Research on the Influencing Factors of Digital Technology-Driven Efficiency Improvement of Rural Passenger, Cargo and Mail Integration

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Abstract: With the rapid development of digital technology, there is a new boost to the efficiency of rural logistics. However, rural logistics is currently facing challenges such as low technical level, slow efficiency and cost problems. Based on the perspective of digital technology, this paper analyses the influencing factors of rural logistics efficiency improvement by taking rural passenger, cargo and postal integration as an example, establishes a rural passenger, cargo and postal integration efficiency improvement index system, constructs a hierarchical analysis - fuzzy comprehensive analysis and evaluation model, and solves the evaluation of the efficiency of rural logistics is located in the range between general and satisfactory and closer to satisfactory, and the overall public satisfaction needs to be improved. The overall public satisfaction needs to be improved. Finally, this paper suggests that rural logistics should accelerate the construction of infrastructure, help digital technology to empower rural logistics, optimise the distribution process, improve the innovation driving force and digital intelligence, and accelerate the integration and sharing of information.

Keywords: digital technology; rural passenger, freight and mail integration; efficiency improvement; AHP; FCE

1. Introduction

The integrated development of rural passenger, cargo and postal services is a new idea to drive rural economic development and rural revitalization in the new era. The Ministry of Transportation and other relevant departments have also held meetings to emphasize the need to promote the integrated development of rural passenger, freight and postal services, and thus promote the development of rural industries. For the improvement of rural logistics efficiency, the integrated development of rural passenger, freight and postal resources can not only fully tap the potential of passenger transportation, freight and postal resources, narrowing the difference between urban and rural express logistics, improve the satisfaction of rural residents, while helping to build the logistics system, promote economic development. Overall, the integrated development of rural passenger, cargo and postal transportation is a rural logistics model with great potential and prospects, but there are also problems in the integrated development of rural passenger, cargo and postal transportation, such as operating costs, efficiency and coverage, so the research on the efficiency of rural passenger, cargo and postal integration needs to be further developed.

Engels pointed out in the Anti-Dühring Theory that productivity is the ultimate cause of all social change and political change. On this basis, rural passenger and freight mail has contemporary digital intelligent technology support, more in line with the requirements of today's digital era, that is, only to adapt to and lead the trend of scientific and technological revolution and industrial change, in order to effectively promote social productivity to achieve the overall leap [1]. In the field of logistics, from the traditional, human and material resources-based operation mode, to the digitalization, intelligence, automation of the new mode of transformation, is the key to improve the efficiency of rural logistics.

In the digital era, in the face of growing market demand and the continuous innovation of logistics industry technology, it is an inevitable trend to develop rural logistics towards digital intelligence. The application of digital technology provides a new opportunity to improve the efficiency of rural passenger, cargo and postal integration.2024 The fourth meeting of the Central Finance and Economy Commission held in February emphasized that reducing the cost of logistics in the whole society is an important measure to improve the efficiency of economic operation. Exploring how to promote the efficiency improvement of rural logistics in the context of digital technology is our current pending problem. In recent years, with the country's attention to rural development and the implementation of rural revitalization strategy and the rise of rural e-commerce, rural logistics has been working toward efficiency improvement. However, the low level of technology, slow efficiency and cost are also problems that have been pending. Based on the perspective of digital technology, this paper discusses the influencing factors of digital technology-driven rural passenger, cargo and postal integration efficiency improvement, and puts forward corresponding countermeasure suggestions.

