Asian Journal of Economics, Business and Accounting

Volume 23, Issue 24, Page 304-314, 2023; Article no.AJEBA.111302
ISSN: 2456-639X

The Relationship between Service Economy and Carbon Emissions in Jiangsu Province China and the Influencing Factors

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Authors' contributions

This work was carried out in collaboration between both authors. Author QY designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author RZ managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEBA/2023/v23i241206

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/111302

Original Research Article

Received: 24/10/2023
Accepted: 29/12/2023
Published: 30/12/2023

ABSTRACT

Aims: G20 leaders Riyadh put forward the approval of the carbon reduction, reuse, recycling and elimination (4R) framework at the 2020 Summit. In order to achieve carbon peak and carbon neutrality, promote the development of low-carbon economy, China is striving to build a new high-efficiency low-carbon market.
Study Design: Taking the service industry in Jiangsu Province as the research object.
Place and Duration of Study: long-term interactive relationship between the carbon emissions of the service industry in Jiangsu Province China and its economic development, from 2005 to 2022.
Methodology: Through the vector autoregressive model (VAR) and Granger causality test. Then, five variables affecting the carbon emissions of the service industry are selected: the level of science and technology, the development of transportation, storage and postal industry, energy efficiency, industrial structure and tourism development.

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Results: As influencing factors, through the least squares method (OLS) analysis, it is found that the factor that has the greatest impact on the carbon emissions of the service industry in Jiangsu Province is the industrial structure, followed by the development of tourism and transportation, storage and postal industry.
Conclusion: It is proposed to promote scientific and technological innovation and technological progress from many aspects, improve the scientific and technological innovation system of tourism, accelerate the upgrading of industrial structure, improve the efficiency of transportation, storage and postal industry, promote the formation of a benign interactive relationship between the development of the service industry and carbon emissions in Jiangsu Province and illustrate how the service industry can develop with high quality while saving energy and reducing emissions.

Keywords: Service industry; carbon emissions; VAR model; Industrial structure upgrade.

1. INTRODUCTION

During the 2020 Summit G20, leaders in Riyadh proposed the approval of the framework 4R which includes reduction, reuse, recycling, and elimination [1]. China is striving to establish a new, high-efficiency low-carbon market to achieve carbon peak and carbon neutrality and promote the development of a low-carbon economy [2]. This study aims to discuss the relationship between the service economy and carbon emissions in Jiangsu province, China.

2. RESEARCH ON THE RELATIONSHIP BETWEEN THE DEVELOPMENT OF THE SERVICE INDUSTRY IN JIANGSU PROVINCE CHINA AND CARBON EMISSIONS

2.1 Data Source in this Paper

The added value of the service industry in Jiangsu Province from 2005 to 2022 is recorded as GDP, which is from the Statistical Yearbook of Jiangsu Province (2005-2022); CP represents the carbon emissions of the service industry in Jiangsu Province in these years, which is from the China Carbon Accounting Database and calculated according to the IPCC carbon emission calculation method (Table 1).

2.2 Empirical Analysis

In this paper, STATA/ SE 15.1 measurement software is used to construct the var model to carry out an empirical analysis of the correlation between carbon emissions and added value of Jiangsu service industry [3]. First, conduct ADF test to ensure the stability of the two variables of CP and GDP in the vector autoregression model; Secondly, the two variables of the same order are coorganized to verify the long-term relationship between carbon emissions and added value of the service industry in Jiangsu Province; After that, the stability of the var model was analyzed using AR root test, residual test and normal distribution test; Then, carry out the Granger causal test; Finally, the variables are dynamically analyzed by pulse response[4].

2.2.1 ADF inspection and cointegration inspection

In order to eliminate the phenomenon of heterovariance in time series, the original data logarithmic number is smoothed, and the variable CP and GDP logCP and logGDP are obtained. The P value of variable logGDP is greater than 0.05, indicating that the sequence is not stable. After taking the second-order difference of its logarithmic sequence, the P value is less than 0.05, indicating that the second-order difference between logCP and logGDP is stable, and the significance level is 5%.

