A Case Study of CR Express Assembly Center Hinterland Calculation Based on the Location Scheme

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Abstract
With the rapidly development of the China Railway Express (CR Express), due to the vicious market competition and the lack of top-level design, freight flow direction and freight organization appears disordered and unreasonable which causes a seriously waste of social resources. In 2020, five assembly centers construction were announced by the National Development and Reform Commission, this will improve efficiency of container cargo collection and distribution system. However, the attraction freight source area of which is still ambiguous. To solve the problem, this paper divided the hinterland of the five assembly centers. A hinterland division model of CR Express assembly center was established by improving the Huff basic method. Considering the factors of decision-making, the factor analysis was employed to evaluate the comprehensive influence and the method of calculating the minimum transport cost was proposed based on the real transport network. Based on this, a case study of 415 freight areas nationwide was conducted and the hinterland distribution map was made by ArcGIS 10.4. At last, the influence of subsidy policy on hinterland scope was discussed. The conclusion could help the railway company to plan the route of assembly and dispatching reasonably, and advance the organization and management of cargo sources. It can also provide directions for freight agents to adjust marketing strategies. Furthermore, it will promote the development of CR Express in high quality and sustainability.

Keywords
China Railway Express, Assembly center, Hinterland, Huff model, GIS

1 Introduction

In the process of continuous advancement of the Silk Road Economic Belt Initiative, the Sino-Europe container block train represented by the China Railway Express (CR Express) has fully take the advantages of strong timeliness, high safety, and low energy consumption. The number of CR Express train increased year by year from 17 in 2011 to 12406 in 2020. However, due to the lack of top-level design and the vicious competition among freight agents of various regions, freight organization became disordered, this unreasonable phenomenon manifested as two aspects. One is a fierce scramble for nonlocal freight sources, resulting a huge scope of sources even reaching 1500km radius to the cities operating CR Express. The other is lower operating frequency in some cities because of the dispersive freight sources while many cities operate the block train simultaneously. As a consequence, the freight flow direction and transport routes of the outbound cargo consolidation and backhaul cargo distribution have become unreasonable, which also cause a huge waste of social resources (Li et al. (2019), Wu et al. (2017), Wang et al. (2017)).

CR Express assembly centers are main hub nodes for the CR Express, and plays an important role in container cargo assembly and transit. In July 2020, the National Development and Reform Commission put forward constructing the demonstration projects of 5 CR Express assembly center in Zhengzhou, Chongqing, Chengdu and Xi'an and Urumqi to promote the development of CR Express from "point-to-point" to "hub-to-hub." The transformation of “hub” will accelerate the formation of an efficient collection and distribution system of “integration of stems and branches, hub collection and distribution”. The construction of assembly center will play a role in inducing the freight volume. Furthermore, it will produce influence on the economic development and industrial structure of these cities and surrounding areas where they are located, and brings great social and economic benefits.

Though the CR Express intermodal transport platforms of the five provinces jointly issued the CR Express High-Quality Development Proposal in 2019, which proposed to put an end to the phenomenon of soliciting goods at a low price that violates the law of the market, and not to compete with the source of goods in a malicious way, however, how to determine the scope of the source of goods was not clearly proposed. Thus, this paper focuses on the study of reasonable hinterland of the assembly center. An improved Huff model is established for dividing hinterland. The freight cost and assembly center characteristics influence on the cargo owner are considered, and their calculation methods are given separately by GIS platform and the factor analysis. Then, a case study is carried out on 415 source regions across the country, and the distribution map of the absolute advantage area of the cargo assembly and dispatch of the assembly centers are drawn. Based on this, the hinterland range is obtained. At last, the rationality and flexibility of the model and method are verified. The conclusion of the study will in favor of reasonably selecting the train station based on the location of the source for freight agents, and making the train operation plan based on the cargo traffic volume of hinterland for the railway company.

2 Literature Review

In related works on CR Express, researchers at home and abroad summarized the current situation, and proposed improvement directions for existing problems(Yang (2021), Li et al. (2019), Wu et al. (2017), Wang et al (2017), Guo et al. (2011)). It becomes a consensus of strengthening the transportation network plan and construct several logistics hubs in China to solve the problem of the supply organization of CR Express.

Besides, it is important to clarify the attraction scope of the hub in the overall planning of the CR Express container supply organization.

