Coupling coordination and obstacle analysis of smart logistics, regional economy, and logistics carbon emission governance under the "dual-carbon" goal

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Abstract: With the proposal of the "dual-carbon" goal, the development of smart logistics has become one of the important means for the logistics industry to reduce carbon emissions. However, there are still many problems in promoting the coordinated development of smart logistics, regional economy, and logistics carbon emission governance. Based on the sample data from Sichuan Province from 2012 to 2021, this article comprehensively uses the entropy-weighted DEMATEL method, coupling coordination degree, and obstacle degree model to measure the level of carbon emissions in the logistics industry. Furthermore, it evaluates the comprehensive development status and coupling coordination degree of smart logistics, regional economy, and logistics carbon emission governance, and effectively identifies the obstacles affecting the coupling coordination degree of the three. The study shows that the overall carbon emissions in the logistics industry in Sichuan Province show a fluctuating upward trend with a faster increase followed by a slower increase. The degree of coordinated development and obstacles of the three subsystems show certain stage differences.

Keywords: Smart logistic; Logistics carbon emissions; Coupling coordination; Obstacle diagnosis

1 Introduction and literature review

With the rapid development of the global economy and increasing attention to environmental issues, reducing carbon emissions has become a global challenge. All industries are actively exploring sustainable development paths, and the logistics industry is no exception. However, the problem of high energy consumption and high carbon emissions in the logistics industry has become increasingly prominent as it continues to expand. In September 2020, China proposed the goal of peaking carbon dioxide emissions and achieving carbon neutrality, striving to reach the peak of carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060. Achieving the "dual-carbon" goal requires joint efforts from the entire society, and the logistics industry, in particular, must actively explore and address carbon emissions issues. Smart logistics is a new logistics model based on information technology and logistics resource optimization. From the experience of developed countries, the development of smart logistics using digital and platform economies has become one of the important means of carbon reduction. However, in the process of achieving the "dual-carbon"

EMIS 2023, February 24-26, Chengdu, People's Republic of China

DOI 10.4108/eai.24-2-2023.2330692

goal, the development of smart logistics faces a series of challenges and obstacles, such as high costs, limited technological level, and inadequate policy support. Therefore, promoting the coordinated development of smart logistics, regional economy, and logistics carbon emission governance and effectively identifying obstacles is crucial for the sustainable development of the logistics industry.

Many domestic scholars' research on the coordinated development evaluation of logistics, economy, and environment mainly focuses on the measurement of coordination level and identification of influencing factors. Research on the measurement of coordination level mainly focuses on the measurement methods and the construction of indicator systems. In terms of measurement methods, methods such as fuzzy comprehensive evaluation, coupling coordination degree model, analytic hierarchy process, grey relational degree method, and entropy weight method are mainly used for evaluation. In terms of indicator system construction, different perspectives (such as "Five New Development Concepts", "Sustainable Development Concept", "DPSIR Model", etc.) are mainly used to select corresponding indicators for subsystems such as smart logistics, high-quality economic development, and environmental governance, and construct an evaluation indicator system. Research on influencing factors mainly focuses on exploring the impact of factors such as technological level, economic structure, policy support, and industrial structure on the coordinated development of the three aspects. For example, Yao Wenpei (2022) studied the coordinated development of the logistics industry, industrial digitalization, and ecological civilization in China's ecological civilization pilot zones, and analyzed the main obstacles in each pilot zone using the obstacle degree model.

In summary, it can be found that the existing research has achieved certain results in the coordinated evaluation of digital logistics, regional economy and ecological environment, and the theoretical model is relatively mature, but usually only objective or subjective single weighting method is used in determining the weight of evaluation indicators, rarely combine the two. At the same time, carbon emissions from the logistics industry are rarely considered in the evaluation of the ecological environment subsystem. There are few studies on the coupling and coordinated development of smart logistics, regional economy and logistics carbon emission governance to identify obstacle factors. Therefore, this paper takes Sichuan Province, which is representative in western China, as an example to explore the changes in the comprehensive development level of smart logistics, regional economy, and logistics carbon emission governance, as well as the coupling and coordinated development among the three , and on this basis, diagnose the impact on coordination. Obstacle factors to development, put forward countermeasures and suggestions to provide theoretical basis and decision-making reference for stakeholders in regional logistics development.