2. Literature Review and Theoretical Framework

With the wide application of digital technology, the relevant research angles and contents are becoming richer and more diversified. Regarding the current research status, the research results of experts and scholars based on rural logistics are getting richer and richer. Foreign scholars Sinaga and Bahagia [2] explored the distribution problem of rural logistics by introducing the coordinated planning system method, echelon inventory concept, single-cycle strategy and transportation routes, and established a nonlinear mixed-integer planning model aiming at minimizing the total annual cost for the agricultural distribution problem in rural logistics system; LI and WANG [3] take the existence of any traditional village has the existence of the premise background and value significance as the starting point, to explore the role of service design in the sustainable development of rural revitalization, to study and explore how to use the design of the new quality of productive forces, to build an innovative mechanism of rural development so as to help rural revitalization to move towards a new stage; Shan [4] reconstructs the rural logistics system with the core of "sharing+wisdom", introduces the concept of sharing economy, builds a shared rural logistics information platform, and conducts a research on the logistics and distribution network, aiming to promote the high quality and high efficiency of the construction and operation of the rural logistics system; Rao et al. [5] proposed a collaborative pickup and delivery operation model for rural logistics that takes into account the integration of buses and passengers and goods, and designed a corresponding cost quantification and sharing strategy to provide reference for the government to promote the collaborative operation of rural logistics and improve the efficiency of bidirectional transport in rural logistics. Rao and Miao [6] also proposed a two-stage collaborative transport model of ‘village → town → county’, based on which they designed a relevant model to plan the optimal transport routes and quantify the cost of alliance collaboration, and studied the cost through the Shapley value method; By analysing the development of rural passenger, cargo and postal integration, Huang [7] puts forward his own insights and opinions on the development of passenger, cargo and postal integration, aiming to promote the win-win development of rural passenger transport and rural logistics. Although some scholars have already conducted research on rural logistics, fewer of them have explored the influencing factors of rural passenger, cargo and postal integration efficiency improvement from the background of digital technology.

Therefore, under the new concept of rural passenger, cargo and postal integration, this paper studies the mechanism of rural logistics efficiency improvement through hierarchical analysis and fuzzy comprehensive evaluation. That is, combined with the current status of China's rural logistics based on hierarchical analysis to determine the weight of its indicators, and then use fuzzy comprehensive evaluation to analyze the elements, to draw the conclusions we want, so as to enhance the efficiency of rural logistics mechanism to have a better proposal and solution countermeasures.

3. Research Methodology of Rural Logistics Efficiency Improvement Mechanism

The first method is AHP (Analytic Hierarchy Process) [8], which is to first decompose the relevant factors of the decision-making problem into different hierarchical structures, up to a specific alternative program, in accordance with the order of the overall objective, the sub-objectives of each level, and the evaluation criteria, and then use the method of solving the eigenvectors of judgment matrices to obtain the preferential weights of each element of each level to an element of the previous level, and then finally weighted sum of the method of stepwise subsumption of the alternative program to the final weights of the overall objective. Finally, the final weight of each alternative to the total objective is summed up by the weighted sum method, and the one with the largest final weight is the optimal program. This method usually involves making AHP questionnaires, finding experts to compare the various index programs under study with each other, scoring them according to the level of importance, and then constructing judgment matrices to assign weights to each index.

The second method is FCE (Fuzzy Comprehensive Evaluation), which was first proposed by Chinese scholar Wang Peizhuang. It is a method of comprehensive assessment of things in a fuzzy and uncertain environment, which aims to achieve a specific goal through the comprehensive consideration of multiple evaluation factors on the evaluation of the subordinate rank status of the evaluated object. This method is particularly suitable for dealing with complex comprehensive evaluation problems that involve multiple dimensions and factors and are difficult to assess directly and quantitatively [9].

3.1. Data Sources and Variable Configuration

Empowering logistics with digital technology is to make the development of logistics more digitalized, intelligent and automated. Combined with the current situation of China's rural decentralization, diversity, high cost and other characteristics, it can be seen that the key to improve the efficiency of rural logistics in the construction of rural infrastructure, digital intelligence technology level, as well as the efficiency of rural logistics and the development of innovation drive. In order to be able to carry out targeted research on the mechanism of rural logistics efficiency improvement and improve the objectivity of the construction of the index system, it is determined that the evaluation index system of this paper includes the following four indicators: facility technology, logistics efficiency, innovation driving force, and the level of digital intelligence, as shown in Table 1.

Table 1. Indicator system for improving the efficiency of rural passenger, cargo and mail integration.

<table>
<tr><th>Goal level</th><th>Primary indicator</th><th>Secondary indicator</th></tr>
<tr><td rowspan="14">Rural Logistics Efficiency Improvement</td><td rowspan="4">A: Facility technology</td><td>A1: Cold chain logistics system construction</td></tr>
<tr><td>A2: Coverage of logistics service outlets</td></tr>
<tr><td>A3: Comprehensive infrastructure</td></tr>
<tr><td>A4: Rural road access rate</td></tr>
<tr><td rowspan="3">B: Logistics efficiency</td><td>B1: Timely logistics and distribution</td></tr>
<tr><td>B2: Low loss rate of agricultural products</td></tr>
<tr><td>B3: Application of common distribution model</td></tr>
<tr><td rowspan="4">C: Innovation Driving Force</td><td>C1: Strengthen technological innovation</td></tr>
<tr><td>C2: Building Specialty Brands for Agricultural Products</td></tr>
<tr><td>C3: Promote rural green logistics</td></tr>
<tr><td>C4: Strengthening the application and integration of innovative logistics models</td></tr>
<tr><td rowspan="3">D: Digital Intelligence Level</td><td>D1: Sharing logistics information in each link of the supply chain</td></tr>
<tr><td>D2: Popularize the development of agricultural e-commerce logistics</td></tr>
<tr><td>D3: Introduction of Digital Intelligence Technology</td></tr>
</table>

