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# Study on the Synergistic Development of "Smart + Green" Logistics Industry in Chongqing

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**Abstract:** Under the background of "digital economy" and "double carbon", logistics industry, as a typical industry with high input, high energy consumption and high emission, is imperative for its intelligent and green transformation. Chongqing, located in the southwest, is an important logistics hub, and the synergistic development of its logistics industry "smart + green" is of great significance to the economic growth and high-quality development of the industry. This paper constructs the index system for the synergistic development of smart logistics and green logistics, and analyzes the development level of smart logistics and green logistics as well as the level of coupling coordination in Chongqing from 2010 to 2022 by using entropy value method and coupling coordination degree model, with the aim of providing a reference for the government to improve the logistics policy as well as the active development of the logistics industry. The study shows that the overall development level of smart logistics and green logistics in Chongqing is on the rise, and the gap between the two is gradually narrowing, and the development level is gradually changing from green logistics development to synergistic development. The development trend of the coupling coordination degree of smart logistics and green logistics is good, and the coupling coordination degree gradually develops into high-quality coordination, and the trend of the coupling coordination degree is consistent with the trend of the development level of smart logistics, and smart logistics has a stronger role in promoting the synergistic development of the two. Among the subsystems, the scale of development, transportation capacity and digitization level in smart logistics and the level of resource utilization and energy use efficiency in green logistics are the short boards restricting the coordinated development of smart and green logistics, and the coordinating role between the subsystems needs to be strengthened.

**Keywords:** Smart logistics, Green logistics, Entropy method, Coupled coordination.

## 1. Introduction

With the deepening development of the digital society, a series of cutting-edge technologies such as big data, cloud computing, Internet of Things and so on are being applied more and more widely, and intelligent equipment has become a solid bridge for modernization. Under the background of digitization, logistics activities, as an important force to promote economic development, are experiencing unprecedented changes, and new modes and new forms of logistics continue to emerge, injecting new vitality into the sustainable development of the logistics industry. The proposal of "dual-carbon" goal indicates that consumers are paying more and more attention to ecological and environmental protection, which puts forward higher requirements for the timeliness of product circulation and the greening of the logistics industry. China's economic development has gradually changed from focusing on the speed of development to focusing on the quality of development, and the synergistic development of "smart + green" has become an important path for the high-quality development of the logistics industry. In the process of modernization and development of the logistics industry, smart logistics can analyze and predict the data, reduce energy consumption and environmental pollution by optimizing routes and reducing the idling rate, so as to promote the development of green logistics; the environmental protection measures of green logistics can also provide more data support for the smart logistics, and force the innovation of digital technology. The synergistic development of smart logistics and green logistics plays a key role in enhancing logistics efficiency, reducing operating costs, optimizing resource allocation, reducing environmental pollution and promoting industrial development. If we only pay attention to smart logistics and ignore green logistics, it will increase resource consumption and environmental burden while high efficiency, which will hinder sustainable development in the long run; if we only pay attention to green logistics and ignore smart logistics, it may lead to inefficient transportation, rising cost, and it is difficult to meet the market demand, which will affect the competitiveness of the logistics industry and the ability of sustainable development.

In 2019, "Promoting the high-quality development of logistics and facilitating the formation of a strong domestic market" pointed out that it is necessary to further consolidate the achievements of cost reduction and efficiency increase in logistics, establish a public information platform for logistics, enhance the level of supply chain intelligence, accelerate the development of green logistics, and improve the logistics standards and norms system. 2022 "Fourteenth Five-Year Plan" Modern Logistics Development Plan pointed out that China's logistics industry exists in a large scale, the release of economies of scale is insufficient, the allocation of logistics resources is unreasonable, the factors are not fully utilized and other issues, logistics needs to be further deepened to reduce costs and increase efficiency. At the same time, environmental protection to the national strategic level, the modernization of the logistics industry to digital, networked, intelligent as a traction, logistics facilities construction and technology and equipment upgrades, green concepts throughout the development of logistics links, and enhance the logistics industry's ability to sustainable development. Chongqing is an

important transportation hub connecting the southwest region and the eastern seaboard, with a number of large-scale railroad freight stations and highway transportation hubs, which is of great significance to the development of the logistics industry. At this stage, the logistics industry in Chongqing is increasing energy consumption, carbon emissions increase year by year, the environmental pressure is increasing day by day; and the use of digital equipment will inevitably lead to energy consumption, especially for the large demand for electricity, smart logistics and green logistics part of the link there are still contradictions and conflicts. Promote the smart green development of the logistics industry, can effectively circumvent the disadvantages of its independent development, improve the efficiency of logistics operations, reduce the degree of environmental pollution, increase the competitiveness of logistics enterprises, resulting in the overall benefits of 1+1>2. Based on this, this paper takes Chongqing as the research object for empirical analysis, to explore the level of synergistic development of logistics industry "smart + green" in Chongqing, aiming to provide suggestions for the high-quality development of logistics industry in Chongqing.

# 2. Research Basis

## 2.1. Literature Review

The synergistic development of logistics industry "smart + green" is an important direction for the high-quality development of the logistics industry, there is coordination and unity, there are also contradictions and conflicts, the academic community is rich in research on smart logistics, green logistics and synergistic development of the logistics industry.

Green logistics involves logistics management, ecological environment, economy and other fields, as early as in the 1990s there are scholars on green logistics research, related research focuses on the connotation of the definition[1],the development of the problems faced[2], green logistics development level measurement[3], the development of countermeasures[4] and other aspects. Green logistics is a bridge connecting logistics supply and consumer demand, breaking the limitations of time and space, which can reduce the impact of logistics activities on the environment and provide safe, efficient and green logistics services[5]. Zhang Jun[6] constructs an index system from five aspects of input, output, resource consumption, environmental pollution and environmental protection to explore the impact of green transformation of the logistics industry on the high-quality development of the circulation industry. Zhang Pei[7] pointed out that the green logistics development process exists in the green awareness is weak, infrastructure is not perfect, the standard system is not sound, the lack of professionals and other issues. Xie Sixin[8] proposed that the development of green logistics must start from the current situation to carry out green transformation, improve the environmental awareness of consumers and enterprises, optimize the allocation of resources, and pay attention to the development of reverse logistics. Lian Jie[9] proposed that the concept of green development should be carried through the supply chain management, accelerate green technological innovation, optimize the logistics organization model.