2 Index System Construction and Data Sources

2.1 Evaluation system construction

Starting from the three aspects of smart logistics, regional economic development and logistics carbon emission governance, this paper constructs three subsystems and refers to the selection of relevant subsystem indicators by domestic and foreign scholars, and integrates the logistics Taking carbon emissions into consideration. When constructing the smart logistics subsystem, considering the development level of the logistics industry and the development level of informatization, 11 secondary indicators such as the total amount of social logistics, logistics network density, and Internet penetration rate were selected; when selecting the indicators of regional economy , taking into account four secondary indicators such as regional GDP and local fiscal revenue; the carbon environment governance subsystem is composed of four secondary indicators such as carbon emissions from the logistics industry in Sichuan Province and forest coverage. The final evaluation index system of systematic coordinated development is shown in Table 1.

2.2 Data sources

Based on the above index system, this paper selects the sample data of Sichuan Province from 2012 to 2021. The corresponding data mainly comes from the "China Statistical Yearbook", "China Logistics Yearbook" and "China Urban and Rural Construction Statistical Yearbook". For example, the relevant data on the total amount of social logistics and the ratio of total social logistics costs to GDP come from the development of logistics industry in Sichuan Province in the "China Logistics Yearbook"; the area of urban logistics storage land comes from the "China Urban and Rural Construction Statistical Yearbook" Sichuan Province's logistics and storage land area; freight volume, Internet penetration rate, etc. are from China Statistical Yearbook. In addition to the data that can be directly obtained above, the data of some indicators are obtained by calculation. For example, logistics network density and carbon emissions of the logistics industry. The relevant calculation formula is as follows:

$$\text{Logistics network density} = \frac{\text{Railway mileage+Road mileage+Inland waterway mileage+Airline mileage}}{\text{Total land area of Sichuan Province}} \quad (1)$$

$$\text{Carbon emissions of the logistics industry} = \sum_{i=1}^{n} E_i \times V_i \times L_i \times F_i \times \frac{44}{12} \quad (2)$$

The relevant data in formula (1) come from the Sichuan Statistical Yearbook (2013-2021). Formula (2) $E_i$represents the consumption of the i-th energy, $V_i$the average low calorific value of the i-th energy, $L_i$the carbon content per unit calorific value of the energy, $F_i$the carbon oxidation rate of the energy, $\frac{44}{12}$and the molecular weight of carbon dioxide. The relevant data come from the "China Energy Statistical Yearbook" and "Guidelines for the Preparation of Provincial Greenhouse Gas Inventories". For some missing data that cannot be obtained, this paper uses the average annual growth rate method for linear interpolation.

Table 1: System coordination degree measurement index system

Subsystem	Dimension	Indicators	Unit
Smart logistics	Development level of logistics industry	Total social logistics	100 million yuan
		The ratio of the total cost of social logistics to GDP	%
		Land area for urban logistics and warehousing	square kilometer
		Logistics Network Density	km/square km
		cargo volume	tons

level of information development	Postal business outlets	place
	internet penetration	%
	Number of domestic patent applications granted	item
	e-commerce sales	100 million yuan
	The number of websites owned by the enterprise	indivual
	IT service revenue	ten thousand yuan
Regional Economic Development	GDP	100 million yuan
	Total import and export	thousands of dollars
	Local fiscal revenue	100 million yuan
	Consumer Price Index	Last year=100
Logistics Carbon Emissions Governance	Carbon emissions in the logistics industry	tons
	Forest cover rate	%
	Urban Green Area	million hectares
	per capita water resources	Cubic meter/person

3 Model Construction and Empirical Analysis

3.1 Entropy weight-DEMATEL combination weight

First, the entropy weight method is used to determine the objective weight of the index, and then the DEMATEL method is used to determine the subjective weight of the index, and then the comprehensive weight of the index is obtained by combining the two.

3.1.1 Entropy weight method

(1) Standardized processing

Let Xij be the original data of the j-th indicator in the i-th year, and Yij be the standardized data of the j-th indicator in the i-th year.

where i=1,2...,n; j=1,2...,k.

For positive indicators:

$$Y_{ij} = \frac{X_{ij} - X_{min}}{X_{max} - X_{min}} \quad (3)$$

For negative indicators:

$$Y_{ij} = \frac{X_{max} - X_{ij}}{X_{max} - X_{min}} \quad (4)$$

Among them, X_{max} and X_{min} represent the maximum value and minimum value of the jth indicator respectively.

