Research on the Evaluation of Regional Logistics Capacity of Gansu Province under the "The Belt and Road" Initiative Based on Gray Correlation Analysis

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Abstract. Gansu Province is a key construction area on “The Silk Road Economic Belt” established by Chinese “The Belt and Road” initiative. In order to evaluate the level of regional logistics capability in Gansu Province, this paper proposes a regional logistics capacity evaluation method based on the gray correlation analysis model. Based on the comprehensive analysis of the factors affecting the regional logistics development capability, the evaluation index system of regional logistics capability is constructed. The combination weighting method model is constructed by combining the analytic hierarchy process (AHP) and entropy weight method, and the weight coefficient of each evaluation index is determined by using the model. Based on the statistical data of all cities (states) in Gansu Province in 2019, combined with the gray correlation analysis model, the regional logistics capacity of 14 cities (states) in Gansu Province was comprehensively evaluated and ranked, and the ranking results were consistent with the actual situation, which verified the effectiveness of the evaluation model, and the regional logistics capacity of Gansu Province was briefly analyzed, which provides theoretical and basic support for the follow-up and in-depth study of regional logistics capacity in Gansu Province.

Keywords: “The Belt and Road” Initiative; Regional logistics capability; Gray correlation analysis; Gansu Province

1 Introduction

Chinese "The Belt and Road" initiative has clearly identified 18 provinces and cities, including Gansu Province, as key construction areas of “The Silk Road Economic Belt”. Gansu Province, located in the northwest inland area of China, has the natural geographical advantage of "Sitting in the Middle and Linking the Four Sides". In recent years, with the rapid development of economy, the logistics industry has developed rapidly, and the scale benefit has initially appeared, which plays an important role in the regional economic development of Gansu Province. However, due to the unbal-

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anced economic and social development of each city (state) and the unreasonable layout of logistics network, there is a big gap in the development level of regional logistics capacity of each city (state) in Gansu Province[1]. This paper unifies the Gansu Province economic society to develop the reality, has comprehensively analyzed the influence city (state) regional logistics capability on the basis of relevant factors, the evaluation index system of regional logistics capability is constructed, and the scientific weight coefficient of the index system is assigned. Based on the statistical data of economic and social development of cities (states) in Gansu Province in 2019, a comprehensive evaluation of the regional logistics capacity of 14 cities (states) in the province was carried out based on the gray correlation analysis model. According to the size of the final correlation coefficient calculated, the regional logistics capability levels of 14 cities (states) are ranked in order, so as to provide theoretical reference and practical basis for comprehensively developing the regional logistics

Level of Gansu Province, improving the logistics capability of underdeveloped cities (states), better promoting the coordinated development of regional logistics and economy, reasonably rectifying the urban development strategy, and finally realizing the effective connection with the national "The Belt and Road" initiative.

2 Research status

In recent years, scholars at home and abroad have made some achievements in the research of regional logistics capability. Taking "regional logistics capability" as the key word to search the English literature, it is found that there is relatively little research on regional logistics capability by foreign scholars, which is mainly based on 32 elements of logistics capability proposed by Michigan

State University (MSU), and carries out micro-level research on enterprise logistics, supply chain logistics and so on. In terms of regional logistics research at the macro level, Pekkarinen[2](2005) conducted a quantitative study on the logistics capability of Siberia, Russia; Anand[3](2012) analyzed, summarized and reviewed the modeling methods of urban logistics; Ekici[4](2016) and others evaluated Turkey's logistics capacity by using artificial neural network method on the basis of establishing an evaluation index system.

