Panel Data Analysis of Energy Conservation and Emission Reduction On High-Quality Development of Logistics Industry in Yangtze River Delta of China

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Panel data analysis of energy conservation and emission reduction on high-quality development of logistics industry in Yangtze River Delta of China

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Abstract

With the implementation of China's carbon neutrality policy, the Yangtze River Delta region, as a benchmark for the development of China's logistics industry, calls for great concern, accompanying the energy consumption and environmental problems. In order to explore how China's logistics industry can achieve both energy conservation and emission reduction (ECER) and high-quality development in the context of carbon neutrality, this study analyzes the relationship between the development of logistics industry and the economy, energy together with environment in the Yangtze River Delta region based on the data of China Statistical Yearbook from 2001 to 2019, by means of the Entropy method and PVAR model. The main findings are summarized as follows: firstly, the economy, industrial structure, energy and environment all have significant impact on the development of logistics industry in Yangtze River Delta region. Secondly, the development of logistics industry in Yangtze River Delta region is not balanced, and the provinces including Jiangsu, Shanghai, Zhejiang and Anhui have great differences in economy, industrial structure, demographic dividend, energy consumption and environmental protection, and the possibility of complementary advantages. Thirdly, the economic development and energy consumption are two-way effects. Environmental protection is relevant to economic development, industrial structure, energy consumption and logistics supply. Finally, in the context of carbon neutrality, this paper gives some suggestions on how to realize the high-quality development of logistics industry in Yangtze River Delta region while considering energy consumption and environmental protection.

Keywords Yangtze River Delta gEnergy conservation and emission reduction g High-quality development gPVAR model gGreen logistics

1. Introduction

The main cause of global climate change is carbon emissions(Han et al., 2021) . With the sense of responsibility, China has not stopped ecological civilization (Gu et al.,2020). China is striving to peak carbon dioxide emissions by 2030 and achieve carbon neutral by 2060 (Liu et al., 2021; Jia et al.,2020). The main objectives of Chinese government are: by 2025, the economic system of green, low-carbon and cyclic development will have taken initial shape, and the efficiency of energy use in key sectors will have increased significantly. Energy consumption per unit of GDP will drop by 13.5% and carbon dioxide emissions per unit of GDP will drop by 18% compared to 2020, the proportion of non-fossil energy consumption will reach about 20%, forest coverage will reach 24.1%, and forest accumulation will reach 18 billion cubic metres, laying a solid foundation for achieving carbon peaking and carbon neutrality. By 2030, the overall green transformation of economic and social development will have achieved significant results, and the energy use efficiency of key energy-consuming industries will reach advanced levels. Energy consumption per unit of GDP will drop significantly, and carbon dioxide emissions will reach a peak and achieve a steady decline.The economic and social development of a country is heavily dependent on transport. In China, it has become the third largest energy consuming sector, generating large amounts of carbon emissions(Wang et al.,2020a). The reduction in energy intensity and the optimisation of the energy mix cannot offset the rapid growth in consumption and population(Zhao et al.,2020). The mitigation of China's environmental problems is of great importance to global ecology(Zeng et al.,2020). The majority of carbon emissions come from the energy sector, with the transport, industrial and residential sectors being the main contributors(Akbar et al.,2021).

By 2060, the green, low-carbon and circular economic system as well as the clean, low-carbon, safe and efficient energy system will be fully established, the energy use efficiency will reach advanced levels, the proportion of non-fossil energy consumption will reach over 80%, the goal of carbon neutrality will be successfully achieved, fruitful results will be achieved with the construction of ecological civilization and the harmonious coexistence between human and nature(CPC，2021)．

China has formulated the relevant development plans for Yangtze River Delta city cluster, which is one of the most developed regions in China, to boost economic growth and regional development(Liu et al.,2020). It is supposed to play a leading role in China’s low-carbon development. Energy-saving and carbon-free technological change plays a key role in the transformation of low-carbon development in the region(Jia et al.,2018). Chinese government clearly puts forward to enhance the development level of integration of Yangtze River Delta, aiming at the advanced technology and industry system, speeding up the construction of G60 high-tech corridor and the industry innovation belt along Shanghai-Nanjing in Yangtze River Delta. It is necessary to speed up the infrastructure interconnectivity and promoting ecological environment to guarantee league, high-level integration and demonstration area of ecological green development in Yangtze River Delta(Zhang, 2021). The development of logistics industry in Yangtze River Delta has always been a benchmark for China’s logistics industry, and it is particularly important to study the development of logistics industry in Yangtze River Delta. The Yangtze River Economic Belt is one of the key economic strategies for China’s sustainable development, and the logistics industry, as the basis for implementing economic integration in Yangtze River Delta, plays a role in the exchange of resources and trade flows(Long et al.,2020) . The feasible and sustainable growth structure is the operational objective for all economies globally(Su et al.,2021). China is transforming towards a new path of green, coordinated and high-quality logistics development. Therefore, based on the data from China Statistical Yearbook 2001-2019, this study explores the high-quality development of logistics industry in Yangtze River Delta from seven dimensions, including economic development, industrial structure, demographic dividend, logistics supply, logistics demand, energy consumption and environmental protection, in the context of carbon neutrality. Finally, some suggestions are provided for how to achieve high-quality development of logistics industry, energy conservation and environmental protection in Yangtze River Delta.

The main contribution of our study lies in the following three points: Firstly, although there is a lot of literature on the development of logistics industry in Yangtze River Delta of China, very little literature focuses on the road to its high-quality development in the context of carbon neutrality from seven dimensions such as economic development, industrial structure, demographic dividend, logistics supply, logistics demand, energy consumption and environmental protection. Secondly, China must develop green logistics to achieve carbon peaking and carbon neutrality. The logistics industry in Yangtze River Delta is a benchmark for the development of China's logistics industry and a pioneer of the future reform. Our study provides theoretical support for the high-quality development of logistics industry in Yangtze River Delta, giving the consideration to energy consumption and environmental protection. Thirdly, our research shows the achievement of carbon peaking and carbon neutrality in the high-quality development of China's logistics industry, demonstrating the efforts and contributions in energy saving and emission reduction.

The following study includes: Section 2 is literature review, Section 3 is the description of variables and data, Section 4 is an empirical analysis, Section 5 is the conclusion and recommendations, and Section 6 is about research gaps and future prospects.

2 Literature review

The low-carbon economic model has posed new challenges to supply chain management, and the exploration of low-carbon supply chain management in theory and practice has become an urgent issue(Li et al.,2019). Logistics supply is the material basis for the operation of logistics system because of its specificity. It is not only the key element in the development of logistics networks, but also the guarantee for modern logistics system(Shi et al.,2019). As the basic platform for transforming the way of economic development, it determines the layout and development of various industries(Wang et al.,2020b). The logistics industry is known as the accelerator of economic development and the third source of profit(Song et al.,2020), and logistics has gradually become one of the pillar industries supporting the economic development of cities(Bingru et al.,2019). Zhang and Li (2020) believe that relying on big data technology to build modern logistics information sharing platform, which attracts the inflow of resources and thus forms the leading industry that dominates regional economic development (Shi, 2021). Compared to other regions, the logistics industry in Yangtze River Delta has always been the benchmark of China's logistics industry. The concentration of logistics industry can optimize the industrial structure and improve the core competitiveness of enterprises through its professional effect(Xu and Fang, 2018). The development of logistics industry has a positive impact on the optimization of industrial structure of neighboring provinces and cities, while promoting the rationalization and upgrading of industrial structure of the region(Gao and Meng, 2013; Liang and Sun, 2019). The logistics industry is seen as an effective tool for employment and economic sustainability, and logistics development can be an important factor in driving economic growth in the long term through the influence of policy(Gao et al, 2020). China's rapid economic growth and industrial upgrading has led to significant changes in the structure of employment, which often requires more skilled workforce, particularly in high-tech industries(Wang et al, 2020c). Urbanization can also contribute to ecologically sustainable development by concentrating population, stimulating innovation and increasing wealth to solve environmental problems(Wu and Liu, 2020). The demographic dividend is therefore particularly important for the economic growth of a region. With the deepening of industrialization and urbanization in China, air pollution caused by huge energy consumption has become the most serious environmental problem, threatening the health of residents and sustainable development(Tang et al, 2020).

According to the World Bank, China has become one of large energy consumers(Yuan et al, 2020). As the large emitter of carbon dioxide, the energy consumption has increased fivefold since its reform and opening up in 1978 (Jiang et al, 2018). The Yangtze River Delta is the most comprehensive economic center in China and plays the key role in energy transition(Pingkuo et al, 2021). China's rapid economic growth has been accompanied by the deterioration in air quality (Hu et al, 2021a). It is essential for China to take measures in decoupling economic growth from carbon emission for sustainable development globally(Wu et al, 2019). It is estimated that the world will need to exploit the resources of five times by 2050 if the production and consumption patterns of economic growth remain at current level(Stegeman et al, 2020; EPSC, 2016).

