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MAXIMIZING SUPPLY CHAIN PERFORMANCE: A CASE STUDY ON CHENGDU EUROPE EXPRESS RAILWAY GOODS USING THE GRAVITY MODEL

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Abstract: *In response to the national "the Belt and Road" initiative, Chengdu embarked on a transformative journey, seizing the potential of industrial transfer. Anchored in the international trade landscape and the specific developmental needs of Sichuan, the city introduced the visionary "Chengdu Europe+" strategy. This strategy triggered a rapid expansion of key international logistics networks, particularly in aviation and railway, and paved the way for the direct operation of "Chengdu Europe Express Railway" connecting to Europe. The successful operation of this railway reinvigorated Chengdu's position as a logistics hub in the western region, fostering closer ties between Europe and Asia.*

This initiative not only overcame the dependence on ports for export-oriented economic growth in the western region but also transformed the inland location into a strategic advantage for European exports. However, amidst its achievements, the Chengdu Europe Express Railway confronts issues such as disorganized supply management and fierce competition among supply organizations.

To address these challenges, this paper delves into the supply organization of the Chengdu Europe Express Railway and presents practical optimization plans. These plans are designed to rectify the existing shortcomings and steer the railway towards continued growth, advancing the region's connectivity with Europe.

Keywords: *Chengdu Europe+, International logistics, Supply organization, Railway connectivity, Belt and Road Initiative*

1. Introduction

In response to the call of the national "the Belt and Road" initiative, Chengdu seized the opportunity of a new round of industrial transfer, based on the international trade pattern and the actual development needs of Sichuan, proposed the "Chengdu Europe+" strategy, followed the "Chengdu Europe+" strategy, accelerated the construction of backbone international logistics networks such as aviation and railway, and prepared to operate the "Chengdu Europe Express Railway" international railway freight trains directly to Europe. The operation of the Chengdu Europe express railway has once again upgraded Chengdu's development advantage as a logistics center in the western region, and also made the connection between Europe and Asia closer. It has broken the disadvantage of relying on ports for the development of export-oriented economy in the western region, and turned the geographical disadvantage of the inland region of the western region into a main advantage for exporting to Europe. Although the Chengdu Europe Express has achieved great success at this stage, it still faces problems such as chaotic supply organization and fierce competition among supply organizations. To adapt to the situation, it is imperative to carry out overall planning for the supply organization of the Chengdu Europe Express Railway. This article conducts research on the supply organization of the Chengdu Europe Express Railway, and proposes reasonable and effective optimization plans for the supply organization to address its shortcomings, in order to promote the further development of the Chengdu Europe Express Railway.

2. Forecast of freight demand for the Chengdu Europe express railway

The freight volume of the Chengdu Europe express railway is influenced by various factors, such as transportation demand, transportation volume, and non market economic factors, which pose certain challenges to the ease and accuracy of prediction. However, grey prediction can understand the dynamic behavior and future development trends of the predicted person, and the prediction accuracy is high. Therefore, this article collects data on Sichuan's total export trade value over the years and combines grey prediction method to predict the demand trend of the freight volume of the Chengdu Europe express railway.

Initialize the modeling original sequence, as shown in Table 1.

Table 1 Sichuan's Gross Export Trade Value from 2018 to 2022 (Unit: RMB 100 million)

Year	2018	2019	2020	2021	2022
Export value	3334.7767	3892.3204	4654.3256	5708.6659	6215.1778

The generation of cumulative sequences and adjacent mean sequences is shown in Table 2.

Table 2 Generation of Accumulated Sequence and Nearest Neighbor Mean Sequence

Year	2018	2019	2020	2021	2022
SN	1	2	3	4	5
$xx(0)$	3334.7767	3892.3204	4654.3256	5708.6659	6215.1778
$xx(1)$	3334.7767	7227.0971	11881.4227	17590.0886	23805.2664
$ZZ(1)$		5280.9369	9554.2599	14735.75565	20697.6775

Calculate grey model development coefficient a and grey action b

$$B=\begin{bmatrix}-Z^{(1)}(2),1\\-Z^{(1)}(3),1\\-Z^{(1)}(4),1\\-Z^{(1)}(5),1\end{bmatrix}=\begin{bmatrix}-5280.9369,1\\-9554.2599,1\\-14735.75565,1\\-20697.6775,1\end{bmatrix} \quad (1)$$

$$Y=\begin{bmatrix}x^{(0)}(2)\\x^{(0)}(3)\\x^{(0)}(4)\\x^{(0)}(5)\end{bmatrix}=\begin{bmatrix}3892.3204\\4654.3256\\5708.6659\\6215.1778\end{bmatrix} \quad (2)$$

$$\begin{bmatrix}a\\b\end{bmatrix}=(B^\wedge T*B)^{-1}B^T.Y \quad (3)$$

The development coefficient a=0.1544 and the grey action b=3177.4594 are calculated.

