economic development. Therefore, analyzing the development of green economy and its influencing factors in Zhejiang Province has significant value for other regions in the country.

The development of green economy in Zhejiang Province is easily restricted by various factors. Therefore, it is particularly important to construct a green economy measurement framework. At present, there is no unified opinion on how to construct such a framework. For example, the green growth measurement framework of the Organization for Economic Co-operation and Development (OECD) mainly considered environmental protection issues from an economic perspective when constructing its indicator framework [3]. By contrast, the green economy progress measurement framework (GEP) emphasized the environmental protection [4]. Some scholars also have different views on how to construct an evaluation index framework. For instance, Ren and other researchers

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established a three-level multi-indicator measurement framework and determined its weight using the Delphi method [5]. Fu and other researchers constructed a measurement framework with dimensions of low-carbon output, low-carbon consumption, low-carbon resources and low-carbon environment [6]. Based on the above studies, this paper selects 11 indicators from two aspects of society and environment to construct a multi-indicator measurement framework to measure the development of green economy in Zhejiang Province.

In the meantime, this paper also analyzes the internal reasons affecting the development of green economy in Zhejiang Province. Combining the research on the influencing factors of the green economy, this paper analyzes the main influencing factors from four aspects: industrial structure, openness to the world, innovation level and development of economy. First, Wang believed that technological progress is foundation to the development of green economy [7]. In the meantime, Economic development level also affects green economy's development. Liu and other researchers use the decoupling development theory to analyze the relationship between economy's development and resource consumption and demonstrate the possibility of green economic development. Based on the "roller coaster" theory (EKC hypothesis), they analyze the impact of economy's development on the degree of environmental pollution to demonstrate the development trend of green economy [8]. Then, Feng and other researchers used the modified Kaya identity to decompose the carbon dioxide emissions of China from 1971 to 2015 without residuals and combined with the changes in the macroeconomic background. They analyzed in detail the emission changes from the "Fourth Five-Year Plan" to the "Tenth Five-Year Plan", emphasizing that accelerating industrial structure adjustment can effectively reduce China's carbon dioxide emissions [9]. Finally, Liu used the panel regression model to analyze the influencing factors of green economy in Hunan Province [10]. The paper discovers that industrial structure, degree of openness, and industrial structure have a major impact on the development of green economy.

In summary, the influencing factors of green economy in Zhejiang Province are multifaceted. Therefore, this paper use time series data in Zhejiang Province between 2007 and 2022 to select relevant indicators and employ ridge regression methods for empirical research. The target of this paper is to explore how these factors specifically impact the development of green economy in Zhejiang and provide suggestions for making policies.

2. Methodology

2.1. Data Source and Description

This paper will use time series data from 2007 to 2022, which is sourced from the Zhejiang Provincial Statistical Yearbook and the China Statistical Yearbook. As the development of green economy in Zhejiang Province cannot be directly measured and there is no unified international consensus on how to construct a Multi-indicator measurement framework for green economy. Therefore, the paper will select relevant indicators from the quality of environmental development, and quality of social development. The entropy weight method will be employed to determine the weights of these indicators, thus constructing a multi- indicator measurement framework. Subsequently, the measurement framework will be used to evaluate the development of green economy in Zhejiang Province. The related indicators are presented in table 1:

Table 1: Multi-indicator measurement framework of green economy.

Primary Indicators	Secondary Indicators	Tertiary Indicators
Quality of Environmental Development	Environmental Governance	Treatment Rate of Waste(TRW)
	Ecological Protection	Green Coverage of Built Areas(GCBA)
		Rate of Forest Coverage(RFC)

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Table 1: (continued).