In order to judge whether there is a pseudo-regression, the logCP and log GDP are co-checked. The unit root test of the residual difference of the variable was obtained with a first order P value of 0.05. Through the inspection, it shows that there is a long-term cointegration relationship between carbon emission and added value of Jiangsu service industry.

2.2.2 VAR model setting

2.2.2.1 Determination of lagging order

According to the final prediction error (FPE) criterion, AIC criterion, SC criterion and HQIC criterion, the lagging order of var model is determined, and the optimal lagging order of VAR model constructed by logCP and log GDP is 3. When the lagging order is 3, the AIC test value is-7.67194, and the HQIC standard test value is-7.73109.

Table 1. Carbon emissions and added value of the service industry in Jiangsu Province from 2005 to 2022

Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
CP(Millions of tons)	19.43	19.94	21.87	24.94	26.14	29.67	32.47
GDP(hundred million CNY)	6612.22	7914.11	9730.91	11888.53	13629.07	17131.45	20842.22
Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
CP(Millions of tons)	35.24	37.42	40.12	41.47	41.86	43.19	45.58
GDP(hundred million CNY)	23517.98	27197.43	30599.49	33931.69	38269.57	42700.49	46936.47
Year	**2019**	**2020**	**2021**	**2022**			
CP(Millions of tons)	48.32	51.07	53.81	56.55			
GDP(hundred million CNY)	50852.05	53638.85	59866.39	62027.5			

Table 2. ADF test results

Variable	ADF test value	P value
log（CP）	-4.109	.0009
log(GDP)	-1.973	.2985
D（D(Dlog(CP))）	-7.003	.0000
D(D(Dlog(GDP)))	-6.187	.0000

2.2.2.2 Estimated model

The estimated results of model parameters with lagging order number of 3 are shown in Table 3, and the endogenous variables based on the model can be seen:

log(CP)=-0.011754-0.1565log(CP(-3))+ 0.1571log(GDP(-3)) （1）

s.e.=0.0102 0.2017 0.2297

t=-1.1600 -0.7800 0.6800

Log(GDP)=-0.0151-0.2913log(CP(-3))+ 0.2648log(GDP(-3)) （2）

s.e.=0.0096 0.1904 0.2169

t=-1.5700 -1.5300 1.2200

Where s.e. represents the standard deviation of the estimated coefficient; The t statistics of the estimated coefficient are represented by t. (1) (2) is an expression of the relationship between the carbon emissions of the service industry in Jiangsu Province and the development of the service industry. After obtaining the carbon emissions and economic added value of the service industry, It is predicted that the carbon emissions of the service industry in Jiangsu Province can be brought into (1) calculation, and the added value of the service industry in Jiangsu Province in the next period can be brought into (2) calculation.

2.2.2.3 Stability test

Judging the stability of VAR model, we can see whether the countdown of each root model of the model is less than or equal to one, that is, we can judge whether the heel of the characteristic equation is in the unit circle. The AR root detection of this model is carried out using STATA/SE15.1 software. From Fig. 1, it can be directly found that each characteristic root is in the unit circle, which shows the relationship between carbon emission and development of service industry in Jiangsu Province. Long-term stability. After the normal distribution test, the residual P values of the two variables of the VAR model are 0.8591 and 0.7090, both of which are greater than 0.05, and the original hypothesis is accepted, that is, the normal distribution is subject to the test.

2.2.2.4 Granger causality test

The Granger causal test between the development of the service industry in Jiangsu Province and its carbon emissions shows that at a significant level of 5%, the rejection of " the cause of carbon emissions in the service industry in Jiangsu Province is not the cause of the development of the service industry " (P = .03), At the same time, it also rejected " Granger's reason why the development of service industry in Jiangsu Province is not the cause of carbon emissions in service industry " (P = .09), that is, statistically speaking, The development of the service industry in Jiangsu Province can significantly affect the carbon emissions of the service industry. In turn, the carbon emissions of the service industry in Jiangsu Province can also significantly affect the development of the service industry [5].