In recent years, domestic scholars have done a lot of research on regional logistics capability under the background of "The Belt and Road Initiative", but most of them focus on the research and analysis of macro-international relations and their strategic significance, such as Luo Ming and Zhang Tianyong[5], who analyzed the connotation of "The Belt and Road" initiative and the position of logistics industry in the strategy. This paper focuses on the analysis of the inconsistency of national interests along the line, regional security and stability issues, as well as some domestic unfavorable factors, which pose a huge challenge to the development of China's logistics industry. In the field of micro-regional logistics research, the research results mainly focus on the analysis and evaluation of regional logistics capabilities. Many scholars use different evaluation models to evaluate and analyze the regional logistics capabilities from different perspectives. For example, Wang Dehua[6]used multivariate statistical methods to construct an evaluation model to evaluate the logistics capabilities of 14 regions in Hunan Province. The influencing factors of regional logistics capability are analyzed, and the cluster analysis of regional logistics capability is carried out. Liu Yan et al.[7]evaluated the competitiveness of urban logistics industry from the perspective of industrial linkage by using entropy weight and TOPSIS combination model. Chen Xiangru et al.[8]took 8 cities in Chengdu metropolitan area as the research object, constructed the evaluation index system of logistics capability, and used the principal component analysis method to rank the logistics competitiveness scores of each evaluation city. According to the fuzziness and incompatibility of the evaluation indexes of regional logistics development level, Zhou Tai[9]et al. Established a fuzzy matter-element evaluation model of regional logistics development level, and carried out a comprehensive evaluation analysis of the development level of regional logistics with an example. Deng Aimin[10]established the evaluation index system of emergency logistics capability, determined the index weight of each level by using fuzzy analytic hierarchy process, and made a comprehensive evaluation of emergency logistics capability by combining fuzzy gray comprehensive evaluation method.

Although the current research on regional logistics capability has become a hot spot, through literature analysis, it is found that there is very little research on regional logistics capability in Gansu Province, which has obvious location advantages under the current"The Belt and Road" initiative. The author searched CNKI with the keywords of "The Belt and Road Initiative", "Gansu" and "regional logistics capability" and found that there was no research article on the evaluation of regional logistics capability.

3 Definition of regional logistics capability

The definition of regional logistics capability can be divided into broad sense and narrow sense. The broad sense of regional logistics capability refers to the operation capability of logistics organization, which includes not only the static capability of fixed assets such as logistics facilities and equipment, energy and capital, but also the operation behavior and management process of logistics enterprises, reflecting the comprehensive logistics function level of a region. In a narrow sense, regional logistics capability refers to the maximum quantity of raw materials or products that can be processed and the maximum quantity of logistics services that can be provided by all logistics fixed assets of regional logistics organizations under certain technical conditions in a certain period of time[11]. Referring to the definition of production capacity, regional logistics capacity is defined as the maximum capacity of regional logistics suppliers to provide logistics services to regional logistics demanders through effective and reasonable organization and utilization of various resources within the system within a certain period of time.

4 Construction of evaluation index system of regional logistics capability

The level of regional logistics capacity is restricted by many factors, such as the level of regional economic development, the situation of regional transportation and the investment of logistics industry. According to the need of the research problem, considering the systematicness, representativeness and availability of the indicators, this paper attributes these factors to three aspects: regional economic development status, consumption and circulation, and logistics supply capacity. This paper finally establishes a regional logistics capability evaluation index system consisting of one first-level index, three second-level indexes and 13 third-level indexes, as shown in Table 1.

Table 1. Evaluation Index System of Regional Logistics Capability

Level 1 indicator	Level 2 indicators	Level 3 indicators
Region Logistics Ability A	Regional Economic Development Status B_1	Gross regional product (100 million yuan) (C_1)
		GDP per capita (10,000 yuan) (C_2)
		Gross output value of tertiary industry (100 million yuan) (C_3)
		Tax revenue status (100 million yuan) (C_4)
		Index of industrial added value above designated size (1 in the previous year) (C_5)
	Consumption and Circulation B_2	Total import and export volume (100 million yuan) (C_6)
		Total retail sales of consumer goods (100 million yuan) (C_7)
		Total amount of transportation, storage and postal services (100 million yuan) (C_8)
	Logistics supply capacity B_3	Highway mileage (km) (C_9)
		Number of civilian motor vehicles owned (10,000) (C_{10})
		Number of employees in transportation, storage and postal services (10,000) (C_{11})
		Number of employees in information transmission, software and information technology services (10,000) (C_{12})
		Number of mobile phone and Internet broadband users (10,000) (C_{13})

