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Service design of green and low-carbon intracity logistics: an AHP approach

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ABSTRACT
Climate change is the greatest global challenge faced by mankind today. With a rise in intelligent shared logistics and public awareness of environmental protection, implicit problems in intracity logistics, such as environmental pollution, resource waste, high carbon energy consumption and greenhouse gas emissions, should be solved urgently to achieve carbon neutrality. On this background, this study combines the analytic hierarchy process and gray correlation method to provide the best decision-making choice and benchmark enterprise for the green and low-carbon development of intracity logistics. In this research, the distribution business of six intracity logistics enterprises with the highest market share in China was investigated in detail. The target hierarchy standard focused on four aspects of green logistics: operation ability, infrastructure, resource utilisation and personnel factors. The four aspects are extended to 16 criteria. Supported by the survey data, this study provides a realistic reference for decision-making and a benchmark case for the low-carbon development of intracity logistics.

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Intracity logistics; enterprise management; hierarchy analysis; gray relational method

1. Introduction

Currently, the global climate and energy consumption patterns are changing at a surprising speed. Green and low-carbon production and consumption have become the key to promoting the construction of a global ecological civilisation (Chen et al. 2022b). Since the beginning of the twenty-first century, global carbon emissions have increased rapidly. From 2000 to 2019, global carbon dioxide emissions increased by 40% (QIRI 2021). According to the world energy statistics yearbook (70th Edition) released by BP Amoco, global carbon emissions have maintained sustained growth since 2013. In 2020, global carbon emissions reached 32.28 billion tons. The sharp increase in greenhouse gas emissions such as carbon dioxide in various countries have had an irreversible negative impact on the global ecosystem.

With the increasing awareness of global climate change worldwide, a series of carbon emission restrictions, such as peak carbon dioxide emissions and carbon neutrality, have been successively implemented (International Transport Forum 2019). According to the analysis report on the market prospect and investment strategic planning of China's carbon neutralisation industry issued by a

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prospective industry research institute, 44 countries and global economies have officially announced plans on carbon neutrality. Among them, the newly revised Climate Change Act of the UK came into force on June 27 in 2019. The UK became the first developed country to make it establish through legislation that it will achieve net zero greenhouse gas emissions in 2050. The 'double carbon' goal has become China's long-term national strategy (International Energy Network 2021). In recent years, Chinese government had release 1 + N documents to guide the carbon emission peak and carbon neutrality policy of China. Here, the '1' refers to the programmatic document as 'Opinions on the complete, accurate and comprehensive implementation of the new development concept to achieve carbon peak emission and carbon neutrality'. And the 'N' includes a representative document as 'Carbon Peak Action Plan by 2030'. These documents clearly clarify the strategic objectives of Chinese government on a long-term development of the energy industry and building a clean, low-carbon, safe and efficient energy system. The future development of China will emphasize energy conservation and clean energy supply, focusing on scientific and technological innovation to promote industrial optimisation and upgrading, and firmly transforming to green, low-carbon and multi-energy integration.

Among them, carbon emissions caused by transportation have always accounted for an important part. In 2018, global transportation ranked first in global greenhouse gas emissions, accounting for 23% (International Transport Forum 2019). According to the estimation of the International Transportation Forum (ITF), the carbon emissions of global transportation will increase by approximately 60% by 2050. The growth can mainly be attributed to the increase in cargo transportation and passenger transport demand in nonurban areas, the total demand is expected to increase by 225% in 2050. According to the global transportation outlook report released by ITF in 2019, from 2015 to 2050, driven by the rapid economic growth in Asia, Africa and Latin America, the global demand for cargo transportation will triple, and the carbon dioxide emissions from freight and logistics activities will remain a major challenge. In addition, according to the Global Express Delivery Development Report released in 2019 by the Development and Research Centre of the State Post Bureau of China, the volume of global express business was nearly 100 billion Renminbi yuan (short for yuan thereof) in 2018, in which Chinese express business accounted for a half. As an important branch of the express industry, intracity logistics also progresses rapidly with the accelerated pace of life and the development of internet. According to the statistics released by the State Post Bureau of the People's Republic of China, the intracity logistics business has been the fastest growing subindustry in China's logistics industry since 2005. By 2019, the cumulative business of intracity logistics reached 11.41 billion packages and 75.18 billion RMB (IResearch 2020).

In 2021, China's intra-city express business revenue reached 81.63 billion yuan, an increase of 4.99 billion yuan from 2020, a year-on-year increase of 6.50 percent (Zhu et al. 2022). Although the number of new energy vehicles continues to rise, while the fuel vehicles are still the main force of the transportation industry currently, and carbon emissions are still huge. Exploring an establishment of a low-carbon sustainable distribution operation system for intra-city logistics will effectively alleviate this problem. Shi et al. (2021) performed a research on China's transportation industry and found that carbon emissions in China's transportation industry showed a distribution pattern of high in the east and low in the west, with hot spots scattering in the central and eastern regions. The research proposed to achieve carbon emission reduction through technological innovation, differentiated governance, talent consolidation and financial support. Sun, Liu, and Li (2022) believed that carbon emission reduction from transportation had become an important driving force for China to achieve carbon neutrality. Energy structure, logistics scale, population, GDP and tertiary industry are the five main factors affecting China's transportation carbon emissions from 2020 to 2019. However, relevant policies should be formulated specifically according to the specific conditions of each province in China.

In this context, as one of the important branches of the express industry, the low-carbon and sustainable development of intracity Logistics will be the top priority in the overall low-carbon transformation of the logistics industry. Most of current research on transportation carbon neutral were conducted from a macro perspective of the economy and the country as a whole. The research scenarios are too broad, which do not cover the specific logistics brands. Therefore, this research focus on Shanghai, Shenzhen, Hangzhou and other cities with high population density, sound infrastructures and high intra-city logistics demand. In this study, various factors affecting the low-carbon development of intracity logistics are comprehensively captured and analyzed. By establishing the Analytic Hierarchy Process (AHP), gray correlation, comprehensive service evaluation model for intracity enterprises, the direct and indirect factors affecting the low-carbon development of intracity logistics services are identified to help enterprises to optimise their operations and management processes. This article aims to answer the following questions:

(1) What are the influencing factors that constitute the hierarchical structure for green intracity logistics?
(2) How can the importance of these factors affecting the low-carbon development of intracity logistics be ranked?

In sections 2 and 3, the AHP and grey correlation method are elaborated, and their application in the development of low-carbon city logistics is introduced. In section 4, the green and low-carbon factors of urban logistics are divided into AHP levels, and the six intracity logistics companies with the highest market share in China are analyzed. A comparison on the low carbon services of the six firms is conducted to evaluate the benchmarking enterprises to provide a reference for the low-carbon development of logistics enterprises in other cities.

