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Research on Life Cycle Quality Evaluation of Urban and Rural Distribution Intelligent Logistics Park Development

Abstract: - In urban and rural distribution, intelligent logistics parks are crucial, and the life cycle is the key to the long-term development of intelligent logistics parks. This paper combines the actual situation of urban and rural distribution intelligent logistics parks, through literature analysis, questionnaire research, etc., using the AHP and gray correlation method to systematically construct a life cycle development quality evaluation system and evaluation scheme for urban and rural distribution intelligent logistics parks that is operable, quantifiable and comparable, and innovatively starts from the digitization, intelligence and greening of urban and rural distribution intelligent logistics parks, and divides the evaluation system is divided into five major aspects (infrastructure and planning, operation management and service, intelligentization level, environmental impact and sustainable development, economic and social benefits). After analyzing the advantages and shortcomings of various single evaluation methods, through the combination and improvement of hierarchical analysis method and gray correlation method, it provides certain theoretical basis and methods with practicality and universality for the evaluation of the development quality of urban and rural distribution intelligent logistics parks, so that urban and rural distribution intelligent logistics parks can carry out the evaluation of the development life in an operable, quantitative and comparative way through this evaluation method, to understand their own This will enable the urban and rural distribution intelligent logistics parks to carry out development life evaluation in an operable, quantifiable and comparable way through this evaluation method, so that they can understand their own level and find out the deficiencies, so that they can clearly define the direction of improvement of the quality of logistics and improve their own level of development.

Keywords: Urban-rural Distribution; Intelligent Logistics Park; Evaluation System; Development Life Cycle.

I. INTRODUCTION

Recently, with the vigorous promotion of agricultural and rural modernization, the regional economy has developed rapidly, and the consumption level of urban and rural residents has been upgraded. This has led to an increased demand for logistics and distribution of industrial goods and daily necessities to the countryside, as well as a growing demand for agricultural products to be delivered to the cities [1].

Logistics parks are rapidly moving into the digital era to improve operational efficiency and competitive market position. Many parks are adopting advanced digital technologies, such as big data, cloud computing, and AI, to optimize supply chain collaboration and management processes. This transformation process has seen varying progress among parks. Some parks have utilized innovative technologies such as IoT and blockchain to build comprehensive logistics information platforms and monitoring systems, which have significantly improved supply chain operational efficiency and service quality, and are in the transformation stage of rapid development. On the contrary, some parks are still facing the problem of information silos due to the lack of clear digital awareness and planning, and the failure to establish a perfect digital management system, and their transformation is still in the initial stage. The digital transformation of logistics parks not only requires the deep integration of key digital technologies, but also the participation of enterprises in the parks, especially small and medium-sized enterprises (SMEs) and the integration of resources and financial investment to jointly achieve the transformation goals [2] .These trends show that the expansion of urban distribution networks to rural areas has become particularly urgent, and it is especially important whether intelligent urban and rural logistics parks can develop in a balanced and sustainable manner and whether the transformation of traditional logistics parks is perfect. Through literature reading and research, it is found that there is no unified evaluation index system in terms of the development quality index of intelligent logistics parks, and it is difficult to judge the development quality under the non-uniform index system, therefore, under the influence of various subjective and objective factors, the establishment of a set of standardized evaluation system is imminent [3].

Regarding the quality evaluation of intelligent logistics parks, Li Jing et al. constructed a quality evaluation index system for logistics node cities from four aspects: regional economic level, logistics development, logistics support industries, and government regulation, and measured the logistics development level of logistics node cities