5 The combination weighting method based on AHP-entropy weight method to determine the weight coefficient

The analytic hierarchy process (AHP) takes into account the knowledge and experience of experts, but because of the subjective uncertainty of expert scoring, the credibility of the evaluation results will be reduced. Although the entropy weight method uses a more objective mathematical method, it can not reflect the knowledge and experience of experts, is not authoritative enough, and may be divorced from the actual situation. In order to minimize the absolute subjectivity and objectivity in the evaluation process, this paper adopts the combination weighting method which combines the analytic hierarchy process and entropy weight method, and considers the subjective and objective factors to get a more scientific and reasonable index weight.

5.1 Analytic Hierarchy Process(AHP)

The Analytic Hierarchy Process (AHP) combines the qualitative and quantitative methods. The qualitative part decomposes the complex problem and forms a number of hierarchical structures according to the dominant relationship of the factors. The quantitative part compares the factors by experts or decision makers, constructs the judgment matrix to determine the relative importance of the factors, and determines the index weight by calculating the eigenvector of the judgment matrix. It is especially suitable for the evaluation with many influencing factors and different standards. The specific steps are as follows:

(1)Establish a hierarchical model. The evaluated object is disassembled into a target layer, a criterion layer and a scheme layer. Construct a pairwise comparison matrix. Using 1~9 to represent the relative importance of one factor compared with another factor, the judgment matrix of pairwise comparison of factors at each level is obtained.

$$A = (a_{ij})_{m\times m}$$

(2)The weight vector is calculated and checked for consistency. Calculate the maximum eigenvalue of the judgment matrix $\lambda_{\max}$, and define the consistency index.

$$CI = \frac{\lambda_{\max} - m}{m - 1}$$

The consistency index CI is used to measure the deviation degree between the judgment matrix A and its characteristic matrix. Only when the deviation degree is small enough, the judgment matrix can be considered to have use value. At the same time, considering that the higher the order of the judgment matrix is, the more difficult it is to achieve consistency, the consistency ratio is defined.

$$CR = \frac{CI}{RI}$$

where *RI* is the average random consistency index under continuous scale, which is used to modify the consistency ratio. *RI* of different orders is different, so the consistency requirement can be relaxed for matrices with higher orders. However, using different standards for the same order matrix with different scale systems will violate our original intention of using it as a measure of the deviation between judgment and characteristic matrix, so we introduce the random consistency index of 1~9 order judgment matrix as a unified evaluation scale. That is, when the consistency ratio $CR<0.1$, the judgment matrix passes the consistency test.

5.2 Entropy method

Entropy weight method is an objective weighting method, which is suitable for the case of sufficient datas. It calculates the information entropy of each index to measure the degree of data confusion, the greater the information entropy, the greater the degree of system confusion. The feature weight is obtained from the data itself. If the value under the index changes greatly, the index will play a greater role in the evaluation and have a larger weight accordingly. The steps are as follows.

(1)Standardize the data of each index. Suppose there are a total of k indicators: $X_1, X_2, \cdots, X_k$, where the j-th index has n sample datas, $X_j = \{x_1, x_2, \cdots, x_n\}$; Assuming that the normalized value of the data is $Y_{1j}, Y_{2j}, \cdots, Y_{nj}$, with:

$$Y_{ij} = \frac{X_{ij} - \min(X_i)}{\max(X_i) - \min(X_i)}, \quad i \in (1, n), j \in (1, k)$$

(2)Calculate the ratio of each index under each scheme. That is, the proportion of the j-th index in the i-th sample, that is, to calculate the variability of the index:

$$p_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}}, i \in (1, n), j \in (1, k)$$