2.2.3 Pulse response function analysis

Through pulse response, we can intuitively analyze the degree of interaction between the development of Jiangsu service industry and its carbon emissions [6]. Fig. 2 shows the chart below 95% confidence interval. As can be seen from the figure, the impact of logx on logy is a gentle rise from 0 to 8 in the first phase, indicating that the development of Jiangsu's service industry has a positive impact on its carbon emissions. The impact of logy on logx has just started to be 0, and it has been a downward trend in the first period. The upward trend in the third and fourth periods is obvious. After that, it has stabilized, it can be seen that the carbon emissions of the service industry in Jiangsu Province are positively related to the development of the service industry.

Table 3. VAR model parameter estimation results

	LOG(CP)	LOG(GDP)
	-0.156520	-0.291330
LOG(CP(-3))	0.201653	0.190370
	-0.780000	-1.530000
	0.157068	0.264828
LOG(GDP(-3))	0.229726	0.216872
	0.680000	1.220000
	-0.011754	-0.015099
C	0.010163	0.009595
	-1.160000	-1.570000
	-0.156520	-0.291330

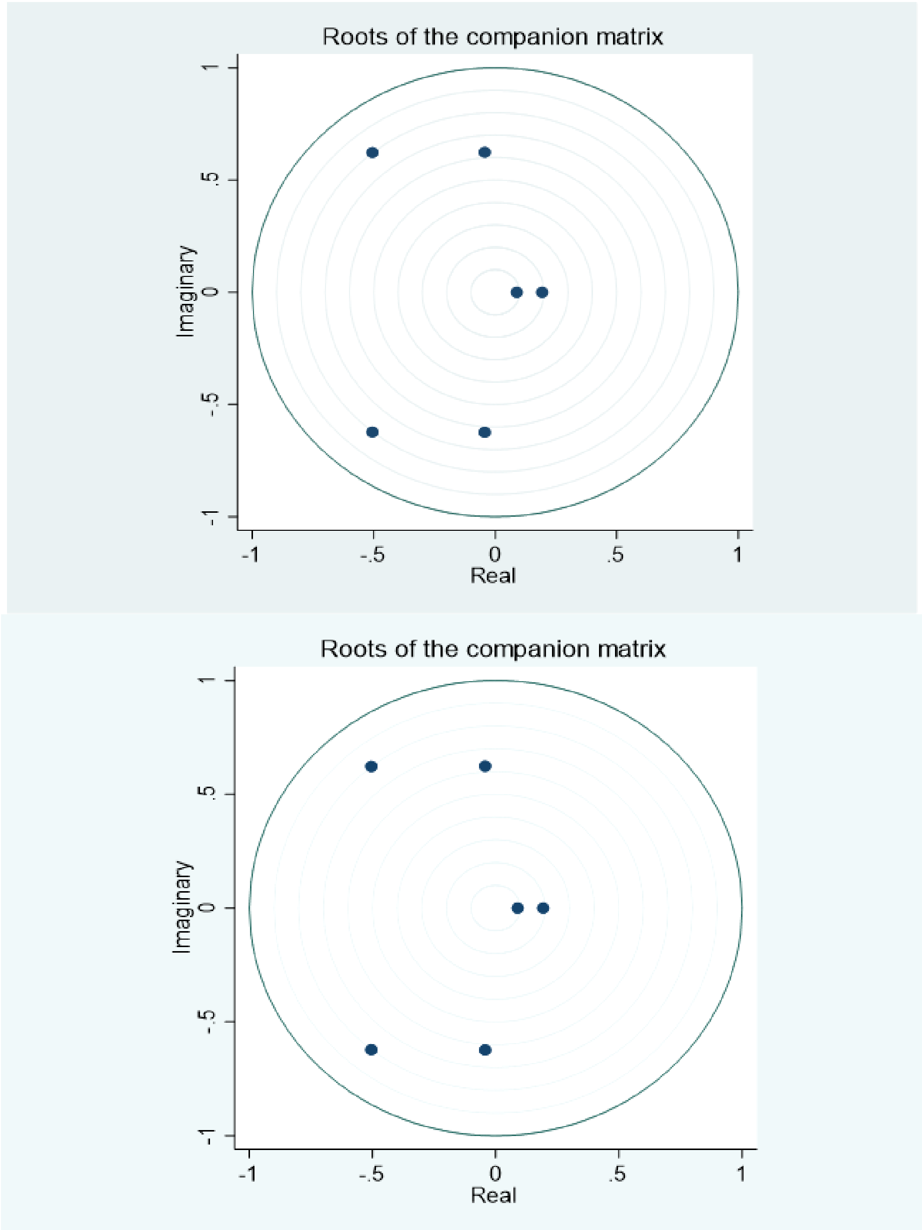

Fig. 1. Model AR root test results

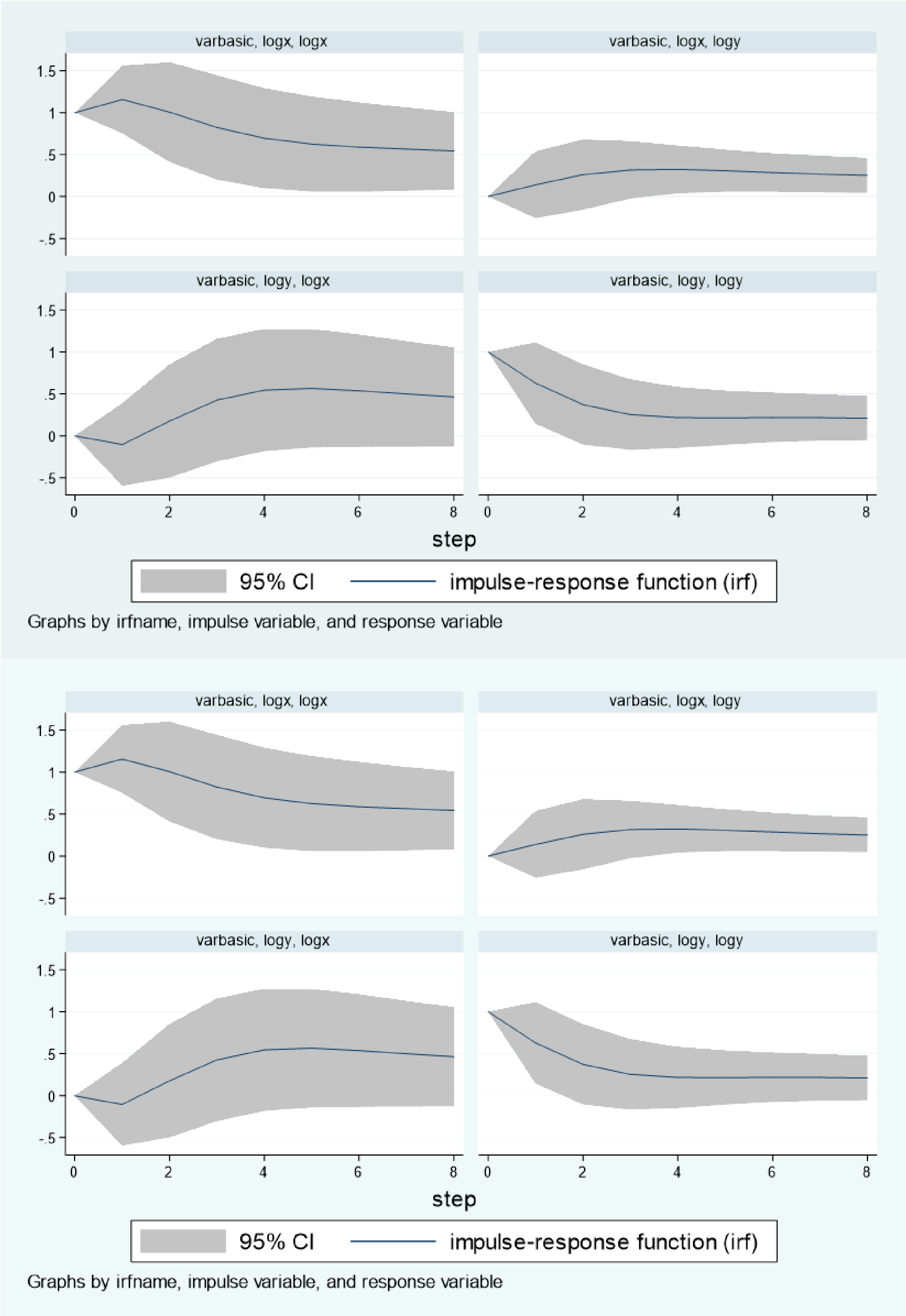

Fig. 2. Pulse response function results

3. ANALYSIS OF THE INFLUENCING FACTORS OF CARBON EMISSIONS IN JIANGSU PROVINCE

3.1 Variable Selection and Data Source

According to the VAR model analysis, there is a relationship between the added value of the service industry in Jiangsu Province and its carbon emissions. There are many factors affecting carbon emissions in the development of the service industry. In this paper, combined with the economic development of the service industry in Jiangsu Province and the proportion of various sub-industries, taking into account the availability of data, the following five variables were selected to study the factors affecting the development of the service industry [7].