Prediction accuracy test is shown in Table3:

Table 3 Prediction accuracy test

SN	Actual Data	Simulation Data	Residual Relative	Simulation Error
$xx(0)(2)$	3892.3204	3992.5603	-100.2399	2.5753%

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$xx(0)(3)$	4654.3256	4659.0721	-4.7465	0.1020%
$xx(0)(4)$	5708.6659	5436.8503	271.8156	4.7615%
$xx(0)(5)$	6215.1778	6344.4696	-129.2918	2.0803%

Based on the data in the above table, it can be calculated that the average simulation relative error is 2.3798%, and the average simulation accuracy is 97.6202%>95%, so its prediction level accuracy level is the first level.

Predict the freight volume of the Chengdu Europe Express Railway in the next four years, and the predicted results are shown in Table 4:

Table 4 Forecast of Sichuan's Gross Export Trade Value in the Next Four Years

Year	2023	2024	2025	2026
Sichuan	7403.6055	8639.5518	10081.8251	11764.8693

From the data in the above table, it can be seen that the total export trade value of Sichuan will continue to grow in the next four years.

From Table 1, it can be seen that the total value of Sichuan's export trade showed an upward trend during the epidemic period, and the Chengdu Europe Express, as the main support for Sichuan's export trade, provided guarantees for trade exchanges during the epidemic period. From Table 4, it can be seen that Sichuan's export trade will become increasingly frequent in the future. As a transportation mode in Sichuan's export trade, the demand for goods transportation on the Chengdu Europe express railway will continue to rise in the future, and effective distribution of goods to ensure transportation efficiency has become a top priority. Therefore, it is imperative to optimize the supply organization of the Chengdu Europe express railway.

3. Determine alternative distribution centers based on fuzzy clustering analysis

Although the supply of goods for the Chengdu Europe Express Railway is widespread in various regions, Sichuan's local supply accounts for over 70% of the goods carried by the railway, with tens of thousands of varieties and products covering about 20 categories. Therefore, this article focuses on the alternative distribution centers for the Chengdu Europe Express Railway distribution center in Sichuan. The fuzzy clustering analysis method can construct uncertain descriptions of 20 cities and states in Sichuan under different node indicator systems, which can intuitively reflect objective situations. Through MATLAB software calculation, the clustering results can be obtained, which serve as the location category for the distribution center[1].

3.1 Establish a node indicator system

Based on the principles of economy, convenience, and other multiple distribution center selection criteria, the following 7 indicators are selected as the selection criteria for distribution centers:

Gross regional product. The development of regional production cannot be separated from the supply of goods under multimodal transportation, and there can be a positive correlation between local GDP and multimodal transportation supply.

Increase in the tertiary industry. The increase in the tertiary industry can reflect the development level of a region's service and transportation industries. Therefore, the larger the increase in the tertiary industry, the faster the development of the transportation and logistics industries, and the more suitable the establishment of distribution nodes for the Chengdu Europe Express Railway.

Regional industrial and commercial development level. The development of industry and commerce has always been linked to consumption, and the export of consumer goods through freight

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transportation by the Chengdu Europe Express Railway is also closely related to this. This indicator can be measured by the total retail sales of consumer goods in the local society.
The transportation distance from the Chengdu Europe Express. The closer to the Chengdu Europe Express, the stronger the logistics support provided by the region.
Development level of foreign economic and trade. The important component of the goods transported by the Chengdu Europe Express Railway is foreign trade goods. The higher the export volume, the more abundant the supply of goods in the region.
The total mileage of highways in various regions. An important indicator that can reflect the development scale of highway construction. When constructing the Chengdu Europe Express Railway distribution center, the transportation mode is generally land transportation. Therefore, the better the highway mileage in a region, the more suitable it is for site selection.
Turnover of goods. It can indicate the supply situation of the local transportation logistics market from one side, reflecting the development level of the local transportation industry. Cities and states with high cargo turnover have relatively developed transportation.

3.2 Preliminary Determination of Alternative Nodes

Sichuan has 18 prefecture level cities and 3 autonomous prefectures under its jurisdiction. As the provincial capital city of Sichuan, Chengdu already has the Qingbaijiang International Railway Logistics Port to collect goods from the Chengdu Europe Express Railway, and is not considered as an alternative distribution center. By consulting the Statistical Yearbook of Sichuan Province (2022) and the statistical data released by various cities and states, the various indicator values of these 20 cities and states were obtained. This article will conduct fuzzy clustering analysis on the distribution center layout of the Chengdu Europe Express Railway in the evaluation index system composed of 7 indicators from 20 prefecture level cities in Sichuan Province. For the convenience of calculation, it will be numbered (i.e. X1-X20: cities and states in Sichuan except for Chengdu; Y1-Y7: established node indicators), as shown in Tables 5 and Tables 6.