2. Literature review

Chen, Zhang, and Zhang (2015) pointed out that low-carbon logistics were an important part in resisting global climate change, so it was particularly important to establish a scientific and comprehensive, urban, low-carbon logistics evaluation system. In their study, the weight was calculated through the entropy weight method to establish a driving force – pressure – state – impact – response (DPSIR) framework, and the results were applied to research on intracity logistics in Beijing. The research results show that the driving force is strong but that the pressure is weak. The 'state' and 'impact' factor scores indicated that the per capita increase in the logistics industry's fixed asset investment and telecommunications business, as well as consistent investments in labour and the implementation of logistics emissions standards, improved the development of Beijing's low-carbon logistics. Mandatory policies could serve as a response factor and foster further improvement.

To calculate the fuzziness and randomness in the decarbonisation evaluation of intracity logistics, Guo et al. (2021) established an evaluation system of decarbonisation development from three dimensions: low-carbon logistics environment support, low-carbon logistics strength and low-carbon logistics potential. Next, the entropy weight method was employed to determine the index weight and to comprehensively calculate the comprehensive determination degree of the research object to which the logistics decarbonisation level belonged. The research results show that China's logistics decarbonisation technology has improved to varying degrees in Beijing, Tianjin and Hebei Provinces from 2013 to 2019, but the development is not uniform. Up to 2019, the three provinces and cities of Beijing, Tianjin and Hebei still exhibited significant differences in terms of the economic environment, logistics industry scale, logistics industry inputs and output ratio, and technical support. Wang et al. (2021) selected Baosteel, Zhanjiang Iron & Steel Co., Ltd. as the subject to conduct research on green logistics from the perspective of green product design, receiving & distribution, warehousing and packaging of green logistics, and logistics performance. His research mainly discussed the relationship among green logistics activities, as well as reducing logistics costs and the satisfaction of customers with logistics services, which may help enterprises understand the significance of green logistics activities and make recommendations for sustainable green development.

2.1. Intra-city logistics

Intra-city logistics refers to providing logistics services from point A to point B within a city. It focuses on accelerating the process and maximising the efficiency of logistics. The concept of intra-city logistics was first proposed by Japanese scholars Taniguchi et al. (1999). At that time, in order to alleviate urban traffic congestion and reduce distribution costs, a model of location selection on urban logistiscs nodes was established and the optimal location was determined. Ren et al. (2020) studied the two-level location path problem considering the external cost of carbon emissions from the perspective of low-carbon economy; Ren et al. (2020) took the impact of road characteristics and distance on route planning of intra-city logistics into consideration, and proved that the cost of the distribution route optimised using fuzzy comprehensive evaluation method and adaptive genetic algorithm was lower.

2.2. AHP and its application in logistics management

The analytic hierarchy process (AHP) was proposed by American OR Professor T.L. Satty in the early 1970s (Satty 1996). The AHP is a multicriteria, decision-making method that combines both quantitative analysis and qualitative analysis (Cho 2022). This method is mainly applied to solve nonstructural problems with multiple objectives and multiple objects. The AHP is characterised by organising various factors into complex problems by dividing them into interrelated and orderly levels (Deng and Zeng 1989a, 1989b). According to the subjective judgment of objective facts, the AHP directly and effectively combines expert opinions with the objective judgment of analysts and quantitatively describes the importance of pairwise comparisons of elements at the same level (Vargas 1990). The weight reflecting the relative importance of elements at each level is calculated by a mathematical method, and the overall priority is obtained by an aggregative weighted index (Kamal et al. 2001).

The AHP can be roughly divided into three steps: problem stratification, relative weight calculation, and consistency verification. Chen et al. (2020a) utilised the hierarchical structure model to build an urban logistics distribution system, and used Petri network method to solve the ‘last-kilometer’ problems. This research mainly focused on the solution of rational planning of distribution routes in crowded environment. It studied merely one aspect of low-carbon development of logistics companies and showed no promotion on the corporate management development. Aized and Srai (2014) developed hierarchical model with Petri network method to calculate the number of delivery tools and plan a route for the ‘last kilometer’ in logistics distribution system. However, it is a systematic problem to improve the distribution efficiency in the process of logistics distribution, and the research lacks relevant elements to support it.

The AHP method has been widely applied in logistics management. Liu and Lyons (2011) applied the AHP-DEA to evaluate the performance of third-party logistics enterprises and established an AHP-DEA combination evaluation model to provide new ideas for the development of logistics enterprises from the perspective of the supply chain. However, the research focused on the comparative study of the integrated elements of logistics in Taiwan and Japan from macro perspective which lacks firm level evidence. Luthra et al. (2017) used the AHP to establish a framework for evaluating sustainable supplier selection from the perspective of the supply chain. This research could not only assist managers and business professionals in distinguishing the selection criteria of important suppliers but also identify the most effective supplier in a sustainable supply chain in a highly competitive market. However, this study findings are based on a single case study, thus its generalisability is low.

Xiong, Zhao, and Lan (2021) employed the AHP method to evaluate the performance of cold chain enterprises and proposed to improve the evaluation system of financial management, cold chain logistics process, development capacity, customer service and other aspects, but it did not provide a research support for the low-carbon, green and sustainable development of cold chain enterprises. Zarbakhshnia et al. (2020) used AHP method and MoorA-G method to study the sustainable decision-making method of logistics outsourcing, but the hierarchical elements of third-party logistics proposed in the hierarchical framework are not closely connected to the sustainable development of logistics enterprises. Wang et al. (2021) proposed a multi-criteria optimisation model for third-party logistics using Fuzzy AHP and Fuzzy VIKOR Methods. This model was studied from the perspective of supplier selection of third-party logistics, however, it did not provide decision-making model suggestions for subsequent sustainable development from the perspective of logistics enterprises.

