The Impact of Green Logistics and Digitalization on Economic Development: Evidence from the Yangtze River Delta Region

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Abstract. Based on research data from the Yangtze River Delta region, this study examines the association between digitization, green logistics and economic development. Using a double fixed-effects model, regression analyses were conducted to investigate the effects of green logistics, wealth per capita, total transportation mileage and education level on economic growth, and the moderating effect of digitization level on the relationship between green logistics and economic growth was examined. The results show that green logistics has a significant positive impact on economic growth, and per capita wealth and education level also have a significant positive impact on economic growth. However, total transportation mileage has a significant negative effect on economic growth. In addition, the study noted that the level of digitization significantly enhances the positive impact of green logistics on economic growth. These findings can provide policymakers and enterprises with a basis for decision-making, which can help promote the development of green logistics and digitalization for sustainable economic growth.

Keywords: Digitalization; Green logistics; Economic development; Yangtze River Delta region

1 INTRODUCTION

The logistics industry is becoming increasingly important, driven by globalization and economic development, but also by environmental pressures that have brought green logistics and digitization to the forefront of attention. The application of digital technology in logistics is in the spotlight, with China in particular leading the way in digital development and having a significant impact on the global digital economy. The Yangtze River Delta region and the Yangtze River Delta are examples of China's digital economy, with booming 5G networks and industries. The digital economy promotes green transformation of cities, but different resource allocation and development stages in each city constrain green transformation. The study fills the research gap on the re-

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lationship between digitalization, green logistics and economic development, and provides a decision-making basis for policy making and enterprises. It aims to provide theoretical support for relevant policies and enterprise decision-making.

2 THEORETICAL ANALYSIS AND RESEARCH HYPOTHESIS

2.1 Relationship Between Green Logistics and Economic Growth

The trend towards globalization has pushed the logistics industry to play a key role in economic development, mainly by lowering market barriers and facilitating coordination mechanisms between buyers and sellers. Traditional logistics activities lead to increased energy consumption and environmental pollution, so green logistics has attracted much attention as a new model aimed at reducing environmental pollution, improving energy efficiency [1] Green logistics is a new model that aims to reduce environmental pollution and improve energy efficiency. By improving transportation efficiency, reducing transportation distance, increasing loading rate, and choosing environmentally friendly transportation modes, green logistics reduces carbon emissions and energy consumption, improves environmental protection and economic efficiency, enhances enterprise competitiveness, and is expected to promote economic growth. With a developed economy and rich logistics resources, the Yangtze River Delta region has great potential for green logistics application, but also faces environmental and energy challenges, and the development of green logistics is crucial to economic growth and sustainable development. Based on the above analysis, the research hypothesis is proposed:

H1: There is a positive relationship between economic growth and the development of green logistics in the Yangtze River Delta region.

2.2 Other Factors Affecting Green Logistics and Economic Growth

In addition to green logistics, wealth per capita, total transportation mileage, and education level are important factors that influence the relationship between economic growth and green logistics[2] . Regions with high levels of wealth have strong consumption and investment capacity, and a high demand for efficient green logistics, which is conducive to the construction of facilities and technology research and development, and attracts more green logistics companies to move in[3].The total transportation mileage reflects the degree of infrastructure development. Regions with a high level of education have a strong sense of environmental protection and are more likely to accept the concept of green logistics, which is conducive to technological innovation and management innovation[4]. Overall, these factors affect the development of green logistics and its contribution to economic growth, so it is assumed that:

H2: Wealth per capita, total transportation mileage, and education level are used as control variables that affect the relationship between economic growth and green logistics to some extent.

3 RESEARCH DESIGN

3.1 Sample Selection and Data Sources

Economic Growth. This paper draws on the work of LONG Ke-lin[5] and LIU Ximei[6] 's study, it adopts prefecture-level city GDP as the explanatory variable to measure economic growth.

Green Logistics. This paper adopts the entropy value method to construct green logistics indicators, which is an objective weight determination method based on the principle of information entropy. The entropy value method can objectively measure the degree of difference of each indicator and determine their relative importance in the comprehensive evaluation.The advantage is that it accurately reflects the information of each indicator. Its advantage lies in accurately reflecting the difference in the information of each indicator, avoiding the interference of subjectively set weights, and eliminating the influence of subjective factors by basing the weights on the data itself. In addition, the entropy value method can fully reflect the importance of the indicators, and the indicators with large differences have larger weights to ensure that the evaluation results are fair and practical. Through the entropy value method to build green logistics indicators, it can accurately measure the amount of information, avoid subjective interference, reflect the importance of indicators, and ensure that the indicators are reasonable and scientific.

