Analysis of Influencing Factors of Green Economy in Yangtze River Delta Based on PLS-SEM

Jiaqi Cui[1] and Kunping Zhu[1*]

[1] School of Mathematics, East China University of Science and Technology, 200237, Shanghai, China

*kpzhu@ecust.edu.cn

Abstract. As a new index to measure the economy, green economy aims to achieve the dual goals of economic growth and environmental protection. Through PLS-SEM, this study discusses the impact of economic development, social development, resources and environment on green economy in China's Yangtze River Delta region, and shows every path coefficient. It is found that economic development and resources and environment have a significant positive impact on green economy, while social development has a weekly negative impact. In addition, the study also reveals the indirect effects of economic development on green economy through the direction of resource, environment and social development. The direct effect of economic development on the green economy in the Yangtze River Delta is slightly greater than the indirect effect, so the green economy can be promoted by directly developing local economy.

Keywords: Structural Equation Modeling, PLS-SEM, Green Economy, Path Coefficient, Mediating effect

1 INTRODUCTION

With the increasingly severe environmental problems, the concept of green economy came into being, aiming to achieve the dual goals of economic growth and environmental protection. In the report [1] in 2009, the concept of green economy was first put forward, emphasizing the close relationship between economic growth and environmental protection. Through continuous development, the theory of green economy has made remarkable progress in theoretical framework and technological innovation, providing important ideas and practical paths for promoting sustainable development and solving global environmental challenges.

At present, China is in the stage of rapid economic growth, but extensive economic growth has made environmental problems increasingly serious, developing green economy is an important way to solve the ecological problems in China's economic development. As one of the important engines of China's economic development, the Yangtze River Delta region is one of the regions with the most active economic development and the strongest innovation capacity in China. The green economy of the Yangtze River Delta region is not only of great significance to the improvement of the local environment and sustainable development, but also provides valuable experience for

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the exploration of green economic models in China and the world. Therefore, it is crucial to analyze the factors affecting green economy in the Yangtze River Delta, which helps enterprises and researchers to formulate effective strategies.

In previous studies on influencing factors of green economy, Spatial Dobbin Model (SDM) [2] was used to build an evaluation index for high-quality development of green economy. Gomonov. K et al. [3] evaluated the relationship between green economy in the EU and traditional socio-economic indicators based on the green economy index and statistical analysis method. Economic development, social development and resources and environment were taken as the first-level indicators, constructed the evaluation index system of China's green economy [4]. However, in the above research process, due to the certain relationship between the variables of economy, resources and environment, the constructed model may have endogeneity problems, so this paper chooses to build a structural equation model (SEM) to explore the influencing factors of green economy in China's Yangtze River Delta region.

Covariance based Structural Equation Modeling (CB-SEM) and partial least square Structural Equation Modelling (PLS-SEM) are two mainstream structural equation models at present, Paper [5] shows that they have great differences in the statistical estimation efficiency of path coefficients. According to literature [6], when attempting to evaluate a path model using CB-SEM, non-normal data can lead to underestimated standard errors and inflated goodness-of-fit measures. Meanwhile, because its path coefficient estimation principle is partial least square method, PLS-SEM is more suitable for data sets with small sample size and lack of normality, and it has higher efficiency in processing more complex models.

2 CONSTRUCTION AND ANALYSIS OF PLS-SEM

The core structure of SEM is simple and consists of several measurement models and structural models. The measurement model explains the correlation between the latent variables and the corresponding observed variables, while the structural model contains the interaction of each latent variable. The two key models jointly build the overall architecture of SEM, and the model diagram is shown in Figure 1.