2.3. Gray relational analysis and its application in logistics management

Gray relational analysis was proposed by Professor Julong Deng in 1979 and has matured after many years of development. Gray relational analysis is a systematic analysis method developed from gray theory for analysing the similarity or difference between the target and the conference as a measure of the relational degree between two factors (Tan and Deng 1995). This analysis method extends the views and methods of General System Theory, Information Theory and Cybernetics to many fields, such as society, economy, ecology and medicine. Combined with mathematical methods, gray relational analysis has developed into a set of theories and methods to analyze process systems with incomplete information. In comparison with other comprehensive evaluation methods, Gray relational analysis has no specific restrictions on the data distribution and the number of samples and mainly carries out relational analysis and model construction for unclear and incomplete information systems, which has no restrictions on the selection of strong relational indicators. Therefore, gray relational analysis can fully utilise information of the original data (Xie and Liu 2009) and explore a system by prediction and decision-making. Therefore, Gray relational analysis can process the uncertainty, multivariable input, discrete data and incompleteness data analysis (Lin, Hwang, and Chan 2009). In summary, Gray Relational Analysis is an evaluation method for the relational degree between two discrete sequences, which aims to quantify the relationship between two factors. If the change in the two factors is consistent, the relational degree between the two factors is large. In contrast, the relational degree between the two factors is small (Deng 1986a, 1986b).

Few relevant studies explore intracity logistics using gray correlation analysis; however, the application to logistics can also provide a reference for this research. Woo and Seung (2015) mainly studied the hierarchical structure and multi-criteria decision-making system of the sitting of logistics distribution stations in South Korea using grey correlation method. However, the research only took one setting in South Korea as a case to verify the model, and the applicability need further confirmation. Yu (2017) used data envelopment analysis and grey correlation analysis to comprehensively evaluate the logistics development efficiency of Ningbo Port and its urban economic synergy effect, but the overall research process lacked empirical data support. Lee et al. (2017) took Taiwan as the research object and used GRA method to explore the key factors leading to the connectivity of International supply chain. However, the study only took Taiwan International Logistics (TIL) as an example and lacked a horizontal comparison of Logistics companies (Lee and Law Kris 2017).

Generally, although scholars have a certain foundation for research on the green development of the intracity logistics industry, most existing studies are case studies of a specific province, place or enterprise. The results fall short of the universality. However, there is still minimal research on the qualitative and quantitative analysis of the relevant elements of the green and low-carbon development of intracity logistics enterprises, as well as the construction of the evaluation index system and decision-making model of the green and low-carbon development of intracity logistics.

3. Research methods

The AHP and gray correlational analysis are combined in this research to establish a comprehensive evaluation system for improving green services of intracity logistics under the background of global peak carbon dioxide emissions and carbon neutrality. The combination of the AHP and gray relational analysis can not only overcome the limitation of the AHP, which cannot fully utilise all the information of various traits, but also avoid the subjectivity of gray relational analysis, leading to more scientific and reasonable analysis results.

3.1. Research steps of analytical hierarchy process

The AHP method is proposed to address the decision-making problems of complex systems, which involves many attributes, variables and subjective factors. The AHP method uses top-down processing to form a hierarchical structure and construct a hierarchical matrix. The low-carbon sustainable development of intracity logistics enterprises involves many factors. Figure 2 shows the AHP hierarchy system of intracity logistics for green development decision-making. The research includes the following steps (Tatsiana and Galyna 2019).

Stage 1 Objective definition for green shared intracity logistics

With the progress of digital transformation, the strategic objectives of intracity logistics enterprises have changed from simply considering the development of corporate profits to also considering both the environment and social values. To adapt to the global trend of carbon reduction and improve the competitiveness of enterprises, it is necessary to reorganise the vast and complex system of intracity logistics. All factors affecting the low-carbon development of intracity logistics enterprises are included in the research, and specific issues are further scoped and defined. This stage includes information collection and issue confirmation. The information collection step includes literature review and expert brainstorming in related fields, such as local distribution and logistics. In this step, the relevant factors affecting the low-carbon development of intracity logistics service design are collected from books, papers, research reports, academic journals, dictionaries, professional websites, etc., regarding the related fields of intracity logistics, low-carbon logistics, service design, AHP theory, and gray correlation theory. Brainstorming was conducted by 10 experts, including senior designers, logistics industry managers, logistics distributors and senior e-commerce practitioners, to collect the nature, scope and influencing factors of the issues for confirmation. The issue confirmation step is performed to determine and analyze issues on this basis and to conceive possible alternative schemes according to needs.

Stage 2 Hierarchical framework establishment for green shared intracity logistics

In this stage, the key factors affecting the low-carbon management of intracity logistics are evaluated and positioned as clusters, criteria and alternatives. The preliminary criteria system is added or deleted through the decision-making of experts. The binary relationship between two affecting factors is determined by the group of experts to construct the hierarchical structure of the whole system.

Stage 3 Pairwise comparison matrix establishment and weight calculation for green shared intracity logistics

The purpose of establishing a pairwise comparison matrix is to compare the elements of the evaluation cluster and criteria to achieve the green development of intracity logistics and to obtain the corresponding weight of the relative importance of all elements at the same level to the upper level or target level. In this study, the goal level and criteria are composed of n subfactors. It is necessary to evaluate the relative importance between two subfactors. Therefore, the relative scale of 1–9 is selected to minimise the comparison between two different factors to improve the accuracy of calculation. In this stage, a pairwise comparison between two elements E_i and E_j ($i, j = 1, 2, \dots, n$) is performed to obtain a_{ij} and the paired comparison matrix $A = [a_{ij}]$ with $n \times n$ elements.

$$A = [a_{ij}] = \begin{bmatrix} 1 \ a_{12} \ \dots \ a_{1n} \\ 1/a_{12} \ 1 \ \dots \ a_{2n} \\ \dots \\ \dots \\ \dots \\ 1/a_{1n} \ 1/a_{2n} \ \dots \ 1 \end{bmatrix} \tag{1}$$

After the establishment of the comparison matrix, the eigenvalue can be solved by the column vector standardisation method, and then the weight of elements at all levels can be obtained as:

$$W_i' = \frac{(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}}{\sum_{i=1}^{n} (\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}} \qquad i, j = 1, 2, \dots\dots, n \tag{2}$$

Stage 4 General ranking and level consistency verification for the green management system of intracity distribution

The established pairwise comparison matrix should be constructed in accordance with the level consistency. However, as there are too many factors at the judgment level, it is difficult for decision-makers to reach an agreement on pairwise comparisons. Therefore, it is necessary to verify the consistency of this value using the consistency index (C.I.), as follows:

$$C.I. = \frac{\lambda - n}{n - 1} \tag{3}$$

As shown in the formula, it is necessary to calculate parameter λ first. The weight W calculated from stage 3 is applied to calculate the consistency vector γ as $[v_i]$.

$$v_i = \frac{\sum_{j=1}^{n} w_j a_{ij}}{w_i} \qquad i, j = 1, 2, \dots\dots, n \tag{4}$$

λ is determined by the arithmetic mean value of γ as:

$$\lambda = \frac{\sum_{i=1}^{n} v_i}{n} \qquad i = 1, 2, \dots\dots, n \tag{5}$$

Substitute λ into $C.I.$ calculation, $C.I. = 0$ indicates that the judgments are equivalent.