Drawing on the studies of Ma Ruonan and Gui Haixia[7] et al. study, this study discards missing data and selects indicators scientifically and systematically to ensure a comprehensive representation of green logistics development. Ten variables are selected to construct research indicators for green logistics development from 1997 to 2019, covering the development scale and green level subsystems. The scale of development subsystem includes the income of logistics industry, the number of logistics enterprises, the volume of cargo transportation, the degree of greening of warehouses, and the number of employees. The entropy value method is utilized to calculate the proportion of weights and improve the scientificity of the analysis. With the increase of entropy value, the magnitude of index change decreases, and the index weight proportion is more accurately measured, and its calculation process is as follows:

In the first step, the collected data were de-measured, in the second step, the intensity of the values of item j in year i was calculated: in the third step, the information entropy of the indicator was calculated, in the fourth step, the redundancy of the information entropy was calculated: in the fifth step, the weight of the indicator was calculated, and in the sixth step, the evaluation score of the indicator was calculated, and the specific calculation results are shown in Table 1.

Table 1. Green Logistics Development Indicator System

sports event	Level 1 indicators	Secondary indicators	weights
Green Logistics	Scale of development	Revenue from logistics (billions of dollars)	0.1476
		Number of logistics enterprises (units)	0.1572
		Volume of cargo transported (tons)	0.0904
		Warehousing area (10,000 square meters)	0.1491
		Number of employees in the logistics industry (10,000)	0.1513
	green level	Waste recycling efficiency (tons/billion dollars)	0.0593
		Energy use efficiency (fuel consumption/tonne)	0.0634
		Proportion of sustainable materials used (%)	0.0796
		Degree of greening of warehouses (%)	0.0628
		Proportion of logistics service providers with green certification (%)	0.0394

Level of Digitization. The entropy value method is used to carry out quantitative research on the level of regional financial development. Entropy value method is an objective and comprehensive evaluation method, which determines the weight value of each index by calculating their entropy values and realizes the comprehensive evaluation of the digitization level of listed companies[8]. The method is not disturbed by subjective factors and utilizes the concept of information entropy to transform indicator variability or information quantity into entropy value. Digitalization level indicator system construction: the first-level indicators are informationization empowerment (the second-level indicators are informationization infrastructure, informationization empowerment results), Internet empowerment (the second-level indicators are Internet infrastructure, Internet empowerment results), and digital transaction (the second-level indicators are digital transaction infrastructure, digital transaction results).

Other Control Variables. In order to limit other factors that may affect economic growth and more accurately measure the impact of green logistics on economic growth, this paper constructs control variables from three levels[9]: economic factors, governmental factors, and social factors, and economic growth, total transportation mileage, and education level are selected as control variables to be measured.

3.2 Model Setup and Variable Definitions

In order to test the impact of digitalization and green logistics on economic growth[10], this paper constructs a double fixed-effects regression model controlling both region and year for regression:

$$\mathrm{GDP}_{it} = \beta_0 + \beta_1 \mathrm{DG}_{it} + \beta_2 \mathrm{X}_{it} + \lambda_i + \gamma_t + \varepsilon_{it} \tag{1}$$

WhereGDP_{it} denotes the economic growth of prefecture-level city i in year t. In this paper, we use the economic growth data of China's sub-prefecture-level cities to directly measure the amount of economic growth in this region.DG_{it} is the core explanatory variable, representing green logistics, andX_{it} is a series of control variables.λ_i denotes different individual regions, andγ_t denotes different years;ε_{it} denotes a random perturbation term;β_0 denotes the intercept term

In addition to this, in order to measure whether there is a moderating effect in this model, the following moderating effect model is constructed:

$$GDP_{it} = \alpha_0 + \alpha_1 DG_{it} * GDP_{it} + \alpha_2 DG_{it} + \lambda_i + \gamma_t + \varepsilon_{it} \tag{2}$$

The data used in this paper come from China Economic Growth Database, China Urban Statistics Yearbook, and Doing Business in China 2022 Report. In the process of rounding, the residual values of the years are screened, and the panel data are organized into panel data through Excel for empirical analysis.

3.3 Descriptive Statistical Analysis

The descriptive statistics of each variable in this paper are analyzed in Table 4 below. The standard deviation of green logistics is small, 9.305, the minimum value is 56.5, and the maximum value is 94.69, indicating that there is no particularly significant difference in green logistics in the sample as a whole. The standard deviation of GDP per capita is the largest, indicating that there are large differences in economic and social development between different prefectures; the standard deviation of total transportation mileage GS is 14.96, which also belongs to the normal range, so it can be assumed that there is not a big difference in total transportation mileage between different prefectures; the standard deviation of education level edu is 30.93, which is second only to the standard deviation of GDP per capita, and it can be assumed that in different prefectures and regions, the education level varies greatly.