For the attraction scope of hubs, the research on the hinterland division of shipping ports is more mature. Researchers tried to look for the relationship between a single port and an industrial trade center by studying the interaction between the seaport and the hinterland in early times (Patton (1958), Ullman (2016)) argued that during the regional development of ports and port systems, the hinterland of ports should be included in the scope of port governance. Therefore, with the continuous improvement of the transportation network, the relationship between the port and the hinterland was more regarded as a competitive relationship between the ports(Mayer (1957), Weigend (1958)). Since then, more and more studies have established mathematical models to describe this kind of competitive relationship, and used the results from the models as the basis for the port hinterland division (Notteboom and Rodrigue (2005), Zhu et al. (2009), Ferrari et al. (2011), Ke et al. (2017)).

(Yang (2002)) used a combined approach of the gravity model and FCE model to determine the attractive power and service areas of ports. (Jiang et al. (2013)) employed the Huff model to calculate the potential-energy value of the influence which the six ports along the Liaoning coast acting on the hinterland city from 1995 to 2009, and it was visualized by GIS tools.

The research on the attracting scope of railway freight transport is generally concentrated on freight corridors (He (2012), Liu (2015)). (Jiang et al. (2018)) used a binary logit model to analyze the hinterland patterns of the CR Express in China and found that the current and the prospective hinterland patterns of two types of products of the CR Express. As a result, Chongqing, Chengdu, Zhengzhou and Wuhan have the same opportunities to become the regional railway hub for IT product transport.

Geographic Information System provides a strong technical support and a border prospect for the study on transportation planning (Wang et al. (2015), Gholam et al. (2017), Liu et al.（2017)). In the research and discussion supported by GIS technology, (Wang et al. (2018)) took the 314 municipal-level administrative units or municipalities that connected directly to China railways as the object. From the perspective of distance and cost, three economic hinterland of railway border ports of CR Express. Alataw, Erehot, and Manzhouli were analyzed.

The related works studied the problems of the operation of the assembly centers for CR Express. However, the research on hinterland division of assembly centers is relatively scarce. Therefore, it is necessary to calculate the hinterland scope of each assembly center. The theory and experience of port hinterland division in the maritime field provides reference, but it should be improved according to the characteristics of the railway corridor. The application of GIS technology in the field of transportation planning also provides support for the research in this paper. This paper takes each CR Express assembly center as the research object, and establishes a model to measure and calculate hinterland scope. Then, the GIS tools are used to solve the model and visualize the conclusion.

3 Model and Approach

3.1 Hinterlands of CR Express Assembly Centers

Hinterland is originally a concept in the maritime field, which refers to the area around the port where sources are to be assembled and dispatched (Huff, D.L., (1960 and 1963)). With the development of international railway through traffic under the Belt and Road Initiative, railway stations far from the coastline have gradually assumed similar functions as maritime ports. Therefore, this paper applies this concept to the field of international railway trains. In this paper, the hinterland refers to the area where the container cargo can be directly reached by one or more modes of transportation from the train operating cities. In other words, the hinterland refers to the scope of freight assembly at the departure and dispatch at the destination. The assembly centers are located at the departure and destination of the whole transportation of the CR Express. They are responsible for assembling container cargo from various sources regions and dispatching the arrived container cargo to those receptive locations through short-distance transportation. The hinterland of CR Express assembly center is the scope of cargo assembly and dispatch for the CR Express.

3.2 Hinterland Division Model of CR Express Assembly Center

The Huff model is an improvement of the gravity model. Comparing to the gravity model, it can better describe the behavior of freight agents in decision-making by analyzing the two components of attraction and distance resistance (Okunuki and Okabe (2002)). It is widely used in the research of consumer decision, the scale of business districts, service scope of public facilities in urban planning and the port hinterland division in transportation planning (Drezner (2004), Sun et al. (2011), Zhang et al. (2015), Paroli and Maraschin (2018)). Based on the basic principle of Huff model, this paper will divide hinterland of the assembly center through appropriate modification.

To divide the hinterland of the CR Express assembly center, the following assumptions can be made considering the actual situation:

(1) All goods that do not meet the conditions of "point-to-point" operation need to be assembled.

(2) Only railway and highway transportation are considered to link the assembly center and the freight area.

(3) When choosing assembly centers, the overseas factors are not considered.

(4) In addition to transportation costs, the decisions of freight agents are also influenced by the characteristics of assembly centers and the socio-economic characteristics of the cities where they are located.

Based on the assumptions, it can be considered that the probability for freight agents choosing a certain assembly center among all options is proportional to the utility of the decision, as shown in equation (1).

$$P_{rk} = \frac{U_k}{\sum_{k \in K} U_K} = \frac{S_k C_{rk}^{-\beta}}{\sum_{k \in K} S_K C_{rK}^{-\beta}}. \tag{1}$$

Where P_{rk} is the probability of an individual freight area r selecting the assembly center k, K is the set of optional assembly centers; U_k is the utility of the decision for assembly center k; S_k is the attraction of the assembly center k, which is the comprehensive influence calculated by multiple indicators; C_{rk} is the minimum freight cost between the two places; β is the distance resistance coefficient, and we take 2 as the empirical value.

