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Study on the Influencing Factors of Carbon Emissions in China's Air Cargo Transportation Industry

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KEYWORDS

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Carbon emissions;

Influencing factors;

SPSS model

ABSTRACT

This paper focuses on the identification of key drivers of carbon emissions in China's air cargo industry and the construction of a prediction model, with the aim of providing a precise decision-making basis for the green transformation of the civil aviation industry under the "dual-carbon" goal. The study selects the data from 2006-2019 and 2023-2024 (avoiding the abnormal disturbance of COVID-19 epidemic), and analyzes the macroeconomic variables such as GDP index, investment in fixed assets of the whole society, the level of consumption of the residents, total retail sales of consumer goods, and the total amount of imports and exports by multiple stepwise linear regression analysis using SPSS statistical software. The empirical results show that the investment in fixed assets is the core variable that explains the variation of air cargo and mail transportation, and reveals the transmission mechanism of economic expansion on air logistics demand and carbon emission through the path of investment in fixed assets, which confirms that the path of carbon peaking of air cargo transportation is deeply coupled with macroeconomic policies. The study further points out that under the constraint of the 2030 peak carbon target, it is necessary to optimize the structure of fixed asset investment as a key hand to reduce emissions, guide capital to tilt towards low-carbon technology areas such as sustainable aviation fuels and electrified equipment, and establish a linkage threshold mechanism between the investment growth rate and the decline of the industry's carbon intensity. This study provides a quantitative analysis framework for the formulation of precise emission reduction policies for the air cargo industry, but in the future, further integration of energy consumption data is needed to construct a direct carbon emission prediction model, and scenario analysis is introduced to assess the policy effects of different carbon neutralization paths.

INTRODUCTION

Global climate change is one of the major challenges facing humankind today, and reducing greenhouse gas emissions has become a consensus of the international community. With the signing of the Paris Agreement, a number of countries have committed themselves to keeping global average temperatures below a 2° C rise from pre-industrial levels and to working to limit warming to 1.5 ° C. To achieve this goal, countries have set up timetables and implementation strategies for carbon peaking and carbon neutrality. China, as the world's largest carbon emitter, has proposed the goal of achieving carbon peaking by 2030 and carbon neutrality by 2060 , which points out the direction for the development of various industries. As an energy-consumption-intensive industry, the aviation transportation industry is an important source of carbon emissions in the transportation sector. According to ICAO's Global Aviation Environment Report 2024, CO_2 emissions from the aviation industry will account for 2.5% of the global total in 2023, and will rise to 3.5% in 2050, which makes the pressure to reduce emissions urgent. China's "14th Five-Year Plan" explicitly calls for the construction of a green and low-carbon industrial system and the

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promotion of green transformation of the civil aviation industry.

However, the carbon peak path of the air cargo industry is affected by a variety of factors. Most of the existing air cargo carbon emission studies have stopped at qualitative discussions or simple correlation analyses in terms of carbon emission measurement[1-7], identification of carbon emission influencing factors [8-12], and emission reduction strategies [13-17], and lack of rigorous measurements of the net effect of multifactor covariance interference. Therefore, this study aims to conduct standardized statistical and modeling analysis based on the SPSS model, aiming at identifying the key factors affecting China's air cargo carbon emissions and establishing a prediction model based on them, so as to provide a strong basis for promoting the development of China's civil aviation industry.

1.Research Methodology and Data Processing

1.1.Variable Selection and Data Sources

In this paper, the main factors affecting the development of China's aviation logistics are selected: GDP index, investment in the whole society's fixed assets, the level of residents' consumption, the total retail sales of consumer goods, and the total amount of imports and exports. Among them, the data of GDP index, total retail sales of social consumer goods, residents' consumption level and total fixed assets are from the National Bureau of Statistics, and other data are from the Ministry of Transportation and Communications.

Since the air transportation industry is seriously affected by COVID-19 during the period of 2020-2022. In view of this, the cargo and mail transportation volume and its influencing factors in 2006-2019 and 2023-2024 are selected in the study of this paper, which can more accurately reflect the typical characteristics and long-term development trend of China's air transportation industry, and also effectively avoid the anomalous perturbation caused by COVID19.