i. Transportation Storage Post (TRS): Measured by the economic added value of the transportation warehousing postal industry.
ii. Energy consumption intensity (ENG): Measured by the energy consumption required for GDP per unit service industry.
iii. Industrial Structure (IS): Measured by the ratio of added value of the service industry in Jiangsu Province to the output value of total GDP.
iv. Tourism Development (TR): Measured by the domestic tourism revenue of Jiangsu Province.
v. Level of Science and Technology (RD): Measured by the annual investment in science and technology in Jiangsu Province.

3.2 Model Setting

To make the carbon emissions of Jiangsu service industry self-variable y, the development of transportation warehousing postal service, energy consumption intensity, industrial structure and tourism development are four variables [8], and multiple linear regression models can be constructed:

$$y = a0+ a1RD+ a2TRS+ a3ENG+ a4IS+a5TR \quad (3)$$

a1, a2,a3, a4 and a5 are the variables for the estimated parameters RD, TRS, ENG, IS, and TR.

In this paper, when using stata/ SE15.1 to process data, in order to eliminate the heterometric, the influencing factors of carbon emissions in Jiangsu Province can be analyzed by taking variables to the logarithmic [9]:

$$logy = b0+ b1logRD + b2TRS+b3logENG + b4logIS + b5logTR \quad (4)$$

3.3 Model Inspection

Taking the carbon emissions of Jiangsu Province's service industry from 2005 to 2022 as the interpreted variable, the development of transportation warehousing postal service, energy consumption intensity, industrial structure and tourism development are the explanatory variables. Multiple regression analysis using STATA/ SE15.1 for (4) type, Table 4 is the estimated result.

Table 4. Analysis Results of regression analysis of carbon emission influencing factors

Variable	Regression coefficient	Standard error	T statistics	P statistics
