Quality Grade Evaluation Index System for the Development of "Belt and Road" Logistics Industry Based on Entropy Weight Grey Correlation Method

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ABSTRACT
This paper introduces energy consumption into input variables and regards carbon emissions as by-outputs to analyze related elements from the three dimensions of mobility, industrialization and serviceability. Besides, the total amount, the growth, the demand, the supply, the consumption and the conventionalized level of logistics are set as the criterion levels and logistics industry GDP, total retail sales of consumer goods, unit energy consumption of the logistics industry, conventionalized level of logistics and other 15 indexes are selected to build the comprehensive evaluation index system for the development quality of the logistics industry. At the same time, the entropy weight method is used to empower all indexes and to establish models and the index system is analyzed according to data related to logistics industries of all cities and districts of Shaanxi Province so as to form a proper quality grade evaluation index system for the development of logistics industry under the background of "Belt and Road Initiative".

Keywords: *Index system, Fuzzy evaluation method, Logistics quality.*

1. INTRODUCTION

On March 1, 2019, the National Development and Reform Commission and other 24 departments and units printed and issued Opinions on Promoting High-Quality Development of Logistics and Accelerating the Formation of A Strong Domestic Market (FGJM [2019] No.352), which emphasized that the logistics industry is the basic, strategic and leading industry to support the development of national economy [1, 2]. Logistics industry of high-quality development is an important constituent part of the economy of high-quality development as well as an indispensable force to improve economy. Opinions put forward 25 concrete measures from six aspects so as to solve prominent problems that restrict the high-quality development of logistics and to promote the formation of a strong domestic market. Besides, it also came up with some countermeasures in terms of standardized construction of logistics enterprises and the evaluation of their development quality, such as the improvement of modern logistics statistics system, the supervision of logistics industry, the establishment of a sound logistics standard and formal system, the better application of logistics standards in the field of logistics, the enhancement of logistics standardization level, the construction of a high quality logistics development evaluation system, so as to evaluate the logistics quality objectively, comprehensively and quantitatively [3, 4].

2. REVIEW OF RELATED RESEARCHES

In recent years, the development of regional logistics has always been a research hot-spot for scholars at home and abroad [5]. They mainly focus on researching logistics efficiency, analyzing logistics space and evaluating logistics development capacity and other aspects in terms of a nation, an economic belt, an economic circle or a Province. For example, Yeo et al used fuzzy comprehensive evaluation method to analyze the logistics development capacity of six container ports, including Shanghai and Hong Kong. Mothilal et al adopted the multiple regression method to analyze the competitiveness of logistics of the United States, India and Hong Kong [6, 7]. Li Pan and Peng Hui-ping used entropy weight Grey correlation analysis method to analyze logistics competitiveness of 9 Provinces and cities along the "Silk Road Economic Belt" in China. Xu Wenjing used the factor analysis method and cluster

analysis method to analyze the logistics competitiveness of 14 coastal port cities in "Belt and Road" planning [7]. Wang Bo, Zhu Honghui and Liu Lin analyzed the regional logistics efficiency along “Belt and Road” with three-stage DEA method [8]. Yuan Dan and Lei Hongzhen used Malmquist index method to analyze the logistics efficiency of China's Silk Road Economic Belt. Liang Hongyan used principal component analysis and gravity model to analyze the spatial network relationship of logistics industries in five urban agglomerations, including the Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebe i regions, middle reaches of the Yangtze River and Chengdu-Chongqing economic zone [9]. Jiang Zhijuan and Dong Qianli studied spatial relations of Provinces and regions by using systematic cluster analysis method [10]. From the above analyses we can find that few researches have studied regional logistics in backward areas, especially countries along “Belt and Road” [11, 12]. Therefore, this paper Build on Quality Grade Evaluation Index System for the Development of “Belt and Road” Logistics Industry Based on Entropy Weight Grey Correlation Method.

3. MODEL BUILDING

3.1. Data Standardization

The above index system includes both positive and negative indexes, so different standardization methods are used.