(3)Find the information entropy of each index. According to the definition of information entropy in information theory, the information entropy of a group of data is:

$$E_j = -\ln(n)^{-1} \sum_{i=1}^{n} p_{ij} \ln p_{ij}$$

(4)And determine that weight of each index, and calculating the weight value of each index through the information entropy:

$$W_j = \frac{1 - E_j}{k - \sum E_j}$$

5.3 Combination weighting method[12]

The combination weighting method of AHP and entropy weight method is used to weight the influencing factors of regional logistics capability, which combines the subjective tendency of the evaluator and the objective characteristics of the data.

$$\vec{W} = [\theta\lambda_1 + (1-\theta)\beta_1] * \vec{W}_1 + [\theta\lambda_2 + (1-\theta)\beta_2] * \vec{W}_2 \quad (1)$$

In the formula (1), $\vec{W}_1$ is the weight vector of the subjective weighting method, $\vec{W}_2$ is the weight vector of the objective weighting method; λ_k is the preference degree of the decision maker for the two weighting methods, with $\sum_{k=1}^{2}\lambda_k = 1$. λ_k is determined by the decision-maker's preference for risk assessment indicators. Relative importance θ needs to be determined according to the specific decision-making problem. β_k is the relative consistency degree of the weighting between the k-th weighting method and other methods; $\sum_{k=1}^{2}\beta_k = 1$, calculated by Spearman rank correlation coefficient.

5.4 Determine the index weight

According to the method described in 5.3 and combined with the construction of the index system in Table 1, the weight coefficient of the evaluation index of regional logistics capability can be determined as follows:

$$w_{AB} = (0.265, 0.304, 0.431)$$
$$w_{B_1C} = (0.264, 0.322, 0.106, 0.218, 0.090)$$
$$w_{B_2C} = (0.218, 0.346, 0.436)$$
$$w_{B_3C} = (0.231, 0.141, 0.321, 0.103, 0.204)$$

6 Evaluation model of regional logistics capability based on multi-level gray correlation degree analysis

The evaluation index system of regional logistics capability is a gray system with uncertain information. Firstly, because there are too many and complex factors affecting regional logistics capability, only limited main indexes can be selected for analysis. Secondly, some of the data of the selected evaluation indicators are known and can be obtained from the existing data, but the data of some indicators are unknown and can not be obtained directly from the statistical data. Therefore, the evaluation system of regional logistics capability has the characteristics of "gray", and it is suitable to use the gray correlation analysis model to carry out the evaluation.

Gray correlation analysis is a mathematical method to quantitatively analyze the correlation degree between two factors in a complex system. The basic idea is as follows[13]: the optimal index value of the decision-making scheme is taken as the entities x_{0k} of the reference sequence X_0 ,the each index value of the evaluated scheme is taken as the entity x_{ik} of the comparison series X_i,calculate the gray correlation degree r_i between the reference sequence and the comparison sequence. Based on the calculated gray correlation degree r_i, the degree of closeness between each evaluation scheme and the ideal scheme (the optimal scheme) can be determined, and then the order of superiority and inferiority of each scheme can be determined. The steps are as follows.

6.1 Construction of reference series

For a system with m evaluation objects and n evaluation indicators, there is the following matrix:

$$V=(V_{ik})_{m\times n}=\begin{bmatrix} V_{11} & V_{12} & \cdots & V_{1n} \\ V_{21} & V_{22} & \cdots & V_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ V_{m1} & V_{m2} & \cdots & V_{mn} \end{bmatrix} \tag{2}$$

In formula (2), i is the serial number of the i-th evaluation object ($i=1,2,\cdots m$), k is the serial number of the k-th evaluation index ($k=1,2,\cdots,n$), v_{ik} represents the evaluation value of the k-th index of the i-th scheme. Now, the best value v_{0k} of each evaluation index in m evaluation schemes is selected, that is, $v_{0k}=\mathrm{O}ptimum(v_{ik})$, to form the reference sequence $V_0=(v_{01},v_{02},\cdots,v_{0n})$.