From above, the probability of selecting each assembly center k for the cargo in area r can be calculated. For a certain area, the sum of the probabilities of each decision is 1. For a certain assembly center, the hinterland is composed of the freight area with the highest probability of all the decisions (Berry and Lamb (1974)).

Although this method can be used to divide the hinterland, some problems still exist. For example, if the selection probability in a certain freight area for multiple assembly centers is very close, this method would ignore the uncertainty of the agent's decision. Taking the outbound cargo collection as an example, as shown in Figure 1. It shows the attraction scope of the assembly centers 1 and 2 respectively represented by different colours, and thus forms the boundary of the hinterland. For the freight area r located near the boundary, when $P_{r1} > P_{r2}$, if the probability gap (P_{r1}-P_{r2}) is large enough, the area r belongs to the attraction scope of the center 1 (blue area) definitely. However, if the values of P_{r1} and P_{r2} are very close, the agents also have similar possibility to choose the assembly center 2 (pink area). Vice versa for the dispatching of backhaul cargo.

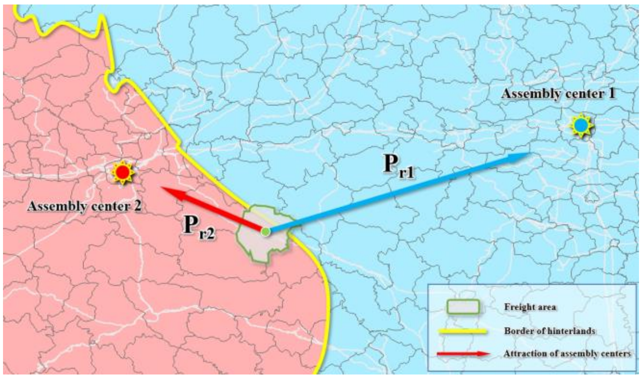

Figure 1: The shortage of Huff basic method

It can be seen that although the traditional Huff model calculates the probability of selecting the assembly center of each freight area, it ignores some details and fails to reflect the uncertainty in the division of the hinterland. To solve this, the method is improved in this paper. After P_{rk} is calculated by Huff model, the probability variance of each assembly center k selected by the freight agents in freight area r is calculated. The probability variance is used as the membership of each assembly center, and the attraction scope of its source is defined accordingly. The calculation of probability variance is as equation (2).

$$M_r = \frac{1}{\delta}\sum_{k\in K}(P_{rk} - \frac{1}{\delta})^2. \tag{2}$$

Where M_r is the membership of the freight area r relative to the assembly center, it refers to the variance of probabilities.

Variance is an index of measuring the dispersion of the value. For the area r, a bigger difference in the probabilities means a bigger attraction of a certain assembly center, and the membership of the freight area r to the assembly center is bigger. On the contrary, if the probability difference of each item or a few items is small and the probabilities tend to average, the freight agents in this area would have more selective assembly centers, and the membership of belonging to a certain assembly center is smaller. The area with large membership can be treated as the absolute advantage area of the assembly center.

Compared with the traditional method of dividing the attraction scope, the method proposed by this paper puts emphasis on the perspective of freight agents. The membership of each assembly center to freight agents is obtained by comparing the probabilities of decisions. It could be taken as the basis for freight agents to choose assembly centers. Theoretically, the conclusions obtained by this method are more reasonable and more consistent with the actual decision-making behavior of freight agents.

3.3 Comprehensive Influence Evaluation

The attraction of the assembly center is a comprehensive influence value. It is necessary to determine the indexes and evaluate the comprehensive influence of the assembly center. When determining the comprehensive influence indexes of the CR Express assembly center, on the one hand, the ability to deliver goods should be considered; on the other hand, the impact of the socio-economic characteristics of the cities where they are located should not be ignored. These indexes reflect the characteristics of the assembly center that have an impact on the decision of the freight agent.

Therefore, indexes of ‘Number of stations (X1)’; ‘Yearly assembly capacity (X2)’;

‘Yearly dispatch capacity (X3)’; ‘Traffic network density (X4)’; ‘Gross regional product (X5)’; ‘Secondary industry production (X6)’; ‘Tertiary Industry production (X7)’; ‘Annual import value(X8)’; ‘Annual export value(X9)’ are selected.