(2) Normalization processing

$$P_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}} \tag{5}$$

Indicates the proportion of the data of the j-th indicator in the i-th year to the total value of the indicator.

(3) Calculate the index entropy value

$$E_j = -\frac{1}{\ln n} \times \sum_{i=1}^{n} P_{ij} \times \ln P_{ij} \tag{6}$$

(4) Calculation index entropy weight

$$\beta_j = \frac{1-E_j}{\sum_{j=1}^{k}(1-E_j)} \tag{7}$$

3.1.2 DEMATEL method

(1) Establish a relationship matrix

Firstly, establish the relationship matrix among indicators in the sub-system of smart logistics, regional economic development and logistics carbon emission governance, and score the degree of influence among the various factors in the matrix according to subjective judgment. In this paper, referring to the research of Zhu Chen et al (2021)., the scores are set from 0 to 4 points, from low to high, indicating "no direct impact", "basically no relationship", "general relationship", "moderate relationship" and "very strong relationship", so as to regulate directly affect the matrix.

$$N = \frac{a_{ij}}{\max(\sum_{j=1}^{n} a_{ij})} \tag{8}$$

Among them, aij represents the data in row i and column j in the relationship matrix, and n is the total number of indicators, which can also be understood as the number of columns of matrix N here.

(2) Calculate the comprehensive impact matrix T

$$T = N \times (I - N)^{-1} \tag{9}$$

where I is an $n \times n$ identity matrix.

(3) Calculate centrality and causality

Before calculating the centrality and cause degree, it is necessary to calculate the influence degree D value and the affected degree C value:

Influence of the jth indicator:

$$D_j = \sum_{i=1}^{n} t_{ij} \tag{10}$$

The degree of influence of the jth indicator:

$$C_j = \sum_{i=1}^{n} t_{ji} \qquad (11)$$

In the formula, $t_{ij}$and t_{ji}both refer to the elements in the matrix T.

Centrality:

$$M_j = D + C \qquad (12)$$

Degree of cause:

$$N_j = D - C \qquad (13)$$

(4) Calculate index weight

The weight value of each index is obtained by normalizing the centrality data, and the specific calculation formula is as follows:

$$\alpha_j = \frac{M_j}{\sum_{j=1}^{n} M_j} \qquad (14)$$

3.1.3 Comprehensive weight

Based on the above-mentioned objective weight and subjective weight value $\alpha_j$obtained $\beta_j$by using the entropy weight method and DEMATEL method, the final comprehensive weight of each indicator is obtained by using the following formula:

$$W_j = \frac{\sqrt{\alpha_j \times \beta_j}}{\sum_{j=1}^{n} \sqrt{\alpha_j \times \beta_j}} \qquad (15)$$

3.2 Three-element coupling coordination model of smart logistics-regional economy-logistics carbon emission governance

In this paper, under the background of the "double carbon" goal, a ternary coupling coordination model of smart logistics-regional economy-logistics carbon emission governance in Sichuan Province is constructed, and the comprehensive development and coupling coordination among the three are evaluated.

(1) Calculation of comprehensive development index

Let U_1, U_2, and U_3 denote the comprehensive development index of the three subsystems of smart logistics, regional economy, and logistics carbon emission governance, respectively. The calculation formula of U_i (i=1, 2, 3) is as follows:

$$U_i = \sum_{j=1}^{n_i} W_j \times Y_{ij} \qquad (16)$$

Among them, n_i represents the number of indicators in the i-th subsystem, W_j represents the combined weight value of each index, and Y_{ij} represents the standardized index value in each system, that is, the dimensionless value of the original data.

(2) Calculate the coupling degree C

The coupling degree is an important part in the process of calculating the coupling coordination degree, and its distribution interval is [0,1]. The larger the value of C, the smaller the degree of dispersion between subsystems; otherwise, the larger the value. The formula for calculating the C value is as follows:

$$C = \left\{ \frac{U_1 U_2 U_3}{\left(\frac{U_1+U_2+U_3}{3}\right)^3} \right\}^{\frac{1}{3}} \tag{17}$$

(3) Calculate the coordination index T

$$T = \alpha U_1 + \beta U_2 + \gamma U_3 \tag{18}$$

Among them, α、β、γis the weight of each subsystem, and the sum is 1. Its value indicates the importance of smart logistics, regional economy and logistics carbon emission governance to the overall development. This paper regards the three subsystems as having an equally important role in the overall development, so it is selected $\alpha = \beta = \gamma = \frac{1}{3}$.