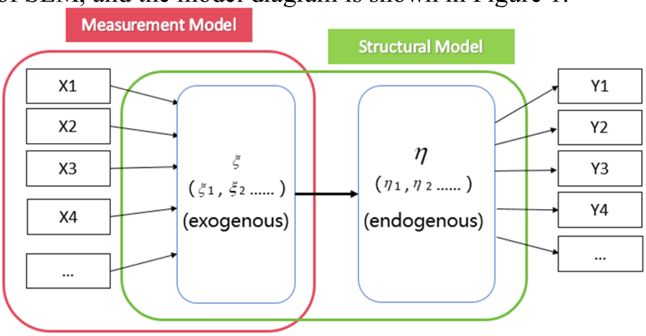

Fig. 1. Structural equation model diagram

In Figure 1, X and Y are observed variables; ξ and η are latent variables. SEM classifies latent variables into exogenous variables and endogenous variables. The measurement model shows the relationship between endogenous variable η and endogenous index Y, exogenous variable ξ and exogenous index X. The specific expression is as follows.

$$X = \lambda_X \xi + \delta \tag{1}$$

$$Y = \lambda_Y \eta + \varepsilon \tag{2}$$

Where, λ_X and λ_Y represent the regression factor load matrix of latent variable ξ and η respectively; δ and ε represent the measurement error of indicators X and Y.

The structural model shows the causal relationship between exogenous and endogenous variables in the model. The model expression is the following:

$$\eta = I\eta + \Gamma\xi + \zeta \tag{3}$$

Where, coefficient I shows the causal relationship between endogenous variables, coefficient Γ is the effect coefficient matrix of exogenous variables on endogenous variables, reflecting the role of exogenous variables on endogenous variables, and ζ is a vector group composed of residual terms.

In contrast, Spatial Dobbin Model (SDM) is to find the relations of things through some correlation relationships existing in space, whose structure is shown in (4). The necessity of SDM is to ensure that there is no spatial autocorrelation among cities. Global Moran index is a test for the existence of spatial autocorrelation, whose formula is shown in (5).

$$M = \lambda_M WM + N\beta + WN\theta + \epsilon \tag{4}$$

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\omega_{ij}(x_i - \bar{x})(x_j - \bar{x})}{S^2\sum_{i=1}^{n}\sum_{j=1}^{n}\omega_{ij}}, \quad -1 < I < 1 \tag{5}$$

Where W is the spatial weight matrix, M is dependent variable matrix, N is independent variable matrix. λ_M, β and θ are coefficient; S^2 is the sample variance and ω_{ij} is the spatial weight relation, which depends on the proximity between cities.

2.1 Description of Variables and Data

In recent years, experts and scholars on the green economy index system literature shows that the green economy related factors are mostly around economic development, social development, resource utilization efficiency, environmental control. As paper [7] indicates, the green economy represents a catalyzer for sustainable development in its three dimensions: economic, social and environmental. Therefore, economic development, social development and resources and environment are taken as latent variables of SEM in this paper.

The observed variables refer to the *Green Development Index, Index System of the Yangtze River Delta* [8], in which indicators with higher weights corresponding to each potential variable are selected, and their weight are used as the initial weights in the model. As for the variable of green economy, this paper draws on the research of Zhou et al. [9], and uses industrial wastewater discharge, sulfur dioxide emissions and industrial solid waste discharge to measure the development level of China's green economy. The positive and negative effects and weight of latent variables and observed variables are shown in Table 1.

Table 1. Relevant indexes of structural equation

Latent variable	Observe variable	Effects of variable	Weight of variable
Economic development	per capita GDP (X1)	+	0.15
	Proportion of value-added of tertiary industry in GDP (X2)	+	0.20
	Ratio of R&D to GDP (X3)	+	0.20
	Per capita disposable income (X4)	+	0.12
Social development	Number of beds in medical institutions per population (X5)	+	0.12
	Urbanization rate of permanent residents (X6)	+	0.08
	Per capita water consumption (X7)	+	0.12
Resources and environment	Average annual concentration of PM2.5 (X8)	-	0.24
	Energy consumption per unit of GDP (X9)	-	0.12
	General industrial solid waste comprehensive utilization rate (X10)	+	0.16
Green economy	Industrial wastewater discharge per unit of GDP (Y1)	-	0.125
	Sulfur dioxide emissions per unit of GDP (Y2)	-	0.125
	Industrial solid waste discharge per unit of GDP (Y3)	-	0.125