Domestic scholars began to study smart logistics in 2009, and gradually moved towards practical application from the theoretical level, mainly focusing on the definition of concept[10], smart logistics model[11], smart logistics technology[12], smart logistics development level measurement[13], influencing factors of smart logistics development[14], and smart logistics talent training[15]. The term "smart logistics" is derived from "smart supply chain", which uses digital technology to sense the external environment, monitor the logistics process in real time, and has the ability of independent judgment, system analysis, scientific decision-making and automatic execution, so as to realize efficient operation of the logistics process[16]. Pei Pei[17] constructed the smart logistics evaluation index system from four dimensions: infrastructure construction, information system construction, security construction and talent construction. Ma Mingqing[18] studied the development level of smart logistics in 31 provinces in China and concluded that the development level of smart logistics in Chongqing is average and there is a large space for development. She also put forward suggestions on integrating digital technology into infrastructure construction, building smart logistics system and promoting multimodal transport. Lin Nan[19] pointed out that the high logistics cost is a factor restricting the progress of the logistics industry. Internet technology should be used to integrate idle labor and promote the intelligent and integrated development of crowdsourcing logistics mode.

Scholars have carried out a series of discussions on the study of the collaborative development of logistics industry. Jing Linbo[20] studied the collaboration between logistics industry and manufacturing industry, and built a coupling coordination model to evaluate the level of collaborative development. Rong Changling[21] analyzed the relationship between smart logistics and shared logistics from multiple perspectives, and studied the coupling mechanism and realization path of smart logistics and shared logistics. Cui Liang[22] calculated the coupling coordination degree of digital logistics, ecological environment governance and regional economic growth based on spatial dimension. He Liming[23] proposed that the development of smart logistics in China plays an important role in integrating social resources, concentrating and dispersing markets, meeting individual needs and creating green ecology. Zhang Xiaoyan[24] pointed out that the digital transformation of logistics can promote low-carbon development, and the green development of logistics can reduce the energy consumption of logistics enterprises, so that enterprises can obtain economic benefits. Hao Shuchi[25] pointed out that smart logistics not only promotes the high-quality development of the logistics industry, but also brings environmental pollution, and the logistics industry should take the path of smart and green development in the future. Xu Chun[26] made an empirical analysis of the element structure of the innovation and development of smart logistics, and proposed an element optimization combination strategy with "environment promotion" as its connotation and "science and technology support" as its driving force.

In summary, the essence of smart logistics is to use new generation information technology to promote the intelligent development of logistics system, improve logistics efficiency and reduce logistics costs. Green logistics is to reduce the impact on the environment in the logistics process, solve the problem of negative externalities, and pursue the coordinated development of economy and ecology. Therefore, the logistics industry "smart + green" synergy is defined as: the full integration of smart logistics intelligence and green logistics environmental protection, the combination of digital

technology and intelligent machinery and equipment, breaking down the information barriers, and promote the logistics industry links to collaborate with each other to reduce the impact of logistics activities on the ecological environment, and the pursuit of the three benefits of the economy, society and the environment. Maximization of economic, social and environmental benefits. At present, academic research on smart logistics and green logistics has achieved certain results, but there are still some limitations. Scholars mostly from the smart of logistics or green logistics one-sided research, on the synergistic development of the logistics industry, most of the existing research is mainly qualitative analysis, empirical research is less, and more synergistic theories applied in the logistics and economic synergy, the logistics industry and the manufacturing industry synergies, smart logistics and shared logistics synergies, the lack of the logistics industry, "smart + Green "There is a lack of systematic research on the synergistic development of the logistics industry. For this reason, further in-depth research is needed on how to strengthen the level of synergy between smart logistics and green logistics, improve the efficiency of logistics enterprises and reduce environmental pollution.

## 2.2. Collaborative Elements of Smart Logistics and Green Logistics

(1) Environmental synergy

Environmental synergy plays an important role in the synergistic development of "smart + green" logistics industry. The environment mainly includes national policy, information technology, logistics market environment, social demand, infrastructure construction and other aspects. The development of smart logistics and green logistics is an important direction for the development of the logistics industry. The government provides tax incentives or subsidies for enterprises adopting smart technologies, and penalizes logistics enterprises with high carbon emissions, which helps to promote the intelligent transformation of enterprises, improve efficiency, reduce pollution and take the road of sustainable development.

(2) Subject synergy

In the field of logistics, the synergistic development of smart logistics and green logistics requires the joint participation of subjects upstream and downstream of the supply chain. Suppliers, manufacturers, distributors and final consumers are not and or lack of role in the supply chain, to complete the whole process from raw material procurement to product sales. Only through the cooperation of the main bodies can we realize resource sharing, cost reduction and efficiency, complement each other's strengths, better meet customer demand, and promote the healthy development of the whole supply chain.

(3) Content synergy

The synergy between smart logistics and green logistics mainly includes three aspects: information synergy, business process synergy and benefit synergy. Firstly, information sharing between various links of logistics activities helps to break the information gap, improve market response speed, and realize a higher level of service quality and customer satisfaction. Second, the flow of goods involves the whole process of the supply chain, and the seamless synergistic operation and joint development strategy among all links can help optimize the process and resource allocation, improve the efficiency of logistics and reduce costs. Third, the development of smart logistics and green logistics requires a large amount of capital investment, and in terms of benefit distribution, it should follow the principles of science, fairness and reasonableness, and establish a capital distribution mechanism to ensure the synergy of interests of all parties.

## 2.3. Synergistic Development Motivation of Smart Logistics and Green Logistics

With the development of the times, the scale of China's logistics is growing, the development of the logistics industry from the rough to lean transformation, and gradually formed a perfect modern logistics system, the guidance of national policy, the development of science and technology, innovation, consumer demand for diversification, green ecological environmental constraints, and many other factors to promote the logistics industry to take the "smart + green "synergistic development road.

(1) National policy is to lead the logistics industry "smart + green" synergistic development of the wind vane. In order to improve the quality of economic development, promote the quality and efficiency of logistics enterprises, and reduce the impact of logistics activities on the ecological environment, China's government departments have actively formulated and implemented relevant policies to guide the logistics industry in the direction of intelligence and greening.The document "Promoting the high-quality development of logistics and facilitating the formation of a strong domestic market" in 2019 emphasizes the importance of solving the problem of imbalance and insufficiency in the development of logistics, pointing out that it is necessary to further consolidate the achievements of logistics cost reduction and efficiency, establish a logistics public information platform, realize resource sharing, and develop a green supply chain.

(2) Information technology innovation promotes the formation of a "smart + green" synergistic development mode in the logistics industry. Big data, artificial intelligence, Internet of Things and other technologies continue to progress, providing support for the synergistic development of smart logistics and green logistics; unmanned vehicle distribution, logistics robots, automatic sorting systems and other equipment are widely used in the logistics industry, promoting the transformation and upgrading of the logistics industry, enhancing the value chain, improving the efficiency of resource utilization and reducing environmental pollution.

(3) Diversified consumer demands have driven the logistics industry to "smart + green" synergistic transformation. Better consumer experience is the key to maintain customer loyalty of logistics enterprises, diversified needs to promote the transformation of the logistics industry driving force, the logistics industry continues to market segmentation, began to refine management, expand the depth and breadth of services, in order to meet consumer demand.