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using the improved entropy weight method [4], Lu Fang (2016) used the SERVQUAL model dimensions and the LSQ evaluation model in combination with the A enterprise's main logistics service products to establish a specific index system for enterprise logistics service quality evaluation [5], Shi Lu et al. in the study of Chengdu high-speed rail logistics node site selection, constructed a high-speed rail logistics node evaluation index system from four aspects of demand, supply, economy, and convenience, and utilized the entropy-right-Topsis method to compare and select five alternative sites, which resulted in the Tianfu Freight Station's The comprehensive performance is optimal[6],Cao Xiaojun et al. designed the evaluation index system from four aspects, namely, economic and social development level, logistics industry development, logistics supply and demand situation and informatization level, and carried out a comprehensive evaluation of the logistics node cities of the western land and sea new corridor by using principal component analysis, entropy weight and grey correlation method, and Kendall's synergy coefficient test, respectively[7],He Shengyu (2013) conducted a comprehensive evaluation of the logistics node cities of the western land and sea new corridor based on the He Shengyu (2013) based on NDSERV's customer perception scale evaluation model four levels combined with the logistics operation process, constructed a new logistics enterprise service quality evaluation system [8], Zhu Ruiying in the modern logistics newspaper pointed out that China's logistics park overall body development level is still unbalanced, uncoordinated characteristics [9], science and technology for the development of logistics parks is also crucial, Fang Pengfei use intelligent information processing technology to build a smart logistics park digital information management system. Intelligent logistics park digital information management system to solve the problem of isolated subsystems, data islands, etc., to improve the security of the park [10], Wang Xuemei and other scholars considered the transportation conditions, market conditions, the impact on the city of three factors, constructed the evaluation index system of the logistics park site selection program, the use of set-pair analysis based on the comprehensive evaluation of the logistics park site selection program method, to determine the optimal program from the alternative options [11], Zhu Xiumei and other scholars believe that digital transformation is still a balanced and coordinated level of development, technology is also vital to the development of logistics parks. Zhu Xiumei and other scholars believe that digital transformation is the deep transformation of core business by enterprises through digital technology to enhance market competitiveness and promote social synergy [12], and the viewpoints of Korea Gao pointed out that digital technology is promoting the fusion of the real and virtual economy, which not only produces innovative changes in the traditional industry, but also gives rise to new industries and models, and becomes a new driving force for the transformation and upgrading of the real economy [13]， Qu Yunlong pointed out that digital transformation can bring advanced technology to enterprises, improve the level of automation of business processes, and reduce human interference in business processes, etc. [14], Chen Xingyu proposed the development of the digital information age, artificial intelligence, Internet of Things, 5G, virtual reality and other types of new technology models continue to promote the modern logistics industry's wisdom transformation and upgrading, modern logistics began to evolve to the wisdom of logistics, the rapid construction and development of smart logistics parks, and the rapid development of smart logistics parks, the rapid development of smart logistics parks. The rapid construction and development of intelligent logistics parks [15], Ruan Zhiqi focuses on the construction of logistics park informationization and digitalization, after systematic and reasonable planning and design, can effectively improve the management, transmission and delivery efficiency of materials [16], with the development of Internet technology, Fan Hongyu proposed that the informationized logistics and distribution system is being continuously used, through automation, intelligence, unmanned and other ways of managing logistics [17].

Through reading and analyzing the above literature, this paper starts from the purpose of realizing the long-term development of urban and rural distribution intelligent logistics parks, combs the evaluation indexes, establishes the evaluation system, and provides references for the long-term development of urban and rural distribution intelligent logistics parks.

II. The Establishment of Quality Evaluation Indicator System of Urban and Rural Distribution Intelligent Logistics Park Development

A. Determination of the Quality Indicator System for the Development of Intelligent Logistics Parks for Urban and Rural Distribution

Through the research on dozens of urban and rural distribution logistics parks across the country, in order to make the service quality evaluation of urban and rural distribution intelligent logistics parks more comparable, operable and quantifiable, and at the same time rigorously follow the principles of systematic, hierarchical, dynamic, concise and scientific, and comprehensive, and combined with the opinions of experts, to determine the final quality evaluation index system of urban and rural distribution intelligent logistics parks (1 first-level indicator, 5 second-level indicators, 21 third-level indicators). and 21 tertiary indicators), as shown in Figure 1 and Figure 2.