Tables 5 Numbering Table for All Cities and Prefectures in Sichuan (Except Chengdu)

Number	City	Number	City
X1	Zigong City	X11	Meishan City
X2	Panzhihua City	X12	Yibin City
X3	Luzhou City	X13	Guang'an City
X4	deyang	X14	Dazhou City
X5	Mianyang City	X15	Ya'an City
X6	Guangyuan City	X16	Bazhong City
X7	Suining City	X17	Ziyang City
X8	Neijiang City	X18	Aba Tibetan and Qiang Autonomous Prefecture
X9	Leshan City	X19	Ganzi Tibetan Autonomous Prefecture
X10	Nanchong City	X20	Liangshan Yi Autonomous Prefecture

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The units of each indicator are different, and the units of each indicator will be indicated in the table, as shown in Tables 6:

Tables 6 Numbering Table of Node Indicator System

Number	Indicator
Y1	Gross Regional Product (100 million yuan)
Y2	Increase in the tertiary industry
Y3	Total retail sales of social consumer goods (100 million yuan)
Y4	Distance from Chengdu Europe Express Railway (kilometers)
Y5	Total local exports (10000 yuan)
Y6	Total highway mileage (kilometers)
Y7	Freight turnover (10000 ton kilometers)

Substitute the data, as shown in Tables 7:

Table 7 Cluster Analysis of Various Cities and Prefectures in Sichuan (excluding Chengdu)

Number	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X1	1601.31	730.64	691.04	224.41	306432	9637	600613
X2	1133.95	408.91	278.29	726.94	171283	5338	593274
X3	2406.08	955.42	1204.28	291.56	698687	19967	1229352
X4	2656.56	1091.91	1010.06	38.73	1136463	10379	756428
X5	3350.29	1620.32	1652.16	110.09	1108895	23838	753900
X6	1116.25	460.35	495.42	264.82	96187	23287	592051
X7	1519.87	594.99	548.70	149.18	380651	13821	471502
X8	1605.53	801.83	660.51	188.46	210751	13287	481175
X9	2205.15	982.47	891.12	222.77	740111	16418	1185219
X10	2601.98	1107.71	1448.73	207.35	479947	30854	1278843
X11	1547.87	721.49	629.72	118.89	594830	8749	750319
X12	3148.08	1223.32	1209.95	329.68	1674766	25341	676257
X13	1417.82	702.12	651.38	276.93	227043	15482	310765
X14	2351.67	1105.10	1281.49	492.24	468958	28823	1202550
X15	840.56	423.16	301.01	206.86	78939	8286	676331
X16	742.51	360.74	485.10	312.43	43445	25550	456169
X17	890.50	454.67	445.23	116.47	131340	12602	320010
X18	449.63	253.20	107.89	409.79	24115	15677	443320
X19	447.04	250.75	127.66	362.57	16212	32989	225117
X20	1901.18	818.65	761.66	484.59	85464	29044	1122181

Data source: Sichuan Statistical Yearbook (2022)

3.3 Fuzzy clustering analysis to determine the candidate scatter center

3.3.1 Data standardization

Standardize the data using the "translation range transformation" method. (Results to 3 decimal places)

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$$X_{ij}^{*} = \frac{x_{ij} - min_{1 \le i \le n}\{x_{ij}\}}{max_{1 \le i \le n}\{x_{i1}\} - min_{1 \le i \le n}\{x_{ij}\}} \qquad (4)$$

According to formula (4), the standardized data is calculated through MATLAB software programming, as shown in Figure 1:

	1	2	3	4	5	6	7
1	0.3976	0.3504	0.3776	0.2698	0.1750	0.1555	0.3564
2	0.2366	0.1155	0.1103	1	0.0935	0	0.3494
3	0.6748	0.5145	0.7100	0.3674	0.4115	0.5291	0.9530
4	0.7611	0.6142	0.5842	0	0.6754	0.1823	0.5042
5	1	1	1	0.1037	0.6588	0.6691	0.5018
6	0.2305	0.1530	0.2509	0.3285	0.0482	0.6491	0.3482
7	0.3695	0.2513	0.2854	0.1605	0.2197	0.3068	0.2338
8	0.3990	0.4024	0.3579	0.2176	0.1173	0.2875	0.2430
9	0.6056	0.5343	0.5072	0.2674	0.4365	0.4007	0.9111
10	0.7423	0.6257	0.8683	0.2450	0.2796	0.9228	1
11	0.3792	0.3437	0.3379	0.1165	0.3489	0.1234	0.4984
12	0.9304	0.7101	0.7136	0.4228	1	0.7234	0.4281
13	0.3344	0.3296	0.3519	0.3461	0.1271	0.3669	0.0813
14	0.6560	0.6238	0.7600	0.6590	0.2730	0.8493	0.9276
15	0.1355	0.1259	0.1251	0.2443	0.0378	0.1066	0.4282
16	0.1018	0.0803	0.2443	0.3977	0.0164	0.7310	0.2193
17	0.1527	0.1489	0.2184	0.1130	0.0694	0.2627	0.0901
18	8.9210e-04	0.0018	0	0.5392	0.0048	0.3739	0.2071
19	0	0	0.0128	0.4706	0	1	0
20	0.5009	0.4147	0.4234	0.6479	0.0418	0.8573	0.8513

Figure1 Standardized Data

3.3.2 Fuzzy similarity matrix

This article uses the maximum minimum method to construct a fuzzy similarity matrix, and its formula is:

$$R = r_{ij} = \frac{\sum_{k=1}^{m} x_{ik} \wedge x_{jk}}{\sum_{k=1}^{m} x_{ik} \vee x_{jk}} \qquad (5)$$