(4) Calculation of coupling coordination degree D

$$D = \sqrt{C \times D} \tag{19}$$

(5) Determining the degree of coupling coordination

the related research of Sun Zhixian et al. (2022) the coupling coordination level classification standard of smart logistics-regional economy-logistics carbon emission governance in Sichuan Province, as shown in Table 2.

3.3 Obstacle degree model

In order to further study the degree of influence of individual indicators on the system and facilitate the identification of indicators that have a greater impact on the system, an obstacle degree model is introduced here. The obstacle degree model judges the influence degree of each index on the system by calculating the obstacle degree of each index. The higher the obstacle degree of the indicator, the deeper its influence on the system. The formula for calculating the index obstacle degree is as follows:

$$O_j = \frac{W_j \times (1 - Y_{ij})}{\sum_{j=1}^{n} W_j \times (1 - Y_{ij})} \tag{20}$$

Among them, W_j is the factor contribution

Table 2 : Classification standard of coupling coordination degree.

Coupling coordination degree D value range	Coordination level	Degree of coupling coordination
(0.0~0.1)	1	extremely disordered
[0.1~0.2)	2	severe disorder
[0.2~0.3)	3	moderate disorder
[0.3~0.4)	4	mild disorder

[0.4~0.5)	5	on the verge of disorder
[0.5~0.6)	6	barely coordinated
[0.6~0.7)	7	junior coordinator
[0.7~0.8)	8	intermediate coordinator
[0.8~0.9)	9	well coordinated
[0.9~1.0)	10	high quality coordination

degree, which is represented by the combined weight of each index; 1-Y_{ij} is the index deviation degree, and Y_{ij} is the standardized data; O_j is the obstacle degree of the jth index.

3.4 Annual Situation Analysis of Carbon Emissions from the Logistics Industry in Sichuan Province

The histogram and annual growth rate chart of the carbon emissions of the logistics industry in Sichuan Province from 2012 to 2021 are shown in Figure 1.

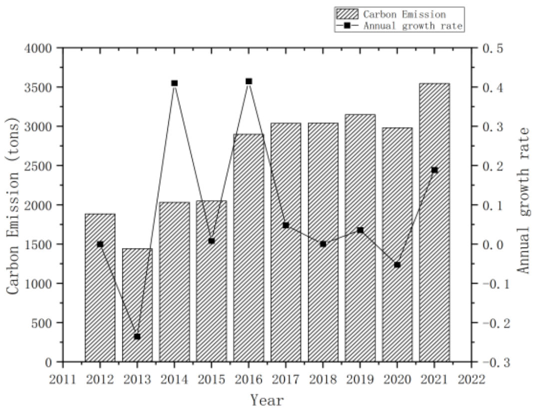

Figure 1: 2012-2021 histogram of carbon emissions in the logistics industry of Sichuan Province and the trend chart of annual growth rate.

It is not difficult to see from Figure 1 that the carbon emissions of the logistics industry in Sichuan Province are on the rise from 2012 to 2021. From the perspective of carbon emissions in each year, the carbon emissions in 2013 were the lowest, about 14.42 million tons; the carbon emissions in 2021 were the highest, reaching 35.44 million tons. From the perspective of annual growth rate, the annual growth rate in 2013 and 2020 is negative, indicating that carbon emissions in these two years have decreased to a certain extent compared with the previous year, and the percentages of decline are 23.5% and 5% respectively. The annual growth rates in the rest of the years were non-negative, among which the annual growth rate in 2016 was the largest, reaching 41.4%, followed by 2014, with an annual growth rate of 41%. From the point of view of the change trend, the fluctuation between 2012 and 2016 is relatively large and the overall upward trend is obvious; the fluctuation between 2017 and 2021 is small and shows a slow upward trend. Overall, although the carbon emissions of the logistics industry in Sichuan Province have increased almost year by year from 2012 to 2021, the growth trend has obviously weakened over time.