Energy and environmental issues have become two major threats to China's sustainable development(Wu et al, 2020). In the development of logistics industry, most of cities focus on economic benefit such as added value rather than pay enough attention to environmental protection, resulting in the inefficient state, further demonstrating the phenomenon "Environmental Kuznets Curve"(Yang et al, 2016). The conflict between economic development and environmental protection has attracted widespread global attention(Hu et al, 2021b). In recent years, the pm 2.5 pollution has become a challenge in the process of industrial development all over the world, and the Yangtze River Delta of China is facing double pressure of economic development and environmental protection(Ji et al, 2021). The government has shifted from low-carbon products to low-carbon technologies in order to improve the level of low-carbon economy(Li et al, 2021).

The growing concern about global warming has led to legislative enactments aimed at progressively reducing the amount of greenhouse gases emitted by industrial sector and its supply chain(Anvar et al, 2018). The development of logistics industry is inseparable from economic development and environmental protection(Wu et al, 2021). China is currently in the critical period of transformation and upgrading of green economy(Liu and Fan, 2021). It has become an opportunity and challenge for China to promote green and high-quality economic development in the context of new economic norms(Wang et al, 2021b). The advanced industrial structure, resource endowment and environmental regulation are conducive to the reduction of environmental pollution(Zhou et al, 2021). Dong (2021) believes that the main scope of regional logistics services is relevant to the basic layout of regional industry chain including transport hubs, transport channels and distribution network in regional economic system, in addition to the micro, meso and macro chain network. Based on the layout mechanism for two-industry linkage chain network, it will form a domestic and international double-cycle network, developing new pattern of mutual promotion and expansion of industry chain. Wang et al. (2021a) have analyzed the current status of logistics development in Yangtze River Delta from five dimensions: economy, carrying capacity, industrial performance, technological innovation and green development. The evolution of logistics network in Yangtze River Delta is centered on the grid of eastern cities such as Shanghai, radiating from east to west, and there is "Matthew effect" and "involution" to a large extent(Tang et al, 2021). Some scholars have used cluster analysis to divide the 27 cities in Yangtze River Delta into four echelons. This study argues that simple cluster analysis tends to ignore the policy differences among different provincial regions and the continuity between spatial territories, so it adopts provincial panel data from seven dimensions, including economy, industrial structure, demographic dividend, logistics supply and demand, energy and environment, to conduct PVAR model regression.

3 Variable Description and data interpretation

3.1 Description of variables and determination of weights

According to the principles of index selection and reviewing relevant literature, this study selects 7 primary indicators and 19 secondary indicators to construct the evaluation system of influencing factors of logistics industry in Yangtze River Delta, and then uses the entropy weighting method to calculate the weights of indicators, as shown in Table 1.

Table 1 Evaluation system of influencing factors of logistics industry in Yangtze River Delta region

Level indicators	Secondary indicators	Type	Weight
Gross domestic product (lnGDP)	X1=Gross Regional Product (100 million Yuan)	+	0.05
	X2= Per capita GDP (Yuan/person)	+	0.05
Industrial structure (lnIS)	X3= Added value of the Primary Industry (100 million Yuan)	+	0.06
	X4= Added value of the secondary Industry (100 million Yuan)	+	0.05
	X5= Added value of the tertiary Industry (100 million Yuan)	+	0.06
	X6= Added Value of Transportation, Warehousing and Postal Services (hundred million yuan)	+	0.05
Demographic dividend (lnDD)	X7= Permanent Population at year-end (ten thousand)	+	0.03
	X8= Number of students in regular institutions of higher Learning (ten thousand)	+	0.02
Logistics supply (lnLS)	X9= Railway operating mileage (ten thousand kilometers)	+	0.03
	X10= Highway mileage (ten thousand kilometers)	+	0.03
Logistics demand (lnLD)	X11= Cargo turnover (100 million ton-km)	+	0.05
	X12= Cargo volume (ten thousand tons)	+	0.04
	X13= Express quantity (ten thousand pieces)	+	0.14
	X14= Crude oil consumption (ten thousand tons)	–	0.03

Energy consumption (lnEC)	*X15= Gasoline consumption (ten thousand tons)*	–	*0.04*
	X16= Diesel consumption (ten thousand tons)	–	*0.03*
Environmental protection (lnEP)	*X17= Forest Area (ten thousand Ha)*	+	*0.08*
	X18= Area of plantation (ten thousand Ha)	+	*0.08*
	X19= Forest coverage rate (%)	+	*0.08*

In this research, the entropy method has been used to determine the weights of indicators, as follows.

(1) Indicator standardisation

When the data is a positive indicator, $$Y_{ij} = \frac{y_{ij} - \min(y_{ij})}{\max(y_{ij}) - \min(y_{ij})} \quad (1)$$

When the data is a negative indicator, $$Y_{ij} = \frac{\max(y_{ij}) - y_{ij}}{\max(y_{ij}) - \min(y_{ij})} \quad (2)$$

where yij is the standardised value of the jth indicator, yij is the original value of the jth indicator, max(yij) is the maximum value in yij, min(yij) is the minimum value in yij, j=1..... .m.

(2) Weighting of indicators

In this study, we use the entropy value method to measure the indicator weights, and the calculation steps are shown below.

Step1: calculate the percentage of the jth indicator, $$P_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}} \quad (3)$$

Step2: calculate the entropy value of the jth indicator, $$E_j = -\frac{1}{\ln n}\sum_{i=1}^{n} P_{ij} \ln P_{ij} \quad (4)$$

Step3: the redundancy of the jth indicator is calculated, $d_j = 1 - e_j$ (5)

Step4: the weight of the jth indicator is calculated , $$W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad (6)$$

Step 5: Calculate the overall rating of development level of logistics industry in Yangtze River Delta,

$$U_i = \sum_{j=1}^{m} Y_{ij} W_j \quad (7)$$

3.2 Description of the data

The data for this study were obtained from China Statistical Yearbook 2001-2019 annual provincial statistics for Jiangsu, Shanghai, Zhejiang and Anhui, with missing values in some years of data filled in using mean interpolation. A panel vector autoregressive (PVAR) model was applied and the model fit results were derived using STATA15 software, with some graphs plotted using

R4.1.1. In order to eliminate the inertia problem of time series data, all the data were logarithmised and all the variables in the model were first order differenced.

4 Empirical analysis

4.1 Model construction

Sims (1980) created the vector autoregressive (VAR) model, which features all variables as endogenous variables to truly reflect the relationship between variables, and Holtz-Eakin et al. (1988) extended it to panel data and proposed the panel autoregressive (PVAR) model(Christiano, 2012).

The relationship between logistics industry and the factors such as the economy, population and energy have generally been studied by previous scholars using fixed effect models or random effect models, but ignoring the possible endogeneity between the model variables. Due to the limitation of variable selection, the studies are not comprehensive enough and ignore many endogenous factors. Therefore, this research uses a panel vector autoregressive (PVAR) model to build six different models in order to analyse the relationship between logistics industry and economic development, industrial structure, demographic dividend, energy consumption and environmental protection in Jiangsu Province respectively.

In order to understand the relationship between the development of logistics industry in Jiangsu Province and economic development, industrial structure and demographic dividend, three models are constructed in turn. Mathematical equation (8), equation (9) and equation (10) correspond to model 1, model 2 and model 3 in Table 4 respectively as follows.

$$Y_{gidl\_it} = \mu_0 + \sum_{j=1}^{k} \mu_j \cdot Y_{gidl\_it-j} + \Omega_{it} + \varepsilon_{it} \tag{8}$$

$$Y_{idll\_it} = \mu_0 + \sum_{j=1}^{k} \mu_j \cdot Y_{idll\_it-j} + \Omega_{it} + \varepsilon_{it} \tag{9}$$

$$Y_{gill\_it} = \mu_0 + \sum_{j=1}^{k} \mu_j \cdot Y_{gill\_it-j} + \phi_{it} + \varepsilon_{it} \tag{10}$$

In order to understand the relationship between the development of logistics industry and economic development, energy consumption and environmental protection in Jiangsu Province, three models have been constructed in turn. The mathematical equations (11), (12) and (13) correspond to model 4, model 5 and model 6 in Table 4 respectively. They are shown below.

$$Y_{gile\_it} = \mu_0 + \sum_{j=1}^{k} \mu_j \cdot Y_{gile\_it-j} + \phi_{it} + \varepsilon_{it} \tag{11}$$

$$Y_{glee\_it} = \mu_0 + \sum_{j=1}^{k} \mu_j \cdot Y_{glee\_it-j} + \omega_{it} + \varepsilon_{it} \tag{12}$$

$$Y_{ilee\_it} = \mu_0 + \sum_{j=1}^{k} \mu_j \cdot Y_{ilee\_it-j} + \omega_{it} + \varepsilon_{it} \tag{13}$$

where, i=1,2,3,4 represent Jiangsu, Shanghai, Zhejiang and Anhui respectively; t=1,2,...t, represents the year; Ygidl=[lnGDPit lnISit lnDDit lnLSit]T is a four-dimensional column vector containing economic development (lnGDP), industrial structure (lnIS), population dividend (lnDD), logistics supply (lnLS); Yidll=[lnISit lnDDit lnLSit lnLDit]T is a four-dimensional column vector containing industrial structure (lnIS), population dividend (lnDD), logistics supply (lnLS), logistics demand (lnLD); Ygill=[lnGDPit lnISit lnLSit lnLDit]T is a four-dimensional column vector containing economic development (lnGDP), industrial structure (lnIS), logistics supply (lnLS), logistics demand (lnLD); Ygile=[lnGDPit lnISit lnLSit lnECit]T is a four-dimensional column vector containing economic development (lnGDP), industrial structure (lnIS), logistics supply (lnLS), energy consumption (lnECit) (lnLS), and energy consumption (lnEC); Yglee=[lnGDPit lnLSit lnECit lnEPit]T is a four-dimensional column vector containing economic development (lnGDP), logistics supply (lnLS), energy consumption (lnEC), and environmental protection (lnEP); Yilee=[lnISit lnLSit lnECit lnEPit]T is a four-dimensional column vector containing industrial structure (lnIS), logistics supply (lnLS), energy consumption (lnEC), and environmental protection (lnEP); Ωit=[lnECit lnEPit] is a two-dimensional row vector containing energy consumption (lnEC) and environmental protection (lnEP); φit= [lnGDPit lnEPit] is a two-dimensional row vector containing population dividend (lnDD) and environmental protection (lnEP). ωit= [lnECit lnEPit] is a two-dimensional row vector containing logistics demand (lnLD) and population dividend (lnDD); μ0 denotes the intercept term vector; k denotes the number of lags; μj denotes the parameter of the jth order of lag matrix; and εit is the random disturbance term.