According to formula (5), the fuzzy similarity matrix R is calculated through MATLAB programming. The details of the results are shown in Figure 2:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	0.4178	0.5005	0.5047	0.3757	0.5527	0.7159	0.8110	0.5675	0.4370	0.7639	0.4225	0.6960	0.4385	0.5253	0.3903	0.4330	0.2489	0.1401	0.5036
2	0.4178	1	0.2655	0.2095	0.1731	0.4323	0.3415	0.3489	0.2668	0.2115	0.3371	0.2412	0.3439	0.3073	0.4693	0.3342	0.2819	0.3307	0.1664	0.3626
3	0.5005	0.2655	1	0.6229	0.6100	0.4412	0.4392	0.4867	0.8604	0.7910	0.5163	0.6666	0.4657	0.8066	0.2893	0.3548	0.2536	0.2206	0.1921	0.6560
4	0.5047	0.2095	0.6229	1	0.6668	0.2947	0.4276	0.4670	0.6573	0.5701	0.5909	0.6485	0.3652	0.5354	0.2690	0.1978	0.2452	0.0979	0.0423	0.4141
5	0.3757	0.1731	0.6100	0.6668	1	0.3458	0.3548	0.3786	0.5611	0.6505	0.4317	0.7461	0.3275	0.5886	0.2095	0.2713	0.2116	0.1289	0.1395	0.4414
6	0.5527	0.4323	0.4412	0.2947	0.3458	1	0.5644	0.5498	0.4277	0.4038	0.4404	0.4075	0.5869	0.4230	0.5379	0.7593	0.5094	0.4132	0.3959	0.5348
7	0.7159	0.3415	0.4392	0.4276	0.3548	0.5644	1	0.7946	0.4988	0.3901	0.6735	0.3707	0.6975	0.3848	0.4395	0.4538	0.5775	0.3000	0.1696	0.4212
8	0.8110	0.3489	0.4867	0.4670	0.3786	0.5498	0.7946	1	0.5528	0.4323	0.6613	0.4108	0.7668	0.4263	0.4433	0.4407	0.5212	0.2958	0.1732	0.5112
9	0.5675	0.2668	0.8604	0.6573	0.5611	0.4277	0.4988	0.5528	1	0.7163	0.5864	0.5876	0.4967	0.7124	0.3286	0.3226	0.2881	0.2175	0.1525	0.6445
10	0.4370	0.2115	0.7910	0.5701	0.6505	0.4038	0.3901	0.4323	0.7163	1	0.4373	0.6419	0.3838	0.8503	0.2569	0.3387	0.2253	0.1674	0.2368	0.6555
11	0.7639	0.3371	0.5163	0.5909	0.4317	0.4404	0.6735	0.6613	0.5864	0.4373	1	0.4156	0.5503	0.4295	0.4726	0.2970	0.4004	0.1611	0.0748	0.4552
12	0.4225	0.2412	0.6666	0.6485	0.7461	0.4075	0.3707	0.4108	0.5876	0.6419	0.4156	1	0.3931	0.6581	0.2442	0.3613	0.2141	0.2004	0.2206	0.5174
13	0.6960	0.3439	0.4657	0.3652	0.3275	0.5869	0.6975	0.7668	0.4967	0.3838	0.5503	0.3931	1	0.4080	0.3750	0.4966	0.5377	0.3542	0.2693	0.4845
14	0.4385	0.3073	0.8066	0.5354	0.5886	0.4230	0.3848	0.4263	0.7124	0.8503	0.4295	0.6581	0.4080	1	0.2534	0.3771	0.2222	0.2375	0.2720	0.7840
15	0.5253	0.4693	0.2893	0.2690	0.2095	0.5379	0.4395	0.4433	0.3286	0.2569	0.4726	0.2442	0.3750	0.2534	1	0.4255	0.4814	0.3203	0.1566	0.3220
16	0.3903	0.3342	0.3548	0.1978	0.2713	0.7593	0.4538	0.4407	0.3226	0.3387	0.2970	0.3613	0.4966	0.3771	0.4255	1	0.4496	0.5104	0.5352	0.4792
17	0.4330	0.2819	0.2536	0.2452	0.2116	0.5094	0.5775	0.5212	0.2881	0.2253	0.4004	0.2141	0.5377	0.2222	0.4814	0.4496	1	0.2768	0.1807	0.2729
18	0.2489	0.3307	0.2206	0.0979	0.1289	0.4132	0.3000	0.2958	0.2175	0.1674	0.1611	0.2004	0.3542	0.2375	0.3203	0.5104	0.2768	1	0.4780	0.3017
19	0.1401	0.1664	0.1921	0.0423	0.1395	0.3959	0.1696	0.1732	0.1525	0.2368	0.0748	0.2206	0.2693	0.2720	0.1566	0.5352	0.1807	0.4780	1	0.3456
20	0.5036	0.3626	0.6560	0.4141	0.4414	0.5348	0.4212	0.5112	0.6445	0.6555	0.4552	0.5174	0.4845	0.7840	0.3220	0.4792	0.2729	0.3017	0.3456	1