The comprehensive influence of assembly center is evaluated by calculating the comprehensive score of each assembly center. Factor analysis based on principal component analysis can extract common factor to simplified variables while retaining the original data information, and calculate the comprehensive score of each assembly center through the factor scores. The basic idea and calculation method are as follows.

The original variable matrix X data is normalized to matrix Z, and the ith variable z_i can be expressed by i common factors as equation (3).

$$z_i = a_{i1}F_1 + a_{i2}F_2 + \cdots + a_{ii}F_i + \varepsilon. \tag{3}$$

Where F_i is the ith common factor to be extracted, and there are i common factors in i variables; ε is a special factor that cannot be explained by the common factor, and its average value is 0; a_{in} is the load of variable i on the nth extracted factor; the loading matrix A is constituted by a_{in}, which is an $i \times i$ matrix before factor extraction.

Calculate the ith eigenvalues λ_i of matrix A. F_n refers to the first n factors whose eigenvalues are greater than 1, which will be extracted. The variance contribution of each factor is calculated as equation (4).

$$\mu_n = \lambda_n / \sum_i \lambda_i. \tag{4}$$

Where μ_n is the variance contribution of the nth factor, and the sum of that reflect the degree of interpretation of the original variables by the factor extraction results.

For each extracted factor, calculate the factor score as shown in equation (5).

$$f_n = w_{n1}z_1 + w_{n2}z_2 + \cdots + w_{ni}z_i \quad n \le i. \tag{5}$$

Where ω_{ni} represents the factor score coefficient of the nth factor on the ith variable, which can be estimated by the method of least squares; f_n is the factor score of the nth factor.

To achieve an objective result, this paper only considers the numerical value and uses the variance contribution of the factor as the weight to calculate the comprehensive score of each assembly center, as shown in equation (6). Because the value of the comprehensive score obtained is very small, and the positive and negative values are not unified, it cannot be directly substituted into the model. It has to be treated as equation (7).

$$S_0 = \mu_1 f_1 + \mu_2 f_2 + \cdots + \mu_n f_n \,. \tag{6}$$

$$S = 1000 / (1 + e^{-S_0}). \tag{7}$$

Where S_0 represents the comprehensive score of an assembly center obtained by factor analysis；S is the comprehensive influence value that attracts each freight area after treated. This method can further amplify the difference in the non-negative processing of the original data, and easier to be substituted into the model.

3.4 The Optimal Path and the Minimum Transportation Cost

The distance from each freight area to the assembly center can be obtained and calculated through the highway and railway network constructed by the GIS platform. There can be two modes of transportation from the freight areas to the assembly center. One is the highway-railway combined transport. Cargos are transported by road to the nearest railway container freight station, and then by rail to the assembly center. The other one is direct access to the assembly center by highway. If there is no railway stations in neighboring regions, it can only be transported to the assembly center by highway, as shown in Figure 2. The goods of freight area 1 to the assembly center can be transported by highway-railway combined mode (red line), or directly by highway (green line); Those of the freight area 2 to the assembly center can only be transported by highway (yellow line).

The minimum transportation cost is calculated as follows.

Step 1. Take the center point of the freight area as the calculation point, set the range with the radius of R as the neighbouring region, and search for the container freight stations of railway in it.

Step 2. According to the existence of railway container freight stations in the neighbouring region, different transportation modes and routes are determined, and calculate or obtain the transportation distance of each route through the GIS tools.

(1) If there is a container freight station in the neighbouring region, the container can be transported by railway (highway-railway combined transport) or highway. In this situation, the road distance to the nearest railway container freight station is calculated as d_road, and the railway distance from the freight station to the assembly center is calculated as d_railway. The highway distance d_highway is calculated if choosing this transportation mode.

(2) If there is no any container freight station in the neighbouring region, it will be directly transported by highway to the assembly center, and the distance d_highway will be calculated.

Step 3. According to different transportation routes, the respective total cost set C1 or C2 is calculated. The average transportation rate for railway of the domestic section (c_railway) is 0.47$/km per FEU, the average transportation rate for highway (c_highway) is 1.16$/km per FEU (Chen et al. (2018)). In addition to transportation cost, the other costs are ignored.

Step 4. Comparing the total transportation cost set of each feasible route to get the minimum value C, which is the minimum cost. The route corresponding to this minimum value is the optimal route.