Constant item	-0.0131718	3.921295	-0.00	0.997
Science and Technology Level (RD)	-0.2254542	0.096790	-2.33	0.035
Transportation Warehousing Post (TRS)	0.4165427	0.105114	3.49	0.001
Energy consumption intensity (ENG)	0.0660832	0.349507	0.19	0.097
Industrial Structure (IS)	-1.259507	0.509169	-2.47	0.027
Tourism Development (TR)	0.6510317	0.186755	3.49	0.004

The statistical results show that the fit is good. After regression analysis, T statistics and P statistics of constant items and five influencing factors were obtained, and the probability that the available scientific and technological level (RD) would not have a significant impact on carbon emissions in the service industry was 3.5%. Reject the original assumption at a significant level of 1%; the probability that the development of the transportation postal warehousing (TRS) industry will not have a significant impact on the carbon emissions of the service industry is 0.01%, and the original assumption is rejected, that is, the development of the transportation warehousing postal industry has a significant impact on the carbon emissions of the service industry; The probability that the impact of energy consumption intensity (ENG) on carbon emissions is not significant is 9.7%, and the original assumption is rejected at a significant level of 10%; The probability that the impact of industrial structure (IS) on carbon emissions is not significant is 2.7%, and the original assumption is rejected at a significant level of 5%; The probability that the impact of tourism development (TR) on carbon emissions is not significant is 0.004, that is, the original assumption is rejected at a significant level of 1% [10]. The results show that each index has passed the test, and each coefficient is brought into the formula (4). The model equation is:

$$Logy = -0.0131718-0.2254542logRD+0.4165427logTRS+0.0660832logENG1.259507logIS+0.6510317logTR \quad (5)$$