(4) Ecological constraints drive the logistics industry to take the "smart + green" sustainable development path. In order to realize the "double carbon" goal, logistics companies need to follow the trend of the times, adjust the development strategy, from the traditional high emissions, high pollution to low energy consumption, high energy efficiency, and the construction of intelligent green logistics system. Energy is an important medium for the development of the logistics industry, only the close combination of intelligent technology and green energy, deep development, in order to promote the optimization and upgrading of industrial structure, the formation of environmentally friendly development.

## 2.4. Synergistic Effect of Smart Logistics and Green Logistics

(1) Economic effect

The synergistic development of "smart + green" logistics industry helps to maximize economic benefits. The development of smart logistics ensures the visualization and transparency of logistics activities, promotes the collection and analysis of basic information in the flow of goods, facilitates the formulation of reasonable plans, realizes the precise scheduling of products, and improves the efficiency of logistics operations and capital turnover; the development of reverse logistics realizes the recycling of resources, and effectively increases the income of logistics. In addition, for problematic links, digital technology can be used to achieve tracking and tracing, repair loopholes, minimize economic losses, logistics industry "smart + green" synergistic development can improve logistics efficiency and reduce logistics costs, improve the profitability of the entire supply chain.

(2) Social effect

The synergistic development of smart logistics and green logistics can improve urban traffic congestion, reduce the incidence of traffic accidents and improve the quality of life of residents. When smart logistics is applied to smart transportation route planning, the use of intelligent algorithms in the logistics scheduling center to coordinate the planning of logistics resources, arrange the optimal transportation routes, and use new energy vehicles to transport goods can improve transportation efficiency, reduce the idling rate, and reduce carbon emissions. Smart logistics and green logistics synergy combines intelligent technology with the concept of green environmental protection, realizing the efficient, safe, environmentally friendly and sustainable development of logistics operations, which is conducive to improving the social image of enterprises and enhancing their market competitiveness.

(3) Environmental effect

The synergistic development of smart logistics and green logistics can reduce the waste of resources, improve the quality of the ecological environment, enhance the environmental awareness of enterprises and the public, and play an important role in promoting green production, green consumption and green circulation, and promoting the development of green economy. The use of intelligent technology to carry out comprehensive and accurate monitoring and management of the logistics process can identify and solve environmental problems in a timely manner and reduce the adverse impact on the environment.

# 3. Indicator System and Synergistic Development Model Construction

## 3.1. Evaluation Index System for Synergistic Development of Smart Logistics and Green Logistics

When constructing the evaluation index system of "smart + green" synergistic development of the logistics industry, after combing through the relevant literature of scholars at home and abroad, we selected the indexes that are used more frequently, and then according to the availability of the index data and the characteristics of the development of smart logistics and green logistics, we added a new sub-system of smart technology in the smart logistics, and added a new sub-system of pollution emission level in the green logistics. Based on the availability of indicator data and the characteristics of the development of smart logistics and green logistics, a new smart technology subsystem is added to smart logistics, and a new pollution emission level subsystem is added to green logistics. For the comprehensive evaluation of smart logistics, 20 secondary indicators are selected from the seven dimensions of infrastructure, development scale, business activities, transportation capacity, digitization level, smart technology and logistics talents. The comprehensive evaluation of green logistics unfolds from the five dimensions of resource utilization level, energy use efficiency, pollution emission level, green support efforts, ecological and environmental benefits, and 19 secondary indicators are selected, and the specific indicator information is shown in Table 1. The data of the indicators for 2010-2022 are mainly from National Statistical Yearbook, Chongqing Statistical Yearbook, Logistics Yearbook, China Energy Statistical Yearbook, Chongqing Municipal Commission of Economy and Information, Ministry of Industry and Information Technology, People's Daily, and Prospect Industry Research Institute, and the mean value method is used to fill in individual missing data.

## 3.2. Evaluation Method

(1) Data standardization

The data of forward indicators and reverse indicators were processed by the method of standardization of polar deviation.

Forward indicators:

$$E_{ij} = \frac{e_{ij} - \min e_{ij}}{\max e_{ij} - \min e_{ij}} \quad (1)$$

Reverse indicators:

$$E_{ij} = \frac{\max e_{ij} - e_{ij}}{\max e_{ij} - \min e_{ij}} \quad (2)$$

(2) Determination of indicator weights

The entropy weight method is used to calculate the index weights, because the entropy value method in the operation of the information is necessary to select the natural logarithm, so the first need to standardized values after the translation processing.

Second, calculate the proportion of indicators:

$$P_{ij} = \frac{z_{ij}}{\sum_{i=1}^{m} z_{ij}} \quad (3)$$

**Table 1.** Smart logistics and green logistics evaluation indicator system

| System | Primary index | Secondary index | Index type | Indicators | Weight |
|---|---|---|---|---|---|
| **Smart logistics A** | Infrastructure $A_1$ | Miles of road routes (kilometers) | Positive indicator | $A_{11}$ | 0.054 |
| | | Railroad mileage in operation (kilometers) | Positive indicator | $A_{12}$ | 0.049 |
| | Scale of development $A_2$ | Number of trucks in operation (vehicles) | Positive indicator | $A_{21}$ | 0.017 |
| | | Civilian ship ownership (ships) | Positive indicator | $A_{21}$ | 0.052 |
| | | Number of smart logistics enterprises (units) | Positive indicator | $A_{23}$ | 0.058 |
| | Operating activities $A_3$ | Investment in fixed assets in the logistics industry (billions of dollars) | Positive indicator | $A_{31}$ | 0.037 |
| | | Number of logistics express (million) | Positive indicator | $A_{32}$ | 0.066 |
| | | E-commerce sales of logistics companies (billion yuan) | Positive indicator | $A_{33}$ | 0.075 |
| | | Value added of the logistics industry (billions of dollars) | Positive indicator | $A_{34}$ | 0.030 |
| | Transportation capacity $A_4$ | Intensity of logistics transport (tons of kilometers/billion dollars) | Positive indicator | $A_{41}$ | 0.050 |
| | | Freight capacity (tons) | Positive indicator | $A_{42}$ | 0.037 |
| | | Hub capacity (tons) | Positive indicator | $A_{43}$ | 0.028 |
| | Digitization level $A_5$ | Internet penetration (%) | Positive indicator | $A_{51}$ | 0.028 |
| | | Revenue from software operations (billions of dollars) | Positive indicator | $A_{52}$ | 0.040 |
| | Smart technology $A_6$ | Intelligent courier locker market size (10,000 sets) | Positive indicator | $A_{61}$ | 0.146 |
| | | Industrial robotics market size (Units) | Positive indicator | $A_{62}$ | 0.032 |
| | | Number of China-European trains (columns) | Positive indicator | $A_{63}$ | 0.087 |
| | Logistics talent $A_7$ | Number of people with tertiary education or above in the logistics industry (persons) | Positive indicator | $A_{71}$ | 0.031 |
| | | Number of logistics employees (10,000) | Positive indicator | $A_{72}$ | 0.023 |
| | | Number of logistics patents granted (pieces) | Positive indicator | $A_{73}$ | 0.059 |
| **Green logistics B** | Level of resource utilization $B_1$ | Land for logistics and warehousing as a percentage of urban construction land area (%) | Positive indicator | $B_{11}$ | 0.034 |
| | | Container utilization rate (%) | Positive indicator | $B_{12}$ | 0.045 |
| | | Proportion of sea-rail transportation (%) | Positive indicator | $B_{13}$ | 0.077 |
| | Energy efficiency $B_2$ | Energy intensity of the logistics industry (tons of standard coal/billion dollars) | Inverse indicator | $B_{21}$ | 0.096 |
| | | Electricity consumption per unit of GDP in the logistics sector (billion kilowatt hours/billion dollars) | Inverse indicator | $B_{22}$ | 0.055 |
| | Pollution emission level $B_3$ | Carbon emission intensity of the logistics industry (tons/billion yuan) | Inverse indicator | $B_{31}$ | 0.102 |
| | | Carbon emissions per unit of transport vehicle (tons/vehicle) | Inverse indicator | $B_{32}$ | 0.056 |
| | | Carbon emissions per unit transport route length (tons/km) | Inverse indicator | $B_{33}$ | 0.044 |
| | | $SO_2$ emissions (tons) | Inverse indicator | $B_{34}$ | 0.039 |
| | Green support strength $B_4$ | Investment in environmental protection (billions of dollars) | Positive indicator | $B_{41}$ | 0.104 |
| | | Investment in environmental pollution control as a share of GDP (%) | Positive indicator | $B_{42}$ | 0.045 |
| | | Level of green technological innovation in the logistics industry (RMB 10,000/million tons of standard coal) | Positive indicator | $B_{43}$ | 0.040 |
| | Ecological environmental benefits $B_5$ | Wastewater discharge (tons) | Positive indicator | $B_{51}$ | 0.046 |
| | | Integrated solid waste utilization rate (%) | Positive indicator | $B_{52}$ | 0.034 |
| | | Harmless treatment rate of domestic waste (%) | Positive indicator | $B_{53}$ | 0.017 |
| | | Centralized treatment rate of sewage treatment plants (%) | Positive indicator | $B_{54}$ | 0.034 |
| | | Urban road traffic noise level (dB) | Positive indicator | $B_{55}$ | 0.062 |
| | | Greening coverage (%) | Positive indicator | $B_{56}$ | 0.049 |
| | | Proportion of good ambient air quality in the city (%) | Positive indicator | $B_{57}$ | 0.020 |

Then, the entropy value of each indicator is calculated:

$$Q_{ij} = -\frac{1}{\ln(m)}\sum_{i=1}^{m} P_{ij} \ln P_{ij} \quad (4)$$

Finally, calculate the index weight:

$$W_j = \frac{1-Q_{ij}}{\sum_{j=1}^{n}(1-Q_{ij})} \quad (5)$$

(3) Calculate the combined score for each system

$$F = \sum_{j=1}^{n} W_{ij} E(e_{ij}) \quad (6)$$

$$\sum_{j}^{n} W_{ij} = 1 \quad (7)$$

## 3.3. Coupled Coordination Degree Model

(1) Measurement of coupling degree

Coupling refers to the development phenomenon that two or more systems influence each other, reflecting the dynamic relationship between systems that are interrelated and coordinated, constructing the coupling degree model of smart logistics and green logistics as follows.

$$C = \left[ \frac{F_A * F_B}{\left(\frac{F_A + F_B}{2}\right)^2} \right]^{\frac{1}{2}} \quad (8)$$

Where C indicates the degree of coupling development between smart logistics and green logistics, and the range of C is [0,1]. the larger the value of C, the closer the relationship between the two, the higher the degree of synergistic development; on the contrary, the lower the degree of synergism, indicating that the system is in a disordered state of development. The coupling degree level judging criteria are shown in Table 2.

**Table 2.** smart logistics and green logistics coupling degree classification criteria

| Cooperation degree | Types and stages of synergies | Development characteristics |
|---|---|---|
| **C=0** | No synergy, nascent stage | Disorganized development of systems with no obvious synergies |
| **0<C≤0.3** | Low synergy, growth stage | Low level of development of systems with fewer synergies |
| **0.3<C≤0.7** | Medium synergy, early stage of development | The systems are meshing with each other and are beginning to develop healthy synergies |
| **0.7<C<1** | Highly synergistic, mid to late development stage | Symbiosis and high level of synergy among systems |
| **C=1** | Benign resonance, the ideal state of development | Subsystems, system-wide healthy and orderly development |

(2) Measurement of coupling coordination

The coupling degree of smart logistics and green logistics system can only represent the degree of mutual influence in the development of the two, and it is difficult to reflect the synergistic effect of their linkage. When the comprehensive development level of the two systems are in a low level state, it will produce the pseudo result of false high coupling degree, so the coupling coordination degree is used to further judge the coordinated development level of the elements within the subsystem. The coupling coordination model is as follows:

$$D = \sqrt{C * T} \quad (9)$$

$$T = \alpha F_A + \beta F_B \quad (10)$$

Among them, the coupling coordination degree D indicates the coordinated development level of smart logistics and green logistics at a certain moment, and the range of D is [0,1], the closer the value of D is to 1, the higher the degree of synergistic development of smart logistics system and green logistics is. t indicates the comprehensive development index of smart logistics and green logistics; α and β are coefficients to be determined, which indicate the importance of the smart logistics system and the green logistics system respectively, and this paper considers that the smart logistics system and green logistics have the same level of importance. logistics system and green logistics have the same degree of importance, from which the values of α and β are set to be 0.5. The coupling coordination degree evaluation criteria are divided into standards as shown in Table 3[27].