4.2 Smoothing tests and selection of optimal lags

(1) Smoothness test

In this study, unit root tests were conducted using four tests, IPS (heterogeneous root test), LLC (homogeneous root test), ADF-Fisher test and PP-Fisher (Table 2 below). All seven series (lnGDP,lnIS, lnDD, lnLS, lnLD, lnEC, lnEP) rejected the original hypothesis of smoothness of variables in all four tests and all were significant at the 1% level, indicating that the data used had good smoothness and could be estimated in a PVAR model.

Table 2 Panel unit root test

Variable	*IPS*	*LLC*	*ADF-Fisher*	*PP-Fisher*
lnGDP	***-4.601 0****	***-4.387 7****	***107.143 0****	***81.404 5****
	0.000 0	***0.000 0***	***0.000 0***	***0.000 0***
lnIS	***-5.756 0****	***-4.373 6****	***21.713 8****	***83.576 4****
	0.000 0	***0.000 0***	***0.000 0***	***0.000 0***
lnDD	***-5.141 0****	***-5.068 2****	***44.963 0****	***94.099 1****
	0.000 0	***0.000 0***	***0.000 0***	***0.000 0***
lnLS	***-8.116 0****	***-8.718 0****	***176.841 1****	***174.160 8****
	0.000 0	***0.000 0***	***0.000 0***	***0.000 0***
lnLD	***-5.257 0****	***-5.264 0****	***41.645 1****	***124.192 6****
	0.000 0	***0.000 0***	***0.000 0***	***0.000 0***
lnEC	***-6.366 0****	***-3.673 3****	***45.749 7****	***189.233 9****
	0.000 0	***0.000 1***	***0.000 0***	***0.000 0***
lnEP	***-3.863 0****	***-14.622 5****	***48.854 8****	***171.789 0****
	0.000 0	***0.000 0***	***0.000 0***	***0.000 0***

Note: P-values for unit root tests are in brackets; ***, ** and * indicate significant at the 1%, 5% and 10% levels respectively.

(2) Selection of the optimal number of lag periods

In order to ensure the validity of parameter estimation of PVAR model, AIC, BIC and HQIC criteria were used to select the optimal lag period. As shown in Table 3 below, the six models in this paper are optimal and the model fitting effect is the best when the lag period is one stage.

Table 3 Optimal lag period selection

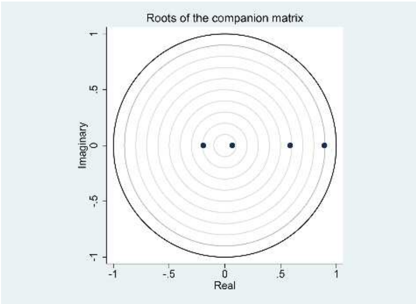
Model	*lag*	*AIC*	*BIC*	*HQIC*
Model1	*1*	*-19.913*	*-18.8336**	*-19.4878*
	2	*-19.6957*	*-18.0202*	*-19.0403*
	3	*-20.5595**	*-18.2448*	*-19.6621**
	4	*5.09663*	*8.09854*	*6.24749*
Model2	*1*	*-12.3569**	*-11.2775**	*-11.9317**
	2	*-12.0947*	*-10.4192*	*-11.4393*
	3	*-11.9791*	*-9.66442*	*-11.0817*
	4	*28.47*	*31.4719*	*29.6208*
Model3	*1*	*-13.2389**	*-12.1594**	*-12.8136**
	2	*-12.9424*	*-11.2669*	*-12.287*
	3	*-13.0316*	*-10.7169*	*-12.1342*
	4	*19.2588*	*22.2607*	*20.4096*
Model4	*1*	*-13.4314**	*-12.352**	*-13.0062**
	2	*-12.9572*	*-11.2817*	*-12.3018*
	3	*-13.0695*	*-10.7549*	*-12.1721*
	4	*26.8832*	*29.8851*	*28.034*
Model5	*1*	*-6.19565**	*-5.11621**	*-5.7704**
	2	*7.73308*	*9.40855*	*8.38845*
	3	*10.0574*	*12.3721*	*10.9548*
	4	*28.6425*	*31.6444*	*29.7933*
Model6	*1*	*-6.31925**	*-5.23981**	*-5.894**
	2	*23.7999*	*25.4754*	*24.4553*
	3	*10.7155*	*13.0302*	*11.6129*
	4	*26.6912*	*29.6931*	*27.8421*

Note: P-values for unit root tests are in brackets; ***, ** and * indicate significant at the 1%, 5% and 10% levels respectively.

4.3 Stability tests and Granger causality tests of the model

(1) Stability test of the model

As can be seen from Figures 1-6 below, all variables of the six models fall within the unit circle, indicating that the stability of six models is good.



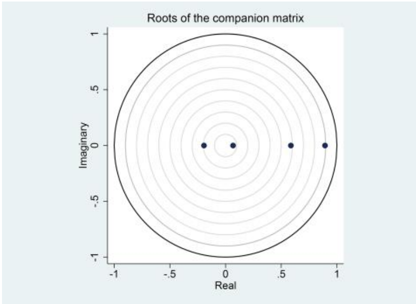
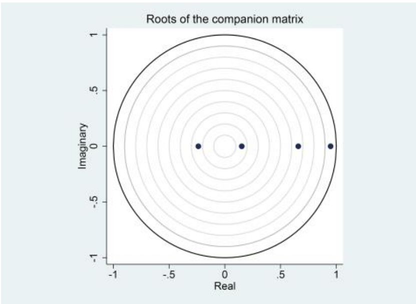


Fig1 Unit root test for model 1 Fig2 Unit root test for Model 2



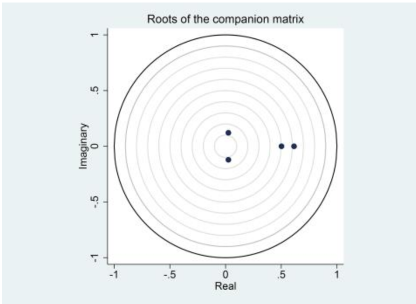
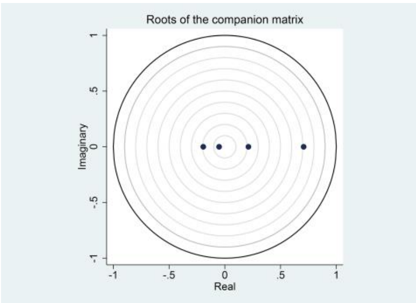


Fig3 Unit root test for Model 3 Fig4 Unit root test for Model 4



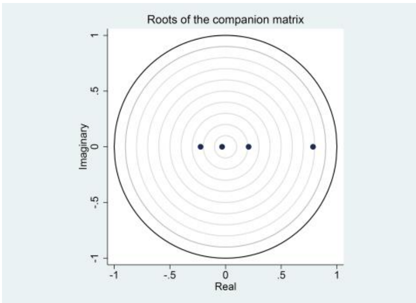


Fig5 Unit root test for Model 5 Fig6 Unit root test for Model 6

(2) Granger causality test

From Table 4 below, we can see that logistics supply is the cause leading to industrial structure, economic development, energy consumption and environmental protection; energy consumption is the cause leading to economic development and industrial structure; environmental protection is the cause of influencing economic development, industrial structure, logistics supply and energy consumption; industrial structure is the cause of influencing demographic dividend and energy consumption; economic development is the cause leading to demographic dividend and energy consumption.