The positive reciprocal matrix generated from evaluation scales 1–9 may lead to different C.I. values at different levels, which is stated as a random index (R.I.). The ratio of C.I. to R.I. is denoted as the consistency ratio (C.R.) as follows:

$$C.R. = \frac{C.I.}{R.I.} \tag{6}$$

Satty (1980) suggested that the matrix has better consistency when $R.I. < 0.1$. This criterion is applied to approximately calculate the hierarchical ranking weight of the relative importance of each factor at the same level to the factors at the previous level.

After calculating the weight of each level, the underlying alternatives are proposed using the same research method to calculate the weight and judge the consistent values of the C.I. and C.R.

3.2. Gray relational analysis and calculation of green management for intracity logistics

Gray relational analysis is a measurement applied in the evaluation of the correlation degree between two discrete sequences. Gray relational analysis aims to quantify the correlation degree between two factors to be measured, which mainly carries out correlation analysis and model establishment for unclear and incomplete information systems. Grey relational analysis can reveal and understand the situation of a system by means of prediction and decision-making. The specific research steps of gray correlation are presented as follows:

Step 1: Identify the reference sequence and comparison sequence from the original matrix D.

The reference sequence is a set composed of the ideal target values of each influence factor. $A_0 = (X_{01}, X_{02} \ldots X_{0j} \ldots X_{0n})$, where $j = 1, 2, 3 \ldots, n$. In addition, compare sequence A_i shows the performance value of each scheme. $A_i = (X_{i1}, X_{i2} \ldots X_{ij} \ldots X_{in})$, where $i = 1, 2, 3 \ldots, m$.

Step 2: Data normalisation of the original decision matrix D

There are three kinds of methods for normalising the data by gray relational analysis: larger-the-better, nominal-the-better and smaller-the-better (Deng 1986a, 1986b). In this study, the larger-the-better method is selected to normalise the original decision matrix. Because this study selects the advantages and disadvantages of the six brands of intracity logistics in terms of green sustainability from the best factors, the higher the value of each factor is, the better the effect is.

When the decision index X_n is normalised to large, X_{ij} is transformed to the measurement of benefit objectives (expected characteristics) X_{ij}^* as follows:

$$X_{ij}^* = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \tag{7}$$

where $\max_j X_{ij}$ is the maximum value in Item j, and $\min_i X_{ij}$ is the minimum value in Item j.

Step 3: Gray relational coefficient calculation

The gray relational coefficient is determined as:

$$\gamma_{0ij} = \frac{\Delta_{\min} + \xi\Delta_{\max}}{\Delta_{0ij} + \xi\Delta_{\max}} \tag{8}$$

where $\Delta_{\max} = \max_i \max_j \Delta_{0oij}$, $\Delta_{\min} = \min_i \min_j \Delta_{0oij}$ and $\xi \in [0,1]$.

ξ is the distinguished coefficient, which is used to control the gray relational coefficient; a value of 0.5 is generally recommended [15].

Step 4 Gray relational grade calculation and gray relational ordinal sorting

For each intracity logistics brand, the weight of each attribute of AHP and the gray relational coefficient are combined to obtain the gray relational grade. In this study, the green management decision of intracity logistics is made based on the comparison of gray relational grade Γ_{oi}. If a brand has a larger Γ_{oi} value, it is recognised as a good brand in terms of green sustainability in intracity logistics. Therefore, the ranking of the decision is conducted based on the sorting of Γ_{oi}. The calculation of Γ_{oi} is shown as follows:

$$\Gamma_{0i} = \sum_{j=1}^{n} [w_j \times \gamma_{0ij}] \tag{9}$$

where w_j is the standardised weight, and $\sum w_j = 1$.

4. Results

4.1. Selection of six intracity logistics service providers

According to big data statistics and artificial evaluation of the change in market and parameter conditions c, a list of the top 10 intracity logistics brands was released by CNPP Brand Data Research Institute in 2019. In the list, Meituan Distribution, Hummingbird Delivery, Dada Express, SF cityrush, Flash delivery and Dianwoda ranked the top six.

At the same time, according to the discussion with logistics experts, it was found that the six intra-city logistics enterprises had their own advantages. Meituan Distribution performed the best in terms of market share, the number of service users, the urban coverage rate, and the number of cooperative merchants. Hummingbird Delivery builds the infrastructure for local communities and new retailing logistics based on existing logistics network of Alibaba Group. As a real-time delivery platform, Dada Express is an open platform for merchants with WalMart and JD mall as endorsements. It broadly covers food and beverage delivery, fresh food delivery, and supermarket-to-home delivery. On the basis of these, the service of Dianwoda also includes collection of payment and purchasing on behalf of the customers, as well as other run errand services. SF cityrush is directly oriented to the C-terminal in the same city, and performs well in such indicators as recognition, distribution speed and service quality, with good user stickiness and brand premium. Flash delivery is the initiator of the 'one-to-one' mode of real-time distribution in the same city. It is a point-to-point delivery for customers (Table 1). Therefore, this research takes these six brands as samples to study the evaluation index of low-carbon sustainable management of intra-city logistics (Figure 1).

4.2. Hierarchical framework establishment of intracity logistics services

The design and planning of the target hierarchical framework was established based on the five principles proposed by Keeney and Raiffa (1993): integrity, measurability or operability, deconstruction, nonrepeatability and minimisation. A questionnaire about the factors considered by consumers in choosing intracity logistics was designed according to the data collected from books, papers and research reports of previous scholars in relevant fields. A total of 415 questionnaires were sent through the internet, on site and e-mail. Among them, 407 questionnaires were returned, including 342 valid questionnaires. Eight factors were obtained: operation ability, infrastructure, resource utilisation, personnel quality, service, safety, after-sales service and preferential activities of green logistics, as shown in Figure 2.

Table 1. Information of intra-city logistics enterprises.

Intra-city logistics company	Registered capital (RMB yuan)	Type of enterprise	Main business and service
Meituan distribution	5,480,000,000	Limited Liability Company	Takeout and distribution, 24-hour delivery services, citywide delivery; one-hour delivery
Hummingbird delivery	10,000,000	Limited Liability Company	Instant delivery
Dada express	6,778,900	Limited Liability Company	Local instant delivery, a full-scene service system consisting of instant delivery, landing delivery and individual delivery
SF cityrush	4,895,202,400	Other companies limited by shares	Instant delivery solutions of all links
Dianwoda	10,595,500	Limited Liability Company	Door-to-door delivery services
Flash delivery	1,241,600	Limited Liability Company	One-hour intra-city instant delivery service, one-to-one urgent delivery service

Note: RMB yuan indicates: Chinese currency of Renminbi Yuan.