6.2 Standardize the index value

In order to facilitate the comparison between every two indicators, the indicators shall be normalized according to Formula (3):

$$X_{ik}=\frac{V_{ik}-\min\limits_i V_{ik}}{\max\limits_i V_{ik}-\min\limits_i V_{ik}} \tag{3}$$

After normalization, the matrix is obtained:

$$X=(X_{ik})_{m\times n}=\begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ X_{m1} & X_{m2} & \cdots & X_{mn} \end{bmatrix}$$

6.3 Calculation of correlation coefficient

Set the sequence $X_i = (X_{i1}, X_{i2}, \cdots X_{in})$ $(i = 1, 2, \cdots m)$ as a comparison sequence, $X_0 = (X_{01}, X_{02}, \cdots, X_{0n})$ is taken as a reference series, the correlation coefficient ξ_{ik} between the two can be obtained by formula (4).

$$\xi_{ik} = \frac{\Delta_{\min} + \rho\Delta_{\max}}{\left|X_{0k} - X_{ik}\right| + \rho\Delta_{\max}} \tag{4}$$

In the formula (4), $\Delta_{\min} = \min_i \min_k \left|X_{0k} - X_{ik}\right|$, $\Delta_{\max} = \max_i \max_k \left|X_{0k} - X_{ik}\right|$, ρ is the resolution coefficient, $\rho \in [0,1]$, according to the solution method of the optimal ρ in reference [14], the subjectivity is removed, the higher resolution is obtained, and the optimal value is obtained, $\rho = 0.69$. Available correlation coefficient matrix:

$$E = (\xi_{ik})_{m\times n} = \begin{bmatrix} \zeta_{11} & \zeta_{12} & \cdots & \zeta_{1n} \\ \zeta_{21} & \zeta_{22} & \cdots & \zeta_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \zeta_{m1} & \zeta_{m2} & \cdots & \zeta_{mn} \end{bmatrix}$$

6.4 Calculation of single-layer correlation degree

Because the importance of each index is different, the calculation of correlation degree is based on the weight multiplied by the correlation coefficient. W represents the weight of a certain layer index relative to the upper layer index, $W = (w_1, w_2, \cdots, w_n)$ (in which, $\sum_{k=1}^{t} w_k = 1$, t is the total number of indicators in this layer), then the correlation degree of this layer is:

$$R = (r_i)_{1\times m} = (r_1, r_2, \cdots r_m) = WE^T \tag{5}$$

6.5 Calculating the final correlation degree of the multi-level evaluation system

Assume that the evaluation system has L layers, the computation of its final degree of association is as follows: First synthesize the correlation coefficients of the indicators at the k level, so as to obtain the upper layer of the system, that is, the correlation degree of the (k-1) layers; Then, based on the correlation degree of this layer, continue to the upper layer, that is, the (k-2) layer, and so on, the correlation degree of the highest layer index of the system is finally obtained, which is the final correlation degree of the system. Sorted according to the size of the final correlation degree $r_i (i = 1, 2, \cdots, m)$ of the system, it can determine the priority of the logistics capacity of each city in the region, so as to achieve the purpose of comprehensive evaluation of regional logistics capacity.

7 Empirical analysis on comprehensive evaluation of regional logistics capability in Gansu Province

7.1 Sample selection and data sources

Based on the sustainable development of regional economy and regional logistics, this paper takes 14 cities (states) in Gansu Province as samples, makes a quantitative study on the 13 evaluation indexes that affect their regional logistics capabilities, and makes a comprehensive evaluation and ranking comparison of the regional logistics capabilities of 14 cities (states) in Gansu Province by using the multi-level gray correlation analysis and decision-making theory. In order to ensure the authenticity and reliability of the data, the original data used in this paper are mainly from the Statistical Yearbook of Gansu Province (2020), the Statistical Bulletin of National Economic and Social Development of Gansu Province (2020), the statistical yearbook of cities (states) in Gansu Province and the relevant data on the websites of statistical bureaus of cities (prefectures), as shown in Table 2. (A: Lanzhou; B: Jiayuguan; C: Jinchang; D: Baiyin; E: Tianshui; F: Wuwei; G: Zhangye; H: Pingliang; I: Jiuquan; J: Qingyang; K: Dingxi; L: Longnan; M: Linxia; N: Gannan)