3.1.1. Facility technology

Facility technology is the most basic guarantee for the sustainable development of rural logistics. It mainly includes the construction of cold chain logistics system, the coverage rate of logistics service outlets, comprehensive infrastructure, and rural road access rate. Cold chain logistics [10] is to ensure that agricultural products in transportation, storage and other links to maintain freshness and reduce losses, but at present, due to the imperfect infrastructure and low circulation, the "first kilometer" and "last kilometer" of the cold chain logistics is still hindered, so the construction of cold chain logistics should not be ignored. Therefore, the construction of cold chain logistics should not be neglected. In addition, there is also the construction of logistics outlets and warehousing centers in rural areas. The distribution of high-coverage outlets can ensure the timely and efficient transportation of agricultural products, reduce intermediate links, and lower logistics costs. The outlets and logistics-related facilities should also be arranged comprehensively and well-built. At the same time, the accessibility of rural roads should also be taken into account.

3.1.2. Logistics efficiency

High logistics efficiency means faster and better delivery of agricultural products, which affects its accessibility, cost and market competitiveness, and has a direct impact on rural logistics, with secondary indicators including timely logistics and distribution, low loss of agricultural products, and the application of the co-distribution model. The timeliness of logistics and distribution can ensure the freshness of products and customer satisfaction, which in turn promotes the continuous sales of products. The common distribution model realizes economies of scale by integrating multiple logistics resources, and its application can reduce distribution costs to promote the integrated development of rural passenger, cargo and postal services.

3.1.3. Innovation drivers

In the current context of rapid development of science and technology, innovation has become the core driving force to promote the development of all walks of life. Rural logistics as an important link between rural and urban, its level of innovation directly affects the development of its economic level. To improve efficiency requires rural logistics to constantly seek innovation breakthroughs and improve the innovation driving force of rural logistics. Secondary indicators include strengthening technological innovation, building specialty brands for agricultural products, promoting rural green logistics, and strengthening the application and integration of innovative logistics models.

3.1.4. Level of digital intelligence

In supply chains, the problem of information silos often inhibits information sharing. The improvement of digital intelligence can promote information sharing and better help rural logistics improve efficiency. Secondary indicators include: sharing of logistics information in each link of the supply chain, popularization and development of agricultural e-commerce logistics, and introduction of digitalization technology. The level of digital intelligence is an important indicator of the degree of modernization of rural logistics, and the introduction of digital technology helps to strengthen the synergy between the various segments of the supply chain, improve operational efficiency, and then play a role in improving efficiency. At the same time, the introduction of e-commerce has enabled agricultural products to be sold to a wider market through the Internet platform, increasing market coverage and sales.

According to this variable configuration to create a questionnaire, contacted three experts engaged in the rural logistics industry and two teachers specializing in logistics to jointly analyze the rural passenger, cargo and postal integration efficiency improvement index system, the questionnaire data analysis scoring.

3.2 Hierarchical Analysis

3.2.1. Construct judgment matrix

First of all, according to Saaty's judgment matrix 1-9 scaling method (as in Table 2), respectively, the first-level indicators in the hierarchy and the second-level indicators of the two-two indicator factors in pairwise comparisons, two-by-two comparisons of the program indicators, and in accordance with the scaling method for scoring, according to the degree of importance of the grades rated. Finally, a judgment matrix of first-level indicators and four judgment matrices of second-level indicators were constructed, as shown in Tables 3 to 7.

Table 2. Judgment matrix 1--9 scaling methods.

scale a_{ij}	Definition.
1	Factor i is equally important to factor j
3	Factor i is slightly more important than factor j
5	Factor i is more important than factor j
7	Factor i is very important than factor j
9	Factor i is absolutely more important than factor j
2,4,6,8	The middle value of the above judgment
reciprocal	If factor j is more important

Table 3. Judgment matrix for Tier 1 indicators.