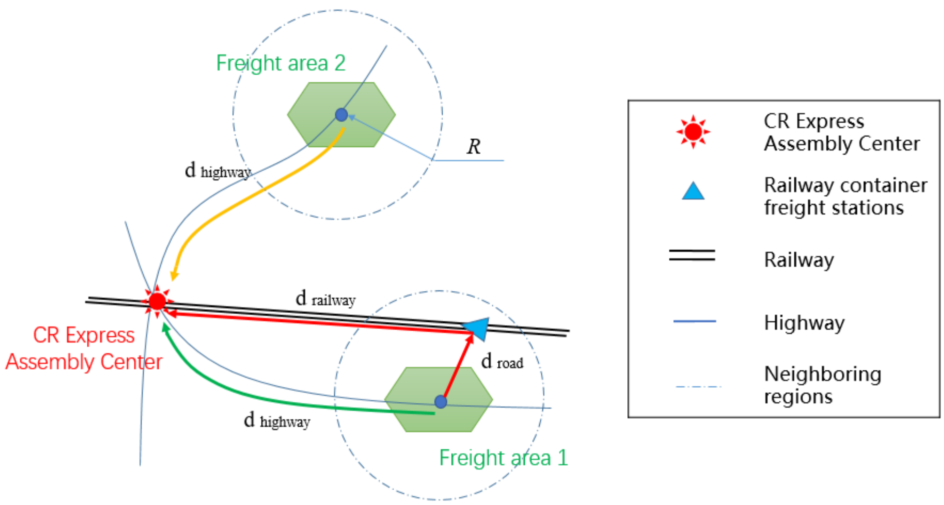

Figure 2: The way of cargos assembled

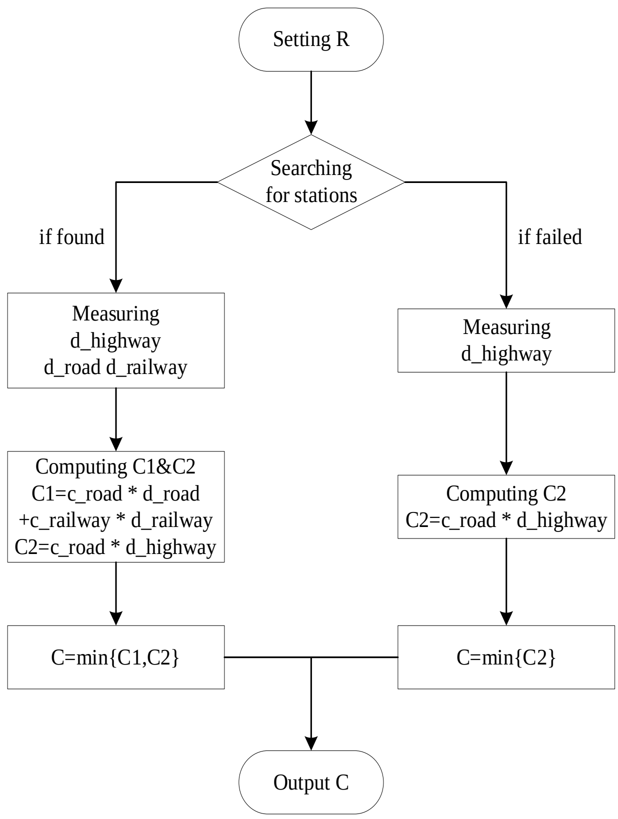

Figure 3: Calculation process of the minimum cost

The calculation process is shown as Figure 3.

4 Case Study

4.1 Description

To solve the problem of the unclear hinterland in the operation of the CR Express and the waste of resources caused by chaos of freight organization, this paper considers various factors and is based on the site location scheme plan of the assembly center announced by the National Development and Reform Commission in July 2020. Based on this plan, according to the model of the hinterland division, the probability is calculated of 415 freight areas nationwide. Finally, the hinterlands are divided on the basis of membership of each assembly center.

4.2 Comprehensive Influence Evaluation Results

Based on the actual survey results of the CR Express and the statistical data of various provinces and cities in 2020, the data of indexes of each CR Express assembly center are shown in Table 1.

Table 1: Data of comprehensive influence indexes of assembly center cities

Index	Assembly center city k				
	Urumqi	**Chengdu**	**Chongqing**	**Xi'an**	**Zhengzhou**
X1 Number of stations	4	3	4	4	3
X2 Yearly assembly capacity (TEU)	2838.3	97426.5	87165.3	133215.8	37391.0
X3 Yearly dispatch capacity (TEU)	0	110582.0	130403.3	86784.5	32859.8
X4 Traffic network Density(km/km2)	3.4	8.3	6.7	5.7	6.6
X5 Gross regional product (million dollars)	51438.1	273076.7	385381.6	154449.8	185009.4
X6 Secondary industry production (million dollars)	13993.8	83518.3	154015.4	51300.4	73360.1
X7 Tertiary industry production (million dollars)	37029.2	179459.9	203570.1	98328.7	109229.6
X8 Annual import value (million dollars)	2579.6	46971.2	35850.1	26169.1	30790.1
X9 Annual export value (million dollars)	4447.0	63300.3	64543.9	27374.5	45451.5