Figure 1. Top 10 brands of logistics enterprises in the same city of China.

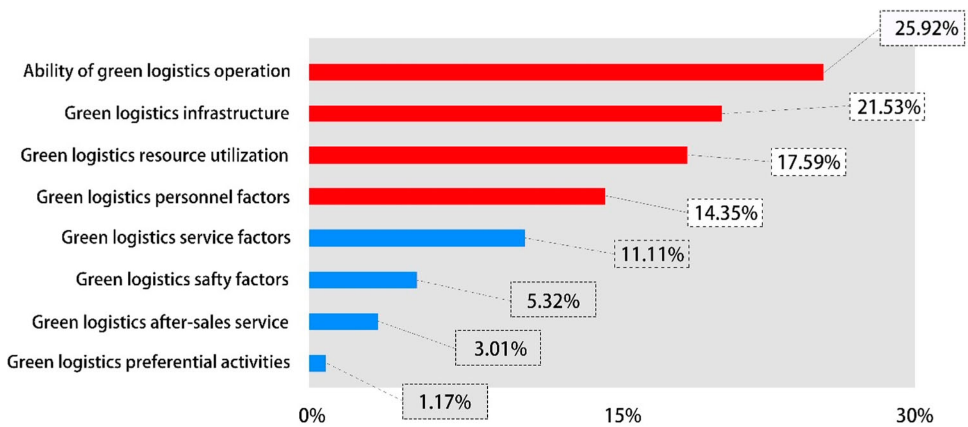

Figure 2. Eight most important factors in choosing intra-city logistics service.

As shown in Figure 2, from the perspective of green and low-carbon development of intracity logistics, current consumers regard the operation ability of green logistics as the most important factor (25.92%). The preferential activities of green logistics are the least important factor, accounting for only 1.17%. This phenomenon indicates that under the background of energy savings and emission reduction, consumers believe that the essential characteristics of logistics are more important for achieving green and sustainable development of intracity logistics. In all eight factors, the first four dimensions with the highest proportion are selected as the research cluster of the AHP hierarchy of this study: operation ability, infrastructure, resource utilisation and personnel quality, accounting for 25.92%, 21.53%, 17.59% and 14.35%, respectively.

Moreover, low-carbon development is a sustainable development pattern with the characteristics of low energy consumption, low pollution and low emission. An evaluation on low carbon development of the intra-city logistics enterprise mainly depends on how the enterprise can achieve three objectives through an integration of resources and sustainable operation using technological innovation and management. Based on a summary of intra-city logistics literatures (Table 2), in which indicators are categories as the system principle, scientific principle, operational principle, qualitative and quantitative combination of the principle, as well as an interview and brainstorming of 10 logistics experts, 16 elements of Criteria are divided into four categories (Figure 3).

Table 2. Reference factors related to low-carbon operation of logistics enterprises.

Cluster	Sub-criteria	Optimal author (reference)											
		Sasikumar and Haq (2011)	Goebel et al. (2012)	Efendigil and Kongar (2008)	Chen et al. (2021)	Wu and Dunn (1995)	Zsidisim and Siferd (2001)	Yuan and Tang (2013)	Qu et al. (2017)	Hashemi, Karimi, and Tavana (2015)	Lee et al. (2017)	Ding et al. (2021)	Aized and Srai (2014)
Operation ability	Stable big data processing				√	√		√			√	√	
	Intelligent and barrier-free communication				√			√			√	√	√
	Timely vehicle scheduling			√	√			√			√	√	
	Accurate route optimisation			√	√						√	√	
Infrastructure	Urban infrastructure					√		√			√		√
	Coverage fraction of distribution nodes					√		√			√	√	√
	Storage capacity of distribution nodes					√		√			√	√	√
	Number of delivery vehicles	√			√								
	Type of delivery vehicles	√			√							√	
Resource utilisation	Consumption of vehicle energy					√				√		√	
	Utilisation of equipment				√			√					
	Usage proportion of recyclable materials	√	√				√	√		√			√
	Consumption of non-renewable resources	√	√				√	√		√			
Logistics Personnel	Professionalism of logistics practitioner						√		√	√		√	√
	Environmental awareness						√		√	√		√	
	Total number of deliverymen						√		√				

4.3. AHP questionnaire design and survey of intracity logistics

In this study, the AHP questionnaire was designed based on the hierarchical framework of intracity logistics services in advance. Ten experts, including an internet operation specialist, logistics company program administrator, computer technician and management manager of Hangzhou logistics enterprise, were interviewed (Table 3). According to the AHP analysis framework, the AHP questionnaire was designed to evaluate the relative importance of the four clusters and the following criteria. The consistency of the questionnaires of each of the 10 experts in this study was separately tested, and the average value was integrated.

4.4. Weight calculation of factors and consistency verification

The questionnaire completed by the logistics expert Mr. Lin was selected as an example. Mr. Lin, who was an internet operation management specialist with 15 years of working experience, drew his conclusion after comparing each of the two factors for this decision-making, as listed in Table 4. The weight was calculated according to the standardisation of the average value of the column vector set.

After the calculation, the consistency of the conclusions obtained by Mr. Lin was verified. Substituting eigenvalues into Equation (3), C.I. and C.R. values of 0.051 and 0.057, respectively were obtained. As the C.R. was less than 0.1, the consistency was acceptable, and the AHP hierarchy and questionnaire were qualified.

4.5. Weight calculation of the selection scheme

According to the scores of 10 experts, the weight values of each evaluation index in the index layer for the target layer were calculated and compared. The results are shown in Table 5. The weight value of operation ability is 0.3363, which indicates that improving the operation ability of the enterprise is an important factor affecting the low-carbon development of intracity logistics. Among the 16 indicators, the professionalism of logistics practitioners under the personnel factors has the greatest impact on the low-carbon development of intracity logistics, with a weight of 0.5805. The second and third factors affecting the green development of intracity logistics are stable big data processing under the operation ability and the usage proportion of recyclable materials under the resource utilisation, whose weight values are 0.3975 and 0.3477, respectively. Other factors, such as intelligent and barrier-free communication under the operation ability, timely vehicle scheduling under the operation ability, accurate route optimisation under the operation ability, urban infrastructure under the infrastructure, coverage fraction of distribution nodes under the infrastructure, storage capacity of distribution nodes under the infrastructure, number of delivery vehicles under the infrastructure, type of delivery vehicles under the infrastructure, consumption of vehicle energy under the resource utilisation, utilisation of equipment under the resource utilisation, consumption of nonrenewable resources under the resource utilisation, environmental awareness under the logistics personnel and total number of deliverymen under the logistics personnel, have minimal influence on the green development of intracity logistics. The weight values are 0.2027, 0.2828, 0.1170, 0.1547, 0.2717, 0.1942, 0.2055, 0.1739, 0.2153, 0.2080, 0.2290, 0.2663 and 0.1532. Therefore, the professionalism of logistics practitioners, stable big data processing and the usage proportion of recyclable materials are the three most important factors for intracity logistics enterprises to achieve low-carbon development. This result meets the basic requirements of green sustainability evaluation of intracity logistics.