Positive index model is shown as follows:

$$d_{xy} = \frac{p_{xy} - \min(p_{xy})}{\max(p_{xy}) - \min(p_{xy})} \tag{1}$$

Negative index model is shown as:

$$d_{xy} = \frac{\max(p_{xy}) - p_{xy}}{\max(p_{xy}) - \min(p_{xy})} \tag{2}$$

p_{xy} means the original data of the y index of the x city while d_{xy} is the value of normalized p_{xy}.

3.2. Determination of Index Entropy weight

R_{xy} is the proportion occupied by the x city of the y index in that index:

$$R_{xy} = \frac{d_{xy}}{\sum_{x=1}^{n} d_{xy}} \tag{3}$$

Q_j is the entropy of the y index:

$$Q_j = -k\sum_{x=1}^{n} R_{XY} \ln R_{xy} \quad \text{, k=1/lnn,} \tag{4}$$

S_y is the entropy of the y index:

$$S_y = 1 - Q_y \Big/ \sum_{y=1}^{m}(1 - Q_y) \tag{5}$$

3.3. Determination of the Correlation Coefficient

Standardized logistics index data d_{xy} forms a matrix $D = (d_{xy})_{n*m}$ which serves as the correlation data array, the object to be evaluated. $D^* = [d_1^*, d_2^*, ..., d_3^*]$ is the reference data array, which also serves as the evaluation criterion. This research selects the overall level of Shaanxi Province as the reference data array.

The correlation coefficient computational formula for the correlation data array D to the reference data array D^* in the y index is shown as follows:

$$T_y = \frac{\min_x \min_y \left|d_y^* - d_{xy}\right| + \rho \max_x \max_y \left|d_y^* - d_{xy}\right|}{\left|d_y^* - d_{xy}\right| + \rho \max_x \max_y \left|d_y^* - d_{xy}\right|} \tag{6}$$

3.4. Determination of Entropy Weight Grey Correlation Degree

$$U_x = \sum_{y=1}^{m} S_y T_y \tag{7}$$

In the formula, U_x refers to the Grey weighted correlation degree between the evaluation object and the evaluation criterion. The larger U_x is, the better the evaluation object will be.

3.5. Construction of the Index System

After comprehensively considering the systematization of indexes, hierarchy and availability of data, the development quality of logistics in countries along “Belt and Road” is evaluated from the three aspects of liquidity, industrialization and serviceability. Based on the above analysis, this paper constructs indexes to evaluate the development quality of logistics industry in countries along “Belt and Road”, which are shown as Table 1.

Table 1. Indexes To Evaluate The Development Quality of Logistics In Countries Along "Belt And Road"

Objective level	Criterion level	Index layer	
liquidity index	Total amount index	Investment amount in fixed assets of logistics industry (100 million Yuan)	P1
		logistics industry GDP(100 million Yuan)	P2
	Growth index	GDP index of the logistics industry (%)	P3
Industrial index	Demand index	Gross industrial output value (ten thousand Yuan)	P4
		Gross output value of farming, forestry, animal husbandry and fishery (ten thousand Yuan)	P5
		Total retail sales of consumer goods (100 million Yuan)	P6
	Supply index	Highway mileage (km)	P7
		Number of operating and carrying trucks owned (tonnage)	P8
		Rotation volume of goods transport (10000 tons-km)	P9
		Express mail service (10000 pieces)	P10
	Demonstrability index	Reduction rate of energy consumption in the logistics industry (Standard tons of coal/ten thousand Yuan)	P11
		Traffic accident loss (ten thousand Yuan)(negative index)	P12
		Emissions of logistics waste gas (100 million m^3)(negative index)	P13
Serviceability index	Informationalized level of logistics	Number of mobile phones (10000 households)	P14
		Total volume of post and telecommunications (100 million Yuan)	P15

4. AN EMPIRICAL ANALYSIS OF DEVELOPMENT QUALITY OF LOGISTICS INDUSTRY OF ALL DISTRICTS IN SHAANXI PROVINCE

An empirical analysis on the development quality of logistics industry in Shaanxi Province is made. The analysis process and results are shown in Table 2 to table 8.