Table 2. Evaluation Index Matrix of Regional Logistics Capability of 14 Cities (States) in Gansu Province

index	Cities (States) in Gansu Province														op-ti-
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
C_1	2837.36	283.41	340.31	486.33	632.67	488.46	448.73	456.58	618.22	742.94	416.38	445.09	303.52	218.33	2837.36
C_2	7.52	11.22	7.34	2.80	1.88	2.67	3.63	2.15	5.47	3.27	1.47	1.69	1.47	3.03	11.22
C_3	1840.30	100.61	96.31	218.56	358.17	268.28	246.23	241.61	270.85	285.18	272.14	259.43	204.34	143.39	1840.30
C_4	177.33	15.19	15.59	20.18	28.44	15.10	13.34	21.24	21.28	39.75	15.08	13.57	10.65	4.85	177.33
C_5	102.0	108.0	115.9	106.6	106.2	101.8	111.8	106.2	112.2	108.2	103.9	111.3	107.3	90.5	111.8
C_6	119.409	10.228	141.898	47.586	38.245	2.297	3.299	4.793	5.423	1.718	2.522	1.9	0.815	0.121	119.409
C_7	1672.002	76.02	101.98	162.9	270.114	144.595	206.933	167.576	255.698	182.212	160.044	146.661	106.014	47.522	1672.00
C_8	255.138	10.572	3.463	18.706	32.829	13.956	17.221	7.814	31.671	11.809	11.255	6.380	6.166	11.411	255.138

C_9	8357.38	664.58	2391.88	12117.7	14005.8	13023.7	11010.8	10619.3	16733.5	16215.4	12626.2	18286.3	7720.7	7669.5	18286.3
C_{10}	92.49	7.31	8.51	24.79	30.44	21.96	20.50	23.89	20.48	31.70	30.58	19.11	24.69	6.85	92.49
C_{11}	3.06	0.08	0.36	0.29	0.46	0.21	0.21	0.37	0.31	0.65	0.32	0.23	0.14	0.07	3.06
C_{12}	2.12	0.05	0.12	0.11	0.26	0.10	0.09	0.13	0.11	0.15	0.11	0.16	0.11	0.13	2.12
C_{13}	791.420	63.546	75.207	223.955	38.472	215.135	190.898	257.241	182.757	303.312	312.010	302.876	228.735	90.046	791.420

7.2 Standardized treatment of indicators

(1) Constructing a reference sequence

Based on the 13 evaluation indexes selected from the evaluation index system of regional logistics capability in Table 1, the evaluation indexes of 14 cities (states) are compared, and the optimal value of each index is selected to construct the reference series as shown in Table 2.

$$V_0 = (2837.36, 11.22, 1840.30, 177.33, 111.80, 119.409, 1672.00, 255.138, 18286.30, 92.49, 3.06, 2.12, 791.420)$$

(2)Standardize the index value

In order to overcome the problem that different evaluation indexes (generally with different dimensions and orders of magnitude) can not be directly compared, and to ensure the reliability of the evaluation results, it is necessary to standardize the original index values. After the original matrix is normalized by formula (3), the normalized matrix in Table 3 is obtained.

Table 3. Standardized processing matrix of regional logistics capability evaluation index of 14 cities (states) in Gansu Province

index	Cities (States) in Gansu Province														optimal value
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
C_1	1.000	0.025	0.047	0.102	0.158	0.103	0.088	0.091	0.153	0.200	0.076	0.087	0.033	0.000	1.000
C_2	0.621	1.000	0.602	0.136	0.042	0.123	0.222	0.070	0.410	0.185	0.000	0.023	0.000	0.160	1.000
C_3	1.000	0.002	0.000	0.070	0.150	0.099	0.086	0.083	0.100	0.108	0.101	0.094	0.062	0.027	1.000
C_4	1.000	0.060	0.062	0.089	0.137	0.059	0.049	0.095	0.095	0.202	0.059	0.051	0.034	0.000	1.000
C_5	0.540	0.822	1.192	0.756	0.737	0.531	1.000	0.737	1.019	0.831	0.629	0.977	0.789	0.000	1.000
C_6	1.000	0.085	1.189	0.398	0.320	0.018	0.027	0.039	0.044	0.013	0.020	0.015	0.006	0.000	1.000
C_7	1.000	0.018	0.034	0.071	0.137	0.060	0.098	0.074	0.128	0.083	0.069	0.061	0.036	0.000	1.000
C_8	1.000	0.028	0.000	0.061	0.117	0.042	0.055	0.017	0.112	0.033	0.031	0.012	0.011	0.032	1.000