Table 4 Results of Granger causality test

Model	*Causal Relationship*	*chi2*	*df*	*P*	*Model*	*Causal Relationship*	*chi2*	*df*	*P*
	lnIS→lnGDP	***1.357 5***	***1***	***0.244 0***		***lnDD→lnIS***	***0.108 2***	***1***	***0.742 0***
	lnDD→lnGDP	***1.935 6***	***1***	***0.164 0***		***lnLS→lnIS***	***38.431 0***	***1***	***0.000 0 ******
Model1	***lnLS→lnGDP***	***44.666 0***	***1***	***0.000 0 ******	***Model2***	***lnLD→lnIS***	***1.249 4***	***1***	***0.264 0***
	ALL→lnGDP	***46.128 0***	***3***	***0.000 0 ******		***ALL→lnIS***	***51.769 0***	***3***	***0.000 0******
	lnGDP→lnIS	***0.785 4***	***1***	***0.375 0***		***lnIS→lnDD***	***0.004 1***	***1***	***0.949 0***

	lnDD→lnIS	0.736 6	1	0.391 0		lnLS→lnDD	1.823 0	1	0.177 0
	lnLS→lnIS	43.691 0	1	0.000 0 ***		lnLD→lnDD	0.366 2	1	0.545 0
	ALL→lnIS	44.951 0	3	0.000 0 ***		ALL→lnDD	3.834 4	3	0.280 0
	lnGDP→lnDD	7.707 9	1	0.005 0 ***		lnIS→lnLS	2.943 7	1	0.086 0*
	lnIS→lnDD	7.642 7	1	0.006 0 ***		lnDD→lnLS	0.126 3	1	0.722 0
	lnLS→lnDD	4.824 0	1	0.028 0 *		lnLD→lnLS	2.595 2	1	0.107 0
	ALL→lnDD	9.073 5	3	0.028 0 *		ALL→lnLS	4.790 8	3	0.188 0
	lnGDP→lnLS	2.617 6	1	0.106 0		lnIS→lnLD	0.199 3	1	0.655 0
	lnIS→lnLS	2.828 0	1	0.093 0 *		lnDD→lnLD	0.410 0	1	0.522 0
	lnDD→lnLS	0.948 1	1	0.330 0		lnLS→lnLD	0.894 5	1	0.344 0
	ALL→lnLS	5.677 1	3	0.128 0		ALL→lnLD	2.775 9	3	0.427 0
Model3	lnIS→lnGDP	0.014 9	1	0.903 0	Model4	lnIS→lnGDP	0.019 4	1	0.889 0
	lnLS→lnGDP	33.217 0	1	0.000 0***		lnLS→lnGDP	40.187 0	1	0.000 0 ***
	lnLD→lnGDP	1.083 8	1	0.298 0		lnEC→lnGDP	6.299 6	1	0.012 0 **
	ALL→lnGDP	52.805 0	3	0.000 0 ***		ALL→lnGDP	69.644 0	3	0.000 0***
	lnGDP→lnIS	0.013 3	1	0.908 0		lnGDP→lnIS	0.048 6	1	0.826 0
	lnLS→lnIS	35.295 0	1	0.000 0 ***		lnLS→lnIS	40.590 0	1	0.000 0***
	lnLD→lnIS	1.138 9	1	0.286 0		lnEC→lnIS	7.018 4	1	0.008 0***
	ALL→lnIS	51.474 0	3	0.000 0 ***		ALL→lnIS	67.513 0	3	0.000 0***
	lnGDP→lnLS	0.035 6	1	0.850 0		lnGDP→lnLS	0.081 4	1	0.775 0
	lnIS→lnLS	0.519 5	1	0.471 0		lnIS→lnLS	0.530 9	1	0.466 0
	lnLD→lnLS	2.229 5	1	0.135 0		lnEC→lnLS	3.818 3	1	0.051 0*
	ALL→lnLS	5.280 1	3	0.152 0		ALL→lnLS	5.620 4	3	0.132 0
	lnGDP→lnLD	0.221 8	1	0.638 0		lnGDP→lnEC	0.172 6	1	0.678 0
	lnIS→lnLD	0.416 1	1	0.519 0		lnIS→lnEC	1.766 7	1	0.184 0
	lnLS→lnLD	0.654 8	1	0.418 0		lnLS→lnEC	4.478 3	1	0.034 0**
	ALL→lnLD	2.268 6	3	0.519 0		ALL→lnEC	22.320 0	3	0.000 0***
Model5	lnLS→lnGDP	39.329 0	1	0.000 0 ***	Model6	lnLS→lnIS	37.312 0	1	0.000 0***
	lnEC→lnGDP	7.452 1	1	0.006 0 ***		lnEC→lnIS	8.150 4	1	0.004 0***
	lnEP→lnGDP	7.026 7	1	0.008 0***		lnEP→lnIS	9.608 7	1	0.002 0***
	ALL→lnGDP	62.817 0	3	0.000 0***		ALL→lnIS	63.330 0	3	0.000 0***
	lnGDP→lnLS	3.301 9	1	0.069 0*		lnIS→lnLS	3.769 2	1	0.052 0*
	lnEC→lnLS	3.637 2	1	0.057 0*		lnEC→lnLS	3.585 9	1	0.058 0*
	lnEP→lnLS	14.537 0	1	0.000 0***		lnEP→lnLS	16.744 0	1	0.000 0***
	ALL→lnLS	25.904 0	3	0.000 0***		ALL→lnLS	20.892 0	3	0.000 0***
	lnGDP→lnEC	11.516 0	1	0.001 0***		lnIS→lnEC	11.588 0	1	0.001 0***
	lnLS→lnEC	4.385 6	1	0.036 0 **		lnLS→lnEC	5.075 4	1	0.024 0**
	lnEP→lnEC	18.316 0	1	0.000 0***		lnEP→lnEC	13.867 0	1	0.000 0***
	ALL→lnEC	31.884 0	3	0.000 0 ***		ALL→lnEC	31.599 0	3	0.000 0***
	lnGDP→lnEP	0.520 7	1	0.471 0		lnIS→lnEP	0.579 5	1	0.447 0
	lnLS→lnEP	6.442 7	1	0.011 0**		lnLS→lnEP	5.017 7	1	0.025 0**
	lnEC→lnEP	0.541 7	1	0.462 0		lnEC→lnEP	0.558 4	1	0.455 0
	ALL→lnEP	6.539 8	3	0.088 0*		ALL→lnEP	5.189 1	3	0.158 0

Note: P-values for unit root tests are in brackets; ***, ** and * indicate significant at the 1%, 5% and 10% levels respectively.

4.4 Regression results of PVAR model for Yangtze River Delta

The regression results of PVAR model for the six models are shown in Figure 7-12 below.

(1) It can be seen from FIG. 7 that economic development has a strong impulse response to itself and has a significant positive impact continuously from the first stage to the sixth stage; The impulse response of economic development to logistics supply is strong, and it has a significant positive impact continuously from the first stage to the sixth stage. Industrial structure has a strong impulse response to economic development and has a significant positive impact from the first stage to the sixth stage. Industrial structure has a strong impulse response to logistics supply and has a significant positive impact from the first stage to the sixth stage. Demographic dividend has a strong impulse response to industrial structure and has a significant positive impact from the first period to the sixth period. Demographic dividend has a strong impulse response to itself and has a positive impact. Logistics supply has a strong impulse response to economic development and has a significant positive impact continuously from the first stage to the sixth stage. Logistics supply has a strong impulse response to itself and has a significant positive impact from the first stage to the sixth stage.

(2) It can be seen from FIG. 8 that the industrial structure has a strong impulse response to itself, and has a continuous and significant positive impact from the first phase to the sixth phase; Industrial structure has a strong impulse response to logistics supply, which has a significant positive impact continuously from the first stage to the sixth stage. Demographic dividend has a strong impulse response to itself and has a significant positive impact from the first period to the sixth period. The impulse response of logistics supply to industrial structure is strong, and it has a significant positive impact continuously from the first stage to the sixth stage. Logistics supply has a strong impulse response to itself and has a significant positive impact on the first stage. Logistics demand has a strong impulse response to itself, and the first stage has a significant positive impact.

(3) It can be seen from FIG. 9 that economic development has a strong impulse response to itself and has a significant positive impact continuously from the first stage to the sixth stage; The impulse response of economic development to logistics supply is strong, and it has a significant positive impact continuously from the first stage to the sixth stage. Industrial structure has a strong impulse response to economic development, and has a significant positive impact from the first stage to the sixth stage. Industrial structure has a strong impulse response to logistics supply, which has a significant positive impact continuously from the first stage to the sixth stage. Logistics supply has a strong impulse response to economic development and has a significant positive impact from the first stage to the third stage. Logistics supply has a strong impulse response to itself, and has a significant positive impact on the previous stage. Logistics demand has a strong impulse response to itself, and the previous period has a significant positive impact.

(4) It can be seen from FIG. 10 that economic development has a strong impulse response to itself and has a significant positive impact continuously from the first stage to the sixth stage; The impulse response of economic development to logistics supply is strong, and it has a significant positive impact continuously from the first stage to the sixth stage. Economic development has a strong impulse response to energy consumption, which has a significant positive impact continuously from the first stage to the sixth stage. Industrial structure has a strong impulse response to economic development, and has a significant positive impact from the first stage to the sixth stage. Industrial structure has a strong impulse response to logistics supply, which has a significant positive

impact continuously from the first stage to the sixth stage. Industrial structure has a strong impulse response to energy consumption, which has a significant positive impact from the first phase to the sixth phase. Logistics supply has a strong impulse response to economic development and has a significant positive impact from the first stage to the third stage. Logistics supply has a strong impulse response to itself, and has a significant positive impact on the previous stage. Logistics supply has a strong impulse response to energy consumption, which has a significant positive impact continuously from the first stage to the sixth stage. Energy consumption has a strong impulse response to economic development, and has a significant positive impact from the first stage to the sixth stage. Energy consumption has a strong impulse response, and has a significant positive effect on the impulse response in the previous period.