Table 2. Logistics Data of Shaanxi Province

Index code	Xi'an city	Tongchuan city	Baoji city	Xianyang city	Weinan city	Yan'an city	Hanzhong city	Yulin city	Ankang city	Shangluo city
P1	6253.18	1803.04	2233.41	1253.3	1922.4	805.89	729.12	578.86	719.02	739.22
P2	4594.25	144.79	598.65	660.16	648.59	435.28	505.44	1043.08	342.23	260.45
P3	109.4	108.9	108.5	109	108.2	110.3	107.8	111.2	107.7	108.5
P4	5423.06	363.17	2856.12	3024.29	2052.56	1302.77	1171.69	4142.71	1379.51	1070.68
P5	4973925	455534	3098458	5525964	4305531	2140939	3713299	2922115	1848597	1811445
P6	4249.81	138.25	783.43	607.64	651.85	284.65	421.05	467.16	297.14	193.73
P7	13383	3996	16563	15899	19262	18162	20494	29380	23053	13803
P8	758198	122633	171345	219231	451507	58194	71124	560659	42161	97206
P9	3509694	972628	1141374	3298573	3857470	241626	672338	6774646	168394	500910
P10	33956	273	2264	4081	1749	711	954	824	617	321
P11	4.61	4.79	5.6	4.98	5.65	4.04	3.87	3.3	3.11	3.8
P12	1788	80	263	71	229	163	131	691	660	128
P13	1444.73	723.15	1394.85	1468.92	5699.03	509.56	1599.22	5734.95	160.36	121.54
P14	1599.61	72.56	332.17	431.12	448.62	261.82	298.39	390.79	224.9	160.64
P15	423.06	14.31	68.54	92.9	81.28	56.08	58.35	85.81	42.96	29.02

Table 3. Standardized Data

	Xi'an city	Tongchuan city	Baoji city	Xianyang city	Weinan city	Yan'an city	Hanzhong city	Yulin city	Ankang city	Shangluo city
P1	0.001256267	0.001848866	0.000719007	0.000225901	0.000445184	0.000374533	0.000195312	8.4958E-05	0.000387273	0.000405986
P2	0.000922741	0.000143941	0.000191402	0.000118564	0.000149329	0.000201426	0.000135074	0.000153481	0.000183448	0.000141683
P3	2.10679E-05	0.00010704	3.32101E-05	1.88239E-05	2.38182E-05	4.96325E-05	2.79886E-05	1.5927E-05	5.65781E-05	5.77993E-05
P4	0.001089372	0.000368467	0.000919982	0.000546387	0.000475415	0.000606618	0.000314497	0.000611015	0.000744566	0.000588968
P5	1	0.468351161	1	1	1	1	1	0.431330748	1	1
P6	0.000853492	0.000137217	0.000251038	0.00010906	0.000150086	0.000131069	0.000112348	6.847E-05	0.000159056	0.00010485
P7	0.002689707	0.004103552	0.005343765	0.002876246	0.004472474	0.008481323	0.005518045	0.004336273	0.012468877	0.007617802
P8	0.152433761	0.126079872	0.055298381	0.039672031	0.104865565	0.027179695	0.019152835	0.082757973	0.022805382	0.053660146
P9	0.705618328	1	0.368367253	0.596922273	0.895933489	0.112858151	0.181061323	1	0.091091338	0.276523577
P10	0.006825881	0.000275759	0.00072888	0.000737613	0.00040491	0.000330211	0.000255872	0.000121143	0.000332085	0.000175109
P11	0	0	0	0	0	0	0	0	0	0
P12	0.999641452	0.999922673	0.999916926	0.999988053	0.999948125	0.999925752	0.999965764	0.999898489	0.999644654	0.999931436
P13	0.999710466	0.99926142	0.999551631	0.999735079	0.998677657	0.999763879	0.999570368	0.999153955	0.999914935	0.999935002
P14	0.000320673	6.96775E-05	0.000105398	7.7116E-05	0.000102884	0.000120405	7.9315E-05	5.71971E-05	0.000119978	8.6583E-05
P15	8.41288E-05	9.78796E-06	2.03134E-05	1.59104E-05	1.75658E-05	2.43071E-05	1.46716E-05	1.21792E-05	2.15569E-05	1.39226E-05