Quality of Social Development	Environmental Pollution	Industrial Wastewater Emissions(IWE)
		Industrial Exhausted Gas Emissions(IEGE)
		Total Energy Consumption(TEC)
	Livelihood Security	Unemployment Insurance Expenditure(UIE)
		Pension Insurance Expenditure(PIE)
		Medical Insurance Expenditure(MIE)
	Education	Number of Undergraduate Students Enrolled in Regular Educational Institutions(NUS)
	Medical Care	Number of Health-Care Personnel(NHCP)

To eliminate the influence of different dimensions on the data, this paper has normalized the data for the aforementioned 11 indicators. Afterwards, the entropy weight method has been employed to determine the weights of indicators. The results of the weights are presented in table 2:

Table 2: Weight of corresponding indicators.

Indicators' Abbreviation	Information entropy(e)	1-e	weight(%)
MIE	0.840	0.160	16.421
PIE	0.846	0.154	15.827
UIE	0.848	0.152	15.649
IEGE	0.886	0.114	11.759
NHCP	0.905	0.095	9.811
IWE	0.924	0.076	7.776
NUS	0.945	0.055	5.610
RFC	0.951	0.049	5.058
GCBA	0.954	0.046	4.777
TRW	0.963	0.037	3.805
TEC	0.966	0.034	3.506

2.2. Method Introduction

The paper collected data from Table 3 and to avoid the influence of dimensions, it normalized them. Subsequently, the paper used the aforementioned indicators to establish a multivariate linear regression model to analyze the main factors affecting the green economy. However, due to the excessive number of indicators in the paper, directly establishing a multivariate linear regression model could result in multicollinearity. Therefore, the paper employed ridge regression to eliminate multicollinearity.

Ridge regression is a method that used to address multicollinearity. When there is a high correlation between independent variables, ordinary least squares may lead to unstable estimates of regression parameters. Ridge regression introduces a small bias into the regression estimates to reduce the mean squared error of standard estimates, thereby obtaining more reliable regression coefficients. It avoids overfitting by adding a penalty term to the regression coefficients, making the estimated regression coefficients more stable and interpretable. The specific results of the ridge regression will be presented in the next chapter.

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3. Results and Discussion

3.1. Preliminary Work

By using the aforementioned indicators' values and their weights, this paper is able to calculate the green economy index (GEI) in Zhejiang Province from 2007 to 2022. The specific model is displayed in the following formula(1) and the corresponding data are illustrated in figure 1:

$$\mathrm{GEI} = 16.421\% \times \mathrm{MIE} + 15.827\% \times \mathrm{PIE} + \cdots + 3.506\% \times \mathrm{TEC} \quad (1)$$

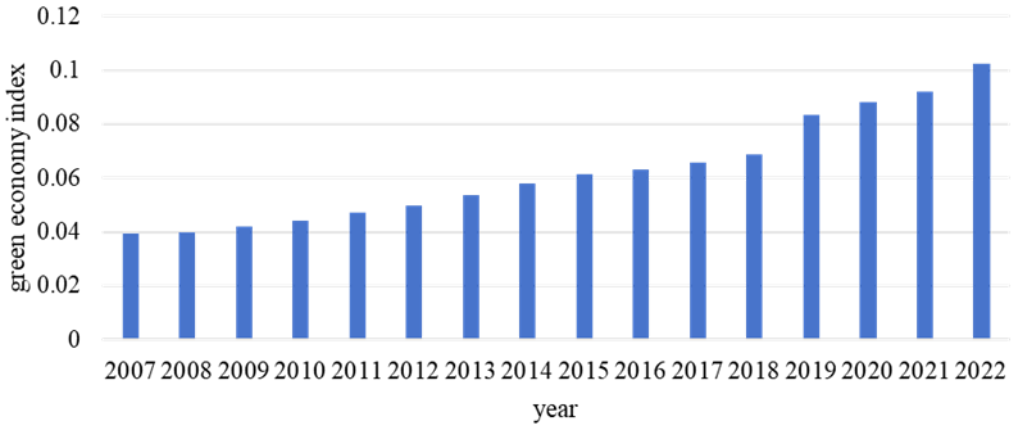

Figure 1: Green economy index (GEI) from 2007 to 2022.

