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GANSU, QINGHAI AND NINGXIA REGIONS OF THE NEW WESTERN LAND AND SEA CORRIDOR FREIGHT NETWORK OPTIMIZATION

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Abstract:

The new western land and sea corridor makes use of a variety of transport modes to reach major ASEAN countries such as Singapore to the south, connects Southeast Asia and North America to the east, and connects Chongqing, Lanzhou and Xinjiang to the north with the China-European Union (CEU) liner train, which is a composite opening-up corridor in the western region for realising the regional linkage and international co-operation with ASEAN and other countries, and organically connecting with the "One Belt, One Road". In order to explore the regional freight network of Gan-Qing-Ning region of the new western land and sea corridor, we establish the model of node socio-economic attractiveness, topological charisma and comprehensive utility maximization, and analyze the index factors by using entropy weighting, Delphi and comprehensive evaluation methods through the Matlab Genetic Algorithm Toolbox to study the influence of node socio-economic attractiveness, topological charisma, node freight volume, logistics and transportation costs and construction costs on the utility of nodes of the new western land and sea corridor. The influence of the regional node utility of Gansu, Qinghai and Ningxia in the corridor. Analyze the problems and factors affecting the selection of nodes in the existing freight transport corridors in the three provinces. Completing the site selection of Gan-Qing-Ning regional node of the new western land and sea corridor and combining the import and export cargo volume of the three provinces to propose the construction of the South-Middle East three-lane freight corridor, and completing the optimization plan of the freight network. The results show that: scientific optimization and improvement of Gan-Qing-Ning regional freight network can promote the construction of freight network in the northwest region of the new western land and sea corridor, to meet the demand for freight transportation in the corridor, and to promote the development of the corridor industry and economic growth. Thus, it provides reference for the development of Gansu, Qinghai and Ningxia region and freight network optimization.

Keywords: *freight network optimization, new western land and sea corridor, genetic algorithm, economic radiation, topological attractiveness*

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1. Introduction

With the "Belt and Road" initiative in 2013 and the "Eleventh Five-Year Plan for Western Development" in 2016, the role of the western region has begun to come to the fore, becoming one of the most important trade routes in Southeast Asia and even globally. (NDRC, 2019) The National Development and Reform Commission released the Master Plan for the New Western Land and Sea Corridor. released the Master Plan for the New Western Land and Sea Corridor, which points out that the corridor connects to the Silk Road Economic Belt in the north, the 21st Century Maritime Silk Road and the China-China-South China Peninsula Econo- mic Corridor in the south, and the Yangtze River Economic Belt in the east. Yangtze River Economic Belt In 2021, the National Develop- meant and Reform Commission further put forward the "14th Five-Year Plan" to promote the high-quality construction of new land and sea corridors in the west, which clearly states that the construction of new land and sea corridors in the west will be basically completed by 2025. It is clearly pointed out that the new western land and sea corridor will be basically built in 2025, and the new western land and sea corridor with more convenient multimodal transportation, more reasonable hub layout and stronger transportation capacity will be fully built in 2035.

The new western land and sea corridor takes Guangxi, Guizhou, Yunnan, Chongqing, Sichu- an, Gansu, Qinghai, Ningxia, Xinjiang, Shanxi and other western provinces and municipalities as the key nodes, and utilizes a variety of trans- portation modes to reach the main ASEAN countries, such as Singapore, to the south, to the east to connect with Southeast Asia, North America and other regions, and to the north to connect with the Chinese-European Union (CEU) liner train in Chongqing, Lanzhou and Xinjiang, etc. It is a composite open corridor for the west to realize the regional linkage with ASEAN and other countries and international cooperation, and organically connects with the "Belt and Road". (Ma et al.,2021) It is a composite open channel for the western region to realize regional linkage and international cooperation with ASEAN and other countries, and organically connect with the "Belt and Road". From 2017 to 2021, the freight volume of the new western land and sea corridor has been growing rapidly, and by the end of 2021, the cumulative volume of cargo transportation in the corridor exceeded 27 thousands TEUs, with a value of 48 billion yuan.

Freight corridors play an obvious role in driving regional economic growth, and it is crucial to carry out freight network optimisation. The article determines alternative nodes based on economic conditions, transport conditions and freight volume, constructs node socio-economic attractiveness model, topological attractiveness model and comprehensive utility maximisation model, and completes the freight network optimisation scheme through node selection and channel optimisation analysis.

2. Literature review

There are various research methods and modelling related to new western land and sea corridors and freight network optimisation.

As for the research on the new western land and sea corridor, there is less specific research literature because the construction of the corridor is still short. At present, scholars at home and abroad mainly study the new western land-sea corridor from the economic field and the economic and trade development between China and ASEAN. From the economic field, (Li et al.,2020) pointed out that the construction of the new western land and sea corridor is of great significance for breaking the emergency logistics obstruction between China and Southeast Asian countries and forming a good cross-border emergency logistics synergy mechanism. (Fu et al.,2020) pointed out that the construction of the new western land and sea corridor can promote the multilevel development of the western region internally, and externally can realise the economic structural change in the Asia-Pacific region. (Wang et al.,2019) pointed out that there are deficiencies in the construction of the new western land and sea corridor and proposed that it can be improved through the construction of a systematic logistics platform and innovative policy coordination mechanism. From the perspective of economic and trade development between China and ASEAN, (OH Yoon Ah et al.,2018) pointed out that since the implementation of China-ASEAN Trade Agreement in 2010, Indonesia has been exporting primary products to China and introducing Chinese manufactured products at the same time, which has aroused concern. has had a significant impact on the bilateral trade between the two countries. In addition, GDP, level of science and technology, and preferential trade zones have a positive impact on bilateral trade. (SV Siar et al.,2020) Pointed out that Chinese investment in ASEAN has significantly boosted bilateral trade between the two countries. (KYAW LYNN et al.,2009) analyses the significant impact of foreign direct investment on Myanmar's import and export trade through the data of Myanmar's import and export and the annual data of foreign direct investment in Myanmar from 1990-2014. (Vatthanamixay et al. 2011) argues that there are contradictions in foreign direct investment. For example, a surge in foreign capital inflows may have adverse effects, especially real exchange rate appreciation may affect the economic performance of recipient countries.