Table 4. Proportion of the Index

	Xi'an city	Tongchuan city	Baoji city	Xianyang city	Weinan city	Yan'an city	Hanzhong city	Yulin city	Ankang city	Shangluo city
P1	0.000324494	0.000513477	0.000209535	6.2043E-05	0.000111139	0.000118897	6.0913E-05	2.41454E-05	0.000123811	0.00012158
P2	0.000238344	3.9976E-05	5.57788E-05	3.25632E-05	3.72795E-05	6.39438E-05	4.21264E-05	4.36199E-05	5.86482E-05	4.24296E-05
P3	5.44184E-06	2.97278E-05	9.67817E-06	5.16991E-06	5.94613E-06	1.57561E-05	8.72898E-06	4.52653E-06	1.8088E-05	1.73091E-05
P4	0.000281385	0.000102333	0.000268103	0.000150063	0.000118686	0.000192574	9.8084E-05	0.000173653	0.000238038	0.000176378
P5	0.258299997	0.130072996	0.291422233	0.274646574	0.249646345	0.317455581	0.311875915	0.122585837	0.319700277	0.299469084
P6	0.000220457	3.81085E-05	7.31581E-05	2.99529E-05	3.74685E-05	4.16086E-05	3.50385E-05	1.94594E-05	5.08503E-05	3.13994E-05
P7	0.000694751	0.00113966	0.001557292	0.000789951	0.001116537	0.002692443	0.001720945	0.001232385	0.003986303	0.002281296
P8	0.03937364	0.035015578	0.016115178	0.010895788	0.026179305	0.008628346	0.005973308	0.02352013	0.007290887	0.016069555
P9	0.182261212	0.277725362	0.107350407	0.163942657	0.223666521	0.03582745	0.056468666	0.284203799	0.029121926	0.082810262
P10	0.001763125	7.65854E-05	0.000212412	0.000202583	0.000101084	0.000104827	7.98005E-05	3.44293E-05	0.000106168	5.24398E-05
P11	0	0	0	0	0	0	0	0	0	0
P12	0.258207384	0.277703886	0.291398023	0.274643292	0.249633394	0.31743201	0.311865238	0.284174949	0.319586673	0.299448551
P13	0.25822521	0.27752024	0.291291568	0.274573814	0.249316227	0.317380623	0.311741924	0.28396335	0.319673082	0.299449619
P14	8.28297E-05	1.93512E-05	3.07153E-05	2.11797E-05	2.56846E-05	3.82233E-05	2.47364E-05	1.62556E-05	3.83569E-05	2.59289E-05
P15	2.17305E-05	2.71837E-06	5.91977E-06	4.36973E-06	4.38524E-06	7.71644E-06	4.57572E-06	3.46139E-06	6.89175E-06	4.16939E-06

Table 5. Entropy of the Index

	Xi'an city	Tongchuan city	Baoji city	Xianyang city	Weinan city	Yan'an city	Hanzhong city	Yulin city	Ankang city	Shangluo city
P1	0.573143543	0.554985459	0.531098959	0.538336749	0.561287079	0.482874051	0.491619055	0.541619844	0.477599503	0.520716693

Table 6. Entropy Weight of the Index

	Xi'an city	Tongchuan city	Baoji city	Xianyang city	Weinan city	Yan'an city	Hanzhong city	Yulin city	Ankang city	Shangluo city
P1	0.090307135	0.094148718	0.099202224	0.097670973	0.092815527	0.109404841	0.10755472	0.096976391	0.110520742	0.101398729