In this paper, the data of 21 regional central cities in the Yangtze River Delta region from 2013 to 2022 are selected as samples. The data comes from the statistical yearbooks of various provinces and cities. Then positive processing and dimensionless processing is carried out by reciprocal and min-max standardization method. Table 2 shows descriptive statistics of data after forward processing.

Table 2. Descriptive statistics of data

Variable	Sample size	Maximum value	Minimum value	Mean value	Standard deviation	Moran's I
X1	210	198404	31237	100739.103	36914.439	0.699
X2	210	74.6	9.9	48.2	11.3	0.781
X3	210	4.438	0.5	2.55	0.741	0.843
X4	210	79610	19582.3	42100.829	13460.535	0.755
X5	210	87.46	25.6	54.668	10.959	0.653
X6	210	89.6	40.96	70.559	9.762	0.706
X7	210	339.97	114.95	211.677	41.396	0.795
X8	210	4.762	1.136	2.452	0.791	0.826
X9	210	5.538	0.662	2.521	0.935	0.916
X10	210	100	61.45	93.379	6.081	-0.752

Y1	210	4.045	0.082	0.675	0.518	-0.585
Y2	210	7.526	0.018	0.817	1.25	0.293
Y3	210	33.527	0.376	10.237	5.972	0.466

Because the Moran index of each index is generally too high, indicating that most indexes have spatial autocorrelation problems, so it is not appropriate to use SDM to study green economy in the Yangtze River Delta region. For PLS-SEM, it doesn't care if cities are next to each other, so spatial autocorrelation doesn't affect it. In addition, although PLS-SEM is selected because of the non-normality of data, the sample size of this paper is sufficient enough (meet the principle of 20 times number of variables [10]), so its non-normality will not affect the estimation of the model.

2.2 Evaluation of the Measurement Model

Firstly, the Bootstrapping method was used to test the attributes of the measurement model, and the results of the reliability and validity indexes are shown in Table 3. In terms of the reliability of the measurement model, Cronbach's α coefficient of each potential factor is greater than 0.7, and the composite reliability (CR) value is greater than 0.8, which indicates that the measurement model has good internal consistency. In terms of the aggregate validity of the measurement model, the load value of the observed variables of each potential factor is greater than 0.7, and the AVE value of each potential factor is greater than 0.5, indicating that the measurement model has good convergence validity.

Table 3. The reliability and validity indexes of measurement model

Latent variable	Observed variable	factor load	AVE	C.R	Cronbach's α
Economic development	X1	0.886	0.722	0.912	0.872
	X2	0.777			
	X3	0.855			
	X4	0.877			
Social development	X5	0.706	0.615	0.825	0.794
	X6	0.926			
	X7	0.701			
Resource and environment	X8	0.852	0.618	0.826	0.792
	X9	0.866			
	X10	0.716			
Green economy	Y1	0.745	0.646	0.845	0.724
	Y2	0.844			
	Y3	0.819			

2.3 Evaluation of the Structural Model

The SEM path relationship can be divided into direct effect and intermediate effect. Bootstrapping and two-tail test were used to test their significance. The analysis results whose paths reach the level of significance are shown in Table 4. ED and RE have significant positive effects on GE, while SD has a significant negative effect on GE. In addition, comparing the confidence interval of "ED→GE" with that of "ED→SD→GE" and “ED→RE→GE”, we can see that the addition of mediating effects leads to a reduction in the uncertainty of the path "ED→GE", and that these two mediating effects can be supported on the premise that the variance of the parameter estimates can be completely attributed to the random sampling variance [11].