SPSS 25.0 is used for factor analysis. The calculation results of the characteristic values of each variable are shown in Table 2. It can be seen that among the 9 common factors to be extracted, the eigenvalues of the first 2 factors are greater than 1, so they are extracted as factors. But the two factors can only explain 91% of the information of the original variable. Thus choose one more factor. The results show that those 9 variables can be attributed to 3 main factors, and the variance contribution is 0.77085, 0.14697 and 0.07571 respectively, which reflect 99% of the information of the original variable. In general, the original variable has less information loss, and the factor analysis effect is ideal.

Table 2: Factor analysis results

Common factor F	**The eigenvalue** λ	**Percentage of variance** μ	**Accumulation of variance percentage** %
1	6.938	77.085	77.085
2	1.323	14.697	91.783
3	0.681	7.571	99.354
4	0.058	0.646	100.000
5	1.614E-15	1.793E-14	100.000
6	2.316E-16	2.574E-15	100.000
7	1.045E-17	1.161E-16	100.000
8	-2.391E-16	-2.656E-15	100.000
9	-1.048E-15	-1.165E-14	100.000

According to equation (6), the factor score obtained is used to calculate the comprehensive influence of each assembly center, and the data are processed according to equation (7). The results are shown in Table 3.

Table 3: The comprehensive influence of each assembly center

Assembly centers	**The score of factor 1**	**The score of factor 2**	**The score of factor 3**	**Comprehensive influence**
Urumqi	1.23569	-0.38016	-0.92072	291.11
Chengdu	1.31654	-0.54398	0.26643	593.87
Chongqing	0.00897	1.77425	0.20797	742.69
Xi’an	-0.65142	-0.5836	1.43527	370.52
Zhengzhou	0.5616	-0.26651	-0.98895	495.00

4.3 Distance Measurement and Calculation

The vectorized electronic map is imported into ArcGIS 10.4, and the distances from 3,407 source areas nationwide to the assembly centers were measured under the optimal route to calculate the minimum transportation costs. According to the actual situation, the searching radius R is set as 100km. In the searching radius, the road network distribution may be ignored because of the close distance and the dense road network. Therefore, the linear distance between the container freight station and the center point of the freight area is calculated as d_road, while the railway distance d_railway and the highway distance d_highway would be measured and calculated corresponding to the network distribution.

4.4 Hinterland Division Calculation Results

The calculation results of the comprehensive influence of each assembly center and the minimum cost of each freight area participating in assembling are substituted into the model to calculate the selection probability and membership. The results are shown in Table 4. Based on the results, the nationwide probability distribution map is made, as shown in Figure 4. For each assembly center, the darker colour of its surrounding area, the greater probability of selecting the assembly center.

Table 5: Hinterland division calculation results

Area r	**Assembly center selection probability P_{rk}**					**Membership**
	Urumqi	**Chengdu**	**Chongqing**	**Xi’an**	**Zhengzhou**	
1	0.86042	0.03901	0.03874	0.03102	0.03081	0.54526
2	0.87647	0.03453	0.03420	0.02755	0.02725	0.57207
3	0.88813	0.03127	0.03092	0.02501	0.02467	0.59194
4	0.78555	0.05988	0.06015	0.04699	0.04742	0.42875
5	0.84040	0.04459	0.04443	0.03533	0.03524	0.51273
⋮						
210	0.01767	0.14722	0.27457	0.14939	0.41114	0.08873
211	0.01611	0.14091	0.26856	0.14691	0.42751	0.09659
⋮						
414	0.52467	0.13415	0.11866	0.12354	0.09898	0.13241
415	0.46669	0.15044	0.13094	0.14161	0.11032	0.08980