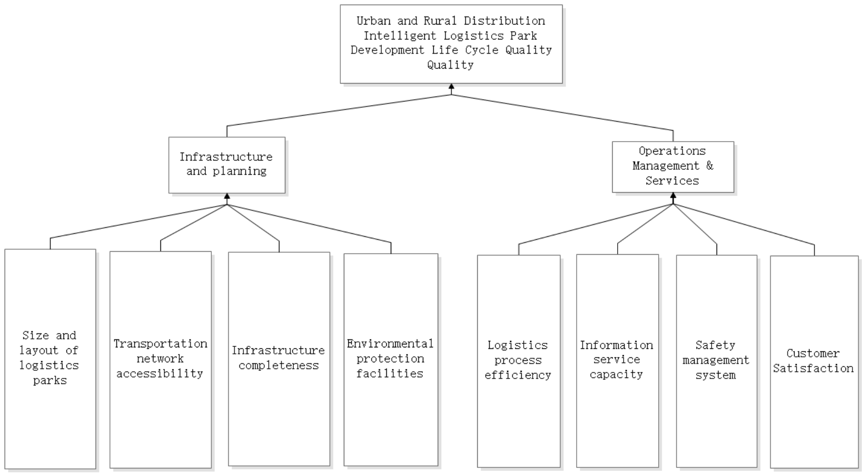

Figure 1: Hierarchical Model of Quality Evaluation Indicators for Urban and rural Distribution Intelligent Logistics Parks(1)

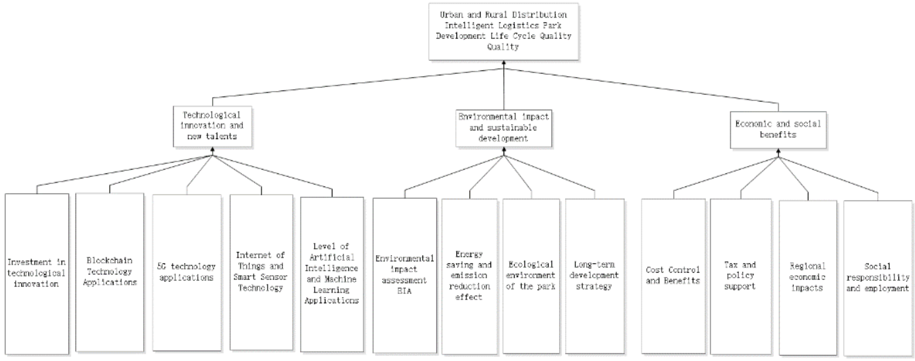

Figure 2: Hierarchical Model of Quality Evaluation Indicators for Urban and Rural Distribution Intelligent Logistics Parks(2)

B. Hierarchical Analysis to Determine Indicator Weights

1) Hierarchical Model and Judgment Matrix Construction: In order to ensure the reasonableness of the construction of indicators and judgment matrix, logistics park managers and professors specializing in logistics were invited to collectively score the relative importance between indicators, and the results of the expert scoring were used as the basis for the construction of judgment matrix. The judgment matrix was also tested for consistency to ensure the reasonableness of the construction of the judgment matrix.

Based on the expert scoring results, the judgment matrix S=(uij)p×p is constructed for each level of indicators, as shown in Tables 1 to 6:

Table 1: Tier 1 Indicators

Urban and Rural Distribution Intelligent Logistics Park Development Life Cycle Quality Quality	Infrastructure and planning	Operations Management & Services	Technological Innovation and New Talents	Environmental impact and sustainable development	Economic and social benefits
Infrastructure and planning	1.0000	5.0000	5.0000	7.0000	9.0000
Operations Management & Services	0.2000	1.0000	1.0000	2.0000	3.0000
Technological Innovation and New Talents	0.2000	1.0000	1.0000	2.0000	3.0000
Environmental impact and sustainable development	0.1429	0.5000	0.5000	1.0000	2.0000
Economic and social benefits	0.1111	0.3333	0.3333	0.5000	1.0000