4.6. Selection of customers on intracity logistics service based on gray relational theory

In this study, gray relational analysis was employed to conduct a performance evaluation of intracity logistics. At this stage, five experts were selected from the ten experts in the previous stage for

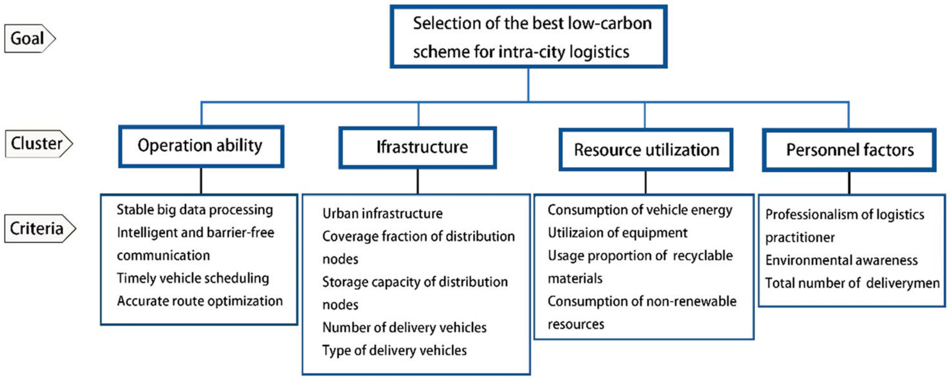

Figure 3. AHP criterion layer of intra-city logistics under low-carbon economy.

further research. Detailed information about the five experts is provided as follows: Expert No. 2 has been engaged in the logistics distribution industry for 7 years. Currently, he is the director of a logistics distribution node in Hangzhou, who has ever worked for FN logistics, Dianwoda delivery, and SF cityrush. He has rich experience for an objective and wise judgement on the importance of hierarchical elements. Expert 3 is an intracity logistics distributor with 8 years of working experience who has served Meituan distribution and FlashEx. Expert 7 is the manager of the operation department of an internet company who has been engaged in the industry for 15 years. Expert 8 is an associate professor at a university in Hangzhou. Expert 7 and expert 8 have also provided computer technical support and program development consultation for Dada Express for a long time. Expert 10 is a manager engaged in the buyer and purchasing industry for 13 years and a senior consumer of logistics and intracity logistics. He provided more comprehensive suggestions and opinions on user experience for this study.

The average score of the questionnaire results is shown in Table 6.

The reference and comparison sequences A_0 and A_i were obtained from the original matrix D. In this research, the reference sequence A_0 is (9, 8.3, 8.8, 8.9, 8.8, 9.4, 8.9, 9, 8.6, 8.7, 8.5, 8, 8.2, 8.5, 8.1, 9.3). The comparison sequence A_i is $A_i = (i_{1x}, i_{2x}, \ldots, i_{16x})$. In this study, the six intracity logistics enterprises with the highest market share in China were selected as the research objects, so i was A, B, C, D, E and F.

To select the advantages and disadvantages of six intracity logistics brands in terms of green environmental protection, the larger-the-better method is used to normalise the original decision matrix, as shown in Table 7.

The maximum and minimum values of each index were obtained to calculate the gray relational distance. The reasonable identification coefficient ξ ranges from 0 to 1. The decision-maker can

Table 3. Background information of the ten experts.

Expert	Employer	Title	Working experience
No. 1	MT intra-city logistics company	Logistics Manager	10 years
No. 2	Sandun logistics distribution node in Hangzhou	Director	7 years
No. 3	S intra-city logistics company	Logistics deliveryman	8 years
No. 4	S intra-city logistics company	Program administrator	7 years
No. 5	S intra-city logistics company	Logistics Manager	8 years
No.6	Internet operation company	Executive director	7 years
No. 7	Internet operation company	Manager	15 years
No. 8	University	Associate professor	12 years
No. 9	Cross border E-commerce	CEO	9 years
No. 10	Cross border E-commerce	Purchasing agent	13 years

Table 4. Eigenvalues of pairwise comparison matrix for green intra-city logistics.

Influential factors	Operation ability	Infrastructure	Resource utilisation	Personnel factors	Mean value	Weight
Operation ability	1	2	2	1	1.4142	0.313
Infrastructure	1/2	1	1	1/6	0.5376	0.119
Resource utilisation	1/2	1	1	1/2	0.7071	0.156
Personnel factors	1	6	2	1	1.8612	0.412

choose different values of ξ according to personal preferences. In this study, ξ was assumed to be 0.5 to conduct a gray relational analysis for 6 brands of intracity logistics services, as shown in Table 8.

The weight of AHP (Table 4) was multiplied by the gray relational results of the green and low-carbon framework for intracity logistics to obtain the gray relational coefficient (Table 7). The advantages and disadvantages of each brand were sorted based on the gray relational coefficient. The greater Γ0i was, the better the performance of the brand. The ranking of the gray relational coefficient is shown in Table 9.

The ranking in Table 8 indicates that the gray correlation value of SF cityrush is 4.0. As a result, SF cityrush is the best of the six brands in the performance of big data processing, rationality of route planning, coverage fraction of distribution nodes, personnel quality and environmental awareness, indicating that SF cityrush is highly recognised for its green, energy-saving and low-carbon characteristics. Its gray relational value is almost twice that of Meituan delivery and much higher than that of other intracity logistics brands. Relatively, Meituan delivery, FN logistics and Dada Express are in the second echelon; their gray correlation values are very similar at 2.1, 1.98, and 1.8, respectively. The gray relational values of Dianwoda delivery and FlashEx are 1.65 and 1.47, respectively, which are the lowest among all six brands, indicating that they achieved the lowest recognition in green environmental protection.

The selection of SF cityrush as the best brand can provide a reference for the green and low-carbon development of other intracity logistics distribution brands as follows:

(1) Forming a management system and environmental protection awareness

In the context of global peak carbon dioxide emissions and carbon neutrality, to achieve low-carbon development, intracity logistics enterprises should establish supervision mechanisms,

Table 5. Influential factors and weight of each criterion.