Table 7. Determination of Correlation Coefficient (10 Prefecture-Level Cities)-1

1	2	3	4	5	6	7	8	9	10
0.656527012	0.675836697	0.686836237	0.67126875	0.646854882	0.707730199	0.703157991	0.713465275	0.744593723	0.724501166
0.656191639	0.674023947	0.686255788	0.671155878	0.646566071	0.707527878	0.703088481	0.713542857	0.744342487	0.72418785
0.655286685	0.67398482	0.686081943	0.671051029	0.646443626	0.707350563	0.702964946	0.713387135	0.744186192	0.724088468
0.65635915	0.674262117	0.687057598	0.671605986	0.646884408	0.708001634	0.703295563	0.714061312	0.745034534	0.724718238
0.376600145	0.686548173	0.367133389	0.371582633	0.379585279	0.361324805	0.362473333	0.758900249	0.378740229	0.379563081
0.656122049	0.674016816	0.686321348	0.671145886	0.64656681	0.707445681	0.70306226	0.713446609	0.744312433	0.724144209
0.657972304	0.678249003	0.691966536	0.674067847	0.650812108	0.717336475	0.709354779	0.718310797	0.75979473	0.733156215
0.854477073	0.84056044	0.752695446	0.715488792	0.767921512	0.740519974	0.725738309	0.821189137	0.773301482	0.793689444
0.508071674	0.370717441	0.800304019	0.571305717	0.418138043	0.869246079	1	0.387235352	0.876201736	1
0.662178572	0.674163755	0.686847107	0.67180737	0.646815552	0.707678387	0.703227888	0.713506241	0.744525681	0.72422746
0.65526557	0.673871348	0.686045458	0.671031245	0.646420395	0.707292605	0.702932666	0.713369108	0.744116513	0.724020005
0.376718875	0.370742247	0.367159526	0.371586484	0.379602726	0.361347432	0.362483832	0.387269208	0.378853625	0.3795854
0.376696015	0.370954511	0.367274502	0.37166803	0.380030512	0.361396772	0.362605135	0.387517705	0.378767368	0.379584239
0.655587103	0.673945208	0.686161263	0.671112303	0.646520755	0.707433224	0.703024152	0.713433848	0.744264288	0.724122567
0.655349894	0.673881722	0.686067774	0.671047967	0.646437528	0.707320988	0.702949587	0.713382893	0.74414306	0.724036495

Table 8. Determination of Entropy Weight Grey Correlation Degree

	Xi'an city	Tongchuan city	Baoji city	Xianyang city	Weinan city	Yan'an city	Hanzhong city	Yulin city	Ankang city	Shangluo city
Correlation degree	0.818128799	0.883657108	0.944822605	0.890459026	0.816368268	1.069864767	1.059452594	0.958322415	1.13230468	1.032606619
Ranking	9	8	6	7	10	2	3	5	1	4

5. CONCLUSION

The index of liquidity: The development level of logistics economy can reflect the development level of logistics industry of a region. The higher the economic development level is, the faster the goods flow speed is, the stronger the competitiveness of the logistics industry will be and the higher the quality of the logistics industry will have. This paper divides the liquidity index into two criteria factors: the total amount and the increment from the macroscopic aspect. Among them, the total amount criterion level includes the investment amount in fixed assets of logistics industry and the logistics industry GDP while the growth index criterion level includes the GDP index of the logistics industry.

The index of industrialization: In order to meet the supply and demand relationship and energy conservation demands, the three criterion level indexes of demand, supply and consumption are set. Demand criterion level includes the three indexes of total industrial output value, gross output value of agriculture, forestry, animal husbandry and fishery and total retail sales of social consumer goods. Supply criterion level includes the four indexes of highway mileage, number of operating and carrying trucks owned, freight turnover and express mail service. There are three indexes under the consumption criterion level, namely, the reduction rate of energy consumption in the logistics industry, the traffic accident loss and the emissions of logistics waste gas.

The index of serviceability: The level of serviceability is restricted by the quality of information services to some extent. In this paper, informationalized level of logistics is selected an index criterion to measure the level of serviceability. It includes the two indexes of number of mobile phones and the total volume of post and telecommunications.

(1) Ankang city, Yan'an city, Hanzhong city and Shangluo city: Logistics industry in these four cities

develops in a healthy way. Their logistics resources can well match the development of the city. Their logistics industry is featured by green development, environmental protection and ecodevelopment and the healthy momentum of their logistics industry is better than the overall development of economy.

(2) Yulin city and Baoji city: The industrial logistics business improves the level of logistics development in these two cities and it plays a leading role in local logistics forms. The logistics industry can well match environmental protection demands.

(3) Xianyang city, Tongchuan city, Xi'an city and Weinan city: Logistics industry in these three cities occupies a large volume, but their development momentum is weak and their resources cannot be well matched, so they find it difficult to develop ecological logistics businesses. Because of their large energy consumption and big negative output of logistics industry, structures of their logistics industry shall be optimized. Besides, there is a lack of large logistics industry leading enterprises in those three cities.

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