Table 2: Secondary indicators (1) Infrastructure and Planning

Infrastructure and planning	Size and layout of logistics parks	Transportation network accessibility	Infrastructure completeness	Environmental protection facilities
Size and layout of logistics parks	1.0000	5.0000	3.0000	3.0000
Transportation network accessibility	0.2000	1.0000	0.5000	0.5000
Infrastructure completeness	0.3333	2.0000	1.0000	1.0000
Environmental protection facilities	0.3333	2.0000	1.0000	1.0000

Table 3: Secondary Indicators (2) Operations Management & Services

Operations management & services	Logistics process efficiency	Information service capacity	Safety management system	Customer Satisfaction
Logistics process efficiency	1.0000	3.0000	1.0000	5.0000
Information service capacity	0.3333	1.0000	0.5000	5.0000
Safety management system	1.0000	2.0000	1.0000	5.0000
Customer Satisfaction	0.2000	0.2000	0.2000	1.0000

Table 4: Secondary Indicators (3) Technological Innovation and New Talents

Technological innovation and new talents	Investment in technological innovation	Blockchain Technology Applications	5G technology applications	Internet of Things and Smart Sensor Technology	Level of Artificial Intelligence and Machine Learning Applications
Investment in technological innovation	1.0000	5.0000	5.0000	7.0000	7.0000
Blockchain Technology Applications	0.2000	1.0000	1.0000	2.0000	2.0000
5G technology applications	0.2000	1.0000	1.0000	2.0000	2.0000
Internet of Things and Smart Sensor Technology	0.1429	0.5000	0.5000	1.0000	1.0000
Level of Artificial Intelligence and Machine Learning Applications	0.1429	0.5000	0.5000	1.0000	1.0000

Table 5: Secondary Indicators (4) Environmental Impact and Sustainable Development

Environmental impact and sustainable development	Environmental impact assessment EIA	Energy saving and emission reduction effect	Ecological environment of the park	Long-term development strategy
Environmental impact assessment EIA	1.0000	3.0000	3.0000	5.0000
Energy saving and emission reduction effect	0.3333	1.0000	1.0000	2.0000
Ecological environment of the park	0.3333	1.0000	1.0000	2.0000
Long-term development strategy	0.2000	0.5000	0.5000	1.0000

Table 6: Secondary Indicators (5) Economic and Social Benefits

Economic and social benefits	Cost Control and Benefits	Tax and policy support	Regional economic impacts	Social responsibility and employment
Cost Control and Benefits	1.0000	1.0000	3.0000	0.5000
Tax and policy support	1.0000	1.0000	2.0000	0.5000
Regional economic impacts	0.3333	0.5000	1.0000	0.1111
Social responsibility and employment	2.0000	2.0000	9.0000	1.0000

2) Consistency Test of Judgment Matrix and Calculation of Indicator Weights: Calculate the maximum characteristic root λmax of the judgment matrix with yaahp software, find the consistency indicator RI, refer to Table 7 average random consistency indicator, and perform the consistency test:

Table 7: Average Random Consistency Indicators

According to the formula$CI = \frac{\lambda_{max}-n}{n-1}$, the results obtained are integrated as shown in Table 8:

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54	1.56	1.58	1.59

According to the formula$CI = \frac{\lambda_{max}-n}{n-1}$, the results obtained are integrated as shown in Table 8:

Table 8: Data Results of Judgment Matrix Consistency Test

judgment matrix	λmax	CI	CR
First level matrix	5.0459	0.0114	0.0102
Two-level matrix(Infrastructure and planning)	4.0042	0.0014	0.0016
Two-level matrix(Operations Management & Services)	5.0204	0.0052	0.0046
Two-level matrix(Technological Innovation and New Talents)	4.1195	0.0403	0.0448
Two-level matrix(Environmental impact and sustainable development)	4.0042	0.0014	0.0016
Two-level matrix (Economic and social benefits)	4.0629	0.0212	0.0236

When the stochastic consistency ratioCR=$\frac{CI}{RI}$<0.10, It is considered that there is a satisfactory consistency in the results of hierarchical analysis ranking, and the CRs are less than 0.1 as seen in Table 10, and it can be considered that there is a satisfactory consistency in the constructed judgment matrix, i.e., the assignment of weight coefficients is very reasonable.