C_9	0.437	0.000	0.098	0.650	0.757	0.701	0.587	0.565	0.912	0.882	0.679	1.000	0.400	0.398	1.000
C_{10}	1.000	0.005	0.019	0.209	0.275	0.176	0.159	0.199	0.159	0.290	0.277	0.143	0.208	0.000	1.000
C_{11}	1.000	0.003	0.097	0.074	0.130	0.047	0.047	0.100	0.080	0.194	0.084	0.054	0.023	0.000	1.000
C_{12}	1.000	0.000	0.034	0.029	0.101	0.024	0.019	0.039	0.029	0.048	0.029	0.053	0.029	0.039	1.000
C_{13}	1.000	0.033	0.049	0.246	0.000	0.235	0.202	0.291	0.192	0.352	0.363	0.351	0.253	0.068	1.000

7.3 Calculation of gray correlation coefficient

According to the calculation formula (4) of the gray correlation coefficient, the minimum difference and maximum difference of the two levels are respectively: $\Delta_{\min} = \min\limits_i \min\limits_k |X_{0k} - X_{ik}|$ =0, $\Delta_{\max} = \max\limits_i \max\limits_k |X_{0k} - X_{ik}|$ =1. Where ρ = 0.69, the gray correlation coefficient can be obtained as shown in Table 4.

Table 4. Gray Correlation Coefficient

index	Cities (States) in Gansu Province													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
ξ_{i1}	1.000	0.414	0.420	0.435	0.450	0.435	0.431	0.432	0.449	0.463	0.427	0.430	0.416	0.408
ξ_{i2}	0.645	1.000	0.634	0.444	0.419	0.440	0.470	0.426	0.539	0.458	0.408	0.414	0.408	0.451
ξ_{i3}	1.000	0.409	0.408	0.426	0.448	0.434	0.430	0.429	0.434	0.436	0.434	0.432	0.424	0.415
ξ_{i4}	1.000	0.423	0.424	0.431	0.444	0.423	0.421	0.433	0.433	0.464	0.423	0.421	0.417	0.408
ξ_{i5}	0.600	0.795	0.782	0.739	0.724	0.595	1.000	0.724	0.974	0.803	0.650	0.967	0.766	0.408
ξ_{i6}	1.000	0.430	0.785	0.534	0.504	0.413	0.415	0.418	0.419	0.412	0.413	0.412	0.410	0.408
ξ_{i7}	1.000	0.413	0.417	0.426	0.444	0.423	0.433	0.427	0.442	0.429	0.426	0.424	0.417	0.408
ξ_{i8}	1.000	0.415	0.408	0.423	0.439	0.419	0.422	0.413	0.437	0.416	0.416	0.411	0.411	0.416
ξ_{i9}	0.550	0.408	0.433	0.663	0.740	0.698	0.626	0.613	0.887	0.854	0.682	1.000	0.535	0.534
ξ_{i10}	1.000	0.410	0.413	0.466	0.488	0.456	0.451	0.463	0.451	0.493	0.488	0.446	0.466	0.408
ξ_{i11}	1.000	0.409	0.433	0.427	0.442	0.420	0.420	0.434	0.429	0.461	0.430	0.422	0.414	0.408
ξ_{i12}	1.000	0.408	0.417	0.415	0.434	0.414	0.413	0.418	0.415	0.420	0.415	0.422	0.415	0.418
ξ_{i13}	1.000	0.416	0.420	0.478	0.408	0.474	0.464	0.493	0.460	0.516	0.520	0.515	0.480	0.426