Figure 2 Fuzzy Similarity Matrix R

3.3.3 Fuzzy equivalence matrix

The transitive closure method is used to calculate t (R) and then establish the fuzzy equivalent matrix. The fuzzy equivalent matrix is obtained through MATLAB programming. The results are shown in Figure 3:

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	0.4693	0.5909	0.5909	0.5909	0.5869	0.7946	0.8110	0.5909	0.5909	0.7639	0.5909	0.7668	0.5909	0.5379	0.5869	0.5775	0.5104	0.5352	0.5909
2	0.4693	1	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693	0.4693
3	0.5909	0.4693	1	0.6666	0.6666	0.5869	0.5909	0.5909	0.8604	0.8066	0.5909	0.6666	0.5909	0.8066	0.5379	0.5869	0.5775	0.5104	0.5352	0.7840
4	0.5909	0.4693	0.6666	1	0.6668	0.5869	0.5909	0.5909	0.6666	0.6666	0.5909	0.6668	0.5909	0.6666	0.5379	0.5869	0.5775	0.5104	0.5352	0.6666
5	0.5909	0.4693	0.6666	0.6668	1	0.5869	0.5909	0.5909	0.6666	0.6666	0.5909	0.7461	0.5909	0.6666	0.5379	0.5869	0.5775	0.5104	0.5352	0.6666
6	0.5869	0.4693	0.5869	0.5869	0.5869	1	0.5869	0.5869	0.5869	0.5869	0.5869	0.5869	0.5869	0.5869	0.5379	0.7593	0.5775	0.5104	0.5352	0.5869
7	0.7946	0.4693	0.5909	0.5909	0.5909	0.5869	1	0.7946	0.5909	0.5909	0.7639	0.5909	0.7668	0.5909	0.5379	0.5869	0.5775	0.5104	0.5352	0.5909
8	0.8110	0.4693	0.5909	0.5909	0.5909	0.5869	0.7946	1	0.5909	0.5909	0.7639	0.5909	0.7668	0.5909	0.5379	0.5869	0.5775	0.5104	0.5352	0.5909
9	0.5909	0.4693	0.8604	0.6666	0.6666	0.5869	0.5909	0.5909	1	0.8066	0.5909	0.6666	0.5909	0.8066	0.5379	0.5869	0.5775	0.5104	0.5352	0.7840
10	0.5909	0.4693	0.8066	0.6666	0.6666	0.5869	0.5909	0.5909	0.8066	1	0.5909	0.6666	0.5909	0.8503	0.5379	0.5869	0.5775	0.5104	0.5352	0.7840
11	0.7639	0.4693	0.5909	0.5909	0.5909	0.5869	0.7639	0.7639	0.5909	0.5909	1	0.5909	0.7639	0.5909	0.5379	0.5869	0.5775	0.5104	0.5352	0.5909
12	0.5909	0.4693	0.6666	0.6668	0.7461	0.5869	0.5909	0.5909	0.6666	0.6666	0.5909	1	0.5909	0.6666	0.5379	0.5869	0.5775	0.5104	0.5352	0.6666
13	0.7668	0.4693	0.5909	0.5909	0.5909	0.5869	0.7668	0.7668	0.5909	0.5909	0.7639	0.5909	1	0.5909	0.5379	0.5869	0.5775	0.5104	0.5352	0.5909
14	0.5909	0.4693	0.8066	0.6666	0.6666	0.5869	0.5909	0.5909	0.8066	0.8503	0.5909	0.6666	0.5909	1	0.5379	0.5869	0.5775	0.5104	0.5352	0.7840
15	0.5379	0.4693	0.5379	0.5379	0.5379	0.5379	0.5379	0.5379	0.5379	0.5379	0.5379	0.5379	0.5379	0.5379	1	0.5379	0.5379	0.5104	0.5352	0.5379
16	0.5869	0.4693	0.5869	0.5869	0.5869	0.7593	0.5869	0.5869	0.5869	0.5869	0.5869	0.5869	0.5869	0.5869	0.5379	1	0.5775	0.5104	0.5352	0.5869
17	0.5775	0.4693	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5775	0.5379	0.5775	1	0.5104	0.5352	0.5775
18	0.5104	0.4693	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	0.5104	1	0.5104	0.5104
19	0.5352	0.4693	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5352	0.5104	1	0.5352
20	0.5909	0.4693	0.7840	0.6666	0.6666	0.5869	0.5909	0.5909	0.7840	0.7840	0.5909	0.6666	0.5909	0.7840	0.5379	0.5869	0.5775	0.5104	0.5352	1

Figure 3 Fuzzy equivalence matrix

3.3.4 Fuzzy clustering results and their analysis

The fuzzy clustering results were obtained through MATLAB programming. In order to eliminate the impact of fuzzy equivalence matrix data on the clustering results and clarify the classification situation, the threshold was adjusted to an appropriate step size (0.1 or 0.05) for analysis. The obtained fuzzy clustering results are shown in Table 8:

Table 8 Summary of clustering results under different thresholds

threshold	class number	Specific clustering situation
λ=0.4	1	{ X1,X2,X3,X4,X5,X6,X7,X8,X9,X10,X11,X12,X13,X14,X15,X16, X17,X18,X19,X20}
λ=0.5	4	{ X19},{X18},{X2}{X1,X3,X4,X5,X6,X7,X8,X9,X10,X11,X12,X13,X14,X15,X16,X17,X20}
λ=0.65	8	{ X19},{X18},{X17},{X15},{X6,X16},{X3,X4,X5,X9,X10,X12,X14,X20},{X2},{X1,X7,X8,X11,X13}
λ=0.7	11	{ X19},{X18},{X17},{X15},{X6},{X16},{X5,X12},{X4},{X1,X7, X8,X11,X13},{X3,X9,X10,X14,X20},{X2}
λ=0.75	12	{X19},{X18},{X17},{X15},{X6},{X16},{X11},{X5,X12},{X4} , { X1,X7,X8,X13},{X3,X9,X10,X14,X20},{X2}
λ=0.8	17	{ X1},{X2},{X4},{X5},{X6},{X11},{X12},{X13},{X15},{X16}, { X17},{X18},{X19},{X20},{X10,X14},{X7,X8},{X3,X9}

λ=0.4, 0.5, 0.6, the clustering results are too concentrated and the classification is not clear, which does not meet the location requirements of the Chengdu Europe Express Railway distribution center;

When λ=0.75, $\lambda\lambda$ =0.8, the clustering results are scattered and do not meet the site selection requirements;

Whenλ=0.65 and=0.7, the clustering results are relatively clear and the clustering characteristics are significant. However, by comparing the distribution of distribution centers after clustering, λ= The clustering result at 0.65 is more in line with the selection category of the distribution center of the Chengdu Europe Express Railway in this article. The specific classification is as follows:

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The goods with the lowest gross domestic product, increase in the tertiary industry, total retail sales of consumer goods, exports, and turnover of goods, but the goods with the highest total road mileage are classified as the first category. The gross domestic product, the increase in the tertiary industry, the total retail sales of consumer goods, and the turnover of goods are relatively low, far from the Chengdu Europe high-speed railway, with low export volume and low total road mileage, which are classified as the second category. The gross domestic product is relatively low, the added value of the tertiary industry is relatively low, the total sales of consumer goods are relatively low, the distance from the Chengdu Europe high-speed railway is relatively close, the export volume is low, the total mileage of highways is low, the turnover of goods is low, and the market prosperity is high (market prosperity=100% of the total local production of wholesale and retail trade), which is the third category. Goods with low gross domestic product but high per capita gross domestic product, low added value in the tertiary industry, low total social consumer goods, low export volume, and low total kilometer mileage, but high turnover of goods and low market prosperity, are classified as the fourth category. Goods with low gross domestic product, low added value of the tertiary industry, low export volume and goods turnover, high total road mileage, and high market prosperity are classified as the fifth category. Goods with higher gross domestic product, higher added value in the tertiary industry, higher total retail sales of consumer goods, higher export volume, and higher turnover of goods are classified as the sixth category. The gross domestic product is relatively low, the per capita gross domestic product is the highest, the added value of the tertiary industry is low, the total retail sales of consumer goods are low, the market prosperity is low, and the goods with the farthest distance from the Chengdu Europe train and the least total road mileage are classified as the seventh category. Goods with high gross domestic product, close to the Chengdu Europe high-speed railway, high added value in the tertiary industry, low total road mileage, low turnover of goods, and low market prosperity are classified as the eighth category.

In summary, whenλ=0.65, the clustering level is clear and the classification features are significant, with cities and states in the sixth category having better conditions as nodes. Therefore, the nodes of alternative distribution centers will be located in eight cities and states: Luzhou City, Mianyang City, Deyang City, Leshan City, Nanchong City, Yibin City, Dazhou City, and Liangshan Yi Autonomous Prefecture.

4. Analysis of logistics connections between cities and states

The above is based on fuzzy clustering analysis to locate alternative distribution centers in 8 cities and states, but the logistics connections of each city and state are not clear, making it difficult to accurately classify the hierarchy. Therefore, on the basis of the original data, principal component analysis and gravity matrix model are used to analyze the logistics connections between each city and state.

4.1 Analysis of Indicator Factors for Each City and State

In order to ensure the rationality of the calculation, standardized data is selected for principal component analysis. This article first conducts KMO and Bartlett's tests using SPSS software to determine whether the principal component analysis method is suitable. The results are shown in Table 9.

Table 9 KMO and Bartlett's test results

KMO sampling suitability quantity		0.703

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Bartlett sphericity test	Approximate chi square	147.372
	degree of freedom	21
	Significance	0.000

From the above table, it can be seen that the KMO value is greater than 0.7 and the significance of Bartlett's sphericity test is less than 0.001, indicating that the data has high significance and can be used for principal component analysis.
Select feature roots with a cumulative contribution rate greater than 85%, and determine the number of factors as 3, as shown in Table10.

Table 10 Overall Explanation of Variance

component	initial eigenvalue			Extract the sum of squares of the load		
	total	Variance percentage	accumulate percentage	total	Variance percentage	accumulate percentage
1	4.230	60.435	60.435	4.230	60.435	60.435
2	1.355	19.361	79.796	1.355	19.361	79.796
3	0.709	10.125	89.921			
4	0.503	7.180	97.101			
5	0.167	2.382	99.483			
6	0.026	0.370	99.853			
7	0.010	0.147	100.000			

Use SPSS to implement principal component analysis and obtain a matrix of component score coefficients, as shown in Table 11.