Influential factors	Weight (average value)	Criterion	Number	Relative weight (average value)
Operation ability	0.3363	Stable big data processing	1	0.3975*
		Intelligent and barrier-free communication	2	0.2027
		Timely vehicle scheduling	3	0.2828
		Accurate route optimisation	4	0.1170
Infrastructure	0.2162	Urban infrastructure	5	0.1547
		Coverage fraction of distribution nodes	6	0.2717
		Storage capacity of distribution nodes	7	0.1942
		Number of delivery vehicles	8	0.2055
		Type of delivery vehicles	9	0.1739
Resource utilisation	0.2600	Consumption of vehicle energy	10	0.2153
		Utilisation of equipment	11	0.2080
		Usage proportion of recyclable materials	12	0.3477*
		Consumption of non-renewable resources	13	0.2290
Personnel factors	0.1875	professionalism of logistics practitioner	14	0.5805*
		Environmental awareness	15	0.2663
		Total number of deliverymen	16	0.1532

Note: The three words with * are the most important factors affecting the green development of logistics in the intre-city.

formulate relevant reward and punishment mechanisms, and strengthen employee education and training to ensure that employees advance low-carbon concepts into service and ensure the effective implementation of low-carbon logistics.

(2) Application of information technology.

Local distribution logistics enterprises can employ relevant technical personnel with high quality and high professional levels and expand the application of information technology in intracity logistics enterprises through high-tech means. This finding can reduce the negative impact of logistics transportation on the ecological environment and the dependence on resources. The application of information technology is helpful for not only for environmental protection but also increasing distribution efficiency.

(3) Packaging improvement.

It is suggested that the existing packaging of intracity logistics can be redesigned to increase its anti-collision and water-resistant features through structure and material design, which can save space, protect items, and realise the cyclic utilisation and recycling of waste parts.

(4) Improvement of transportation route.

The reasonable dispatch of goods sources and vehicles, optimised transportation route planning and scientific distribution node layout should be achieved through stable big data processing to avoid empty wagon transportation in two-way transportation, which can effectively reduce energy waste.

5. Discussion and conclusions

5.1. Theoretical contributions

With the continuous progress of industrialisation, the inefficient usage of industrial fuels has caused a sharp increase in global carbon emissions and greenhouse effects. In the face of global warming, many countries are jointly undertaking the important task of sustainable development. In recent years, the intracity logistics business has developed rapidly. However, as an industry with high energy consumption and high resource utilisation, it is a key governance industry for energy conservation and emission reduction. Therefore, the green development of the intracity logistics industry is not only the primary task of the government but also the target and focus of this paper. We contribute to the intra-city logistics literature in the following ways:

First, an objective and effective multi criteria evaluation framework for low-carbon development of intra-city logistics was established in this study.

Due to the lack of research on the low-carbon development of intra-city logistics, in considering the rising demand for the last kilometre of distribution, the purpose of this study is to provide a

Table 6. Evaluation of six intra-city logistics brands.

	Item															
Brands	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Meituan delivery	7.8	7.9	8.2	8.3	8.1	9	7.7	8.3	7.6	7.4	8.2	7	6.8	6.3	7	8.7
FN logistics	8.1	7.6	7.9	7.7	7.8	8.5	7.4	8.3	7.4	7.8	7	6.6	6.5	7.1	7.5	8.6
Dada express	6.4	7.2	7	7.8	7.2	8	8.2	7.4	7.2	7.8	8	6.8	6.6	6.9	7.6	7.8
SF cityrush	9	8.3	8.8	8.9	8.8	9.4	8.9	9	8.6	8.7	8.5	8	8.2	8.5	8.1	9.3
Dianwoda delivery	6.4	6.4	7.3	8.2	6.8	7.3	8.1	6.9	7.6	7.1	6.2	7.2	7	7	7.2	7.5
FlashEx	5.6	6.9	6.7	7.4	6.4	6.8	8.1	7.3	6.6	6.8	4.8	7.1	7.2	6.6	6.8	6.7

Table 7. Normalised value of the six intra-city logistics brands.

	Item															
Brands	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Meituan delivery	0.65	0.79	0.71	0.6	0.71	0.85	0.2	0.67	0.5	0.32	0.92	0.29	0.18	0.00	0.15	0.77
FN logistics	0.74	0.63	0.57	0.2	0.58	0.65	0.00	0.67	0.4	0.53	0.59	0.00	0.00	0.36	0.54	0.73
Dada express	0.24	0.42	0.14	0.27	0.33	0.46	0.53	0.24	0.3	0.53	0.86	0.14	0.06	0.27	0.62	0.42
SF cityrush	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dianwoda delivery	0.24	0.00	0.29	0.53	0.17	0.19	0.47	0.00	0.5	0.16	0.38	0.43	0.29	0.32	0.31	0.31
FlashEx	0.00	0.26	0.00	0.00	0.00	0.00	0.47	0.19	0.00	0.00	0.00	0.36	0.41	0.14	0.00	0.00
Reference	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 8. Grey correlation coefficients.

	Item															
Brands	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Meituan delivery	0.35	0.21	0.29	0.4	0.29	0.15	0.8	0.33	0.5	0.68	0.08	0.71	0.82	1.00	0.85	0.23
FN logistics	0.26	0.37	0.43	0.8	0.42	0.35	1.00	0.33	0.6	0.47	0.41	1.00	1.00	0.64	0.46	0.27
Dada express	0.76	0.54	0.86	0.73	0.67	0.54	0.47	0.76	0.7	0.47	0.14	0.86	0.94	0.73	0.38	0.58
SF cityrush	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dianwoda delivery	0.76	1.00	0.71	0.47	0.83	0.81	0.53	1.00	0.5	0.84	0.62	0.57	0.71	0.68	0.69	0.69
FlashEx	1.00	0.74	1.00	1.00	1.00	1.00	0.53	0.81	1.00	1.00	1.00	0.64	0.59	0.86	1.00	1.00
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9. Grey correlation value and ranking for low carbon evaluation of six intra-city logistics brands.

Ranking	Brands	Grey relational coefficient
1	SF cityrush	4
2	Meituan delivery	2.1
3	FN logistics	1.98
4	Dada express	1.8
5	Dianwoda delivery	1.65
6	FlashEx	1.47

multi-criteria decision-making evaluation standard with practical value for the low-carbon development of intra-city logistics. Zhou, Xu, and Shaikh (2019) analyzed the green supply chain of Pakistan, however, the senior managers were not invited to participate in the research, resulting in certain limitations in the research results. Therefore, in order to obtain a more comprehensive, objective and constructive low-carbon management decision-making framework for intra-city logistics enterprises, the invited experts include logistics company managers, program administrator, logistics manager of logistics, executive director of Internet operation company, buyers and other logistics management personnel. In this way, the more objective and accurate evaluation and decision-making criteria are generated.