3.5 Empirical Analysis of the Coordinated Development of Smart Logistics, Regional Economy, and Logistics Carbon Emission Governance in Sichuan Province

3.5.1 Analysis of the comprehensive development level of smart logistics, regional economy and logistics carbon emission governance

The trend chart of the comprehensive development index of the three subsystems of smart logistics, regional economic development and logistics carbon emission control in Sichuan Province from 2012 to 2021 is shown in Figure 2:

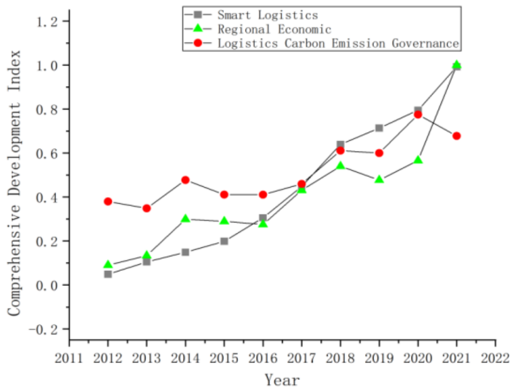

Figure 2 : 2012-2021 Trend Chart of Comprehensive Development Index of Sichuan Province's Intelligent Logistics, Regional Economic Development and Logistics Carbon Emission Governance.

It can be seen from Figure 2 that the comprehensive development level of smart logistics, regional economy and logistics carbon emission governance in Sichuan Province from 2012 to 2021 showed a clear upward trend. Among them, the development level of the smart logistics industry has increased from 0.05 to 0.99 year by year. The development momentum is rapid, with the fastest growth rate between 2015 and 2018, with an average annual growth rate of 44%; the level of economic development shows a fluctuating upward trend, with varying degrees of decline in 2014 and 2018, and in 2013-2014 The growth rate is the fastest in the two time periods of 2020-2021. Compared with the former two, the change trend of the development level of logistics carbon emission governance is slightly flat, and the overall volatility is not large. The comprehensive score is maintained between 0.4 and 0.7, but it shows a zigzag upward trend. On the whole, the development level of logistics carbon emission governance from 2012 to 2017 was significantly higher than the other two, but as time went by, the gap between the three gradually narrowed, and the trend of simultaneous development became more and more obvious.

3.5.2 Coupling and coordination analysis of smart logistics, regional economy and logistics carbon emission governance

The coupling degree, coordination index and coupling coordination degree among the three subsystems of smart logistics, regional economy and logistics carbon emission governance in Sichuan Province from 2012 to 2021 are shown in

Table 3.

On the whole, from 2012 to 2021, the coupling coordination degree of smart logistics, regional economy and logistics carbon emission governance in Sichuan Province showed an increasing trend year by year, increasing from 0.345 to 0.936, with an average annual growth rate of 12.04%, and the degree of coordination was mild Dissonance progresses to fine coordination. Specifically, the process can be roughly divided into four stages:

(1) The first stage (2012-2013): The development of smart logistics, regional economy and logistics carbon emission governance in Sichuan Province is mainly in the stage of mild and imminent imbalance, but the coupling and coordination degree in this stage is on the rise. The

Table 3: 2012-2021 Coupling and Coordination Degree of Sichuan Province's Smart Logistics, Regional Economy and Logistics Carbon Emission Governance Subsystems.

Year	Coupling degree C value	Harmonization index T value	Coupling coordination degree D value	coordination level	Degree of coupling coordination
2012	0.688	0.173	0.345	4	Mild disorder
2013	0.867	0.196	0.412	5	On the verge of disorder
2014	0.899	0.309	0.527	6	Barely coordinated
2015	0.958	0.3	0.536	6	Barely coordinated
2016	0.985	0.331	0.571	6	Barely coordinated
2017	1	0.446	0.668	7	Junior Coordinator
2018	0.998	0.597	0.772	8	Intermediate Coordinator
2019	0.987	0.597	0.767	8	Intermediate Coordinator
2020	0.989	0.712	0.839	9	Well coordinated
2021	0.984	0.89	0.936	10	High quality coordination

rate reached 19.33%. Combined with the respective comprehensive evaluation scores at this stage, the development level of smart logistics and economy obviously lags behind the level of logistics carbon emission governance , resulting in a low degree of coupling coordination at this stage. But at this time, smart logistics and economic development show a clear upward trend, and the degree of coordinated development of the three also has a clear upward trend.

(2) The second stage (2014-2016): With the rapid development of smart logistics and economy, the degree of coupling coordination has increased year by year, and the degree of coordinated development has also changed from unbalanced to barely coordinated. Among them, in 2014, the degree of coupling coordination increased the fastest, an increase of nearly 27.9% over the previous year. Combined with the analysis in Figure 2, the main reason is that the economic development of the year has improved the overall coupling coordination. However, the

development level of smart logistics at this stage is still slightly lagging behind.