(5) It can be seen from FIG. 11 that economic development has a strong impulse response to itself and has a significant positive impact continuously from the first stage to the sixth stage; The impulse response of economic development to logistics supply is strong, and it has a significant positive impact continuously from the first stage to the sixth stage. Economic development has a strong impulse response to energy consumption, which has a significant positive impact continuously from the first stage to the sixth stage. Economic development has a strong impulse response to environmental protection, and has a significant positive impact continuously from the first stage to the sixth stage. Logistics supply has a strong impulse response to economic development and has a significant positive impact from the first stage to the sixth stage. Logistics supply has a strong impulse response to itself, and has a significant positive impact on the previous stage. Logistics supply has a strong impulse response to energy consumption, which has a significant positive impact continuously from the first stage to the sixth stage. Logistics supply has a strong impulse response to environmental protection, and has a significant positive impact continuously from the first stage to the sixth stage. Energy consumption has a strong impulse response to economic development, and has a continuous and significant positive impact from the second phase to the sixth phase. Energy consumption has a strong impulse response to logistics supply, and has a continuous and significant positive impact from the second phase to the sixth phase. Environmental protection has a strong impulse response to itself, and has a significant positive impact on the previous stage. The impulse response of energy consumption to environmental protection is strong, and it has a significant positive impact continuously from the first stage to the sixth stage. Environmental protection has a strong impulse response to itself and has a significant positive impact from the first stage to the sixth stage.

(6) It can be seen from FIG. 12 that the industrial structure has a strong impulse response to itself, and has a continuous and significant positive impact from the first phase to the sixth phase; Industrial structure has a strong impulse response to logistics supply, which has a significant positive impact continuously from the first stage to the sixth stage. Industrial structure has a strong impulse response to energy consumption, which has a significant positive impact from the first phase to the sixth phase. Industrial structure has a strong impulse response to environmental protection and has a significant positive impact from the first stage to the sixth stage. The impulse response of logistics supply to industrial structure is strong, and it has a significant positive impact continuously from the first stage to the sixth stage. Logistics supply has a strong impulse response to itself, and has a significant positive impact on the previous stage. Logistics supply has a strong impulse response to energy consumption, which has a significant positive impact continuously from the first stage to the sixth stage. Logistics supply has a strong impulse response to environmental protection, and has a

significant positive impact continuously from the first stage to the sixth stage. The impulse response of energy consumption to industrial structure is strong, and it has a continuous and significant positive impact from the second phase to the sixth phase. Energy consumption has a strong impulse response to logistics supply, and has a continuous and significant positive impact from the second phase to the sixth phase. Energy consumption has a strong impulse response, and has a significant positive effect on the impulse response in the previous period. The impulse response of energy consumption to environmental protection is strong, and it has a significant positive impact continuously from the first stage to the sixth stage. Environmental protection has a strong impulse response to itself, and the previous period has a significant positive impact.

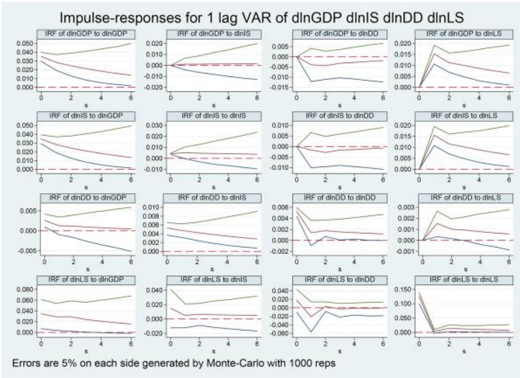


Fig7 The Regression Result of PVAR Model 1

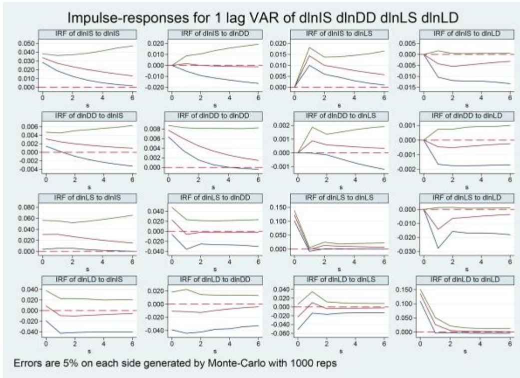


Fig8 The Regression Result of PVAR Model 2

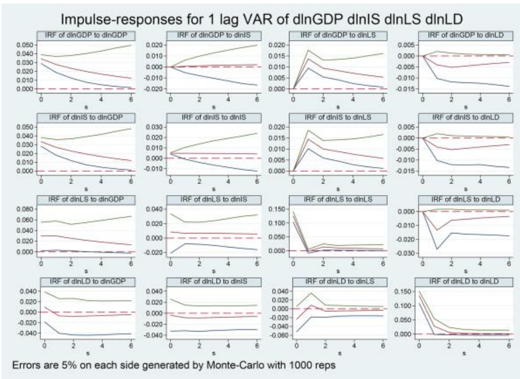


Fig9 The Regression Result of PVAR Model 3

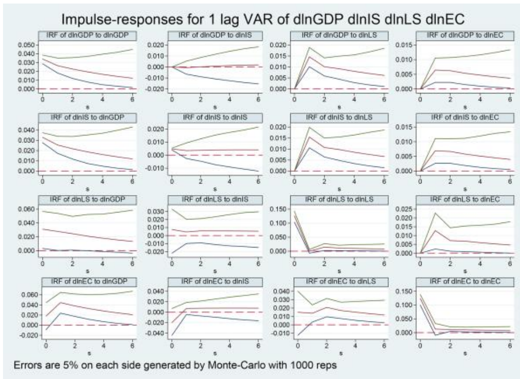


Fig10 The Regression Result of PVAR Model 4

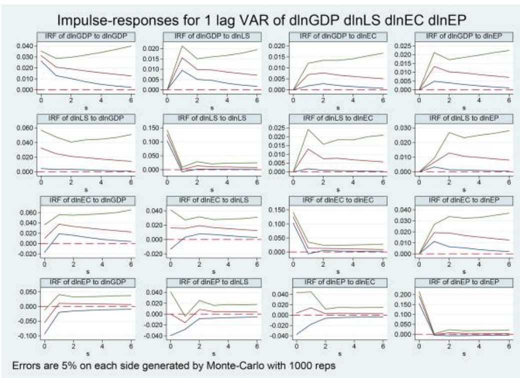


Fig11The Regression Result of PVAR Model 5

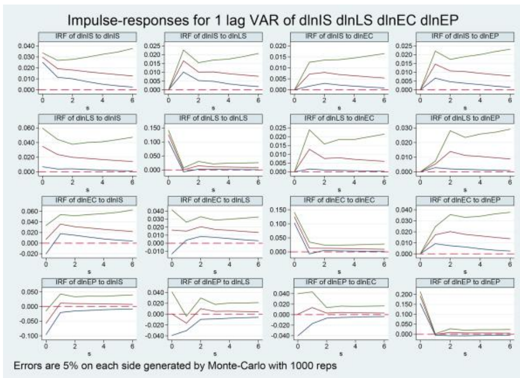


Fig12 The Regression Result of PVAR Model 6

4.5 Provincial GMM estimation results

(1) As can be seen from FIG. 13, GMM estimation results of Jiangsu province in Model 1 have a significant positive impact, that is, the development of logistics industry in Jiangsu province has a significant positive impact on economic development; The GMM estimation of Shanghai has a significant negative impact, which reflects the significant spillover effect of logistics development in Shanghai. The GMM estimation results of Anhui province have significant positive and negative effects, which reflects the present situation that the development of logistics industry in Anhui province varies greatly among different regions; The GMM estimation results of Zhejiang province are not significant.

(2) As can be seen from Figure 14, GMM estimation results of Zhejiang province in Model 2 have a significant positive impact, that is, logistics industry development in Zhejiang province has a significant positive impact on the industrial structure of Zhejiang province, and has a significant positive impact on regional economic development; The GMM estimation results of Jiangsu and Shanghai have a significant positive impact, which reflects that the proportion of logistics development is equal in industrial economic structure of Jiangsu and Shanghai. The GMM estimation results of Anhui province are not significant.

(3) As can be seen from FIG. 15, GMM estimation results of Zhejiang province in Model 3 have a significant positive impact, that is, logistics industry development in Zhejiang province has a significant positive impact on the industrial structure of Zhejiang Province, and has a significant positive impact on regional economic development; The GMM estimation results of Anhui and Jiangsu have a significant positive impact, which reflects that the development of logistics industry in Anhui and Jiangsu takes a larger proportion in the development of industrial economic structure; The GMM estimation of Shanghai is not significant, which reflects that the logistics industry in Shanghai does not take a prominent proportion in the economic structure of Shanghai.

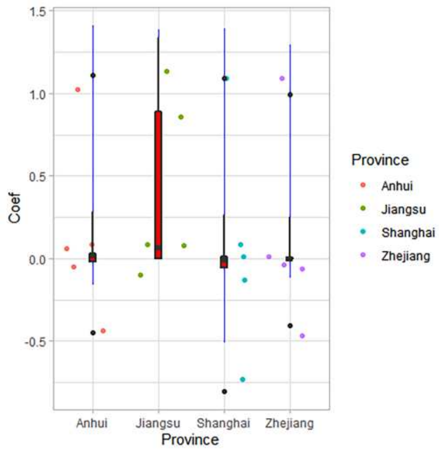
(4) As can be seen from FIG. 16, GMM estimation results of Jiangsu province in Model 4 have a significant positive impact, that is, the development of logistics industry in Jiangsu province has a significant positive impact on economic development, and energy consumption is also the largest; The results of GMM estimation in Shanghai have a significant negative impact, which reflects that the spillover effect of logistics industry development in Shanghai is significant and the problem of overcapacity is prominent. The GMM estimation results of Zhejiang and Anhui have a significant positive impact, which reflects that Anhui province has a better performance in energy consumption from the perspective of logistics development.

(5) As can be seen from Figure 17, GMM estimation results of Jiangsu province in Model 5 have a significant impact, that is, the development of logistics industry in Jiangsu province has a significant impact on energy consumption and environmental protection, and energy consumption is also the largest; The GMM estimation of Shanghai has a significant negative impact, which reflects the poor energy consumption and environmental protection of logistics industry in Shanghai. The GMM estimation results of Zhejiang and Anhui have significant effects, but Anhui has better performance in environmental protection and energy consumption than Zhejiang.

(6) It can be seen from Figure 18 that GMM estimation results of Jiangsu province in Model 6 have a significant impact, that is, the development of logistics industry in Jiangsu province has a significant impact on the industrial structure, and demographic dividend and logistics demand also have the greatest impact on the industrial structure; The GMM estimation of Shanghai has a

significant positive impact, which reflects that logistics demand of Shanghai has a significant positive impact on local economic development. The GMM estimation results of Zhejiang and Anhui have a significant impact, but the logistics demand and industrial structure of Zhejiang has a more significant role in promoting economic structure than Anhui.

(7) To sum up, in terms of economic development, Jiangsu > Shanghai > Zhejiang > Anhui showed a trend of sustained growth. Since 2010, Jiangsu has overtaken Shanghai; In terms of industrial structure, Jiangsu > Zhejiang > Shanghai > Anhui showed a trend of continuous growth. In terms of demographic dividend, Jiangsu > Anhui > Zhejiang > Shanghai showed a trend of continuous growth. In terms of energy consumption, Jiangsu > Shanghai > Zhejiang > Anhui; It showed a trend of first increasing and then decreasing; In terms of environmental protection, Anhui > Zhejiang and Jiangsu > Shanghai, showing a steady and sustainable growth trend; In terms of logistics demand, Zhejiang > Jiangsu > Shanghai > Anhui, Zhejiang began to grow rapidly after 2013; In terms of logistics supply, Anhui > Jiangsu > Zhejiang > Shanghai, Anhui began to grow rapidly after 2010.



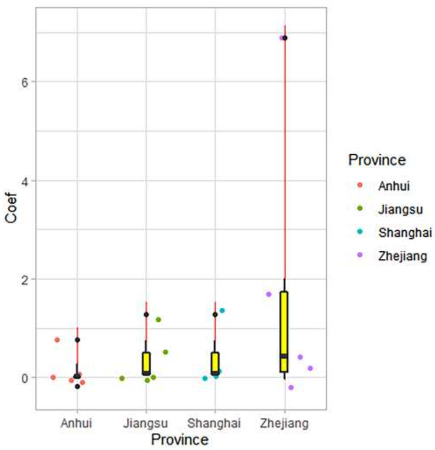
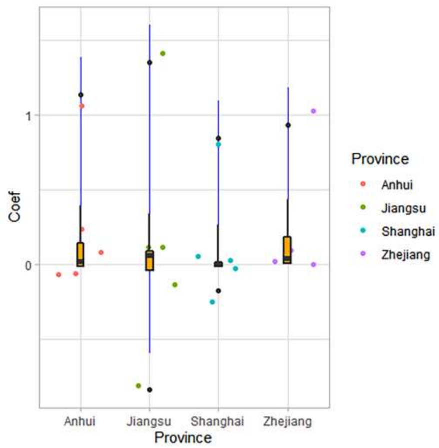


Fig13 Box Scatter Coefficient of Provincial GMM Estimation Result in Model 1

Fig14 Box Scatter Coefficient of Provincial GMM Estimation Result in Model 2



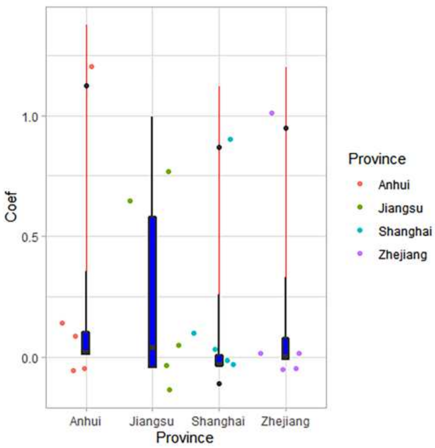
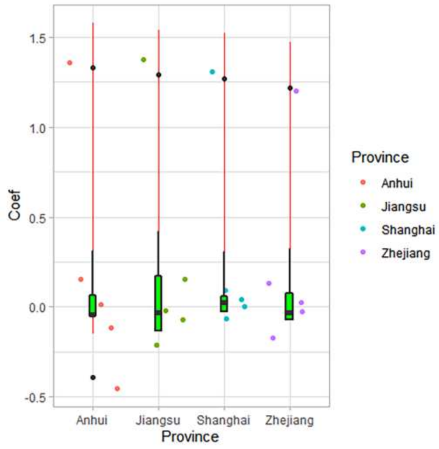


Fig15 Box Scatter Coefficient of Provincial GMM Estimation Result in Model 3

Fig16 Box Scatter Coefficient of Provincial GMM Estimation Result in Model 4



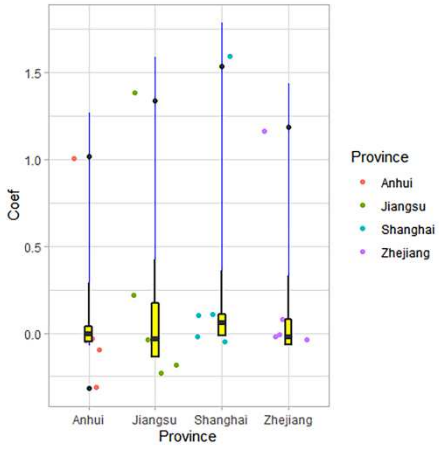


Fig17 Box Scatter Coefficient of Provincial GMM Estimation Result in Model 5

Fig18 Box Scatter Coefficient of Provincial GMM Estimation Result in Model 6

5. Conclusions and recommendations

5.1 Conclusions

(1) Logistics supply is the cause leading to economic development, industrial structure, energy consumption and environmental protection. That is, the construction of national infrastructure such as railway and highway operating mileage has a significant impact on economic development, industrial structure, energy and environment of Yangtze River Delta. Environmental protection and logistics supply have bidirectional effects. That is, the construction of national infrastructure such as railway and highway operating mileage has a direct impact on the forest coverage rate in Yangtze River Delta; Industrial structure is the cause leading to energy consumption and demographic dividend. That is, the proportion of primary, secondary and tertiary industries has a direct impact on the consumption of crude oil and other energy and the number of population in Yangtze River Delta.

(2) The development of logistics industry in Yangtze River Delta is not balanced, there is the possibility of complementary advantages. Logistics industry does not take up a large proportion in industrial structure of Shanghai, and it has poor performance in environmental protection. Although there are many universities in Shanghai, it is not dominant in demographic dividend. In the recent 10 years, Anhui has made great progress and improvement in logistics supply and environmental protection, and the consumption of crude oil and other energy is the least. It reflects the development of Anhui is positive in the field of new energy, but the disadvantage of its location in the inland is not dominant in economic development and industrial structure. In the face of strong competition and siphon effect from the other three provinces, the logistics demand of Anhui is slightly insufficient; Jiangsu has great advantages in economic development, industrial structure and demographic dividend, but it consumes too much energy such as crude oil, so it needs to transform and upgrade to new energy and seek green and sustainable development. The advantage of Zhejiang lies in logistics demand and industrial structure, and it is good in environmental protection, but it is not good in demographic dividend, and logistics supply has not kept pace with the growth rate of logistics demand.

(3) Economic development and energy consumption have bidirectional effects. That is, crude oil and other strategic energy have a vital impact on economic development of Yangtze River Delta; Environmental protection is the cause leading to economic development, industrial structure, energy consumption and logistics supply. That is, environmental protection has a significant and direct

impact on regional economic development, industrial structure distribution and energy consumption.

5.2 Recommendations

(1) In terms of logistics supply, the construction of 5G network infrastructure should be accelerated to form the integration of Internet of Things in Yangtze River Delta, form the basic conditions for upgrading industrial chain, and lay a good foundation for the consumption cycle. From supply end to product end, the green and healthy development should be carried out to help the rise of some brands; In terms of logistics demand, it has promoted domestic demand through upgrading industrial chain, expanded external demand through the "Belt and Road" initiative, released consumption demand through "keeping housing from speculating", accelerated the construction of urban agglomeration in Yangtze River Delta, formed a large Internet of things, accelerated the construction of rural revitalization, and exploited the potential of rural consumption.

(2) The government should vigorously promote the development of new energy industry, relying on science and technology to reduce energy consumption, such as the photovoltaic industry, wind and tidal power generation; In terms of environmental protection, the government should vigorously promote the development of new energy vehicle industry through tax subsidy policies to reduce the emission of carbon dioxide and prepare for carbon neutrality by 2060. The construction of urban agglomeration can be divided into urban core area, agricultural ecological area and ecological protection area according to functions, in order to promote sustainable economic development.

(3) In terms of demographic dividend, local governments should increase preferential policies for talent introduction, relax household registration restrictions to promote talent flow and education equity. In terms of industrial structure, we will increase investment in key areas such as biotechnology, information technology, block chain, artificial intelligence, integrated circuits and quantum information, and make up for the weaknesses in core technologies to form the integration of industries, universities and research institutes.

(4) The four provinces and cities in Yangtze River Delta are suggested respectively. The proportion of logistics industry in Shanghai's industrial structure is small, so we should increase the proportion of logistics industry in Shanghai's economic structure appropriately. Shanghai has a poor record in environmental protection and should increase the area covered by forests. Although Shanghai has many colleges and universities, it is not advantageous in terms of demographic dividend. Shanghai should relax the settlement policy and increase the introduction of talents. Anhui has a great progress and improvement in logistics supply and environmental protection, the consumption of crude oil and other energy is the least, which reflects the development of Anhui province is positive in the field of new energy. The disadvantage of location in the inland is not dominant in the economic development and industrial structure, and in the face of strong competition and siphon from the other three provinces, there is slightly less logistics demand at the same time. Anhui should increase the demand for logistics, attract excellent enterprises to settle in through preferential tax policies, and open the settlement policy to attract talents. Jiangsu enjoys great advantages in economic development, industrial structure and demographic dividend, but it consumes too much energy such as crude oil, so it needs to transform and upgrade to new energy and seek green and sustainable development. For example, in photovoltaic power generation and new energy vehicles, preferential tax policies can attract new energy industries to open up upstream and downstream supply chains and realize green transformation and upgrading. Zhejiang performs well in logistics demand, industrial structure and environmental protection, but it does not have an advantage in demographic dividend, so it should liberalize the settlement policy and high salary to

attract talent inflow. Logistics supply has not kept pace with the growth rate of logistics demand, and it is necessary to increase the construction of transportation infrastructure to meet the growth of logistics demand.

(5) Considering from the supply side, we should upgrade the international brands through industrial chain, open up the upstream and downstream industrial chain, adjust the industrial structure, invest in new energy and environmental protection industries, and form the internal circulation of logistics industry in Yangtze River Delta; Considering from the demand side, we should accelerate the construction of rural revitalization to exploit the potential of rural consumption, adhere to the prevention and control of consumption demand to promote domestic demand, through the Belt and Road and other international trade to expand external demand, form the external cycle of logistics industry in Yangtze River Delta. The dual circulation including internal cycle and external cycle can help the rapid development of logistics industry in Yangtze River Delta.

6. Research deficiencies and future prospects

Although we have used the data of Yangtze River Delta in China Statistical Yearbook from 2001 to 2019, we believe that it is not comprehensive to use the only data of the past 20 years since China has been carrying out reform and opening-up for more than 40 years. In the future we will collect more data for research. Despite the background of carbon neutrality, we study the relationship between logistics and economy, energy and environment in Yangtze River Delta from seven dimensions of economic development, industrial structure, demographic dividend, logistics supply, logistics demand, energy consumption and environmental protection. However, there are still many indicators related to regional logistics development, and we will add more indicators for research in the future. In addition, due to limited space, part of variance decomposition is omitted in this paper, which we think has no impact on the conclusion of the study.

References

Akbar M W, Yuelan P, Maqbool A, Zia Z, Saeed M (2021) The nexus of sectoral-based CO 2 emissions and fiscal policy instruments in the light of Belt and Road Initiative. Environmental Science and Pollution Research :1-15.https://doi.org/10.1007/s11356-021-13040-3

Anvar S H, Sadegheih A, Zad M A V (2018) CARBON EMISSION MANAGEMENT FOR GREENING SUPPLY CHAINS AT THE OPERATIONAL LEVEL.J. Environmental Engineering & Management Journal (EEMJ) 17(6).https://doi.org/10.30638/eemj.2018.133

Bingru C, Zeyun K, Lijuan D (2019) Evolution of Time and Space Efficiency of Provincial Logistics in the Yangtze River Economic Belt.J. Scientia Geographica Sinica 39(12): 1841-1848.Available online:<http://geoscien.neigae.ac.cn/EN/10.13249/j.cnki.sgs.2019.12.001>(accessed on October 29, 2021)

Christiano L J (2012) Christopher A Sims and vector autoregressions. The Scandinavian Journal of Economics 114(4):1082-1104.https://doi.org/10.1111/j.1467-9442.2012.01737.x

CPC Central Committee, State Council (2021) Opinions on fully, accurately and comprehensively implementing the new development concept and doing a good job in carbon neutrality. CCTV network.Available online:<http://news.cctv.com/2021/10/24/ARTIG5kMA9zECwP9oaEim2hN211024.shtml> (accessed on October 29, 2021)

Dong C (2021) Linkage layout of two industries and high-quality development of logistics industry . China Circulation Economy 35(04):3-12. https://doi.org/10.14089/j.cnki.cn11-3664/f.2021.04.001

European Political Strategic Centre (2016) Sustainability Now! A European Vision for Sustainability, EPSC Strategic Notes, European Commission: Brussels, Belgium. Available online:<http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2016-0224+0+DOC+XML+V0//EN>(accessed on October 29, 2021)

Gao X, Cao M, Yang T, Basiri A (2020) Transport development, intellectual property rights protection and innovation: The case of the Yangtze River Delta Region, China. Research in Transportation Business & Management 37: 100563.https://doi.org/10.1016/j.rtbm.2020.100563

Gao Xiuli, Meng Feirong (2013) Empirical analysis of logistics industry development on industrial Structure optimization: Based on spatial Panel Dubin Model. Tropical geography 33(06):703-710.https://doi.org/10.13284/j.cnki.rddl.002489

Gu W, Chu Z, Wang C (2020) How do different types of energy technological progress affect regional carbon intensity? A spatial panel approach. Environmental Science and Pollution Research 27(35): 44494-44509.https://doi.org/10.1007/s11356-020-10327-9

Han Y, Jin B, Qi X, Zhou H (2021) Influential Factors and Spatiotemporal Characteristics of Carbon Intensity on Industrial Sectors in China. International Journal of Environmental Research and Public Health 18(6): 2914. https://doi.org/10.3390/ijerph18062914

Holtz-Eakin D, Newey W, Rosen H S (1988) Estimating vector autoregressions with panel data. Econometrica: Journal of the econometric society: 1371-1395.https://doi.org/10.2307/1913103

Hu H, Zhang Y, Rao X, Jin Y (2021a) Impact of Technology Innovation on Air Quality—An Empirical Study on New Energy Vehicles in China. International Journal of Environmental Research and Public Health 18(8): 4025. https://doi.org/10.3390/ijerph18084025

Hu S, Zeng G, Cao X, Yuan H, Chen B (2021b) Does Technological Innovation Promote Green Development? A Case Study of the Yangtze River Economic Belt in China. International Journal of Environmental Research and Public Health18(11): 6111.https://doi.org/10.3390/ijerph18116111

Jia N, Gao X, An H, Sun X, Jiang M, Liu X, Liu D (2020) Identifying key sectors based on cascading effect along paths in the embodied CO2 emission flow network in Beijing-Tianjin-Hebei region, China. Environmental Science and Pollution Research 27(14): 17138-17151.https://doi.org/10.1007/s11356-020-08217-1

Jiang L, Folmer H, Ji M, Zhou P (2018) Revisiting cross-province energy intensity convergence in China: A spatial panel analysis.Energy Policy 121: 252-263.https://doi.org/10.1016/j.enpol.2018.06.043

Jia P, Li K, Shao S (2018) Choice of technological change for China's low-carbon development: evidence from three urban agglomerations. Journal of environmental management 206: 1308-1319.https://doi.org/10.1016/j.jenvman.2017.08.052

Ji Y, Du J, Wu X, Wu Z, Qu D, Yang D (2021) Robust optimization approach to two-echelon agricultural cold chain logistics considering carbon emission and stochastic demand. Environment, Development and Sustainability: 1-24.https://doi.org/10.1007/s10668-021-01236-z

Liang W, Sun H (2019) Research on the dynamics of China's new urbanization, logistics and industrial structure based on PVAR model: A case study of the Yangtze River Economic Belt . Journal of Xinjiang university (philosophy, humanities and social sciences)47(04):9-19.https://doi.org/10.13568/j.cnki.issn1000-2820.2019.04.002

Li B, Geng Y, Xia X, Qiao D (2021) The impact of government subsidies on the low-carbon supply chain based on carbon emission reduction level. International Journal of Environmental Research and Public Health 18(14): 7603. https://doi.org/10.3390/ijerph18147603

Liu H, Fan L B (2021) Research on the threshold effect of technological innovation and firm performance: Panel data analysis of Chinese manufacturing firms from the perspective of supply chain.Logistics Science and Technology 44(01):128-134.https://doi.org/10.13714/j.cnki.1002-3100.2021.01.032

Liu H, Fan L, Shao Z (2021) Threshold effects of energy consumption, technological innovation, and supply chain management on enterprise performance in China's manufacturing industry. Journal of Environmental Management 300: 113687. https://doi.org/10.1016/j.jenvman.2021.113687

Li Q, Chen X, Huang Y (2019) The stability and complexity analysis of a low-carbon supply chain considering fairness concern behavior and sales service. International journal of environmental research and public health 16(15): 2711. https://doi.org/10.3390/ijerph16152711

Liu Y, Zhang X,Pan X, Ma X,Tang M (2020) The spatial integration and coordinated industrial development of urban agglomerations in the Yangtze River Economic Belt, China. Cities 104: 102801.https://doi.org/10.1016/j.cities.2020.102801

Long R, Ouyang H, Guo H (2020) Super-slack-based measuring data envelopment analysis on the spatial–temporal patterns of logistics ecological efficiency using global Malmquist Index model. Environmental Technology & Innovation 18: 100770.https://doi.org/10.1016/j.eti.2020.100770

Pingkuo L,Pengbo G, Qiqi L (2021) External orderliness-synergy of electric power industry in Yangtze River Delta during energy transition period. Journal of Cleaner Production 280: 124381.https://doi.org/10.1016/j.jclepro.2020.124381

Shi Ning, LI Zeping, Zhao Shengli, Zhou Li (2019) Construction of modern logistics system based on interconnectivity. Science and technology management research 39(15):191-197.https://doi.org/10.3969/j.issn.1000-7695.2019.15.028

Shi F G (2021) Study on the coupling relationship between leading industrial agglomeration and logistics development: A case study of the five provinces in Northwest China . Journal of Chongqing Technology and Business University (Social Science Edition) 38(02):33-46.https://doi.org/10. 3969 /j.issn.1672-0598. 2021. 02. 004

Sims C A (1980) Macroeconomics and Reality. Econometrica: Journal of the Econometric Society 48: 1-48. https://doi.org/10.2307/1912017

Stegeman I, Godfrey A, Romeo-Velilla M, Bell R, Staatsen B, van der Vliet N, ..., Costongs C (2020) Encouraging and enabling lifestyles and behaviours to simultaneously promote environmental sustainability, health and equity: key policy messages from INHERIT. International journal of environmental research and public health 17(19): 7166. https://doi.org/10.3390/ijerph17197166

Song Y, Yeung G, Zhu D,Zhang L, Xu Y, Zhang L (2020) Efficiency of logistics land use: The case of Yangtze River Economic Belt in China, 2000–2017. Journal of Transport Geography 88: 102851.https://doi.org/10.1016/j.jtrangeo.2020.102851

Su C W, Xie Y, Shahab S, Faisal C, Nadeem M, Hafeez M, Qamri G M (2021) Towards achieving sustainable development: Role of technology innovation, technology adoption and CO2 emission for BRICS. International Journal of Environmental Research and Public Health 18(1): 277. https://doi.org/10.3390/ijerph18010277

Tang Y, Chen Y, Yang R, Miao X (2020) The unified efficiency evaluation of china's industrial waste gas considering pollution prevention and end-of-pipe treatment. International Journal of Environmental Research and Public Health 17(16): 5724. https://doi.org/10.3390/ijerph17165724

Tang Jianrong, XUE Rui, CAO Lingyu (2021) Dynamic connection and unbalanced evolution of logistics network in Yangtze River Delta: A social network perspective. East China Economic Management 35(03):19-30.https://doi.org/10.19629/j.cnki.34-1014/f.201029011

Wang L, Fan J, Wang J, Zhao Y, Li Z, Guo R (2020a) Spatio-temporal characteristics of the relationship between carbon emissions and economic growth in China's transportation industry. Environmental Science and Pollution Research 27(26): 32962-32979.https://doi.org/10.1007/s11356-020-08841-x

Wang L, Wang K, Zhang J, Zhang D, Wu X, Zhang L (2020b) Multiple objective-oriented land supply for sustainable transportation: A perspective from industrial dependence, dominance and restrictions of 127 cities in the Yangtze River Economic Belt of China.Land Use Policy 99: 105069.https://doi.org/10.1016/j.landusepol.2020.105069

Wang L, Xue Y, Chang M, Xie C (2020c) Macroeconomic determinants of high-tech migration in China: The case of Yangtze River Delta Urban Agglomeration.Cities 107: 102888.https://doi.org/10.1016/j.cities.2020.102888

Wang Peng, ZHANG R Q, LI Yan (2021a) Measurement and evaluation of high quality logistics development in Yangtze River Delta region -- Also on the construction of new logistics system in post-epidemic period . Industrial Technical Economics 40(03):21-29.https://doi.org/10.3969 /j.issn.1004－910X.2021.03.003

Wang X, He Y, Rao C (2021b) Evaluation index system design and coordinated development analysis for the industrial green development system and regional non-waste system in the Yangtze River Economic Zone. Environmental Science and Pollution Research: 1-17. https://doi.org/10.1007/s11356-021-12807-y

Wu D, Liu J (2020) Threshold Effects of Restraining Factors on China's Provincial Ecological Footprint in the Process of Urbanization. International journal of environmental research and public health 17(7): 2407. https://doi.org/10.3390/ijerph17072407

Wu H, Xu L, Ren S, Hao Y, Yan G (2020) How do energy consumption and environmental regulation affect carbon emissions in China? New evidence from a dynamic threshold panel model. Resources Policy 67: 101678.https://doi.org/10.1016/j.resourpol.2020.101678

Wu X, He S, Guo J, Sun W (2021) A multi-scale periodic study of PM2. 5 concentration in the Yangtze River Delta of China based on Empirical Mode Decomposition-Wavelet Analysis. Journal of Cleaner Production 281: 124853.https://doi.org/10.1016/j.jclepro.2020.124853

Wu Y, Tam V W, Shuai C, Shen L, Zhang Y, Liao S (2019) Decoupling China's economic growth from carbon emissions: Empirical studies from 30 Chinese provinces (2001–2015). Science of the Total Environment 656: 576-588.https://doi.org/10.1016/j.scitotenv.2018.11.384

Xu Qiuyan, Fang Shengfei (2018) Research on economic spillover effect and spatial heterogeneity of logistics industry agglomeration: Spatial econometric analysis based on provincial data.

Industrial technology economics 37(02):58-65.https://doi.org/ 10.3969 /j.issn.1004 －910X.2018.02.007

Yuan H, Feng Y, Lee C C, Cen Y (2020) How does manufacturing agglomeration affect green economic efficiency? Energy Economics 92: 104944.https://doi.org/10.1016/j.eneco.2020.104944

Yang Kaijun, MAO Bowei, Hu Han (2016) Total factor energy efficiency of logistics industry in the Yangtze River Economic Belt: Based on SBM and GML index model including carbon emissions. Journal of Beijing institute of technology (social science edition) 18(06):54-62. https://doi.org/10.15918/j.jbitss1009-3370.2016.0607

Zeng Y, Gulzar M A, Wang Z, Zhao X (2020) The effect of expected financial performance on corporate environmental responsibility disclosure: evidence from China. Environmental Science and Pollution Research 27(30): 37946-37962.https://doi.org/10.1007/s11356-020-09719-8

Zhang Zhaoan (2021) Shanghai Elements in the National "14th Five-Year Plan" . Shanghai People's Congress Monthly 03:24.https://doi.org/10.16702/j.cnki.cn31-1590/d.2021.03.009

Zhang Xicai, Li Hailing (2020) Research on development mode of modern agricultural cold chain logistics based on big data. Science and technology management research 40(07):234-240.https://doi.org/10.3969/j.issn.1000-7695.2020.7.031

Zhao L, Zhao T, Yuan R (2020) Factors driving the change of household CO2 emissions through 2040 in China: based on decomposition and scenario analyses. Environmental Science and Pollution Research 27(29): 36865-36877.https://doi.org/10.1007/s11356-020-09706-z

Zhou K, Wu J, Liu H (2021) Spatiotemporal variations and determinants of water pollutant discharge in the Yangtze River Economic Belt, China: A spatial econometric analysis. Environmental Pollution 271: 116320.https://doi.org/10.1016/j.envpol.2020.116320

Statements and Declarations

Author contribution Hui Liu and Linbang Fan drafted the original manuscript, conceptualized and designed the study. Zhaoxia Shao contributed to the translation of English manuscript. Cunfang Li contributed the resources and analysis. Linbang Fan revised the manuscript and is the corresponding author. All authors have read and approved the manuscript for publication.

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