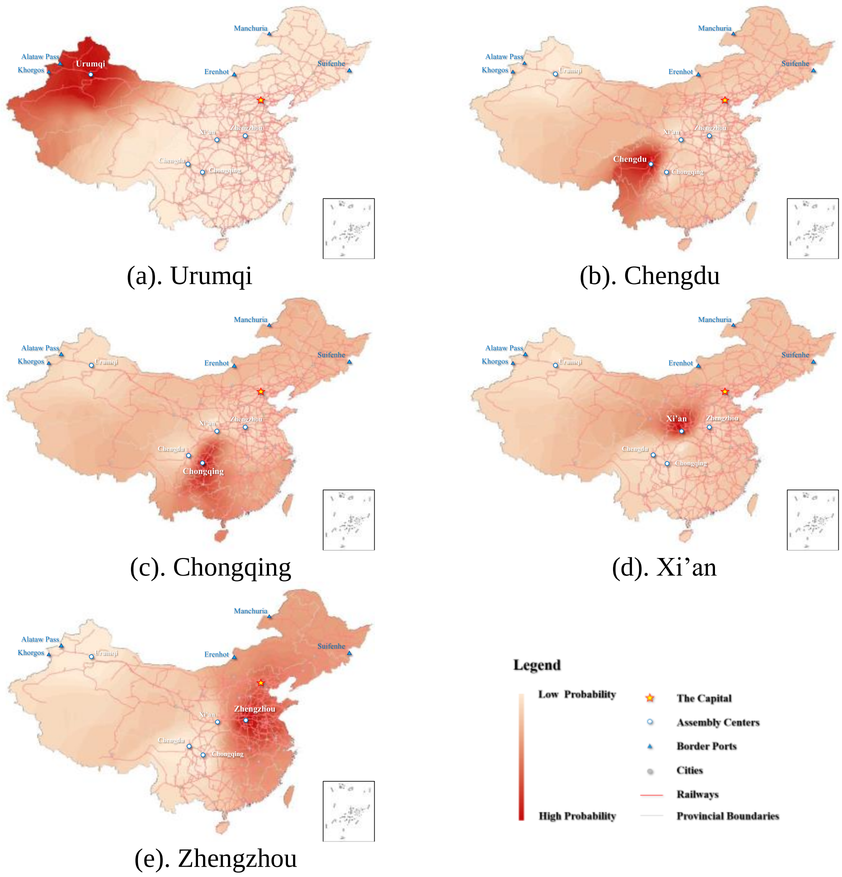

Figure 4: Probability distribution of assembly decision

The calculation result of the selection probability is an important reference for the division of the hinterland, but it cannot be regarded as the final conclusion. There are many areas in Figure 4 with similar colour shades in different subgraphs, which means that these areas have similar selection probabilities for different assembly centers. If these regions are directly used as the public hinterland of assembly centers, the source organization of the assembly centers still cannot be clearly and reasonably planned. Whereas, calculating the membership of the assembly center of each freight area, the absolute advantage area and swing area of each assembly center can be clearly seen according to the distribution of membership, as shown in Figure 5.

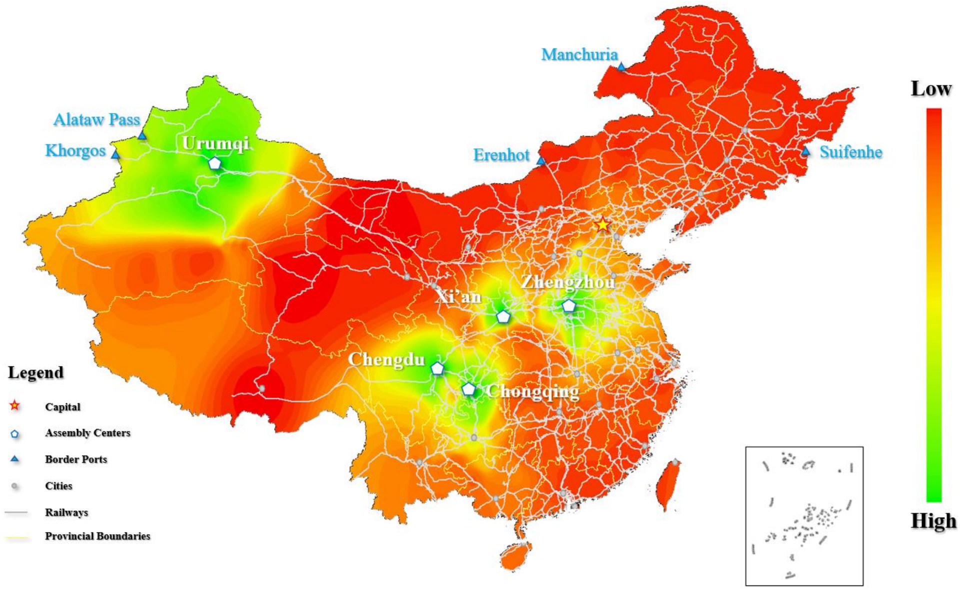

Figure 5: The absolute advantage area of each assembly center

In Figure 5, different colour represents different membership, gradient from green to red means the membership from high to low as the colour indicator bar shows on the right of the figure. It can be seen that the closer to the assembly center, the higher the membership is. The red area in the figure is less affected by a specific assembly center, so the freight agents in this area can choose any assembly center under a certain probability.