Indicators	Facility Technology	Logistics Efficiency	Innovation Driving Force	Digital Intelligence Level
Facility Technology	1	2	2	1
Logistics Efficiency	0.5	1	0.5	0.333
Innovation Driving Force	0.5	2	1	0.5
Digital Intelligence Level	1	3	2	1

Table 4. Facility technology judgment matrix.

Indicators	A1	A2	A3	A4
A1	1	2	2	5
A2	0.5	1	2	2
A3	0.5	0.5	1	0.5
A4	0.2	0.5	2	1

Table 5. Logistics efficiency judgment matrix.

Indicators	B1	B2	B3
B1	1	0.5	0.333
B2	2	1	0.5
B3	3	2	1

Table 6. Innovation driving force judgment matrix.

Indicators	C1	C2	C3	C4
C1	1	4	2	0.5
C2	0.25	1	0.5	0.333
C3	0.5	2	1	1
C4	2	3	1	1

Table 7. Digital intelligence level judgment matrix.

Indicators	D1	D2	D3
D1	1	0.5	0.5
D2	2	1	2
D3	2	0.5	1

3.2.2. Calculation process

Calculate the relative weights of each element in each level of judgment matrix, calculate the maximum feature root and consistency index for consistency test of judgment matrix.

The maximum characteristic root and its corresponding eigenvector, the solution formula: $AW = \lambda_{max}W$ (where $\lambda_{max}W$ represents the maximum characteristic root of A, and W represents the normalized eigenvector.

The maximum feature root formula is $\lambda_{\max} \approx \sum_{i=1}^{n} \frac{(AW)_i}{nW_i}$

Then the consistency test is carried out to analyze the compatibility and error, according to which the compatibility index is defined as CI, i.e., the consistency index

$CI = \frac{\lambda_{\max} - n}{n-1}$ (n represents the order of the judgment matrix)

If CI = 0, then it is consistent; if CI is not 0, then the consistency can be tested whether the consistency passes or not according to CR < 0.1, and it is necessary to compare the CI with the average stochastic consistency index RI (as in Table 8), i.e., $CR = \frac{CI}{RI}$

Table 8. Average randomized consistency indicators.

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58	1.59

3.2.3. Deriving results

The weight value and CI value are calculated from the comprehensive scoring of the judgment matrix of the first-level indicators, as shown in Table 9, combined with Table 8, we can see that the RI value of the fourth-order matrix is 0.89, and according to the formula $CR = \frac{CI}{RI}$, it is obtained that CR = 0.017 < 0.1, and the consistency test is passed.

Table 9. Rural logistics efficiency improvement judgment matrix.

AHP hierarchical analysis results					
term	Eigenvector	Weight value (%)	Maximum Eigenroot	CI value	Consistency test result
Facility Technology	1.3	32.498	4.046	0.015	CR=0.017<0.1 pass
Logistics Efficiency	0.5	12.506			
Innovation Driving Force	0.775	19.374			
Digital Intelligence Level	1.425	35.625			

The eigenvectors, weight values, maximum eigenroot CI values and consistency test results of the judgment matrix of the secondary indicators are shown in Tables 10--13.

Table 10. Results of the facility technical judgment matrix.

term	Eigenvector	Weight value (%)	Maximum Eigenroot	CI value	Consistency test result
A1	1.828	46.712	4.234	0.078	CR=0.089<0.1 pass
A2	0.998	24.957			
A3	0.554	13.849			
A4	0.619	15.482			

Table 11. Results of the logistics efficiency judgment matrix.

term	Eigenvector	Weight value (%)	Maximum Eigenroot	CI value	Consistency test result
B1	0.491	16.378	3.009	0.005	CR=0.009<0.1 pass
B2	0.892	29.726			
B3	1.617	53.896			

Table 12. Results of the innovation driving force judgment matrix.

term	Eigenvector	Weight value (%)	Maximum Eigenroot	CI value	Consistency test result
C1	1.288	32.19	4.196	0.065	CR=0.074<0.1 pass
C2	0.395	9.886			
C3	0.908	22.712			
C4	1.408	35.212			

Table 13. Results of the digital intelligence level judgment matrix.