(3) The third stage (2017-2019): In this stage, the degree of coupling coordination first increases and then decreases. From 2017 to 2018, smart logistics and economic development continued to maintain a rapid growth trend, and the gap with the comprehensive development level of logistics carbon emission governance was further narrowed, and the overall coupling and coordination level increased, from reluctant coordination to primary coordination and then to intermediate coordination stage; 2018 -In 2019, the level of economic development and carbon environment development have declined to varying degrees. Compared with the previous period, the gap between the three has widened. The specific performance is that the level of economic and environmental development lags slightly behind the development level of the smart logistics industry, resulting in a decline in coupling coordination.

(4) The fourth stage (2020-2021): In this stage, the degree of coupling and coordination continues to rise, and the level of coordinated development has also entered the stage of good coordination and high-quality coordination. From the perspective of their respective comprehensive development levels, the rapid rise in the level of smart logistics industry and economic development has brought pressure on logistics carbon emission governance, resulting in a decline in the development level of logistics carbon emission governance at this stage.

3.6 Analysis of Influencing Factors of Coupled and Coordinated Development

Calculate the obstacle degree of each index according to the obstacle factor model, and learn from the practice of Gong Yueqin （2022）and others to select the top five indicators with the highest obstacle degree each year as the main obstacle factors. The main obstacle factors for each year and the degree of obstacle is shown in Table 4.

Table 4: 2012-2021 The main obstacle factors and obstacle degree of Sichuan Province's Smart Logistics, Regional Economy and Logistics Carbon Emission Governance Subsystems.

Year	Obstacle factors					Obstacle				
2012	Forest cover rate	The number of websites owned by the enterprise	Land area for urban logistics and warehousing	Local fiscal revenue	Postal business outlets	50.00%	26.73%	20.02%	19.39%	19.11%
2013	Forest cover rate	The number of websites owned by the enterprise	The ratio of the total cost of social logistics to GDP	internet penetration	Postal business outlets	50.00%	19.09%	17.80%	17.79%	17.28%
2014	cargo volume	Urban Green Area	internet penetration	The ratio of the total cost of social logistics to GDP	Logistics Network Density	17.36%	16.99%	16.97%	16.95%	16.36%
2015	cargo volume	per capita water resources	Land area for urban logistics and warehousing	internet penetration	Urban Green Area	20.07%	18.66%	16.20%	15.96%	15.51%
2016	per capita	cargo volume	Total import and export	internet penetration	The ratio of the total cost	16.62%	16.17%	14.89%	14.62%	13.56%

2017	water resources per capita water resources	Carbon emissions of the logistics industry	internet penetration	Total import and export	of social logistics to GDP Number of domestic patent applications granted	14.43%	13.71%	13.35%	12.03%	11.56%
2018	Carbon emissions of the logistics industry	Total social logistics	The number of websites owned by the enterprise	IT service revenue	Total import and export	13.72%	9.48%	9.25%	9.16%	8.72%
2019	Consumer Price Index	Carbon emissions of the logistics industry	per capita water resources	Number of domestic patent applications granted	Total social logistics	16.96%	14.65%	9.42%	9.04%	8.80%
2020	Consumer Price Index	Carbon emissions of the logistics industry	cargo volume	Total social logistics	The number of websites owned by the enterprise	16.96%	13.23%	9.48%	8.07%	5.42%
2021	Carbon emissions of the logistics industry	per capita water resources	cargo volume	Total social logistics	The ratio of the total cost of social logistics to GDP	18.06%	6.12%	1.88%	0.00%	0.00%
2018	Carbon emissions of the logistics industry	Total social logistics	The number of websites owned by the enterprise	IT service revenue	Total import and export	13.72%	9.48%	9.25%	9.16%	8.72%
2019	Consumer Price Index	Carbon emissions of the logistics industry	per capita water resources	Number of domestic patent applications granted	Total social logistics	16.96%	14.65%	9.42%	9.04%	8.80%
2020	Consumer Price Index	Carbon emissions of the logistics industry	cargo volume	Total social logistics	The number of websites owned by the enterprise	16.96%	13.23%	9.48%	8.07%	5.42%
2021	Carbon emissions of the logistics industry	per capita water resources	cargo volume	Total social logistics	The ratio of the total cost of social logistics to GDP	18.06%	6.12%	1.88%	0.00%	0.00%