4 EMPIRICAL ANALYSIS

4.1 Correlation Analysis

Table 2. Correlation analysis

	GDP	DG	pGDP	GS	EDU
GDP	1				
DG	0.283***	1			
pGDP	-0.377***	0.313***	1		
GS	0.0730	0.433***	0.413***	1	
EDU	-0.464***	0.102	0.202**	0.676***	1

As shown in Table 2 above, the correlation coefficient between variables is more significantt, so the presence of multicollinearity is suspected and the standard deviation inflation factor is used for testing:

According to the results of vif test, the value of vif is only 1.82, which is much less than 10, so it can be considered that the model does not have serious multicollinearity, and the information independence between variables is better.

4.2 Benchmark Regression Analysis

As shown in Table 3, after completing the construction of the model, according to the analysis of its regression results, it can be seen that the explanatory variables in columns (1), (2), and (3), are satisfied to be significant at the level of P-value less than 0.01. The adjusted coefficient of determination in column (1) is 0.6, and column (2) has a null value in the data, and the adjusted coefficient of determination and F-value can't be measured, but through the t-value test and F-value test of the explanatory and control variables in column (2), it can also show that the model 2 has a more sufficient credibility, and the same can be obtained in column (3). In summary, the regression results of the model are good, and the empirical analysis has a certain degree of reliability.

Table 3. Double fixed effects regression results

VARIABLES	(1) GDP	(2) GDP	(3) GDP
DG	2.671***	2.0363***	2.06498***
	(48.60)	(47.26)	(47.40)
PGDP			0.52428***
			(6.8444)
GS		-0.0097	-0.48857***
		(-1.266)	(-6.4156)
EDU			0.18614***
			(7.4654)
Constant	-1.558***	0.0507***	0.85817***
	(-28.74)	(13.071)	(18.8071)
R-squared	0.655		
Number of id	41	41	41
F test	0	0	0
r2_a	0.603	.	.
F	7652	.	.

t statistics in parentheses* p < 0.05,** p < 0.01,*** p < 0.001

The article mainly analyzes the impact of green logistics on economic growth, focusing on the total mileage of transportation. When mileage is not considered, the DG regression coefficient is 2.671 and the PGDP regression coefficient is 3.057, indicating that the faster the development of green logistics, the lower the economic growth. When considering the number of miles, the regression coefficient of PGDP is -2.036 and the regression coefficient of GS is 0.48857, which indicates that the total number of miles of transportation has a negative impact on economic growth, which is consistent with common sense. Therefore hypothesis 1 is valid.

4.3 Robustness Tests

This paper chooses total factor productivity FVAR to replace the amount of economic growth as the explanatory variables[11], and re-performs the double fixed-effects regression, the results are as follows, and it can be seen that the conclusions are basically the same as the above, so the robustness test passes, and the model is smooth and has sufficient realistic explanatory power.

5 ANALYSIS OF IMPACT MECHANISMS

5.1 Moderating Effects Test

In order to verify whether there is a moderating effect in the model, the interaction term of green logistics DG and digitization level Digit is used, and the double fixed effect model is adopted again for estimation, which shows that the interaction term of green logistics DG and digitization Gigit is significant at the 0.01 level, and in terms of the coefficients, the coefficients of the interaction term and the coefficients of green logistics are consistent with each other in terms of the direction of the coefficients, so it proves that the model does have a positive moderating effect. Therefore, hypothesis 2 is established.

5.2 Optimized Solution of the SBM Model

In addition to that, this paper re-measures the green logistics indicators through the SBM super-efficiency model and re-performs the regression analysis.

Input-output analysis is performed based on the Kuhn-Tucker condition. However, the DEA model suffers from artificial relaxation with radial selection bias, based on this, this paper adopts the super-efficient SBM analysis model proposed by Tone, which is:

min:

$$P^* = \frac{\frac{1}{q}\sum_{i=1}^{q}\frac{\bar{x}}{x_{ik}}}{\frac{1}{w_1+w_2}\left(\sum_{r=1}^{w_1}\frac{\bar{y}^{g}}{y_{rk}{}^{g}}+\sum_{l=1}^{w_2}\frac{\bar{y}^{b}}{y_{lk}{}^{b}}\right)}$$

$$\mathrm{s.t.}\ \bar{x} \ge \sum_{j=1,\neq k}^{n}\lambda_i\,\bar{y}^{g} \le \sum_{j=1,\neq k}^{n}\lambda_i\,y_r^{g} \qquad \bar{x} \ge x_k$$

$$\bar{y}^{g} \ge y_k^{g}\bar{y}^{b} \ge y_k^{b}\sum_{j=1,\neq k}^{n}\lambda_i = 1$$

$$\lambda_i \ge 0, i = 1,2,\ldots,q; j = 1,2,\ldots,nr = 1,2,\ldots,u_1; l = 1,2,\ldots,u_2$$