In terms of freight network optimisation, (Zhang et al., 2023) and others use factor analysis to evaluate the regional urban freight development level based on the axial-spoke network theory, taking 16 prefecture-level cities in Anhui Province as examples for analysis, and then determining the radial scope of the hub city and its affiliation based on the affiliation model to ultimately determine the spatial layout of the regional highway freight network. (Liu et al., 2020) based on the axial-spoke theory, with 18 prefectural cities in Henan Province as the object of study for the construction of freight network, the introduction of speed index and freight index to improve the gravity model and affiliation model, more effective quantification of regional inter-city freight attraction relationship, the construction of the regional urban transport corridor system, and to determine the spatial layout of the regional axial-spoke freight network. (Pan et al., 2012) studied the railway freight node hierarchical classification layout planning problems, through comparative analysis of existing freight node layout planning technology routes, put forward the railway freight node hierarchical classification layout planning research ideas and methodology system, the design of the railway freight node sub-category source demand forecasting method, professional carrier city layout method, hierarchical classification node quantity planning model and site selection layout model. (Yu et al., 2017) constructed a two-layer model to optimise the air express transport network, the upper model designs the network and allocates the transport volume with the objective of minimising the total transport cost, and the lower model calculates the associated traffic volume when users are in equilibrium. (Shimizu et al., 2011) designed a stochastic rule-based resource optimisation model for global freight network optimisation scenarios under uncertainty. (Guelat et al., 1990) constructed a study based on the basic model of multi-commodity flow operation in intermodal network and designed Gauss-Seidel linear approximation algorithm to solve the shortest path with intermodal switching cost. (Friesz et al., 1986) constructed a network optimisation model for shippers and transport companies based on the decision-making process of shippers selecting transport companies and transport companies formulating transport plans, taking into account the maximisation of the respective interests of shippers and transport companies, aiming at predicting the state of the entire freight transport network in a more comprehensive way. (Davendralingam et al., 2014) argues that increasing investment in new aircraft to meet potential trip demand affects the airline network structure, which in turn affects the company's risk and profit potential, and that robust portfolio optimisation is achieved based on the theory of parallel engineering, taking into account aircraft allocation, airline operations and passenger demand. (Powell et al., 1986) describes the unladen motor carrier vehicle load planning problem as a fixed-cost network design problem, where the service level constraints are heuristically represented by a set of minimum frequencies on the links, and proposes a local improvement heuristic algorithm for re-optimising freight routes on the road network.

The existing literature is summarised to identify what can be learned from existing research and the remaining issues, which are analysed below:

What can be learnt from existing studies:

1) mature research methods. TOPSIS method is widely used in node evaluation research; in freight network optimization, the vast majority of studies have adopted the OD flow theory method, which has produced great benefits in practical application; multimodal transport path optimization modelling methods are mature, and on the basis of considering the basic cost, time, and cargo loss, and then considering carbon emission, noise pollution, etc., so as to make the multimodal transport process more in line with the Green and sustainable development requirements.
2) The theory and method of calculating the charisma degree of hub nodes are more mature, taking into account the three indicators of node

connectivity, connectivity and socio-economic attractiveness, and at the same time, taking into account the freight volume and cost indicators, to build a more perfect model for solving the charisma degree of nodes.
3) On the multimodal transport path optimization to derive the freight network optimization program evaluation index system and modeling solution, and then according to the results of the solution to give the corresponding recommendations and measures have been more literature research, which can provide reference for the research of this paper.

Existing research problems:
1) Due to the rapid economic development of the Southwest region, most of the existing studies are carried out in the Southwest region such as Chongqing, Guangxi, Guizhou, etc. of the Western Land-Sea New Corridor, and there are fewer studies in the Northwest region such as Gansu, Qinghai and other provinces.
2) Most of the foreign studies on the new western land and sea corridor are carried out from the economic radiation, the "Belt and Road" driving role, etc., and there are fewer studies on the analysis of the current situation of the regional freight transport; the domestic studies on the new western land and sea corridor are mainly focused on the economic radiation and the rail-water intermodal transport, and there are fewer studies on the development of the industries in the Northwest region and the optimisation of the freight transport network.
3) For the study of freight network optimisation, most of the evaluation indicators in the existing literature are qualitative, and at the same time, they are basically controlled from the macroscopic aspect, and less consideration is given to the quantitative factors, which does not achieve the goal of combining qualitative and quantitative factors.

Comprehensive evaluation of urban freight transport can provide reference for the construction of urban freight transport evaluation system and evaluation direction. The study of freight transport spatial network structure can provide a basis for optimising the urban freight transport spatial network structure. Provide new ideas for regional freight network layout planning and further enrich the theory of regional freight network planning and development. Provide suggestions for improving the freight network layout and reducing the total cost of freight network in Gan, Qing and Ning regions of the new western land and sea corridor. At the same time, Gan, Qing and Ning, as the hub of the new western land and sea corridor in the northwest region, has obvious location advantages, and the optimisation of the freight network will help to strengthen the connection with other countries and further enhance the level of opening up of the northwest region to the outside world. Promote the upgrading of industrial chain and value chain, and accelerate industrial transformation and upgrading. It is conducive to promoting the deep economic development of Gansu, