Analysis of the Coupled and Coordinated Development and Spillover Effects of the Triple System of Digital Logistics, Resilient Economy and Ecological

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Abstract. In the era of stable economic development, the resilient economy has become an important element of high- quality economic development, the integration of the logistics industry and digitalisation is becoming closer, digital logistics has become a new driving force to enhance the resilience of economic development and promote ecological environmental governance,and digital logistics,the resilient economy economic development and ecological environmental governance as a coupled and coordinated open system is promoting high-quality development in all provinces. Based on the panel data of 30 provinces in China, the article constructs the indicator framework from the three perspectives of resilient economy, digital logistics and ecological environment governance, designs the indicator system for measuring the level of development of economic resilience and the ternary system coupling model, applies the entropy weighting method-Topsis for the indicator processing, and measures the degree of coordination of the coupling of digital logistics, resilient economy and ecological environment governance, and uses the Kernel Using Kernel density estimation, Moran's I index to measure the coupling coordination degree of the ternary system, spatial autocorrelation data analysis, as well as spatio-temporal evolution research.The spatial Durbin model is used to analyse the driving factors of the three coupled coordination and its spatial spillover effect.

Keywords: Digital Logistics; Resilient Economy; Coupling Coherence; High-Quality Development; Spatial Spillovers.

1 Introduction

The economy and the environment are mutually reinforcing systems, and their coupled and coordinated development emphasises the integrity, comprehensiveness and endogeneity of the system[1] . The report of the 20th Party Congress proposes that efforts should be made to enhance the resilience of the industrial chain supply chain and promote the economy to achieve effective qualitative improvement and reasonable quantitative growth[2]. Enhancing the resilient economy is the key to realising economic transformation and upgrading, and moving towards high-quality development. At this stage, with the rapid development of information technology, the trend of digitalisation of the logistics industry has become increasingly obvious[3] , and the digital construction of the logistics industry, as the internal driving force and foundation for promoting economic development and ecological

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environment governance, has the characteristics of interconnection, coordinated development, stability and efficiency[4]. Therefore, it is of great significance to analyse the coupled and coordinated relationship between digital logistics, resilient economy and ecological environment governance, and to study the coupling of the three to achieve smooth, sustainable and healthy development of resilient economy. In recent years, scholars have mainly focused on digitalisation, resilient economy and environment to carry out a wealth of research, respectively, on the impact of digitalisation on resilient economy[5], the role of digital economy on the resilience of the industrial chain to enhance the mechanism and ecosystem construction[6],[7] , and the role of governmental governance on the advancement of digitalisation and resilient economy[8],[9]. On the basis of theoretical research, existing scholars analyse the industry- economy-environment interaction relationship from a quantitative perspective. It is found that the coupling coordination degree of digital logistics, economy and carbon environment is growing[10]. In addition, some scholars have also analysed the spatial spillover effects of industrial structure, ecology and economy[11]-[13] . In summary, the existing results mainly study the coupled coordination relationship between economic development and ecological environmental protection, but lack the exploration of the coupled coordination relationship of the ternary system of digital logistics, resilient economy and ecological environmental governance. In the paper, on the basis of elucidating the coupling coordination mechanism, the compreh ensive evaluation index system of the ternary system is constructed by using the entropy weight method to accurately measure the coupling coordination degree of digital logistics, resilient economy and ecological environmental protection in each province and analyse the dynamic development trend of the coupling coordination degree by combining with the Kernel density estimation method, and using spatial autocorrelation Moran'I index to analyse the spatial correlation and The strength of the linkage is analysed, and the spatial spillover effect is analysed by using the spatial Durbin model, so as to clarify its spatial distribution pattern and evolution law, and to provide policy support and reference for the national and local governments to improve the digital logistics, resilient economy and ecological environment governance.

2 Mechanism of the coupled role of digital logistics,resilient economy and ecological environmental governance system

Digital logistics, resilient economy and eco-environmental governance constitute an interconnected system, which have a positive coordinated development effect on each other. The coupled and coordinated relationship between digital logistics and resilient economy and ecological governance. Digital logistics can promote industrial upgrading to enhance the resilient economy, and digital logistics compresses the spatial and temporal distance through digital technology connection[14], which can improve the efficiency of information transmission between regions, deepen the breadth and depth of spatial correlation, and strengthen the ecological synergy of inter-regional governance, and thus promote ecological environmental governance[15].

The coupled and co-ordinated relationship between the resilient economy and digital logistics and eco- environmental governance. An enhanced resilient economy optimises supply chains and improves logistics efficiency[16]. The development of a resilient economy creates a sustainable, inclusive and adaptive economic model with higher environmental requirements, which promotes technological innovation to improve eco- environmental governance and achieve low-carbon development[17].

The coupled and coordinated relationship between ecological environmental governance and digital logistics and resilient economy. In order to improve the quality of the ecological environment, the construction of a good ecological pattern will promote the greening of digital logistics and the formation of a recycling and sustainable development system. A good ecological environment helps to enhance the ability to withstand external shocks and increase the speed of recovery, while improving resource utilisation and reducing production costs, thus enhancing the resilient economy.

3 Indicator design

3.1 Data sources

The data are mainly obtained from the statistical yearbooks of 30 provinces, China Statistical Yearbook, China Financial Yearbook, China Logistics Yearbook and the official bulletin data of the National Bureau of Statistics, etc., from 2012 to 2021, and the data are dimensionless processed by the polar method, and a small amount of missing data are filled in by linear interpolation method. The sample period of 2012-2021 is chosen to comprehensively evaluate and analyse the evolution trend of digital logistics, resilient economy and ecological environmental governance in each province, and this paper carries out empirical analyses based on the above relevant statistical data.

3.2 Data sources

In the design of indicators in this paper, we fully draw on the research results of scholars, while combining the actual situation of provinces across the country, andconstructing the evaluation index system of the level of each province. First of all, the construction of digital logisticsrelated indicators, the definition of the indicators of digital logistics can be reflected by the logistics industry and the level of digitalisation, respectively, and the first-level indicators are constructed from the input of the logistics industry[18], the output of the logistics industry[19] and the level of digitalisation. Economic resilience is divided into three aspects: resistance, resilience and innovation[20]. Resilience is mainly reflected in the ability of the economic system to operate stably and reduce losses when encountering risky crises; resilience refers to the ability of the economic system to self-adjust and gradually recover after experiencing risks;and innovativeness refers to the ability of the economic system to innovate and transform and develop in a sustainable way after adjusting and recovering. The firstlevel indicators are constructed from the three dimensions of resistance, resilience and innovation. Ecological and environmental governance is the first-level indicator constructed from the three dimensions of the level of environmental pollution, environmental pollution control and the state of the ecological environment.The results are shown in Table 1.

Table 1. Coupling coordination evaluation index system

Level 1 indicators	Secondary indicators	Tertiary indicators	Type of indicator	Indicator weights
digital logistics	Logistics inputs	Value added of the logistics industry	forward	0.0384
		Investment in fixed assets in the logistics industry	forward	0.039659
	Logistics output	Cargo turnover	forward	0.065029
		volume of freight	forward	0.038421
		express mail volume	forward	0.16606
		workforce	forward	0.031741
		parcels	forward	0.059818
		Total postal and telecommunication operations	forward	0.082467
	Level of digitisation	Internet penetration	forward	0.017742
		Telephone penetration (including mobile phones)	forward	0.023576
		Fibre optic cable line length	forward	0.0443
		Number of enterprises with e-commerce trading activities	forward	0.076857
		E-commerce sales	forward	0.098332
		E-commerce purchases	forward	0.106326
		Number of websites owned by enterprises	forward	0.068004
		Internet broadband access port	forward	0.04327
resilient economy	resistance	GDP per capita	forward	0.053047
		Urban registered unemployment rate	negative direction	0.024826
		External trade dependence	negative direction	0.008841
	resilience	Per capita disposable income of urban residents	forward	0.052969
		Total retail sales of consumer goods	forward	0.075996
		General budget revenue from local finances	forward	0.072577
		urban population	forward	0.057154
	innovativeness	Local financial expenditure on education	forward	0.05133
		Total investment in fixed assets	forward	0.069047
		industrialisation	forward	0.069736
		Local finance expenditure on science and technology	forward	0.131984
		Number of undergraduate students in general higher education	forward	0.041768
		Deposits from financial institutions	forward	0.090781
		Financial self-sufficiency rate	forward	0.035007
		Domestic patent applications and authorisations	forward	0.164937
Ecological and environmental governance	Environmental pollution levels	Total CO2 emissions	negative direction	0.020525
		Sulphur dioxide emissions	negative direction	0.014824
	Environmental pollution control	Investment in industrial pollution control completed	forward	0.134688
		Non-hazardous domestic waste disposal rate	forward	0.008337
		Soil erosion control area	forward	0.238747
	ecological state	Surface water resources	forward	0.159082
		Area of urban green space	forward	0.12422

forest cover	forward	0.072576
Effective irrigated area	forward	0.118046
Total groundwater supply	forward	0.108955

3.3 Research methodology

Entropy weighting method. The entropy weight method is used to determine the weights. Assuming that m is the number of evaluation years and n is the number of provinces, the entropy weighting method is processed as follows.

(1)Standardization of indicators

$$\mathrm{Z}_{ij} = \frac{X_{ij} - X_{\min}}{X_{\max} - X_{\min}}$$
$$Z_{ij} = \frac{X_{\max} - X_{ij}}{X_{\max} - X_{\min}} \quad (1)$$

where is a negative indicator. i denotes the province, j denotes the measured and denote each initial each subsystem indicator data and the standardised indicator data, respectively.

(2)Normalization of indicators

$$\mathrm{Y}_{ij} = \frac{Z_{ij}}{\sum_{i=1}^{m} Z_{ij}} \quad (2)$$

where is the standardised value, and is the sum of all provincial data for the jth indicator, and is the normalised value of the indicator.

(3)Calculating entropy

$$E_j = -\mathrm{k} \sum_{i=1}^{m} \mathrm{Y}_{ij} \ln \mathrm{Y}_{ij}, \mathrm{k} = \frac{1}{\ln mn} \quad (3)$$

(4)Calculation of the weights of the indicators

$$\mathrm{D}_j = 1 - E_j$$

$$W_j = \frac{\mathrm{D}_j}{\sum_{j=1}^{n} \mathrm{D}_j} \quad (4)$$

Coupling harmonization model. This paper uses a coupled coordination degree model to analyse the relationship between digital logistics, resilient economy and ecological governance.

(1) Coupling of ternary systems

$$\mathrm{C} = \left[\frac{\mathrm{U(u_1)} \times \mathrm{U(u_2)} \times \mathrm{U(u_3)}}{\left(\frac{\mathrm{U(u_1)} + \mathrm{U(u_2)} + \mathrm{U(u_3)}}{3}\right)^3}\right]^{\frac{1}{3}} \quad (5)$$

Among them.and denote the comprehensive score of digital logistics, carbon emissions, and resilient economy, and C is the coupling degree, which takes values between [0,1]. Reflecting the strength of the degree of interaction between the ternary system, to further explore the level of coordinated development, the coupling coordination degree model of the three is constructed as follows.

(2) Coupled Coordination Model

$$\mathrm{D} = \sqrt{\mathrm{C} \times \mathrm{T}}$$

$$\mathrm{T} = \mathrm{aU_1} + \mathrm{bU_2} + \mathrm{cU_3} \quad (6)$$

Where D is the degree of coupling coordination, T represents the total comprehensive coordination index of the three systems, and a, b, c are coefficients to be determined, which are used as the weights of the comprehensive evaluation score. The size of the weight reflects the importance of the ternary system, and digital logistics, resilient economy and ecological environmental governance are equally important, so a, b, c three coefficients are set to 1/3.The results are combined with the evaluation criteria for the level of coupling coordination in Table 2.

Table 2. Evaluation criteria for coupling coordination level

degree of coupling coordination	0.2＜D⩽0.4	0.4＜D⩽0.5	0.5＜D⩽0.6	0.6＜D⩽0.8	0.8＜D⩽1
hierarchy	moderate disorder	on the verge of becoming dysfunctional	Primary coordination	Intermediate level coordination	Quality coordination

Kernel Density Estimation Methods. The Kernel density estimation method is able to examine the trend of spatio-temporal variation of the estimated samples by constructing the density function and using its distributional characteristics, and its specific density function formula is:

$$f(x) = \frac{1}{Nh}\sum_{i=1}^{n} K\left[\frac{X_i - x}{h}\right] \tag{7}$$

where N is the number of provinces; K is the stochastic kernel function, Gaussian kernel function is used in this paper; h is the density estimation bandwidth.

Analysis of spatial autocorrelation data. In this paper, we analyse the spatial clustering and correlation of the system through global spatial autocorrelation and local spatial autocorrelation.

(1) Global spatial autocorrelation

The global Moran index reveals whether there is spatial autocorrelation in the degree of coupling coordination.

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(\chi_i - \bar{\chi})(\chi_j - \bar{\chi})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \tag{8}$$

where is the number of regions, and denotes the sample variance, the and are the values of their attributes, and represents its mean value, and is the spatial weight of the study area.

(2) Local spatial autocorrelation

The Local Moran' I was calculated to analyze the specific spatial clustering patterns of the coupling coordination degree in each province.

$$I_i = \frac{(\chi_i - \bar{\chi})}{S^2}\sum_{j=1}^{n} W_{ij}\left(\chi_j - \bar{\chi}\right) \tag{9}$$

where is the sample variance, and $W_{ij}$is the spatial weight, and $\bar{\chi}$represents its mean value.

Spatial spillover effects. The Spatial Durbin Model (SDM) integrates the extent to which the lagged terms of multiple factors affect the dependent variable.

(1) Selection of Indicators of Influencing Factors

In order to explore the influencing factors of the coupling coordination level of digital logistics, resilient economy and ecological environmental governance, with the degree of coupling coordination as the explanatory variable, and with reference to the relevant literature, three aspects of the indicators are selected as the explanatory variables, and the selection of indicators is shown in Table 3.

Table 3 Results of the selection of indicators for the degree of coupling coordination and its influencing factors

Variable type	Level 1 indicators	Tertiary indicators	Variable Code
explanatory variable	degree of coupling coordination	degree of coupling coordination	CD
explanatory variable	digital logistics	Cargo turnover	GTV
		Businesses with e-commerce activities	EAE
	resilient economy	unemployment rate	UR
		Disposable income of urban residents	URPCDI
		Domestic patent applications and authorizations	DIPAAQ
	Ecological and environmental governance	Total CO2 emissions	CDET
		Surface water resources	SWR

(2) Spatial Durbin model

$$\mathrm{CD_{it}} = \mathrm{C} + \rho \mathrm{W} \times \mathrm{CD_{it}} + \beta_1 \mathrm{GTV_{it}} + \beta_2 \mathrm{EAE_{it}} + \beta_3 \mathrm{UR_{it}} + \beta_4 \mathrm{URPCDI_{it}} + \beta_5 \mathrm{DIPAAQ_{it}} + \beta_6 \mathrm{CDET_{it}} + \beta_7 \mathrm{SWRQ_{it}} + \mu_i + \nu_t + \varepsilon_{it} \quad (10)$$

The where$\mathrm{CD_{it}}$are the explanatory variables for region i in year t, the$\mathrm{EV_{it}}$、$\mathrm{ECS_{it}}$ 、$\mathrm{PCRG_{it}}$、 $\mathrm{SCRT_{it}}$ 、 $\mathrm{IPCI_{it}}$ 、 $\mathrm{LFSTE_{it}}$ 、 $\mathrm{CDET_{it}}$ and μ_i and ν_t and ε_{it} denote the spatial autocorrelation coefficients of the explanatory variables as well as the associated disturbance terms, respectively.“see Appendix for Table 3 of results”.

4 Analysis of empirical results of coupled and coordinated development of digital logistics, resilient economy and ecological environment

4.1 Analysis of the degree of coupling and coordination of digital logistics, regional economy and ecological and environmental governance

The data in Table 4, derived from equations (4) (5) (6), show that from 2012 to 2021, the overall coordinated development level of digital logistics, resilient economy and ecological environmental governance in China has shown a steady increase year by year, but there are differences in the development between regions.The coupling coordination in 2020 has shown a small drop compared with the past, which may be due to the fact that the macroeconomic decline due to the impact of the new Crown Pneumonia epidemic. The table intuitively shows that the economy shows recovery and growth in 2021, and the overall mean value of the coupling coordination degree of the 30 provinces is close to 0.5, and in general, the coupling coordination degree of the ternary system is between the stage of imminent dislocation and the stage of primary coordination, and the provinces in the stage of imminent dislocation and above account for 76.7% of the provinces and the fluctuating range of coupling coordination is not large, which reflects that the coupling coordination degree of the ternary system has stability.

Analyze the data in Table 4.Further examining the spatial characteristics of the eastern, central and western regions, the coupling coordination degree of the triad system is generally higher in the eastern region, while the average value of the coupling coordination degree of most provinces in the central and western regions is lower than the national average. This is because the eastern region has the advantage of the coast, good location conditions, and its industrial structure is mostly dominated by high-tech digital industries, while the economic strength is stronger, the demand for logistics services is greater, with the ability to cope with economic shocks, and a relatively strong ability to repair and protect the environment, logistics enterprises are also more concerned about the green logistics, so that the ternary system can be well interacted with each other. In contrast, due to the limitations of natural resources and geographic location, digital infrastructure and transport facilities in the central and western regions are weak, and the demand for logistics is relatively small, hindering the development of digital logistics. Most of the provinces in the region have weak economic strength, and their economic development is constrained by the ecological environment, unbalanced industrial development, weak ability to cope with economic shocks, and relatively low investment in pollution control and environmental improvement, which makes coordination among the triadic systems more difficult. The western region needs to take comprehensive measures to improve the coordination between the three, to prevent the system from falling into a state of imbalance, and can fully rely on the Western Development Programme to increase investment in digital logistics, improve the resilience of the economy, and synergistically promote ecological and environmental governance.

Table 4 Coupling harmonization by province, 2012-2021

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Beijing	0.444	0.451	0.472	0.487	0.493	0.513	0.511	0.527	0.525	0.540
Tianjin	0.303	0.301	0.318	0.326	0.320	0.319	0.322	0.335	0.332	0.334
Hebei	0.464	0.476	0.495	0.491	0.496	0.513	0.538	0.538	0.533	0.536
Shanxi	0.337	0.355	0.355	0.357	0.365	0.377	0.387	0.398	0.391	0.406
Neimenggu	0.374	0.393	0.404	0.398	0.407	0.413	0.419	0.426	0.420	0.441
Liaoning	0.440	0.449	0.455	0.444	0.438	0.440	0.445	0.450	0.444	0.454
Jilin	0.316	0.322	0.333	0.336	0.345	0.351	0.357	0.361	0.356	0.364
Heilongjiang	0.378	0.394	0.397	0.392	0.402	0.413	0.414	0.425	0.422	0.430
Shanghai	0.400	0.395	0.430	0.446	0.480	0.486	0.473	0.504	0.499	0.510
Jiangsu	0.528	0.546	0.560	0.586	0.602	0.600	0.630	0.636	0.643	0.646
Zhejiang	0.503	0.516	0.536	0.557	0.572	0.574	0.595	0.628	0.639	0.652
Anhui	0.397	0.426	0.440	0.458	0.489	0.491	0.511	0.523	0.536	0.542
Fujian	0.399	0.414	0.431	0.448	0.463	0.462	0.472	0.492	0.484	0.495
Jiangxi	0.349	0.359	0.375	0.396	0.407	0.422	0.435	0.461	0.460	0.475
Shandong	0.536	0.546	0.572	0.576	0.609	0.627	0.638	0.647	0.641	0.657
Henan	0.463	0.479	0.496	0.509	0.533	0.547	0.564	0.575	0.570	0.577
Hubei	0.393	0.414	0.437	0.454	0.483	0.489	0.499	0.511	0.515	0.524

Hunan	0.402	0.412	0.433	0.442	0.455	0.469	0.481	0.503	0.504	0.515
Guangdong	0.597	0.620	0.631	0.661	0.696	0.717	0.747	0.780	0.773	0.795
Guangxi	0.349	0.362	0.377	0.393	0.402	0.418	0.427	0.443	0.444	0.445
Hainan	0.243	0.250	0.263	0.266	0.275	0.280	0.287	0.293	0.294	0.331
Chongqing	0.313	0.328	0.349	0.361	0.377	0.391	0.401	0.409	0.413	0.427
Sichuan	0.432	0.446	0.469	0.479	0.498	0.522	0.550	0.568	0.576	0.582
Guizhou	0.280	0.301	0.324	0.340	0.355	0.370	0.385	0.397	0.393	0.397
Yunnan	0.326	0.350	0.367	0.383	0.397	0.417	0.437	0.445	0.446	0.446
Shanxi	0.367	0.376	0.388	0.399	0.408	0.424	0.440	0.451	0.445	0.462
Gansu	0.268	0.282	0.296	0.301	0.312	0.321	0.333	0.341	0.339	0.353
Qinghai	0.188	0.194	0.209	0.211	0.222	0.232	0.247	0.251	0.249	0.272
Ningxia	0.192	0.203	0.217	0.215	0.230	0.231	0.239	0.242	0.238	0.264
Xinjiang	0.330	0.351	0.366	0.374	0.376	0.388	0.396	0.406	0.399	0.428

4.2 Kernel density estimation for coupled and coordinated development of ternary systems

Derived from equations (7).Fig. 1. is the three-dimensional distribution map of Gaussian kernel density drawn by MATLAB2021a software, and based on the method of Kernel density estimation, the spatial and temporal evolution trend and difference characteristics of digital logistics, resilient economy and ecological environmental governance are analysed through its distribution location, trend, ductility and polarization phenomenon. The figure 1 shows the kernel density estimation of the degree of coordination of ternary system coupling from 2012 to 2021. According to the distribution position of the density curve, it can be found that the distribution curve mainly shows the trend of "single main peak" and basically stays unchanged and moves slightly to the right, and the height of the peak rises firstly and then decreases, which indicates that the level of coordinated development of each province's ternary system coupling has increased steadily and the internal development of the ternary system has increased steadily, and the level of coordination of the ternary system has decreased. The overall level of coordinated development has been steadily rising, with little internal fluctuation, and the slight trailing shows that there is polarisation in coordinated development, and the internal development gap is relatively even.