Second, based on the low-carbon management framework of local logistics enterprises, the advantages, disadvantages and development direction of low-carbon management of local distribution enterprises are clarified.

Li (2022) ever used DEMATEL and ISM to establish an interpretive structural model to reflect the hierarchical relationship of the factors that affect the low-carbon operation of logistics enterprises, so as to find the fundamental factors that affect the low-carbon development of logistics enterprises. But the model was not applied, verified and analyzed in real cases. The research results of Lee et al. (2017) have not been applied to specific logistics companies. While in this study, a comprehensive and systematic analysis on the elements of low-carbon development management of the six intra-city logistics enterprises with the highest market share in China enables enterprises to recognise their advantages and disadvantages in low-carbon sustainable development, and facilitates enterprises to improve their disadvantages, and also provides reference standards for other intra-city logistics enterprises in low-carbon green sustainable development.

Third, we build a reference point for green and low-carbon development of intra-city logistics enterprises in the same city to facilitate consumers' choice.

Shaw et al. (2012) used the analytic hierarchy process and fuzzy multi-objective linear programming method to study the procurement strategy of logistics supply chain in view of the carbon emission. Their study mainly aimed at the selection of suppliers for enterprises. While this study builds a data reference point for the low-carbon development of intra-city logistics enterprises after ranking the factors affecting the low-carbon development.

5.2. Practical implications

This study provides the following practical implications.

Firstly, this study can help the intracity logistics enterprises to understand the actual operating situation and discover the problems of low carbon transformation. It can put forward the scientific methods to evaluate the management system of logistics enterprise. It is of great significance to reduce energy consumption, save logistics costs and improve the competitiveness of enterprises in intracity logistics, and provides guidance and judgment basis for the low-carbon long-term development of intracity logistics enterprises. At the same time, the construction of logistics infrastructure is conducive to the establishment of a well-organised transportation network and provides a necessary guarantee for the development of low-carbon and low-energy consumption of intracity logistics. It is important to establish a multilevel training system in society, schools and enterprises to improve the quality of logistics personnel and their awareness of low-carbon environmental protection for the sustainable development of logistics in the same city.

Secondly, the development of any industry is inseparable from the policy support of the government. The development of logistics enterprises is closely related to the development of other industries and has an important supporting role in the development of the whole social economy. Therefore, the government should attach importance to the low-carbon development of the logistics industry and introduce relevant policies to promote the transformation and upgrading of the logistics industrial structure. In addition, the government can also optimise the spatial layout of transportation, scientifically plan a comprehensive, three-dimensional transportation system, optimise the layout of comprehensive transportation hub projects, adjust and optimise a collection and distribution system, and promote the energy conservation and emission reduction of the same city distribution industry from the spatial layout. Last, the government can adjust the layout of warehousing and logistics parks, reasonably arrange business outlets, and promote logistics parks and logistics enterprises with strong points to reduce costs and energy consumption.

Finally, all distribution stations, parks, warehouses and enterprises of intracity logistics should strive to break regional restrictions and take full advantage of the region, stations and parks. Intracity logistics enterprises should strengthen their integration and build a cross-regional and cross-industrial development community. By building a stable big data system for intracity logistics, the information exchange and integrated utilisation of resources can be strengthened to realise the linkage development of regional logistics.

5.3. Research significance and limitations

For intracity logistics, 'low carbon' will be not only a new development opportunity, but also the responsibility of intracity logistics enterprise. Only a transformation from 'high carbon' to 'low carbon' will have industrial advantages. As a result, this research mainly analyzed the low carbon development influential factors from different aspects of intracity distribution enterprise in a combination of definition and characteristic of intracity distribution logistics.

Although some conclusions and achievements of practical significance have been obtained in this research, there are still some problems to be solved due to the limitations of various conditions. First, as the research on low carbon intracity logistics management evaluation index system is very rare, and the data collection from intracity logistics enterprises is relatively difficult, the establishment of evaluation index system is not yet complete, which needs further improvement based on a survey on actual conditions of enterprise. Second, this study took of the six intracity companies in China with the highest market share as the research samples. Due to the uncertainty of the environment of intracity logistics, the research results may not be appropriately applied around the world. Future research may involve more cities, brands in different periods to achieve more valuable guidance.

Third, although the intracity logistics develops rapidly, the research on it is still in groping stage. The collected documents and data are not comprehensive. Some part of the source data comes from online, but different website uses different information statistical method. As a result, the data obtained from different website about the same problem has some differences, which introduce errors for practical analysis. Finally, the research on low-carbon logistics is a complicated issue, which involves path optimisation, cost control, relevant stakeholders, performance evaluation and other factors. Based on the content of this research, subsequent research can also be carried out from the aspects of cost control, performance evaluation and so on.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article.

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Appendix

Questionnaire on low carbon elements of intracity logistics

Dear friends:

Hello!

Thank you for taking this survey. This is a questionnaire on the low-carbon and sustainable development of intracity logistics. We hope to use your knowledge and experience to determine the key elements involved in the sustainable development of intracity logistics. Your valuable opinions will become an important reference for this research. The data is only used for statistical analysis. Please feel free to fill the questionnaire. There is no right or wrong question, please fill in according to the actual situation.

Thank you very much for your help!

1. Gender

A. Male B. Female

2. Your age

A. Under 18 B. 18–25 C. 26–30 D. 31–40 E.41–50 F. over 50

3. Please select 8 factors and draw a √ in the table

Safety	Management structure of the company	Resource utilisation	Transportation and distribution monitoring
Energy consumption simplification	Green logisitics preferential activities	Distribution costs reduction	Fuel substitution
Logistics operation capability	Energy efficiency improvement	Transportation structure adjustment	Automation level
Informatisation level	Traffic conditions improvement	Allocation of social resources	Classification management
Fine management	Infrastructure	Logistics tracking system	Intelligent control
Digitisation	Pricing standardisation	Automobile exhaust control	Resource integration and coordination
Government management	Packaging standardisation	Distribution network setup	Personnel factors
Service factors	Personnel factors	Equipment recycling	Environment certification of equipment
Vehicle design optimisation	Customer satisfaction	Government management enhancement	Logistics coverage expansion
Enterprise cooperation expansion	After-sales services		