3.4 Results Analysis

The regression coefficient of science and technology level is-0.2254542l, that is, the expenditure of Jiangsu Province on science and research accounts for every percentage point increase in the GDP of the service industry, which can make the carbon emission of the service industry 0.2254542l percentage point. From the coefficient of regression equation, it can be seen that the improvement of science and technology level in Jiangsu Province has a low impact on carbon emissions in service industry, because the cultivation of high-end talents is a long-term process, which is difficult to achieve results in a short period of time [11]. However, it cannot be ignored that the level of science and technology can improve the role of reducing carbon emissions in the service industry. On the one hand, the improvement of the level of science and technology can indirectly help the service industry reduce carbon emissions by improving the efficiency of energy utilization; On the other hand, financial investment in science and technology can be used to develop and introduce advanced production technology and methods, as well as to purchase and design advanced technology and equipment [12]. Processing energy to increase combustion rate and reduce carbon emissions, purify the waste generated by production, and then discharge, reduce the carbon emissions of the service industry from the source.

Energy consumption intensity affects carbon emissions from the service industry. For every percentage point increase in energy consumption per unit output value of the service industry, the total carbon emissions will increase by 0.066083 percentage points. Carbon dioxide emissions from energy consumption account for up to 77. 27% of all carbon emissions, reducing energy consumption intensity can reduce carbon emissions from productive energy consumption. The impact of continuous technological progress on carbon emissions has two sides. On the one hand, the improvement of technological level can improve the efficiency of energy use, thereby reducing carbon emissions per unit of economic output value; On the other hand, technological progress has led to increased energy efficiency, which in turn leads to economic growth, but economic growth will consume more energy and increase carbon emissions. This is the " rebound effect " produced by technological progress [13].

The regression coefficient of the industrial structure is-1.2595, that is, every percentage point increase in the added value of the service industry in Jiangsu Province, and the carbon emissions decrease by 1.2595 percentage points, which shows that the adjustment of the industrial structure is more obvious to reduce carbon emissions. Help. At the same time, since the added value of the secondary industry accounts for nearly half of the GDP of Jiangsu Province and has the greatest energy consumption, the industrial structure has been adjusted to reduce the proportion of the secondary industry appropriately. Accelerate the development of the tertiary industry, and further coordinate the tertiary industry in the industry, promote energy conservation and emission reduction in Jiangsu Province, and achieve a low-carbon economy[14].

For every percentage point increase in tourism revenue in Jiangsu Province, carbon emissions in the service industry will increase by 0.6510317 percentage points. While promoting economic development, tourism will also cause a certain degree of damage to the environment. Research shows that the carbon emissions generated by tourists account for 4.4% of the global carbon emissions. At the same time, tourism promotes the development of transportation, catering and accommodation industries, and also increases the carbon emissions of the service industry[15]. In 2020, the number of domestic tourists received by Jiangsu Province was 47.17412 million, and the domestic tourism revenue was 813.631 billion yuan. Large-scale tourism activities carried out by tourists and related industries to meet their needs will also increase carbon emissions in Jiangsu Province.

The return coefficient of carbon emissions affecting the service industry in transportation, warehousing and postal industry is 0.4165427. For every percentage point increase in the revenue of transportation and warehousing postal industry in Jiangsu Province, carbon emissions will increase by 0.4165427 percentage points. Transportation, warehousing and postal service is one of the basic industries to promote the rapid development of social economy. In recent years, the transportation industry in Jiangsu Province has developed rapidly, from 55.737 billion yuan in 2000 to 315.72 billion yuan in 2019. The rapid development has also increased carbon emissions.

According to the final prediction error (FPE) criterion, AIC criterion, SC criterion and HQIC criterion, the lagging order of var model is determined, and the optimal lagging order of VAR model constructed by logCP and log GDP is 3. When the lagging order is 3, the AIC test value is-7.67194, and the HQIC standard test value is-7.73109.