Table 4. Path coefficient and significance level

Path relation	Path coefficient	Standard deviation	T statistics	P values	Confidence interval
ED→RE	0.677	0.026	26.308	0.000**	[0.627,0.727]
ED→GE	0.517	0.103	10.020	0.000**	[0.445,0.588]
ED→SD	0.817	0.022	37.954	0.000**	[0.772,0.856]
RE→GE	0.503	0.063	7.947	0.000**	[0.391,0.641]
SD→GE	-0.252	0.065	3.876	0.000**	[-0.379,-0.124]
ED→SD→GE	-0.206	0.056	3.675	0.000**	[-0.220,-0.192]
ED→RE→GE	0.341	0.043	7.969	0.000**	[0.317,0.365]

Note: ED denotes economy development; SD denotes social development; RE denotes resource and environment; GE denotes green economy

The data shows that the indirect effect of economic development on green economy through resource and environment is 0.341, which indicates the existence of complementary intermediary effect. The indirect effect of economic development on green economy through social development is -0.206, indicating the existence of competitive mediating effect. The final path analysis diagram is shown in Figure 2.

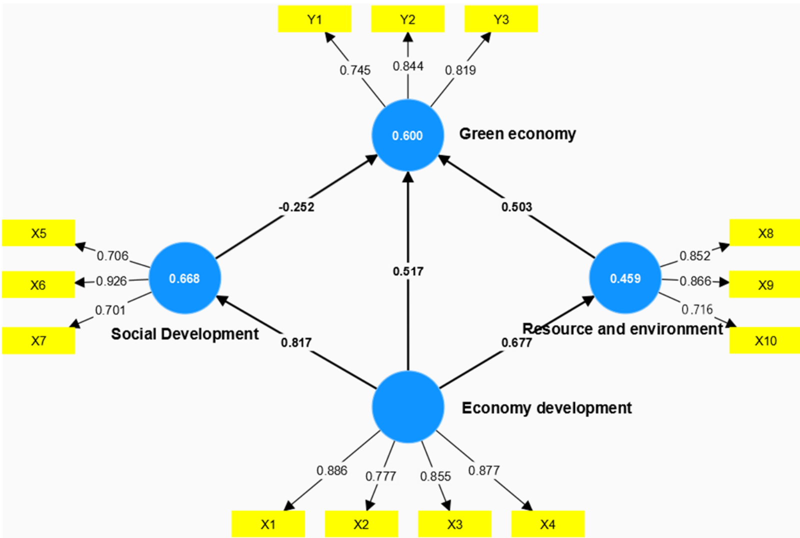

Fig. 2. Path coefficient analysis diagram

The variation explanation quantity of green economy is 0.600, indicating that the explanatory ability of social development, economic development and resource and environment to the variation quantity of green economy is 60.0%. In a similar way, Economic development could explain 49.3% of the variance of social development, and it can explain 45.9% of resource and environment variation.

3 CONCLUSION

On one hand, there are direct effects in the Yangtze River Delta region. Economic development, resources and environment have a strongly positive impact on green economy, whose path coefficients are 0.517 and 0.503 respectively. However, social development has a weakly negative impact on green economy, whose path coefficient is -0.252. On the other hand, there are two indirect effects about the path “economic development →green economy”. As a medium, resources and environment promotes the transformation of economic development to green economy. However, with the increase of economic activities, the level of social development and residents' living standards will gradually improve, followed by the increase in demand for resources, which will have a negative impact on the green economy.

It can be seen from the analysis that improving economic development mode is the key to improving green economy, which can be achieved through direct and indirect ways. The effect coefficient of direct influence is 0.517, and the effect coefficient of indirect improvement of green economy through investment environment and resources is 0.341, which is slightly lower than the direct effect. Therefore, in order to improve the green economy in the Yangtze River Delta region, this paper believes that more attention can be paid to the development of high-tech industries and the increase of gross domestic product without destroying the environment.

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