The weights of the indicators were calculated using yaahp software and the results obtained are shown in Table 9 Table 10:

Table 9: Tier 1 Indicator Weights

Middle tier elements	weights	arrange in order
Infrastructure and planning	0.5882	1
Technological Innovation and New Talents	0.1406	2
Operations Management & Services	0.1406	3
Environmental impact and sustainable development	0.0810	4
Economic and social benefits	0.0496	5

Table 10: Weights of Secondary Indicators

Options	weights	arrange in order
Logistics Park Area and Layout	0.3127	1
Environmental Protection Facilities	0.1091	2
Completeness of infrastructure construction	0.1091	3
Technological Innovation	0.0821	4
Convenience of Transportation Network	0.0572	5
Logistics Process Efficiency	0.0549	6
Safety Management System	0.0492	7
Environmental Impact Assessment	0.0431	8
Information Service Capability	0.0278	9
Social Responsibility and Employment	0.0245	10
5G Technology Application	0.0190	11
Blockchain Technology Application	0.0190	12
Energy Saving and Emission Reduction Effect	0.0150	13
Park Ecological Environment	0.0150	14
Cost Control and Benefits	0.0110	15
Internet of Things and Smart Sensor Technology	0.0102	16
Artificial Intelligence and Machine Learning Application Level	0.0102	17
Tax and Policy Support	0.0102	18
Customer Satisfaction	0.0087	19
Long-term Development Strategy	0.0079	20
Regional Economic Impact	0.0038	21

3) Analysis of Evaluation Model Solution Results: According to the calculation results, from the perspective of primary indicators, infrastructure and planning, technological innovation and new talents, operation management and services have a greater impact, which also matches the actual situation in the big data environment, and needs to increase the degree of importance. From the perspective of the secondary indicators, the relative importance of various types of indicators ranked in the top five are logistics park area and layout, environmental protection facilities, infrastructure construction completeness, technological innovation, investment, transportation network accessibility grasp, according to the ranking of the weight of the construction of logistics parks infrastructure and rationalization is the key. At present, due to the logistics building and other types of buildings with different functionalization requirements, industrialized image and huge volume and other characteristics of the city surrounding environment and traffic will produce huge pollution and load, building energy consumption and resource environment problems is the current park infrastructure construction facing the prominent key point [18], the traditional park of scattered, chaotic, non-standardized, non-intensive, high vacancy rate and the ecological of modern logistics parks, Integration, intelligence, network forming an obvious form of contrast, traditional logistics parks want to modern logistics park transformation should be seized here.

III. Gray Correlation Method to Determine the Gray Correlation Coefficient

Grey correlation analysis measures the degree of correlation between factors based on the degree of similarity of changes in the developmental dynamics of the factors, which in essence is to calculate and analyze the degree of difference or similarity of the correlation series. If the change trend of two factors is in the same direction, it means that the degree of association between them is high, and vice versa, the degree of association is low. In order to better determine the factors affecting the quality development of urban and rural distribution intelligent logistics parks, the correlation between the factors can be calculated by calculating the gray correlation degree, the use of gray correlation degree can be compared and analyzed to evaluate the advantages and disadvantages of the object, and its requirements and calculations of the relevant data are also relatively small, and it does not require a typical distribution law, which facilitates the quantitative analysis of the complex system [19]. The specific calculation process is as follows:

A. Determination of Reference and Comparison Sequences

Set up a reference sequence:

$$X0= \{X0(1),X0(2)...,X0(n)\} \tag{1}$$

Set up a reference sequence:

$$Xi= \{Xi(1),Xi(2),...,Xi(n)\}\ i=1,2,...,m \tag{2}$$

$$Y=\begin{bmatrix} x_0(1) & \cdots & x_m(1) \\ \vdots & \ddots & \vdots \\ x_0(n) & \cdots & x_m(n) \end{bmatrix} \tag{3}$$