Table 11 Component Score Coefficient Matrix

	component		
	1	2	3
Y1	0.233	-0.033	0.121
Y2	0.231	-0.051	0.026
Y3	0.230	0.048	-0.077
Y4	-0.066	0.574	0.625
Y5	0.197	-0.215	0.107
Y6	0.076	0.514	-0.893
Y7	0.164	0.304	0.436

Based on the data in the above table, the functional expressions of the principal components can be obtained separatelyFF_{ii}:
$FF_1 = 0.233YY1 + 0.231Y2 + 0.230Y3 - 0.066Y4 + 0.197Y5 + 0.076Y6 + 0.164Y7$ (6) $FF_2 = -0.033YY1 - 0.051Y2 + 0.048Y3 + 0.574Y4 - 0.215Y5 + 0.514Y6 + 0.304Y7$ (7)
$FF_3 = 0.121YY1 + 0.026Y2 - 0.077Y3 + 0.625Y4 + 0.107Y5 - 0.893Y6 + 0.436Y7$ (8)
By using SPSS software, the corresponding values of,FF_1, FF_2, FF_3 and for each city and state can be calculated. By setting the regression method, the obtained principal component scores are calculated as FACA1_ 1. FACA2_ 1. FACA3_ Displayed in the form of 1, the results are shown in Figure 4.

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City	FAC1_1	FAC2_1	FAC3_1
Zigong	-.23488	-.75875	.55710
Panzhihua	-1.09078	.83961	2.89611
Luzhou	.94697	.49320	.68642
Deyang	.97391	-1.68398	.28339
Mianyang	1.91322	-.63038	-.85229
Guangyuan	-.63102	.34400	-.84691
Suining	-.38077	-.91914	-.32575
Neijiang	-.25873	-.74165	-.13773
Leshan	.73711	-.05791	.77639
Nanchong	1.28610	1.00563	-.78277
Meishan	-.05066	-1.19131	.51219
Yibin	1.50828	-.08749	-.10981
Guang 'an	-.47160	-.43845	-.28136
Dazhou	.95048	1.82029	.42394
Ya'an	-.90873	-.69474	.61694
Bazhong	-.89074	.57828	-1.15259
Ziyang	-.87740	-1.09673	-.66340
Aba Tibetan and Qiang Autonomous Prefecture	-1.38076	.30527	.26455
Ganzi Tibetan Autonomous Prefecture	-1.30933	.99722	-2.04486
Liangshan Yi Autonomous Prefecture	.16932	1.91703	.18044

Figure 4 Calculation Results of Factor Scores

In summary, calculate the comprehensive score values of each city and state, and the formula is:

The comprehensive score of the city and state(FF) =

$\sum^{3}_{ii}$ (The score function value of the component i factor in the city and state × Contribution rate of component i), where is the percentage of variance of Contribution rate of component i (see Figure 5 for details).

City	FAC1_1	FAC2_1	FAC3_1	F
Zigong	-.23488	-.75875	.55710	-.23
Panzhihua	-1.09078	.83961	2.89611	-.20
Luzhou	.94697	.49320	.68642	.74
Deyang	.97391	-1.68398	.28339	.29
Mianyang	1.91322	-.63038	-.85229	.95
Guangyuan	-.63102	.34400	-.84691	-.40
Suining	-.38077	-.91914	-.32575	-.44
Neijiang	-.25873	-.74165	-.13773	-.31
Leshan	.73711	-.05791	.77639	.51
Nanchong	1.28610	1.00563	-.78277	.89
Meishan	-.05066	-1.19131	.51219	-.21
Yibin	1.50828	-.08749	-.10981	.88
Guang 'an	-.47160	-.43845	-.28136	-.40
Dazhou	.95048	1.82029	.42394	.97
Ya'an	-.90873	-.69474	.61694	-.62
Bazhong	-.89074	.57828	-1.15259	-.54
Ziyang	-.87740	-1.09673	-.66340	-.81
Aba Tibetan and Qiang Autonomous Prefecture	-1.38076	.30527	.26455	-.75
Ganzi Tibetan Autonomous Prefecture	-1.30933	.99722	-2.04486	-.81
Liangshan Yi Autonomous Prefecture	.16932	1.91703	.18044	.49

Figure 5 Comprehensive score values of each city and state

4.2 Analyze the logistics links between cities and states based on the Gravity model

We will use the comprehensive scores of each city and state in Sichuan obtained through principal component analysis as the comprehensive value of logistics development capacity of each city and state. By substituting this comprehensive value into the gravity model, we can obtain the formula for logistics connection[2][3]:

$$L_{ij} = \frac{k \times m_i m_j}{D_{ij}^2} \times k_{ij} \qquad (9)$$

Because the main mode of transportation in Sichuan is by road, and the Chengdu Europe Express Railway also accounts for a large proportion of multimodal transportation by road, this article chooses road mileage as the distance between cities. For the convenience of calculation, the overall comprehensive value of logistics development capacity in each city and state is linearly shifted by 1 unit.