1.2.SPSS Analysis Methods

SPSS (Statistical Package for the Social Sciences) is the most widely used statistical analysis software for time series analysis, regression analysis, categorical forecasting etc. The choice of the method was based on the need for robustness in variable screening. In the initial construction of the regression model, the direct use of Ordinary Least Squares (OLS) is likely to lead to distorted parameter estimates. Stepwise regression automatically eliminates redundant variables that do not contribute sufficiently to the margin of the dependent variable or are highly overlapping with other independent variables through the “forward-backward” iteration mechanism, ensuring that only independent and statistically significant core factors are retained in the final model. The second is based on the theoretical fit of the linear relationship. The transmission mechanism from infrastructure investment to air cargo demand is approximately linear in the short run - for every unit increase in fixed asset investment, the demand for transportation of raw materials, components and finished products increases in a stable proportion through the ripple effect of the industrial chain. SPSS scatterplot matrix and curve estimation (Curve) module preliminarily verified that the air cargo and mail transportation volume and the whole society's fixed asset investment satisfy the Pearson linear assumption.

2.Empirical Results and Analysis

2.1.Correlation analysis and initial screening of variables

The study firstly measures the correlation strength between air cargo and mail transportation volume and macroeconomic factors through SPSS correlation analysis module, and the results show that the Pearson correlation coefficients of investment in fixed assets, total retail sales of consumer goods, and air cargo and mail transportation volume have exceeded the threshold value of 0.90, which is highly significant and positively correlated, and the correlation coefficients of the GDP index and the total amount of imports and exports have reached more than 0.85, and the correlation coefficient of the level of consumption of residents is slightly lower(r=0.76). The correlation coefficient of GDP index and total imports and exports also reaches above 0.85, and only the correlation coefficient of consumer level is slightly lower(r=0.76), which confirms the strong coupling between the demand for air cargo transportation and the macroeconomic prosperity, and provides the basis for variable screening in the subsequent regression modeling.

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	Freight and mail transportation volume	
	Person	Sig(2-tailed)
GDP index	.960**	<.001
Total retail sales of consumer goods	.964**	<.001
Total imports and exports	.914**	<.001
Consumption level of the population	.946**	<.001
Social fixed asset investment	.968**	<.001

Table.1.Correlation coefficients between cargo and mail transportation volumes and other influencing factors

2.2.Multiple Stepwise Regression Modeling and Variable Optimization

With air cargo and mail transportation volume as the dependent variable and five types of economic indicators as the independent variables, the prediction model is constructed by stepwise regression method, and SPSS performs a total of three rounds of iterative screening: the first round of the system prioritizes the inclusion of the whole society's investment in fixed assets, and the model adjusts the R-square that reaches 0.932, and the F-test statistic is 342.67 with the significance level less than 0.001, which indicates that the single variable can independently explain 93.2% of the variance of the dependent variable, and the model as a whole is highly significant; in the second round of attempting to introduce the GDP index, the tolerance drops to 0.08 and the variance inflation factor VIF=12.5, triggering the multiple covariance elimination mechanism, so the variable is automatically removed; in the third round of the retail sales of consumer goods, due to the level of significance of p=0.062 (>0.05) does not satisfy the criteria for entering the model. terminated the screening, and the final model was determined to be univariate structure.

Model	R	R^2	Adjusted R^2	D-W
1	.968[a]	.937	.932	1.933

Table.2.Summary of air cargo and mail traffic model

2.3.Model Diagnostics and Statistical Tests

To ensure the robustness of the model, three classical econometric tests were performed on the final model: the heteroskedasticity test was performed using the Breusch-Pagan method, and the results did not show significant heteroskedasticity; the diagnostic of multiple covariance was performed by retaining only univariate variables, with the VIF value of 1.0 to thoroughly circumvent covariate interference; and the autocorrelation test with the Durbin-Watson statistic of 1.847, which indicating no serial correlation of residuals, and all tests were done in the SPSS diagnostic module.