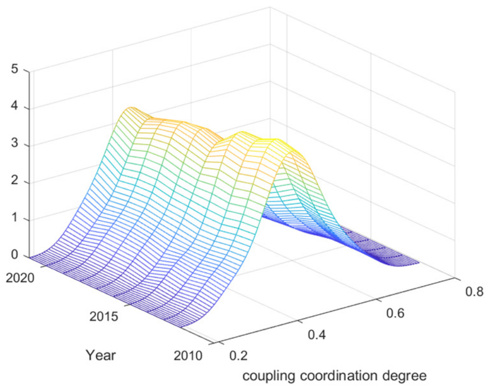

Fig. 1. Trends in the spatial and temporal evolution of the coordinated development of triple coupling

4.3 Spatial autocorrelation data analysis of the coupled coordination degree of digital logistics, regional economy and carbon environmental governance

Global spatial autocorrelation analysis of coupled coordination degrees. The data in Table 5,using stata software,derived from equations (8), based on the provincial spatial geographic weight matrix to calculate the global Moran index of coupled coordination degree in 30 provinces, the results of which passed the 5% significance test, indicating the spatial agglomeration of coupled coordination degree. The Moran index of the coupling coordination degree of digital logistics, resilient economy and ecological environmental governance is 0.061 in 2017,0.049 in 2021, both positive, indicating that the spatial aggregation degree of the coupling coordination degree shows a positive correlation.The results are shown in Table 5.

Table 5 Global Moran's Index of Coupling Coordination Degree

Year	Moran (I)	P	Z
2017	0.061	0.008	2.649
2021	0.049	0.019	2.247

Local spatial autocorrelation analysis of coupled coordination degrees. The local Moran index indicates the degree of spatial agglomeration within a local area, derived from equations (9),i.e. local spatial autocorrelation, which can be described by a Moran scatter plot. Provinces and cities located in the first and third quadrants indicate that the neighbouring provinces and cities of the province and city have a facilitating and synergistic effect on the coupled and coordinated development of the province and city; provinces and cities located in the second and fourth quadrants indicate that the neighbouring provinces and cities of the province and city have a negative effect on the coupled and coordinated development of the province and city. Using GeoDa software to draw the Moran scatter plot for 2021, Fig.2.the results do not fluctuate much, indicating that the temporal correlation is stable and mainly shows the characteristics of "high - high" agglomeration and "low - low" agglomeration. The provinces located in the first quadrant of the high-high agglomeration area indicate that the province has high coupling and coordination ability, and the neighboring provinces also show the agglomeration phenomenon of high coupling and coordination ability, and have strong spatial correlation. Provinces in the third quadrant of low-low agglomeration have weak correlation, but agglomeration with neighboring areas.