Where.P^* is the target efficiency value, n is the number of decision units, q is the number of decision unit inputs, andw_1 is the desired output, andw_2 is the undesired output, andx_i and$y_r{}^g$ and$y_l{}^b$ are the elements in the corresponding input matrix, desired output matrix, and non-desired output matrix, andλ_i is the weight vector. which are used as explanatory variables to replace the green logistics DG, and the regression is re-run, and the results are shown in Table 4 below.

Table 4. Regression results under SBM model

VARIABLES	(1) GDP	(2) GDP
SBM-DG	0.0241***	0.0297***
	(19.42)	(25.13)
PGDP		0.149***
		(142.5)
GS		0.0032*
		(104.1)
EDU		0.00211***
		(23.36)
Constant	-1.699***	-1.735***
	(-104.2)	(-129.8)
R-squared	0.124	0.131

t statistics in parentheses* $p < 0.05$,** $p < 0.01$,*** $p < 0.001$

SBM-DG is significantly and positively correlated with GDP with coefficients of 0.0241 and 0.0297, respectively.PGDP coefficient is 0.149 and R-squared is 0.124 and 0.131, respectively.The results of the study support the hypothesis of the positive impact of green logistics on economic growth, as well as wealth per capita, education, and the total number of miles of transportation have a positive impact on economic growth.

6 CONCLUSIONS AND POLICY RECOMMENDATIONS

Taking the Yangtze River Delta region as an example, this study explores the relationship between digitalization, green logistics and economic growth through empirical analysis. The findings show that green logistics has a positive impact on economic growth, as do wealth per capita and education level. However, the total transportation mileage showed a negative impact in the final model, possibly due to environmental problems caused by excessive transportation. Digitalization level plays an important role in enhancing the relationship between green logistics and economic growth. Synthesizing the findings of the study, the following policy recommendations are made: continue to promote the development of green logistics, raise the level of wealth and education per capita, scientifically plan the construction of transportation, and further increase the level of digitization. These initiatives will help to promote economic growth, reduce environmental pollution and improve the quality of economic development.

REFERENCES

1. Zhu Hongbin. Design of green supply chain management system for energy enterprises based on suppliers' green evaluation[J]. Logistics Science and Technology, 2024, 47(06):123-129.
2. Yao Wenyu. Research on the impact of innovation on China's economic growth and economic volatility[D]. Southwest University of Finance and Economics, 2022.
3. Tang Yunyi, Li Fangzhuo. Digital Infrastructure Policy Enabling Enterprise Digital Transformation: Evolutionary Logic and Policy Orientation[J]. Journal of Seeking Truth, 2024, 51(02):59-68.
4. XIE Xindi, YAN Bing, ZHANG Yu. How overseas economic and trade cooperation zones boost the high-quality development of China's outward foreign direct investment[J]. Nankai Economic Research,2024(01):77-95.
5. LONG Ke-lin. Analysis of time-varying factors and spatial difference drivers of carbon intensity in China's logistics industry[D]. Tianjin University of Technology, 2023.
6. LIU Ximei, XU Yuanyuan. Construction of evaluation index system for intelligent green and low-carbonization of third-party logistics enterprises under complex scientific thinking[J]. Journal of North China Electric Power University (Social Science Edition), 2020, (01):35-41.
7. MA Ruonan,GUI Haixia. Research on the degree of coordination of green logistics-low carbon economy coupling in Yangtze River Delta[J]. Journal of Yuncheng College,2022,40(06):34-41.
8. Wang Ying,Yang Hang,Zhang Xiaowen. Digital Inclusive Finance, Consumption and Common Wealth[J]. Statistics and Decision Making,2023,39(03):148-153.
9. Yan Yiyao. Evaluation and analysis of low-carbon logistics efficiency of Chinese provinces based on weighted SE-SBM model under dual-carbon objectives[D]. Shanxi University, 2023.
10. Hou Kaiyue, Zhang Qinghong. An empirical study on the relationship between logistics development and economic growth in Shandong Province[J]. China Storage and Transportation, 2021(04):120-123.
11. Fu Y, Zheng WJ, Zhao B et al. Research on predictive maintenance system of railroad wagon carriages[J]. Intelligent Rail Transportation,2022,59(05):32-37.