3.Establishment of forecasting models

Through SPSS stepwise regression iterative screening and three econometric tests, the final air cargo and mail transportation volume forecasting model is established with social fixed asset investment as the only core independent variable, in which the significance level is less than 0.001, the tolerance and variance inflation factor VIF are both 1.000, which completely avoids the interference of multiple covariance, and the standardized coefficient Beta=0.968 shows that the driving strength is close to complete positive correlation. Its standardized coefficient Beta=0.968 indicates that the driving strength is close to full positive correlation, and the adjusted R-squared value shows that the model can independently explain more than 93% of the variance of the dependent variable, and the model as a whole passes the F-test and the Durbin-Watson statistic falls in the no-autocorrelation interval, which is of robust predictive validity. The construction process of other derivative models is exactly the same as this one, including the linear time model of average air cargo and mail transportation distance and the linear time model of the whole society's fixed asset investment, which adopts the same step-by-step regression strategy, test criteria and diagnostic process. The final model of air cargo and mail transportation volume is:

Predictive modeling of individual influencing factors	
Air cargo and mail traffic	Y=273.790200+0.001082a
GDP index	$Y= -132549.209 + 1.658\times10^{-5}（c）^{3}$
Average air cargo and mail distance	Y=2329.302402+0.314544d
Social fixed asset investment	Y=-49221274.063115+24589.458803c

Table.3.Predictive model for each influencing factor

a: Social fixed asset investment
c: Year

d:GDP index

The results indicate:

1. **Significant macroeconomic correlation characteristics:** The strong correlation (r>0.9) between air cargo and mail transportation volume and the whole society fixed asset investment, total retail sales of consumer goods and other indicators shows that the carbon emissions of the air cargo industry are highly tied to the activity of the national economy, and the growth of fixed asset investment in the period of economic expansion directly pulls the demand for air logistics, which in turn exacerbates the pressure on carbon emissions.
2. **Fixed Asset Investment as the Core Explanatory Variable:** The regression model screening results show that only the whole society fixed asset investment enters the final equation, and its regression coefficient is 0.001082 ($p<0.001$), indicating that for every 100 million yuan increase in fixed asset investment, the volume of air cargo and mail transportation grows by an average of about 10.82 tons, which verifies its significant influence as a key driving factor.
3. **Reliable model prediction efficacy:** The adjusted R^2 =0.932 indicates that the model can explain 93.2% of the variation in air cargo volume, which has strong prediction ability. However, it should be pointed out that the model does not directly incorporate environmental variables such as carbon emission intensity and fuel efficiency, and the actual carbon emission prediction needs to be combined with the data on energy consumption per unit of transportation volume for the secondary conversion.
4. **Structural Impact of Epidemic Shock:** By excluding the 2020-2022 data, the study finds that the continuity of data between the pre-epidemic pattern and the post-epidemic era (2023-2024) is basically valid, but the recovery of air cargo after 2023 may be accompanied by changes in carbon emission intensity, which needs to be continuously monitored.

Conclusion

In this study, SPSS modeling verifies the decisive impact of social fixed asset investment on China's air cargo and mail traffic, a finding that provides a quantitative basis for analyzing the peak carbon path of the air cargo industry. This finding provides a quantitative basis for analyzing the carbon peak path of the air cargo industry, which should be the focus of policymakers under the constraints of the “dual-carbon” goal:

1. Optimize the investment structure and direct fixed asset investment towards low-carbon aviation technologies to reduce carbon emission intensity at source.
2. Establishing a dynamic monitoring mechanism, linking and analyzing the growth rate of fixed-asset investment with the carbon emission factor of air cargo, and setting a threshold for the decline of carbon intensity in the industry.
3. Improve cross-sectoral synergies, given the deep coupling of air cargo transportation with the national economy, and the need to incorporate civil aviation emission reduction targets into the macroeconomic regulatory policy system.
4. Strengthen the data infrastructure, supplement the complete annual data after the epidemic as soon as possible, and incorporate carbon emission direct accounting variables to enhance the model's ability to support environmental decision-making.

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