**Table 3.** Smart logistics and green logistics coupling and coordination degree classification criteria

| Coordination degree of coordinated development | categorization | Level of coordination | Degree of coordination |
|---|---|---|---|
| **0≤D<0.1** | Dysfunctional recessionary | 1 | extreme disorder |
| **0.1≤D<0.2** | | 2 | severe disorder |
| **0.2≤D<0.3** | | 3 | moderate disorder |
| **0.3≤D<0.4** | | 4 | mild disorder |
| **0.4≤D<0.5** | Harmonized Transitional | 5 | on the verge of becoming dysfunctional |
| **0.5≤D<0.6** | | 6 | sue for harmonization |
| **0.6≤D<0.7** | Harmonized developmental | 7 | Primary coordination |
| **0.7≤D<0.8** | | 8 | Intermediate level coordination |
| **0.8≤D<0.9** | | 9 | good coordination |
| **0.9≤D<1** | | 10 | Quality coordination |

# 4. Empirical Analysis of "Smart + Green" Synergistic Development of Logistics Industry in Chongqing

## 4.1. Comprehensive Development Level of Smart Logistics and Green Logistics in Chongqing

According to the evaluation method described, the comprehensive development level of smart logistics and green logistics and their sub-systems in Chongqing is calculated, as shown in Table 4, and the trend chart of the comprehensive development level of smart logistics and green logistics systems is drawn (Figure 1). Overall, from 2010 to 2022, the development levels of smart logistics and green logistics and their sub-systems in Chongqing have

shown a steady upward trend, and the development trend is good. With the passage of time, the gap between the development level of the smart logistics system and the green logistics system has gradually narrowed, and the development of green logistics has gradually changed from being ahead of its time to a synergistic development of the two. Staged view, during 2010-2015, the development level of green logistics is higher than the development level of green logistics, and the gap between the two is larger, mainly due to the earlier development of green logistics, while the smart logistics has just started and is in the early stage of development. 2016-2019, the development level of smart logistics is higher than the development level of green logistics, depending on the Internet of Things, big data, artificial intelligence and other logistics technology gradually maturity, as well as a series of policies and measures introduced by the state, after a period of development and implementation, the development of smart logistics has achieved significant results. 2020-2022, the development level of smart logistics and green logistics is gradually equalized, and the gap is small.

**Table 4.** Comprehensive development level of smart logistics and green logistics and its subsystems in Chongqing

| Particular year | Smart logistics | | | | | | | Green logistics | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | $A_6$ | $A_7$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ | $B_5$ |
| **2010** | 0.000 | 0.062 | 0.000 | 0.030 | 0.000 | 0.000 | 0.000 | 0.022 | 0.060 | 0.093 | 0.045 | 0.084 |
| **2011** | 0.001 | 0.047 | 0.006 | 0.060 | 0.005 | 0.003 | 0.008 | 0.008 | 0.083 | 0.095 | 0.045 | 0.093 |
| **2012** | 0.005 | 0.048 | 0.014 | 0.062 | 0.012 | 0.011 | 0.014 | 0.028 | 0.053 | 0.057 | 0.037 | 0.129 |
| **2013** | 0.007 | 0.045 | 0.027 | 0.010 | 0.017 | 0.018 | 0.025 | 0.023 | 0.044 | 0.038 | 0.046 | 0.109 |
| **2014** | 0.022 | 0.047 | 0.038 | 0.032 | 0.021 | 0.022 | 0.038 | 0.051 | 0.065 | 0.102 | 0.040 | 0.117 |
| **2015** | 0.037 | 0.053 | 0.052 | 0.034 | 0.026 | 0.019 | 0.047 | 0.055 | 0.040 | 0.036 | 0.056 | 0.110 |
| **2016** | 0.050 | 0.057 | 0.069 | 0.045 | 0.032 | 0.023 | 0.059 | 0.073 | 0.039 | 0.028 | 0.043 | 0.107 |
| **2017** | 0.058 | 0.052 | 0.077 | 0.069 | 0.037 | 0.037 | 0.076 | 0.090 | 0.024 | 0.037 | 0.068 | 0.128 |
| **2018** | 0.066 | 0.049 | 0.095 | 0.076 | 0.041 | 0.074 | 0.084 | 0.064 | 0.048 | 0.119 | 0.055 | 0.111 |
| **2019** | 0.080 | 0.051 | 0.105 | 0.052 | 0.048 | 0.102 | 0.095 | 0.080 | 0.055 | 0.129 | 0.103 | 0.144 |
| **2020** | 0.085 | 0.053 | 0.128 | 0.057 | 0.054 | 0.108 | 0.100 | 0.053 | 0.063 | 0.166 | 0.116 | 0.219 |
| **2021** | 0.088 | 0.060 | 0.155 | 0.065 | 0.063 | 0.183 | 0.107 | 0.072 | 0.084 | 0.190 | 0.123 | 0.219 |
| **2022** | 0.103 | 0.069 | 0.208 | 0.062 | 0.069 | 0.265 | 0.111 | 0.146 | 0.096 | 0.195 | 0.154 | 0.236 |

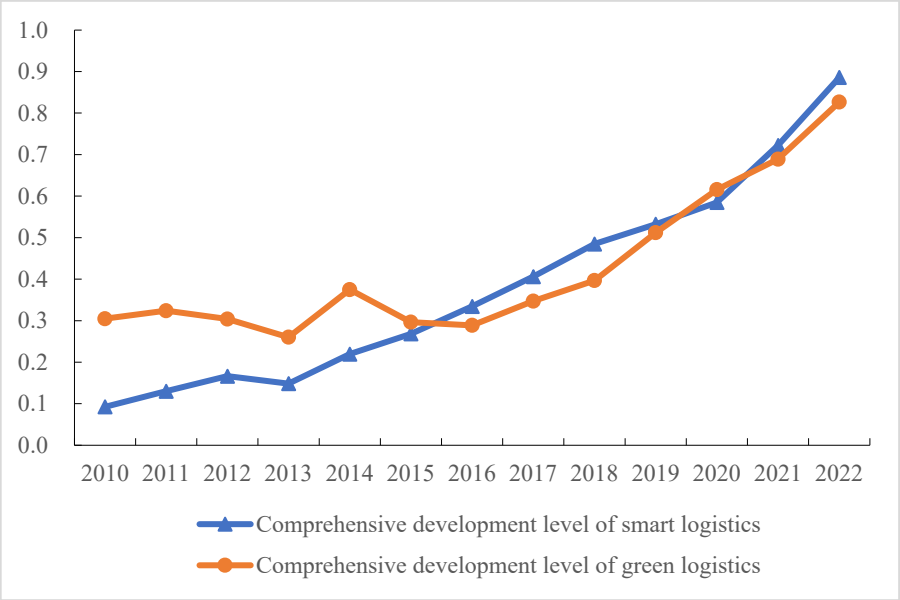


**Figure 1.** Comprehensive development level of smart logistics and green logistics system in Chongqing

## 4.2. Degree of Coupling and Coordination between Smart Logistics and Green Logistics in Chongqing

(1) Overall analysis

The coupling degree and coupling coordination degree of smart logistics and green logistics in Chongqing are calculated according to the coupling coordination degree model, as shown in Table 5. Overall, the value of the coupling degree of smart logistics and green logistics in Chongqing from 2010 to 2022 is greater than 0.8, and the two systems are closely connected and in a state of efficient synergy. The coupling and coordination degree of the two systems rises year by year, maintaining an average annual growth rate of 7%, and the synergistic development trend is good, from on the verge of dysfunction through mutual friction to reach the state of high-quality coordination. In terms of phases, the coupling coordination degree of smart logistics and green logistics in Chongqing was on the verge of dysfunction in 2010-2013, barely coordinated in 2014-2016, and experienced the primary coordination stage, intermediate coordination stage, and good coordination stage successively in 2017-2021, and the two synergistic development goals were gradually strengthened, and reached the state of high-quality coordination in 2022. The coordinating roles of the smart logistics system and the green logistics system have been continuously strengthened, and despite the fact that the coordination level of the two is at the level of high-quality coordination, it is still necessary for all parties to continue their efforts in order to realize the high-quality development

of the logistics industry.