term	Eigenvector	Weight value (%)	Maximum Eigenroot	CI value	Consistency test result
D1	0.593	19.762	3.054	0.027	CR=0.051<0.1 pass
D2	1.471	49.048			
D3	0.936	31.19			

3.3. Fuzzy Integrated Evaluation

3.3.1. Data collection

In terms of data sources, 24 sample rural passenger, cargo and mail integration counties approved in Shandong Province before 2024 were selected for data research, utilizing both on-site and network research forms. On the basis of the rural logistics efficiency improvement evaluation system constructed above, a satisfaction questionnaire was designed based on digital technology, in which satisfaction was measured in five dimensions: very satisfied (5), satisfied (4), average (3), dissatisfied (2), and very dissatisfied (1). The overall situation of the questionnaire survey is as follows: 145 questionnaires were received, and 120 questionnaires were screened for validity, with a validity rate of 82.76%, as shown in Table 14.

Table 14. Questionnaire data.

Target level	Tier 1 Indicators	Secondary indicators	Questionnaire results				
			Very satisfied	Satisfied	General	Dissatisfied	Very dissatisfied
Rural Logistics Efficiency Improvement	A: Facility technology	A1: Cold chain logistics system construction	13	56	37	12	2
		A2: Coverage of logistics service outlets	23	55	30	10	2
		A3: Comprehensive infrastructure	28	38	37	14	3
		A4: Rural road access rate	19	54	29	15	3
	B: Logistics efficiency	B1: Timely logistics and distribution	29	49	28	11	3
		B2: Low loss rate of agricultural products	16	48	40	16	0
		B3: Application of common distribution model	28	51	27	12	2
	C: Innovation Driving Force	C1: Strengthen technological innovation	20	51	31	15	3
		C2: Building Specialty Brands for Agricultural Products	23	44	33	15	5
		C3: Promote rural green logistics	18	39	40	21	2
		C4: Strengthening the application and integration of innovative logistics models	28	41	31	18	2
	D: Digital Intelligence Level	D1: Sharing logistics information in each link of the supply chain	26	52	26	13	3
		D2: Popularize the development of agricultural e-commerce logistics	21	50	36	11	2
		D3: Introduction of Digital Intelligence Technology	22	54	31	11	2

3.3.2. Data inspection

In order to ensure the reliability of the data collected from the questionnaire, this paper analyzes the reliability of the questionnaire.

1. Reliability analysis

Reliability analysis (i.e., Cronbach's alpha coefficient), also known as reliability analysis, aims to study whether the data are true and reliable, i.e., whether the sample of the study answered the questions truthfully, and whether the test respondents answered the questions seriously. The reliability analysis of the questionnaire is an important part of assessing the stability and consistency of the results of the questionnaire, the reliability analysis can respond to the internal relationship between each question item of the questionnaire, in order to test the consistency of the data, it mainly focuses on the questionnaire scale samples are reliable and trustworthy. After the reliability analysis, if the Cronbach's Alpha coefficient of the scale is above 0.9, it means that the reliability of the scale is very good; if the Cronbach's Alpha coefficient of the scale is between 0.8-0.9, it means that the reliability of the scale is acceptable; if the Cronbach 's Alpha coefficient is between 0.7-0.8, it indicates that the scale needs to be reworked; if the reliability coefficient of the scale is 0.7 or less, it indicates that the scale needs to be discarded.

2. Validity analysis

Validity test [11], that is, to test the validity of the questionnaire, in general terms, to determine whether the design of the question items is reasonable, whether it can effectively respond to the research objectives of the researcher, the validity is good, then it shows that the internal consistency of the questionnaire data can be passed. The validity analysis of the questionnaire is realized based on principal component factor analysis, which is realized by comparing whether the factor loading coefficients of the items are optimal in the same principal component. The main criteria for judging are KMO value greater than 0.6 (correlation exists), $P<0.05$ (significant). And the cumulative variance explained is greater than 50%.

3.Test results

In this paper, the data of this questionnaire were analyzed for reliability and validity using SPSS, and the results of reliability and validity tests were obtained as in Table 15 and Table 16. Regarding the reliability analysis, the Cronbach's alpha coefficient value is 0.917, which is greater than 0.9. From the above Cronbach's alpha coefficient value judging criteria, it can be seen that the data collected by this questionnaire has a high degree of credibility, and the reliability of the initial evaluation index system constructed in this paper is strong. Regarding the validity analysis, the KMO value is 0.922, higher than 0.9, and the result of Bartlett's sphericity test shows that the significance P is 0.000, so the consistency of this questionnaire can be passed.