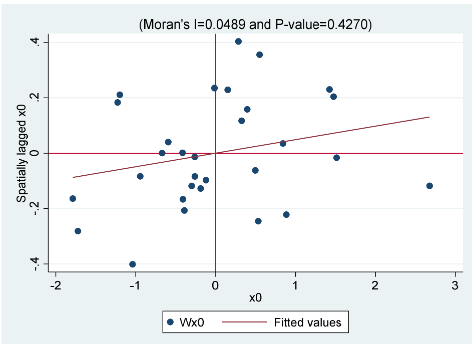

Fig. 2. Localized Moran scatter plot of coupling coordination degree

4.4 Empirical analysis of the spatial Durbin model

Analysis of Spatial Durbin Model Results. This can be seen from Table 6. After the fixed effects test, Hausman test, derived from equations (10)and LR test results showed that they were all significant, the study chose the spatial Durbin model model with double fixed effects of province and time to analyse the data. The explanatory variables all have significant effects on the explained variables under the model setting, further verifying the robustness of the benchmark regression.Both the spatial autoregressive coefficients and the coefficients of the spatial interaction terms are significantly positive, which indicates that there is an endogenous interaction effect of the coupled and coordinated development of the ternary system among regions as well as a significant spatial spillover effect of the neighbouring regions on the coordinated development of their own regions. The table 6 shows that the coupling and coordination degree of the three systems in this region has a significant positive influence.Further decomposition of the spatial spillover effects, from the point of view of the direct effect, it shows that after overcoming the error due to spatial correlation, increasing the cargo turnover, e-commerce enterprises and disposable incomes of urban residents in the same region will promote the coordinated development of the ternary system, while increasing the unemployment rate, which will destabilise the overall economy, and increasing the carbon emissions and destroying the ecological environment will have an inhibitory effect on the ternary system, and the results of surface water resource volume are not significant. The results of surface water resources are not significant to its role is not obvious. From the perspective of indirect effect, the cargo turnover, the number of e-commerce enterprises and the disposable income of urban residents can have a positive spatial spillover effect on the ability of geographic neighbours to resist risks through spatial characteristics, and the transmission of information breaks through the geographical constraints, and transmits arly warning signals for the external regions to make timely adjustments. Unemployment and carbon dioxide emissions have a negative impact on the coupling of neighbouring regions. In terms of the total effect, under the influence of direct and indirect effects, the total effect is significant.The result of total effect shows that the proportion of Surface water resources in this region does not play a significant role in promoting the coupling and coordination of the three systems, and other influencing factors can have a significant driving effect.

Table 6 Global Moran's Index of Coupling Coordination Degreeee

P	direct	Indirect	Total
GTV	0.000	0.006	0.002
EAE	0.000	0.006	0.002
UR	0.000	0.026	0.013
URPCDI	0.426	0.575	0.546
DIPAAQ	0.683	0.028	0.034
CDET	0.011	0.093	0.074
SWR	0.000	0.313	0.611

Robustness Tests. The reliability of the conclusions is further tested by robustness tests. In this paper, the method of transforming the matrix is chosen for the robustness test, and the economic-geographical nested matrix is chosen. The results of the test show that the conclusions are consistent with those before the matrices were replaced, thus inferring that the conclusions obtained in this paper are robust.

5 Conclusions

This paper investigates the coupled and coordinated development of digital logistics, resilient economy and ecological environmental governance, and carries out spatial autocorrelation analyses, spatial and temporal trends, as well as studying the spatial spillover effects. The study finds that, firstly, the coupling and coordination degree of each province is mostly concentrated in the range between on the verge of dissonance and barely coordinated, and there is a development gap between regions. Second, the ternary system is closely connected, and the coupling coordination degree has obvious positive spatial correlation and indicates a strong degree of agglomeration. Third, the coordinated development of the provinces shows an upward trend, and the internal structure is relatively stable. Fourth, the analysis of spatial spillover effects of the ternary system shows that the variables are able to produce significant spatial spillover effects on the coupled coordinated development of geographic neighbourhoods through spatial characteristics.

Accordingly, this paper puts forward the following three suggestions. First, the state should accelerate the digitalisation process of the logistics industry, improve the layout network construction, strengthen the strength of the association of each subject, so as to reinforce the ability of each subject of the logistics supply chain to resist economic risks. Digital construction can provide early warning to the economy so that it can make timely and appropriate decisions, and it can also help logistics enterprises achieve intelligent management of the production process, improve production efficiency and reduce the impact on the ecological environment. Second, logistics enterprises use high-tech means such as the Internet of Things, big data and artificial intelligence to optimise all aspects of the logistics business, improve transport efficiency and accuracy, help reduce inventory backlogs, lower logistics costs and improve the ability of enterprises to respond to market changes. It can also help enterprises achieve real-time monitoring and optimisation of energy consumption, thus reducing energy consumption and carbon emissions. Third, local governments should support and subsidise incentives to establish diversified economic business forms. Work together to build a synergistic regional industrial-economic-environmental network to effectively leverage the regional radiation benefits of the ternary system. Create a regional digital logistics industrial park and promote the spatial flow of information and technology, thereby improving the level of regional synergistic development and forming a new pattern of benign mutual promotion of interregional systems.

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