**Table 5.** The state of smart logistics and green logistics coupling and coordination in Chongqing

| Particular year | Coupling C | Composite development index T | Degree of coupling coordination D | Level of coordination | Degree of coordination |
|---|---|---|---|---|---|
| **2010** | 0.845 | 0.199 | 0.410 | 5 | on the verge of becoming dysfunctional |
| **2011** | 0.904 | 0.227 | 0.453 | 5 | on the verge of becoming dysfunctional |
| **2012** | 0.956 | 0.235 | 0.474 | 5 | on the verge of becoming dysfunctional |
| **2013** | 0.962 | 0.204 | 0.443 | 5 | on the verge of becoming dysfunctional |
| **2014** | 0.965 | 0.297 | 0.536 | 6 | sue for harmonization |
| **2015** | 0.999 | 0.282 | 0.531 | 6 | sue for harmonization |
| **2016** | 0.997 | 0.312 | 0.557 | 6 | sue for harmonization |
| **2017** | 0.997 | 0.377 | 0.613 | 7 | Primary coordination |
| **2018** | 0.995 | 0.441 | 0.662 | 7 | Primary coordination |
| **2019** | 1.000 | 0.522 | 0.723 | 8 | Intermediate level coordination |
| **2020** | 1.000 | 0.600 | 0.775 | 8 | Intermediate level coordination |
| **2021** | 1.000 | 0.706 | 0.840 | 9 | good coordination |
| **2022** | 0.999 | 0.856 | 0.925 | 10 | Quality coordination |

(2) Subsystem cross analysis

According to formula (8), calculate the coupling degree of the comprehensive development level of each subsystem of smart logistics and green logistics (Figure 2), and the coupling degree of the comprehensive development level of each subsystem of green logistics and smart logistics (Figure 3). Since the change rule of the coupling degree of smart logistics and green logistics tends to be stable in 2018-2022, and the time is closer to the current stage, which has a greater reference value, only the data of the last five years are shown. Figure 2 shows that the coupling degree of smart logistics and green logistics subsystems is between 0.5 and 0.9. Among them, the mean values of smart logistics and pollution emission level, green support strength and ecological and environmental benefits are 0.80, 0.70 and 0.83 respectively, and the whole is in the range of 0.7-0.9. These three subsystems are highly synergistic with smart logistics, and they can drive the efficient development of smart logistics along with self-development. The average value of the coupling degree between smart logistics and resource utilization level subsystem and energy efficiency subsystem is 0.63, 0.59, the whole is in the range of 0.5-0.7, in the early stage of synergistic mutual friction between the elements, resource utilization level and energy efficiency have not yet played a full role in promoting the development of smart logistics development. Figure 3 shows that the coupling degree of green logistics with business activities and smart technology is greater than 0.7, showing an upward trend, promoting each other, and the synergistic development is in a good state. Green logistics and infrastructure and logistics talent coupling degree between 0.6-0.8, the overall downward trend, but the average value of 0.66 and 0.69. Currently in the early stage of synergistic, but green logistics and infrastructure, logistics talent, the promotion of the two weaker, if the continued decline will constrain the development of green logistics, should be further strengthened the greening of the logistics infrastructure, to improve the people's attention to green environmental protection. should further strengthen the greening of logistics infrastructure and increase people's attention to green environmental protection. The coupling degree between green logistics and the scale of development, transportation capacity and digitization level is mostly located around 0.55, which is in a relatively stable state, and the synergy between green logistics and this subsystem needs to be further strengthened.