Table 15. Reliability analysis.

Cronbach's Alpha	item count
0.917	14

Table 16. Validity analysis.

KMO and Bartlett test		
KMO Sampling Suitability Measure	0.922	
Bartlett's test of sphericity	Approximate chi-square	775.688
	Degrees of freedom	91
	Significance	0.000

3.3.3. Calculation process

1. Determine the set of evaluation factors for the evaluation object [12]

Determine the set of evaluation factors for the evaluation object $U_i=\{u_1, u_2, ... , u_m\}$, $U_{ij}=\{u_{i1}, u_{i2}, ... , u_{in}\}$, where $i \in \{1,2,... ,m\}$, $j \in \{1,2,... , n\}$, and i denotes the number of first-level indicators and j denotes the number of second-level indicators in the rural passenger, cargo and mail integration efficiency improvement index system, i.e., U_i denotes the ith first-level indicator and U_{ij} denotes the jth second-level indicator under the ith first-level indicator layer.

2. Establishment of rubric set

Establish the rubric set $V= \{v_1, v_2, v_3, v_4, v_5\}$, where v_1, v_2, v_3, v_4, v_5 denote very satisfied, satisfied, general, dissatisfied and very dissatisfied respectively. Their corresponding evaluation results are 5, 4, 3, 2, 1, respectively, then the evaluation result matrix is $(5, 4, 3, 2, 1)^T$

3. Construct affiliation matrix

The degree of affiliation refers to the size of the possibility of multiple evaluation subjects to make some kind of evaluation of an evaluation object in a certain evaluation index. rij=indicator to get the corresponding comment on the valid data/total valid data, through the data in Table 14 can be calculated the degree of affiliation, to get the matrix of affiliation in Table 17.

Table 17. Affinity matrix.

	Very satisfied	Satisfied	General	Dissatisfied	Very dissatisfied
A1	0.108	0.467	0.308	0.1	0.017
A2	0.192	0.458	0.25	0.083	0.017
A3	0.233	0.317	0.308	0.117	0.025
A4	0.158	0.45	0.242	0.125	0.025
B1	0.242	0.408	0.233	0.092	0.025
B2	0.134	0.4	0.333	0.133	0
B3	0.233	0.425	0.225	0.1	0.017
C1	0.167	0.425	0.258	0.125	0.025
C2	0.192	0.367	0.275	0.125	0.041
C3	0.15	0.325	0.333	0.175	0.017
C4	0.233	0.342	0.258	0.15	0.017
D1	0.217	0.433	0.217	0.108	0.025
D2	0.175	0.417	0.3	0.091	0.017
D3	0.183	0.45	0.258	0.092	0.017

4. Deriving results

According to the weight data derived from the AHP method, the composite score is calculated through spsspro, as in Table 18.

Table 18. Fuzzy composite evaluation scores.

		Very satisfied	Satisfied	General	Dissatisfied	Very dissatisfied	aggregate score	
A	Affiliation degree	0.15509613	0.44601843	0.28638682	0.10298214	0.01951648	3.608	3.630
	Normalization of affiliation degree [weight]	0.154	0.442	0.284	0.102	0.019		
B		Very satisfied	Satisfied	General	Dissatisfied	Very dissatisfied		
	Affiliation degree	0.20504528	0.41478424	0.25841432	0.10849934	0.01325682	3.690	
	Normalization of affiliation degree [weight]	0.205	0.415	0.258	0.108	0.013		
C		Very satisfied	Satisfied	General	Dissatisfied	Very dissatisfied		
	Affiliation degree	0.18885038	0.36732816	0.27671462	0.145159	0.02194784	3.556	
	Normalization of affiliation degree [weight]	0.189	0.367	0.277	0.145	0.022		
D		Very satisfied	Satisfied	General	Dissatisfied	Very dissatisfied		
	Affiliation degree	0.18579524	0.43045462	0.27049774	0.09467144	0.01858096	3.670	
	Normalization of affiliation degree [weight]	0.186	0.43	0.27	0.095	0.019		

4. Discussion of Results

The results of the hierarchical analysis method show that: the level of digital intelligence level has the highest weight, and the facility technology is only 3% lower in the second, followed by innovation driving force and logistics efficiency. The cold chain logistics system construction has the highest weight in the facility technology index, the application of common distribution mode has the highest weight in logistics efficiency, the application of strengthening the integration of innovative logistics mode has the highest weight in innovation driving force, and the strengthening of technological innovation is only 3% lower, and the popularization and development of agricultural products' e-commerce logistics has the highest weight in the digital intelligence level.