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4. CONCLUSION AND RECOMMENDATION

This paper analyzes the coupling relationship and change trend of service industry development and its carbon emissions in Jiangsu Province from 2005 to 2022 by using related theories and VAR model empirical analysis, verifies the significant impact between the two, and analyzes the factors affecting the development of service industry, Select 5 variables of scientific level, energy consumption intensity, industrial structure, tourism development, transportation and warehousing and postal industry, and carry out regression analysis with carbon emissions in service industry, and get the following conclusions and suggestions:

Promote scientific and technological innovation and technological progress from culture, policies, infrastructure and other aspects, optimize the structure of energy consumption, actively introduce advanced technologies to improve carbon emission efficiency, reduce energy consumption per unit output value, form a regional governance pattern, and accelerate the transformation of innovation achievements. Relying on scientific and technological innovation to promote the development of industry to low pollution, low energy consumption and high efficiency, promote scientific and technological innovation, industrial structure upgrading and carbon emission efficiency to form a benign interactive development [16]. At the same time, give full play to the role of carbon emission efficiency in promoting the upgrading of industrial structure. It is necessary to speed up the upgrading of industrial structure as the focus of work, strengthen the construction of innovative market and financial support system, and improve the business environment. Vigorously develop high-tech industries and low-carbon green environmental protection industries, and improve the efficiency of industrial input-output.

Improve the tourism science and technology innovation system, strengthen investment in low-carbon technologies and professionals, and use technological innovation to drive tourism emission reduction [17]. On the one hand, we should improve the environmental monitoring facilities and new energy supporting facilities in scenic spots, establish a comprehensive tourism environment monitoring network system, and strengthen the construction of tourism greenhouse gas statistical accounting system.

Make full use of modern high-tech such as big data and cloud computing to promote the digital upgrading of tourism and create smart low-carbon tourist attractions. On the other hand, we can promote the efficiency of carbon emission in tourism by giving full play to the agglomeration effect of tourism, coordinate the planning of infrastructure construction by relevant departments, scientifically layout and overall development, strengthen the integration of tourism resources in the region, and build an efficient and low-carbon tourism industry agglomeration area. Tourism industry gathering areas should be continuously optimized to improve ecological efficiency, form a positive demonstration effect of comprehensive environmental management, and strengthen information communication with peripheral tourism markets. Promote advanced technology and scientific emission reduction methods, drive the development of tourism in surrounding areas, and gradually form a linkage development pattern with complementary advantages [18].

Improve the efficiency of transportation, warehousing and postal industry, develop and use new technologies and energy sources to reduce carbon emissions [19]. First, we should carry out demand-side management of the transportation industry, scientifically control the transportation demand, adopt motor vehicle license plate restriction control, improve the transportation efficiency, improve the slow transportation infrastructure such as trails and non-motorized lanes, and publicize and guide passengers to choose slow transportation mode or choose public transportation mode. Secondly, we should improve the level of industrial structure and scientific and technological innovation ability, optimize and improve the transportation road network, and use Internet technology and big data science to establish real-time and accurate intelligent transportation system. Provide good external environment and technical support for improving transportation efficiency, and promote structural optimization and upgrading of transportation. Third, we should increase investment in technology research and development, including material, technology, technological improvement and innovation, as well as the efficiency and scope of the use of various low-carbon clean energy such as solar energy, light energy and hydrogen energy, and comprehensively promote the low-carbon green development of transportation, warehousing and postal industry.

ACKNOWLEDGEMENTS

Every achievement and growth of me can not be separated from the care and guidance of teachers and classmates. Here I would like to thank those teachers and students who have given me selfless help. Thank you for your help in your study and life. Good teachers and friends are the most precious wealth in our lives. Thanks to my mentor Jun Sun, his patient teaching and good guidance, leading me to take less detours and step forward on the road of learning. Secondly, thanks to all the teachers of the business school who gave me knowledge and gave me warm help during the postgraduate study. Thank them for their generous and enthusiastic guidance to me. Again, thank my roommate for the many good memories I left during my short graduate school. Special thanks to Ruoping Zhang, with me, in the writing process of the paper to communicate with each other, give me valuable advice and help. Finally, I want to thank my parents, their love and care for me is my inexhaustible motivation to move forward!.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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