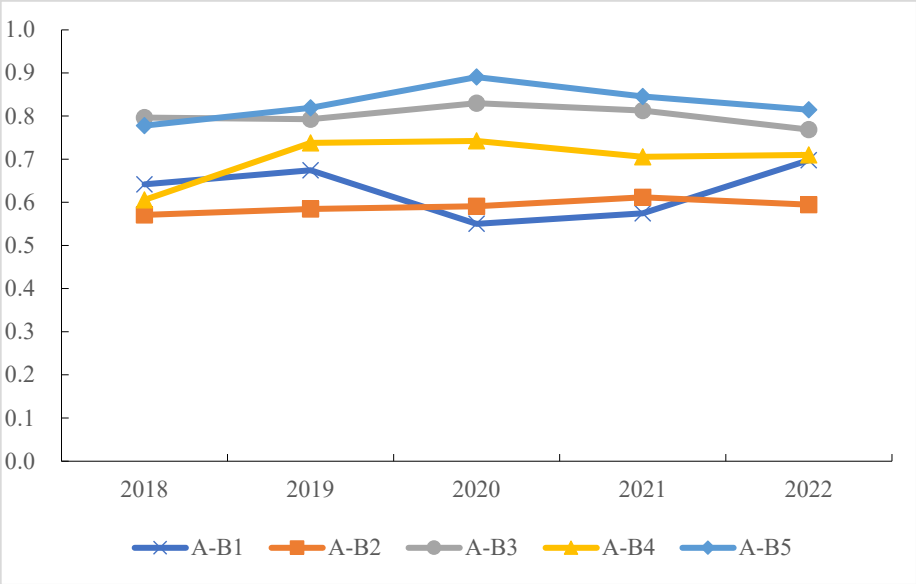


**Figure 2.** Trend of coupling degree between smart logistics and green logistics subsystems

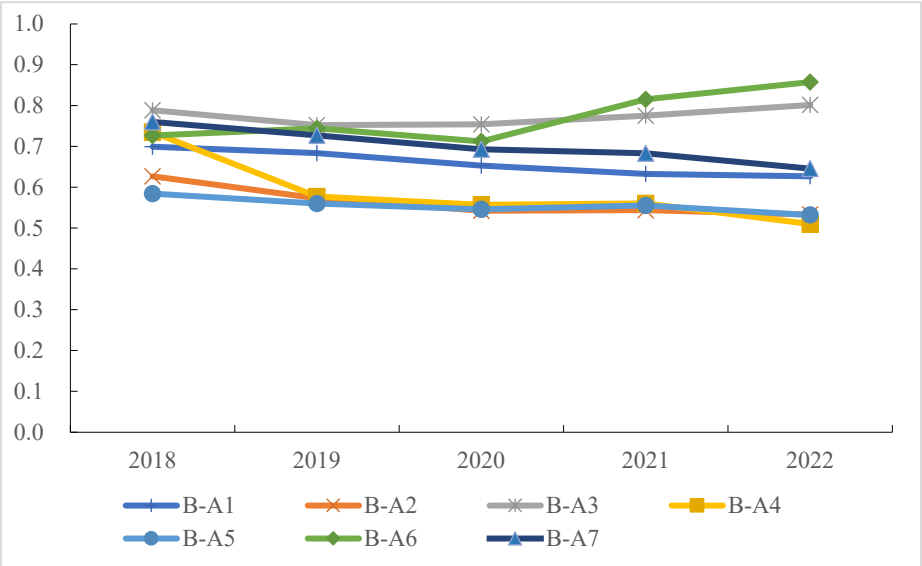


**Figure 3.** Trend of coupling degree between green logistics and smart logistics subsystems

According to the coupling coordination degree formula (9)(10), the coupling coordination degree of cross-matching between smart logistics and green logistics and each other's sub-systems is calculated respectively, and the calculation results are shown in Table 6.The coupling coordination degree of cross-matching between smart logistics and green logistics and each other's sub-systems shows an upward trend in the period of 2010-2022, which exhibits a benign synergistic development trend. Observing the coupling coordination degree in the past 13 years, it is found that the coupling coordination degree between the subsystems reaches the highest in 2022, and most of the indicators are in the stage of primary coupling coordination, and there is a large space for progress in the mutual coordination role of smart logistics and green logistics with each other's subsystems. Among them, the coupling coordination degree of smart logistics and resource utilization level, pollution emission level, green support strength and ecological and environmental benefits are all in the coupling coordination degree between 0.6-0.7, belonging to the primary coupling coordination stage. The coupling coordination degree of green logistics and smart technology reaches up to 0.684, and smart logistics and energy use efficiency are in the barely coordinated stage. The coupling and coordination degree of smart logistics subsystems and green logistics varies greatly, and the coupling and coordination degree of green logistics and business activities and smart technology are in the primary coupling and coordination stage, and these two smart logistics subsystems have a good promotion effect on the development of green logistics; while green logistics and infrastructure and logistics talents are only in the barely coordinated stage, and green logistics and the scale of development, transportation capacity, and the level of digitization are at the stage of near-disorder, and the coordination effect on the comprehensive development level of green logistics is weak.

**Table 6.** Degree of coupling coordination of smart logistics and green logistics with each other's subsystem cross-matching in Chongqing

| Particular year | Smart logistics A | | | | | Green logistics B | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $AB_1$ | $AB_2$ | $AB_3$ | $AB_4$ | $AB_5$ | $BA_1$ | $BA_2$ | $BA_3$ | $BA_4$ | $BA_5$ | $BA_6$ | $BA_7$ |
| **2010** | 0.212 | 0.273 | 0.305 | 0.254 | 0.297 | 0.101 | 0.371 | 0.000 | 0.310 | 0.000 | 0.000 | 0.000 |
| **2011** | 0.182 | 0.322 | 0.333 | 0.276 | 0.332 | 0.142 | 0.351 | 0.206 | 0.374 | 0.202 | 0.181 | 0.224 |
| **2012** | 0.260 | 0.307 | 0.313 | 0.281 | 0.382 | 0.200 | 0.348 | 0.257 | 0.371 | 0.244 | 0.240 | 0.254 |
| **2013** | 0.243 | 0.284 | 0.274 | 0.287 | 0.357 | 0.206 | 0.330 | 0.290 | 0.224 | 0.257 | 0.261 | 0.284 |
| **2014** | 0.325 | 0.346 | 0.387 | 0.306 | 0.401 | 0.300 | 0.364 | 0.345 | 0.332 | 0.298 | 0.300 | 0.346 |
| **2015** | 0.349 | 0.321 | 0.313 | 0.350 | 0.415 | 0.324 | 0.355 | 0.352 | 0.317 | 0.296 | 0.273 | 0.344 |
| **2016** | 0.395 | 0.337 | 0.310 | 0.346 | 0.434 | 0.346 | 0.358 | 0.375 | 0.338 | 0.310 | 0.285 | 0.361 |
| **2017** | 0.437 | 0.314 | 0.350 | 0.407 | 0.478 | 0.377 | 0.367 | 0.404 | 0.393 | 0.336 | 0.337 | 0.403 |
| **2018** | 0.420 | 0.390 | 0.490 | 0.404 | 0.481 | 0.402 | 0.374 | 0.440 | 0.417 | 0.358 | 0.413 | 0.428 |
| **2019** | 0.454 | 0.414 | 0.512 | 0.484 | 0.526 | 0.450 | 0.401 | 0.482 | 0.403 | 0.396 | 0.478 | 0.470 |
| **2020** | 0.419 | 0.437 | 0.558 | 0.510 | 0.598 | 0.478 | 0.426 | 0.529 | 0.433 | 0.428 | 0.508 | 0.498 |
| **2021** | 0.478 | 0.497 | 0.609 | 0.546 | 0.631 | 0.496 | 0.451 | 0.572 | 0.460 | 0.457 | 0.596 | 0.522 |
| **2022** | 0.600 | 0.540 | 0.644 | 0.608 | 0.676 | 0.540 | 0.489 | 0.644 | 0.476 | 0.488 | 0.684 | 0.550 |

# 5. Conclusions of the Study and Recommendations for Countermeasures

## 5.1. Conclusions of the Study

Based on the theory of composite system, this paper constructs the evaluation index system of "smart + green" synergistic development of logistics industry, analyzes the development level of smart logistics and green logistics and the level of coupling coordination of Chongqing through entropy weight method and coupling coordination model, and draws the following conclusions:

(1) Driven by multiple factors. The development level of the subsystems of smart logistics and green logistics in

Chongqing is not the same, but the development level is on an upward trend, and the comprehensive development level of the two has been gradually improved, and has experienced the stage of leading development of green logistics, equal level of development of the two, leading development of smart logistics, and equal level of good level, and has now shifted to the period of high-quality development, which has fully reflected the promotion of synergistic development of the system by various factors in different phases. . The indicators such as the market scale of smart express cabinets, the number of China-European liner trains, the e-commerce sales of logistics enterprises, the number of expresses in the logistics industry, the investment in environmental protection, the intensity of carbon emissions in the logistics industry, the intensity of energy consumption in the logistics industry, and the proportion of sea-railway transportation carry a larger weight, which indicates that these indicators are the key indicators affecting the level of development of the smart logistics and green logistics, and that they have a stronger promotional effect on the enhancement of the level of development of the logistics industry.