As the distance increases, the membership shows a gradual decline (except the Xinjiang and Tibet region of China, where the membership difference of adjacent areas is large because of geographical conditions, such as Taklamakan Desert, Tianshan Mountains, Qinghai-Tibet Plateau and the railway distribution network). The red area in the figure is less affected by a specific assembly center, so the freight agents in this area can choose any assembly center under a certain probability.

When dividing the hinterland of the assembly center by the method of calculating the membership, the green and yellow area represents the higher membership. These regions can be regarded as the absolute advantage area of each assembly center, which is the hinterland. From Figure 5, the hinterland of the Urumqi Assembly Center is mainly in the northwest region, basically covering most of Xinjiang province. The hinterland of the Chengdu Assembly Center is mainly located in Sichuan province, covering most of the central and eastern parts of Sichuan. The hinterland of the Chongqing Assembly Center including central Chongqing, northwest Guizhou, and north-eastern Sichuan. The Xi'an Assembly Center hinterland concentrated in the central region, including central and southern Shaanxi, eastern Gansu and western Shanxi. The hinterland of Zhengzhou Assembly Center mainly includes Henan, northern Anhui, western Shandong, southern Hebei and eastern Shanxi.

It can be seen that the calculation method of membership in this paper considers both the certainty and uncertainty in decision-making behaviours of freight agents. The hinterland of each assembly center is divided from the perspective of the agents of each freight area, which is more consistent with the actual situation. It provides a reference for the railway company to coordinate the overall planning of the domestic transportation of the CR Express. On the other hand, it can also clear the advantages and disadvantages in various freight areas for assembly centers, so as to allocate resources rationally and develop sustainably.

5 Discussion

In the actual operation of the CR Express, local governments have kinds of subsidies in order to ensure the stability of cargo flow and attract the sources. For example, the freight cost of CR Express (Zhengzhou) reduced to 4500$ per standard container in Henan province; the subsidy was 20% of the freight cost for laptop computers of CR Express (Chengdu); for CR Express (Wuhan), the subsidy made the freight cost equal between train and marine. Most of the subsidy rate in local government achieved 10%~40%.

The subsidy policy aggravated the situation of scrambling for sources for freight agents, which caused some effect to the hinterland of assembly centers differently. In the future, subsidies will be gradually reduced and the impact on hinterland selection will also be reduced.

6 Conclusion

The confusion of the operating routes in the CR Express domestic section and the competition for the sources caused the social resources waste. It is essentially caused by the lack of reasonable division of the hinterland. To solve this problem, based on the location scheme, we took each assembly center as the object. By improving the Huff model and using membership as the criterion for dividing the hinterland, the model for the division of the hinterland of the CR Express assembly center was proposed.

The GIS tools were used to conduct a case study of the 415 freight areas in China. According to this, the absolute advantage areas of cargos assembly and dispatch in each assembly center were clear and their hinterlands were gotten. Then, the impact of subsidy policy on hinterland division was further discussed.

The methods presented in this paper and conclusions we got can help us in many aspects.

First, the problem of unreasonable scope of cargo assembly and dispatch could be effectively solved. From the perspective of top-level design, the railway company can strengthen the planning and management of the source organization. For the assembly of outbound cargo, based on the situation of the source in hinterlands, the railway company could design an operation plan to determine the transportation route, and guide the flow of assembly cargos. For the dispatch of backhaul goods, if its final destination lies in the absolute advantage area of a certain assembly center, it may be considered to be transported to the corresponding assembly center and then to the destination. If it lies in a swing area, the factors such as the passing capacity of port and the requirements of the freight agents should be considered, cargos will be transported to a specific assembly center for ensuring transportation balance and meeting the demands of the agents.

Secondly, it can reduce the waste of social resources and achieve the effective allocation of social resources. Each freight agent objectively grasps the advantages and disadvantages of different region according to the hinterland division, and distributes the goods reasonably, thereby avoiding vicious competition among each other. At the same time, it is also easy to achieve scale economies of source organization and make full use of social resources.

Thirdly, it can improve the quality of services and promote the stable and sustainable development of CR Express. For cargo sources in swing areas, the transport route can be selected by the agents independently, which provides impetus for each assembly center to improve service capabilities and levels. Therefore, under the condition of orderly competition, better logistics services can be provided to promote the stable and sustainable development of the CR Express.

In future research, we can add some new assembly center locations, refine the transportation cost calculation method and consider the actual situation in each region to make the values of relevant parameters closer to the reality.

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