7.4 Calculation of relational degree of multi-layer structure

The correlation degree of each index of layer B can be calculated according to formula (5).

$$R_{B_1} = W_{B_1C} E_{B_1C}^T = (0.8497,0.6384,0.5211,0.4634,0.4632,0.4483,0.4925,0.4562,0.5202,0.4893,0.4408,0.4714,0.4460,0.4226)$$

$$R_{B_2} = W_{B_2C} E_{B_2C}^T = (1.0000,0.4176,0.4933,0.4482,0.4549,0.4191,0.4243,0.4189,0.4348,0.4196,0.4188,0.4157,0.4129,0.4115)$$

$$R_{B_3} = W_{B_3C} E_{B_3C}^T = (0.8961,0.4102,0.4259,0.4962,0.5096,0.4997,0.4802,0.4898,0.5428,0.5633,0.5132,0.5779,0.4629,0.4418)$$

In the above formula, $E_{B_1C}, E_{B_2C}, E_{B_3C}$ are respectively matrices composed of the corresponding data in Table 4. Furthermore, the correlation degree of the highest level index A can be obtained.

$$R_A = (r_1, r_2, r_3) = W_{AB}\left\lfloor R_{B_1}, R_{B_2}, R_{B_3} \right\rfloor$$
$$= (0.9154, 0.4729, 0.4716, 0.4728, 0.4807, 0.4616, 0.4665, 0.4593, 0.5040, 0.5000, 0.4653, 0.5004, 0.4432, 0.4146)$$

7.5 Ranking of regional logistics capability in Gansu Province

According to the correlation degree in RA , the order of regional logistics capability of each city (state) in Gansu Province is as shown in Table 5.

Table 5. Ranking of regional logistics capacity of cities (states) in Gansu Province

City(State)	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Correlation degree	0.9154	0.4729	0.4716	0.4728	0.4807	0.4616	0.4665	0.4593	0.5040	0.5000	0.4653	0.5004	0.4432	0.4146
Sort	1	6	8	7	5	11	9	12	2	4	10	3	13	14

8 Conclusion

Based on the analysis of the factors affecting regional logistics capability, this paper selects 13 indicators from three aspects to quantitatively evaluate regional logistics capability. The selection of indicators is comprehensive and representative. The combination weighting method of AHP and entropy weight method is used to weight the relevant influencing factors of regional logistics capability, which integrates the subjective tendency of the evaluator and the objective characteristics of the data, and is more scientific and accurate. Based on the original statistical data of the corresponding indicators of 14 cities (states) in Gansu Province in 2019, this paper obtains the ranking of regional logistics capabilities of cities (states) in Gansu Province through the gray correlation analysis and decision-making method, and the results are consistent with the actual situation.

The analysis shows that the regional logistics capacity of 14 cities (states) in Gansu Province is uneven, and Lanzhou, the provincial capital, is far ahead, and the regional logistics capacity shows an unbalanced development trend. Generally speaking, there are four echelons, Lanzhou is in the first echelon, and the regional logistics capacity is far superior to other cities. Jiuquan City, Longnan City and Qingyang City are in the second echelon, and the regional logistics capacity of the three regions is not very different. Tianshui, Jiayuguan, Baiyin, Jinchang, Zhangye, Dingxi, Wuwei and Pingliang are in the third echelon, and there is a certain gap in their regional logistics capabilities. Linxia and Gannan are in the fourth echelon, and the regional logistics capacity is generally weak.

In order to improve the overall logistics capacity of Gansu Province, it is necessary to proceed from the overall situation, carry out the overall planning of regional logistics, effectively integrate regional logistics resources, establish regional logistics information sharing and collaboration platform, enhance the comprehensive competitiveness of regional logistics leading enterprises, and realize the sustainable and healthy development of regional logistics and regional economy. Of course, the research method and process used in this paper are also applicable to the quantitative evaluation of logistics capability in other economic regions, and it will provide an important reference for the healthy development of regional logistics in China.

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