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Then, according to formula (8), the logistics connection matrix table (to 2 decimal places) between 20 cities and states in Sichuan and the 8 alternative distribution centers obtained from the fuzzy clustering analysis can be calculated. The specific results are shown in Table 12:

Table 12 Logistics Contact Matrix between 8 Alternative Distribution Centers and 20 Cities and Prefectures in Sichuan

	X3	X4	X5	X9	X10	X12	X14	X20
X1	41.10	5.29	4.28	24.73	6.79	47.60	2.49	1.39
X2	0.53	0.77	0.79	1.14	0.59	0.67	0.43	8.53
X3	0.00	12.35	11.20	30.15	16.51	120.99	9.29	3.72
X4	17.91	0.00	278.21	18.05	20.43	8.95	6.19	3.29
X5	13.53	358.33	0.00	19.07	58.41	11.72	14.66	5.31
X6	1.16	4.85	7.71	1.21	5.59	1.02	3.79	0.49
X7	3.98	7.39	8.95	3.21	40.80	3.31	4.17	0.62
X8	30.34	5.91	4.52	12.61	7.69	20.61	2.45	1.04
X9	25.45	20.94	16.87	0.00	11.43	42.25	4.94	6.61
X10	18.53	29.67	54.76	13.41	0.00	15.97	56.27	3.39
X11	6.55	15.12	9.88	74.82	5.65	7.32	2.19	2.44
X12	122.01	13.05	12.20	40.57	17.20	0.00	7.12	4.98
X13	3.14	2.79	3.95	1.77	39.67	3.46	8.33	0.50
X14	10.62	9.74	14.98	6.35	59.31	7.64	0.00	2.31
X15	1.22	2.39	1.80	9.89	0.87	1.68	0.43	1.17
X16	0.84	1.58	2.26	0.70	5.49	0.76	8.39	0.27
X17	0.67	1.48	0.87	0.96	0.79	0.74	0.23	0.13
X18	0.13	0.38	0.35	0.20	0.18	0.13	0.11	0.10
X19	0.16	0.26	0.22	0.54	0.13	0.20	0.08	0.18
X20	3.20	3.60	4.06	6.58	2.79	3.95	1.80	0.00

5. Establishment of the Chengdu Europe Express Railway Distribution Center

From Table 12, it can be seen that different alternative distribution centers have significant differences in the logistics attractiveness of each city and state. Taking Deyang City as an example, compared to the other 7 alternative distribution centers, this node has a significant logistics attraction to Mianyang City, which is more than 7 times the logistics connection value of other alternative distribution centers to Mianyang. Deyang City is closest to the Chengdu Europe Express Railway and is located at the intersection of the ancient Silk Road Economic Circle and the Yangtze River Delta Urban Agglomeration. In 2017, Deyang City began preparing to build the Deyang International Railway Logistics Port as the distribution center of the Chengdu Europe Express Railway, which is more in line with the standards of first-class nodes. Taking into account the cities and states with higher logistics connection values with nodes as the cities and states for logistics and cargo collection services at this node, nodes with higher logistics connection values are considered as primary distribution centers. Finally, the layout of distribution centers for Chengdu Europe Express in Sichuan Province is shown in Table 13.

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Table 13 Distribution Center Layout of Chengdu Europe Express Railway in Sichuan Province

Primary distribution center	Secondary distribution center	Third level distribution center	The city/state served
Deyang	Mianyang		Guangyuan
		Nanchong	Dazhou, Guang'an, Bazhong, Suining
			Aba Tibetan and Qiang Autonomous Prefecture, Ziyang
Leshan	Liangshan Yi Autonomous Prefecture		Panzhihua
	Yibin		Zigong, Neijiang, Luzhou
			Ya'an, Meishan, Ganzi Tibetan Autonomous Prefecture

According to Table 13, draw the flow direction of goods at the distribution center of the Chengdu Europe Express Railway in Sichuan Province, as shown in Figure 6:

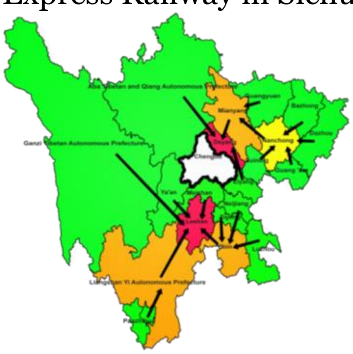

Figure 6 Freight Flow Diagram of Chengdu Europe Express Railway in the Distribution Center of Sichuan Province

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References

Wang Zhendong. Research on Railway Logistics Park Planning Based on Fuzzy Clustering [D]. China Academy of Railway Sciences, 2019.

Xue Sheng. Research on the Site Selection of G Company's Recycling Center in Chengdu City [D]. Chengdu University of Technology, 2019 DOI: 10.26986/d. cnki.gcdlc. 2019.000738.

Li Qian. Research on Optimizing the Layout of Logistics Node Cities in the Beijing Tianjin Hebei Region [D]. North China Electric Power University, 2019.