The fuzzy comprehensive evaluation result shows that the comprehensive evaluation result of rural logistics efficiency improvement is 3.630, which is between general and satisfactory and slightly close to satisfactory. The comprehensive evaluation results of the first-level indicators are 3.608, 3.690, 3.556, and 3.670 for facility technology, logistics efficiency, innovation driving force, and digitalization level, respectively, and it can be seen that the satisfaction level of the first-level evaluation indicators of rural logistics efficiency improvement is located between general and satisfactory, and is relatively close to the satisfaction level. It can be seen that the satisfaction level of the first-level evaluation indicators of rural logistics efficiency improvement lies between "average" and "satisfactory", and is relatively close to the satisfaction level. The satisfaction levels of logistics efficiency and digitalization are higher than the overall satisfaction level, while the satisfaction levels of facility technology and innovation driving force are slightly lower than the overall satisfaction level, and the satisfaction level of facility technology is the lowest among them.

5. Limitations

The study has certain limitations. Firstly, in terms of the weights of the hierarchical analysis method, the weights obtained by experts in scoring often depend on their subjective judgment, and the experience and views of different experts may lead to differences in weight allocation, and the objectivity and accuracy of the final evaluation results may be affected. In the future, we will contact more and more professional experts to conduct comprehensive scoring to improve the consistency of the results. Secondly, the data of the questionnaire comes from 24 sample counties of rural passenger, cargo and postal integration approved by Shandong Province before 2024, and the scope of the survey has some limitations, the results will have some limitations, and there may be discrepancies with the evaluation score of the improvement of the efficiency of rural logistics in the whole country, so in the future, we will continue to collect the data to expand the scope and improve the representativeness of this study.

6. Conclusion of the Analysis of Factors Affecting the Efficiency Improvement of Rural Passenger, Cargo and Mail Integration Driven by Digital Technology

6.1. Infrastructure Development to Help Digital Technology Empower Rural Logistics

Facility technology has the lowest level of satisfaction. First of all, we should promote the two-way integration of urban and rural cold chain network, and strengthen the construction of cold chain logistics system, which can not only reduce losses by reducing the rate of loss on the way, but also maintain the freshness and enhance competitiveness, so as to achieve high-quality development, and help digital technology to empower rural logistics. At the same time, it is necessary to strengthen the infrastructure of rural outlets to ensure that outlets cover all administrative villages, and even natural villages, to solve the problem of the rural express "last kilometer", improve coverage, improve the rural logistics network system, and enhance the interaction between digitalization and the integration of rural cargo and postal services. Finally, it is necessary to increase the construction and transformation of rural roads, improve the access rate of rural roads, better promote the integration of rural passenger, cargo and postal logistics development, the formation of a wide range of coverage, smooth connection of the rural road network.

6.2. Optimization of the Distribution Process, Improve Distribution Efficiency

The highest satisfaction score for logistics efficiency shows that people are currently more satisfied with the current distribution efficiency. Rural areas can invoke more big data and artificial intelligence technology to predict and plan the logistics demand and distribution process, reduce unnecessary time waste in the transportation process, and realize real-time sharing and intelligent processing of logistics information. This kind of precise logistics management can significantly improve the efficiency of logistics, which is a concrete embodiment of the integrated development of rural passenger, cargo and postal services. The government can also increase the investment in intelligent equipment, promote the integration of multiple subjects on the rural express digital logistics network, and also improve the efficiency of logistics and distribution and the efficiency of packaging of agricultural products, and promote the efficiency of rural passenger, cargo and postal integration.