B. Dimensionless Processing

Due to the non-metricity between the indicators of each programmatic level, it is necessary to standardize each data series and convert them to dimensionless data before evaluation. In this paper, the initialization method is used, and the calculation formula is as follows:

$$x_i(K) = \frac{x_i{'}(K)}{x_i{'}(1)} \tag{4}$$

C. Calculate the Sequence Difference

The absolute values corresponding to the reference and comparison series at each moment after the data were dimensionless, were calculated as follows:

$$\Delta i(k)=|x0(k)-xi(k)|(k=1,2,...,m;i=1,2,...,n) \tag{5}$$

D. Calculation of Correlation Coefficients

According to the steps of gray correlation calculation, the correlation coefficients of X0 and Xi with respect to the indicators of the Kth are calculated as follows:

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k)-x_i(k)| + \rho \max_i \max_k |x_0(k)-x_i(k)|}{|x_0(k)-x_i(k)| + \rho \max_i \max_k |x_0(k)-x_i(k)|} \tag{6}$$

Where, ρ is the discrimination coefficient,ρ∈(0,1),the smaller the value of ρ,the greater the difference of correlation coefficient, the stronger the differentiation ability. Usually,ρ takes the value of 0.5,k=1,2,... ,m.

IV. Analysis of evaluation findings and recommendations

A. Analysis of Results

After completing the evaluation, the results need to be analyzed in depth. First, by comparing the total scores of each urban and rural distribution intelligent logistics park, it is possible to gain a preliminary understanding of the level of development quality of each park. Second, a detailed analysis of the scores for each primary and secondary indicator can reveal differences in the performance of the parks in different aspects. For example, some parks may be excellent in infrastructure and planning, but have deficiencies in operation management and service, and some still have problems such as lack of informationization infrastructure construction, imbalance of intelligent infrastructure construction, and difficulty in implementing ecological infrastructure construction, which affect the process of high-quality development of logistics parks [20]. This analysis helps the park to find its own strengths and weaknesses, and provides a direction for subsequent improvement.

B. Recommendations for Improvement

Based on the results of the evaluation, specific recommendations for improvement are provided for each campus. These recommendations should be highly targeted and practical. For example, if the park scores low on technological innovation and new talents, it can be suggested that the park increase its investment in technological research and development, strengthen cooperation with universities and scientific research institutions, and attract and cultivate more new talents. If the park's environmental impact and sustainable development score is low, it can be suggested that the park should strengthen the construction of environmental protection facilities, improve the efficiency of energy utilization, and reduce waste emissions.

V. Conclusion

This study not only fills the research gaps in this field through the research on the development quality evaluation system of urban and rural distribution intelligent logistics parks, but also provides important theoretical support and practical guidance for the planning and development of urban and rural distribution intelligent logistics parks. Through the comprehensive application of AHP and gray correlation method, we have successfully constructed a multi-level, multi-dimensional, operable and comparable evaluation system, which can comprehensively and systematically assess the development quality of urban and rural distribution intelligent logistics parks.

In practice, the evaluation system has been applied to the evaluation process of Leling Ledda Intelligent Logistics Park, and the results show that the system is able to effectively identify the park's strengths and weaknesses in different aspects, providing a clear direction for the park's improvement. For example, through the evaluation system, we found that the park has achieved remarkable results in digitalization and intelligence, but there is still room for improvement in environmental impact and sustainable development. This has prompted the park to increase its investment in environmental facilities and optimize its energy use structure, thus improving the overall development quality of the park.

In addition, this study also found that the development quality of urban and rural distribution intelligent logistics parks not only depends on the advancement of infrastructure and technology, but is also closely related to the park's operation and management, technological innovation ability and the construction of human resources. Therefore, in the future development of the park, in addition to continuing to increase the investment in infrastructure construction, it should also focus on improving the efficiency of operation and management, and strengthening technological innovation and talent cultivation in order to realize the sustainable development of the park.

Finally, this study also emphasizes the dynamism and adaptability of the evaluation system. With the changes in the external environment and the continuous development of the park, the evaluation system should be constantly updated and optimized to ensure that it can continue to provide effective support for the quality improvement of the park.

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