It can be seen from the table that the main obstacles affecting the overall coupling coordination degree during 2012-2013 include: forest coverage, the number of websites owned by enterprises, the ratio of total social logistics costs to GDP, and local fiscal revenue . Most of the obstacles at this stage come from the smart logistics and regional economic subsystems, indicating that the influence of these two subsystems is the main factor during this period; the main impact indicators from 2014 to 2016 are: freight volume, per capita water resources, and Internet penetration rate , The ratio of the total cost of social logistics to GDP , etc. At this stage, there are not only indicators from the smart logistics and regional economic subsystems, but also some indicators from the logistics carbon emission governance subsystem, but the former two are still the main ones, which shows that although the influence of smart logistics and regional economic development is still the main one in this stage , but the impact of logistics carbon emissions governance on the overall coordination is on the rise; from 2017 to 2019, the main obstacles are: per capita water resources, carbon emissions in the logistics industry, consumer price index, and total social logistics. Most of the obstacles at this stage come from the subsystems of logistics carbon emission governance and regional economic development, and some of them come from the smart logistics subsystem. It can be seen that regional economy and logistics carbon emissions governance have a greater impact on the overall coordinated development at this stage; the main influencing factors in 2020-2021 are: consumer price index, carbon emissions of the logistics industry, per capita water resources, freight volume, etc. . The distribution and change of obstacle factors in this stage are similar to those in the previous stage, so it can be considered that the influence of regional economy and logistics carbon emission governance is still the main factor in this stage.

4 Conclusions and Implications

This paper uses the coupling coordination model to analyze the coupling coordination relationship between smart logistics, regional economic development and logistics carbon emission governance in Sichuan Province from 2012 to 2021, and combines the obstacle degree model to conduct a comprehensive analysis of the main influencing factors affecting the coupling coordination degree of the three. The main research conclusions and implications are as follows:

(1) From 2012 to 2021, the overall carbon emissions of the logistics industry in Sichuan Province showed a fluctuating upward trend at first and then slowly. Especially after 2017, the growth rate of carbon emissions in the logistics industry has dropped significantly, with little difference between years. Although the annual growth rate of carbon emissions in the logistics industry has been controlled in recent years, the total amount is still rising. Therefore, it is necessary to further promote the development of smart logistics, and reduce carbon emissions by optimizing logistics processes, improving resource utilization efficiency, and reducing energy consumption. carbon emission.

(2) Judging from the comprehensive development of the three subsystems of smart logistics, regional economic development and logistics carbon emission governance in Sichuan Province, the level of smart logistics industry and economic development showed a clear upward trend from 2012 to 2021. The development of the comprehensive level of platoon governance is slightly flat. And it can be seen that the trend of smart logistics and economic development in the same direction is obvious, which shows that the development of smart logistics industry and the economic development of Sichuan Province have a mutual promotion effect: economic development has driven the development of smart logistics industry, and the development of smart logistics has further promoted economic development. It is precisely because the rapid development of the two has brought certain pressure on the governance of logistics carbon emissions in Sichuan Province, which has hindered the development of the logistics carbon emissions governance subsystem to a certain extent, resulting in a slow growth in its comprehensive development index, so it is necessary to promote Reform the regional economic structure, optimize the industrial structure of smart logistics, and promote the development of green economy and low-carbon logistics.

(3) Judging from the degree of coupling and coordination of smart logistics, regional economic development, and logistics carbon emission governance in Sichuan Province, with the improvement of the comprehensive development level of the three subsystems, the coordinated development of the three subsystems has also gradually increased in the past 10 years. rising trend. The degree of coupling coordination has increased from 0.345 in 2012 to 0.936 in 2021, and the level of coordination development has experienced a change from mild imbalance to high-quality coordination.

(4) From the perspective of the obstacle factors that affect the coordinated development of coupling, the change rules of the main obstacle factors in each year are as follows: In 2012-2013, most of the obstacle factors came from the smart logistics and regional economic subsystems, indicating the comprehensive development of these two subsystems in this stage The level is relatively lagging; some of the main obstacles in 2014-2016 come from the logistics carbon emission governance subsystem, but most of them still come from the smart logistics and regional economic subsystem. Most of the main obstacles in 2017-2021 come from the regional economy and logistics carbon emission governance subsystem, indicating that the development of economy and logistics carbon emission governance in this stage lags behind the development of smart logistics industry.

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