6.3. Enhance Innovation Drive and Promote Technology and Model Innovation

Improving the drivers of innovation is simply a matter of technological and modal innovation. Firstly, innovations can be made in cost aspects such as logistics and transportation modes and logistics packaging. The digital development of rural logistics is also emphasizing environmentally friendly and sustainable development, and its development promotes the application of green technology, information technology and other innovative elements in the whole agricultural industry chain, and the logistics packaging can be made of green and recyclable materials, while the construction of facilities can choose more energy-saving materials and optimize the layout of buildings. At the same time, the omnipotence and sustainability of each logistics resource can be strengthened and viewed with a developmental perspective. It can also promote the application of multimodal transportation, cold chain logistics, rural e-commerce logistics and other emerging logistics modes, and at the same time, strengthen the publicity power and influence, expand sales outlets, so that the rural related industries are getting bigger and bigger.

6.4. Information Fusion and Sharing, and Promote the Level of Digital Intellectualization

The level of digital intelligence has the greatest weight and is the main factor affecting the improvement of rural logistics efficiency. Digital technology helps to build a logistics resource sharing platform based on the Internet and big data technology, breaking down information silos. Digital technology empowering rural logistics is mainly reflected in the development of smart logistics, which should promote the integration of rural industries and smart logistics platforms, and promote the open sharing of logistics-related data. The enhancement of the level of digital intelligence and the sharing of information fusion can also realize the automated monitoring and automatic diagnosis of the logistics process in urban and rural cold chain logistics, reduce the human cost, and effectively reduce the transportation cost and time. At the same time, we can not ignore the use of digital technology in the digital intelligence technology and brand marketing means to help farmers to open up the e-commerce sales channels, strengthen the interaction of e-commerce logistics, promote the transformation of logistics and e-commerce industry to intelligence, digitalization, and upgrading rural logistics development, to grasp the future trend. Publicity and promotion through e-commerce platforms and social media and other channels to improve the visibility and added value of agricultural products, which in turn promotes the development of rural logistics, but also indirectly promotes the efficiency of rural passenger, cargo and postal integration to improve a good method.

References

[1] XU Zheng, ZHENG Linhao, CHENG Mengyao. Internal Logic and Practical Concept of New Quality Productivity Enabling High Quality Development. Contemporary Economic Research, 2023(11):51-58.

[2] T S Sinaga; S N Bahagia. Integrated Logistics and Transportation Routing in Rural Logistics System Journal IOP Conference Series: Materials Science and Engineering. Volume 528, Issue 1. 2019. pp 012081 (8pp)

[3] Shasha LI; Xiaodong WANGNew. quality productivity: an empirical study of service design as a new driving force for rural revitalization Journal |. Journal | Social Science Theory and Practice. Volume 6, Issue 1. 2024

[4] Hanbing Shan. Construction and Operation of Rural Intelligent Logistics System under the Background of Sharing Economy. Journal | Journal of Journal | Journal of Humanities, Arts and Social Science. Volume 7, Issue 8. 2023

[5] Rao Weizhen, Miao Xiaohe, Zhu Qinghua. Research on the operation mode and method of rural logistics collaborative pickup and delivery considering the integration of public transportation with passenger and cargo. Systems Engineering Theory and Practice,1-25.

[6] Rao Weizhen, Miao Xiaohe. Research on the optimization of rural passenger and cargo integration logistics collaboration path and cost sharing problem. China Management Science,1-22[2025-02-22].

[7] Huang Xinyu. Study on the Integrated Development of Rural Passenger, Cargo and Postal Transportation in the Context of Rural Revitalization--Based on the Practical Exploration in Hunan Province. Price Theory and Practice, 2022, (03).

[8] ZHOU Jing, SUN Jian. Performance evaluation of cold chain logistics enterprises based on AHP-DEA model. Social Science Series, 2015, (05):114-119.

[9] LI Yunhua, SONG Su, WEI Lianyu, SUN Wenxia. Selection of Logistics Service Providers by Fuzzy Comprehensive Evaluation Method. Journal of Hebei University of Technology, 2011, (05):94-97+100.

[10] Wang Junwen. Empirical evidence and suggestions for synergistic development of regional agricultural e-commerce and cold chain logistics in the context of rural revitalization. Business and Economic Research, 2023, (23):107-111.

[11] YANG Liu, DU Wei, FANG Ping, et al. Development and reliability test of the Social Emotional Scale. Psychological and Behavioral Research,2023,21(04):446-453.

[12] Wei Liu; Zhen Liu. User experience evaluation of intelligent sports bracelet based on multi-factor fusion Journal | International Journal of International Journal of Product Development. Volume 26, Issue 1-4. 2022. PP 102-116