From the data presented in the figure 1, this paper discovers that the enhancement of green economy in Zhejiang Province exhibits stage-specific characteristics. Initially, from 2007 to 2009, it shows a slow increase, with an average growth of 7.69%. From 2010 to 2018, there is a significant acceleration in green economy, with an average growth of 56.00%. From 2019 to 2022, the green economy of Zhejiang Province experiences rapid growth, with an average increase of 22.89%. Overall, the level of green economy in Zhejiang Province has been steadily improving from 2007 to 2022. This indicates that the achievements in green economic development in Zhejiang Province are significant and worthy of emulation by other provinces. Additionally, according to the data in table 2 , the environmental development level accounts for approximately 36.68%and the social development level accounts for about 63.32%. This suggests that the level of social development plays a more significant role in promoting the development of the green economy. Therefore, this paper will further select relevant influencing factors from the level of social development to analyze the intrinsic mechanism of green economy's development in Zhejiang Province.

Based on the above analysis, this paper will select relevant indicators from aspects such as the openness to the world, innovation level, economic development level and industrial structure, to serve as independent variables affecting the development of green economy. The corresponding indicators and their explanations are displayed in the following table 3:

Table 3: GEI and its influencing factors in Zhejiang province.

Variables	Name	Calculation Method
Y	green economy index(GEI)	It is constructed by using the entropy weight method
X1	openness to the world	The Proportion of Total Import and Export Trade to GDP

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Table 3: (continued).

X2	innovation level	The Proportion of Research and Development Expenditure to GDP
X3	development of economy	GDP of Zhejiang Province
X4	industrial structure	The Proportion of the Secondary Industry's Domestic Product to GDP

3.2. Linear Model Results

Based on the aforementioned methods, this paper will further conduct regression analysis on the above-mentioned indicators to select the main factors affecting the development of green economy in Zhejiang Province. The paper initially employs the ordinary least squares (OLS) method to establish the regression model. The outcomes of the model are presented in table 4:

Table 4: OLS regression.

	Coefficient	t	P	VIF	R^2	Adjusted R^2	F
Constant	-0.006	-0.097	0.925	-			
X1	0.540	1.621	0.133	5.846			
X2	0.476	9.750	0.000[a]	1.437	0.971	0.960	F=91.040 P=0.000[a]
X3	0.480	2.743	0.019[b]	20.147			
X4	-0.405	-0.415	0.686	32.350			
Y: Green Economy Index(GEI)							

a Note denotes the significance level of 1%.
b Note denotes the significance level of 5%.

Based on the results of the OLS, this paper found that the adjusted R^2 of this regression model is high, indicating a high quality of fit, and it has passed the F-test, suggesting a linear relationship. At the same time, at the 1% significance level, the proportion of research and development is significant. At the 5% level, the level of economic development is significant. However, the openness to the world and industrial structure are not significant. Therefore, the innovation level and the development of economy are main factors that influence on the green economy.

$$Y = 0.540 \times X_1 + 0.476 \times X_2 + 0.480 \times X_3 - 0.405 \times X_4 - 0.006 \quad (2)$$

However, the VIF values for both the development of economy and industrial structure are greater than 10. This indicates that the model has severe multicollinearity. Multicollinearity increases the standard error of the regression coefficients, thereby reducing the precision of the estimates of the regression coefficients. Moreover, due to the presence of multicollinearity, the regression coefficients of individual independent variables may no longer have a clear interpretive meaning. This makes it difficult for the paper to determine the impact of a single independent variable on the dependent variable.

3.3. Ridge Regression Results

Therefore, to address the multicollinearity in the OLS model, the paper ultimately decides to use ridge regression to establish the regression model. The specific results of the ridge regression are presented in table 5:

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Table 5: Ridge regression.

K=0.116	Cofficient	t	P	R^2	Adjusted R^2	F
Constant	0.042	2.865	0.015[b]			
X1	0.401	2.175	0.052[c]			
X2	0.451	10.207	0.000[a]	0.961	0.947	F=68.225 P=0.000[a]
X3	0.322	6.911	0.000[a]			
X4	-0.848	-4.767	0.001[a]			
Y: green economy index(GEI)						

a Note denotes the significance level of 1%.
b Note denotes the significance level of 5%.
c Note denotes the significance level of 10%.