(2) From 2010 to 2022, the coupling and coordination degree of smart logistics and green logistics rises year by year, with a good development trend, and the elements are gradually upgraded from on the verge of being out of tune to a state of high-quality coordination after mutual friction. In the past thirteen years, the coupling and coordination degree between smart logistics and green logistics in Chongqing has changed significantly, fully reflecting the increasing importance of the state of the digital economy and green ecology, the introduction of relevant government policies to promote the development of the logistics industry, so that the logistics industry from the scale of development of sloppy growth to the quality of intensive growth to improve the transformation. "smart + green" synergistic development mode has become the industry development trend, but there are still conflicts between the improvement of efficiency and green environmental protection, and the promotion of intelligent and green development of the logistics industry requires the joint efforts of all parties.

(3) In 2018-2022, the coupling degree of resource utilization level, energy use efficiency and smart logistics is between 0.5-0.7, which belongs to medium synergy, slightly lower than the coupling degree of other subsystems of green logistics and smart logistics, while the coupling and coordination degree of various subsystems of green logistics and smart logistics is in the reluctant coordination and primary coordination, and the promotion effect of resource utilization level and energy use efficiency on smart logistics is relatively weak, with a relatively weak effect. The promotion effect of resource utilization level and energy use efficiency on smart logistics is relatively weak, with greater development potential. The coupling degree of development scale, transportation capacity, digitization level and green logistics are all located around 0.55, belonging to the benign coordination stage. At the same time, the coupling degree of coordination between the three and green logistics is on the verge of being out of order, and the whole is lower than the coupling and coordination level between other sub-systems of smart logistics and green logistics, and the scale of development, transportation capacity, and digitization level are relatively weak in the promotion of the development of green logistics, and there is a large space for improvement.

## 5.2. Recommendations for Countermeasures

(1) Strengthen infrastructure construction and improve the logistics network system. The coordinated development of the logistics industry not only needs to develop key influencing factors, but also pay more attention to the development of short boards, and the balanced development of all parties is more conducive to the promotion of sustainable development of logistics. Chongqing development scale, transportation capacity and other aspects of the relatively low level of development, restricting the synergistic development of smart logistics and green logistics, sound infrastructure and improve the logistics network is crucial to the development of the logistics industry. First of all, the government should appropriately increase the investment in transportation, enhance the carrying capacity of trunk highways, rationally layout the transportation network, strengthen the links and exchanges between places, realize the efficient flow of factors of production, promote the effective allocation of resource factors, and promote the extension of the industrial chain and the formation of industrial clusters. Secondly, a number of logistics hubs are built in Chongqing and the surrounding areas to realize the seamless connection of land, water, railroad and air transport through multimodal transportation, forming a complete logistics and transportation network and improving the efficiency of logistics and transportation. Finally, Chongqing, as an important hub of Yangtze River inland ports, should give full play to its geographical advantages, increase investment in and construction of inland ports, increase the number of berths and throughput capacity, and improve the efficiency of port transportation; and strengthen cooperation with cities along the river to promote the integrated development of ports, and to promote the sustained and healthy development of the economy and society.

(2) Increase the support for smart logistics and promote the transformation and upgrading of enterprises. The high initial investment cost of smart logistics equipment and the difficulty of obtaining returns in the short term is the biggest obstacle to the smart upgrading and transformation of logistics enterprises. In order to promote the high-quality development of the economy, the government should encourage logistics enterprises to adopt smart logistics technology through the development of tax incentives and rewards, and the establishment of the smart green development fund. Establish smart logistics demonstration projects in some key areas or important logistics nodes to help enterprises implement smart logistics facilities construction and technological transformation, and provide guidance services to encourage other enterprises to follow suit. In addition, establish a disciplinary mechanism, implement green operation programs in practice, and penalize enterprises that pollute the environment, so as to guarantee the smart and green development of the logistics industry.

(3) Promote the construction of logistics information platforms and strengthen supply chain cooperation. The two indicators of e-commerce sales and software business income have a greater weight in the evaluation of the development level of smart logistics, indicating that information construction plays an important role in the development of the logistics industry. Logistics enterprises should break the inherent ideas of the traditional industry, build logistics information platforms, introduce advanced technologies such as artificial intelligence, Internet of Things, and big data analysis, promote supply chain information sharing and

cooperative operations, improve supply chain visualization and management efficiency, respond positively to market demand, and reduce supply risks. In addition, logistics information standards should be unified among enterprises to simplify the data exchange process and reduce the cost and risk of information transmission; strengthen inter-industry cooperation through the establishment of a mutual trust mechanism to form a logistics alliance to realize resource sharing, risk sharing and market expansion. Finally, the government should improve the policies and regulations in the sharing platform, establish a sound network security management system, protect the security of the logistics information system, prevent data leakage, and safeguard the stability of logistics operations.

(4) Create a favorable policy environment to promote the synergistic development of the logistics industry. First, the government should improve logistics policies and regulations, take environmental protection as the engine of sustainable development of the logistics industry, optimize the "dual-carbon" digital environment of the logistics industry, formulate standards and norms for smart logistics and green logistics, improve the smart and green collaborative mechanism, ensure that the level of technology and environmental protection requirements have been effectively implemented, strengthen environmental supervision, and promote the benign development of the industry. Second, enhance the understanding of "smart logistics" and "green logistics" digital environment. Secondly, we will enhance the publicity of the concept of "smart + sharing" logistics development and related policies, invite experts in the field of logistics to give lectures, promote the industry to deeply understand and grasp the important value and development trend of "smart + sharing" logistics, and formulate the development plan of smart logistics and green logistics according to the characteristics of the development of smart logistics and green logistics in Chongqing. According to the characteristics of the development of smart logistics and green logistics in Chongqing, the government can formulate synergistic strategies to improve the level of synergistic development of the two. Thirdly, the government can organize logistics enterprises, scientific research institutions and industry associations to carry out technical research, experience exchange and project cooperation on smart logistics and green logistics, so as to form a consensus and synergy, and strike a balance between economic development, environmental protection and social benefits.

(5) Expand the scale of logistics personnel and improve the quality of logistics talents. First of all, universities and scientific research institutions cooperate with logistics enterprises to promote the synergistic development of industry, academia, research and application, and to cultivate composite logistics talents. Schools improve the talent training mechanism and encourage logistics practitioners to cross-field study of information technology, environmental science, environmental protection laws and regulations, and other knowledge and skills to improve the comprehensive quality. Secondly, enterprises should formulate training programs for logistics talents, set up practice bases for smart logistics and green logistics, provide opportunities for logistics personnel to operate in the field, provide guidance on the application of smart logistics technology, and allow practitioners to accumulate experience in practice, so as to narrow the gap between school cultivation and actual demand. Finally, to address the problem of fewer logistics talents and slower growth, formulate a flexible talent introduction policy, and implement differentiated introduction policies for outstanding talents at different levels and in different fields, so as to push the industry forward.

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