According to table 5, the model has passed the F-test, manifesting a significant linear relationship between the dependent variable and the independent variables. Besides, the model's coefficient of determination is 0.947, demonstrating a high degree of fit. Furthermore, the paper has conducted a VIF test on the model, and the results show that the VIF values are less than 10, indicating that the model does not suffer from severe multicollinearity.

$$Y = 0.401 \times X_1 + 0.451 \times X_2 + 0.322 \times X_3 - 0.848 \times X_4 + 0.042 \quad (3)$$

Additionally, through the t-test, the paper discovers that the degree of openness has promoted the development of green economy in Zhejiang Province. Its coefficient is 0.401, significant at 10% level. A higher degree of openness implies a strong dependence of Zhejiang Province's economy on the international market. To cope with changes and demands in the international market, local governments should increase the proportion of green, low-carbon industries. This has fostered the development of the green economy.

In the ridge regression model, the level of innovation in Zhejiang Province has also promoted the development of green economy. Its coefficient is 0.451 and significant at the 1% level. This manifests that an increase in the level of innovation contributes to a win-win situation for economic development and innovation. An increase in the level of innovation means that more resources are invested in research activities, thereby promoting technological innovation. These technologies play an important role in reducing pollution emissions, improving resource efficiency, and enhancing environmental quality, thus directly driving the development of green economy.

Furthermore, the development of economy has a significant positive impact on the development of green economy. Its coefficient is 0.322 and significant at the 1% level. An increase in GDP means that the Zhejiang provincial government can promote and optimize the industrial structure. Transitioning from high energy-consumption industries to low-carbon and green industries helps to promote the development of green economy.

However, in the model, the industrial structure has a restraining effect on the development of green economy in Zhejiang Province. Its coefficient is -0.848, significant at the 1% level. Since the secondary industry is often high-energy-consuming, when its total output value has a high proportion in GDP, a large amount of energy is often invested in these industries. This may lead to an imbalance in the industrial structure, which is not conducive to the development of green economy.

4. Conclusion

According to the analysis above, the paper concludes that from 2007 to 2022, the overall development of green economy in Zhejiang Province has been steadily improving. Among these, the level of social development plays a more significant role in promoting the development of the green economy. To further analyze the intrinsic factors influencing on the development of the green economy in Zhejiang Province, the paper selects four aspects from the level of social development: the openness to the

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world, the innovation level, the development of economy and the industrial structure for analysis. By using ridge regression to construct a multivariate linear regression model, it is found that the openness to the world, the innovation level and the development of economy have promoted the development of green economy in Zhejiang Province, while the industrial structure has a significant inhibiting effect. However, the limitation of this paper lies in the possibility that the model may not have fully considered other factors affecting the development of green economy in Zhejiang Province. To further validate the conclusions of this paper, future research could consider introducing more variables. Based on the conclusion, to further promote the development of green economy in Zhejiang Province, the paper proposes following suggestions:

Firstly, optimize the industrial structure. Local governments should formulate industrial policies to gradually phase out high-pollution industries and reduce the proportion of the secondary industry's total output value in GDP. At the same time, the government should encourage and support the development of green and low-carbon industries, reducing the entry threshold and operating costs for green industries.

Secondly, accelerate the research and development of green technologies and improve resource utilization efficiency. Local governments should set up special funds to accelerate the popularization and application of green technologies. In addition, the government should promote energy-saving and emission-reduction technologies, encouraging enterprises to adopt advanced production processes and equipment to reduce energy consumption and pollution emissions.

Thirdly, promote openness and insist on international exchange and cooperation. Local governments should expand open areas, attract more foreign investment and provide financial and technical support for the development of green economy. Meanwhile, it should learn from the experience of developed countries and promote the enhancement of green economy in Zhejiang Province.

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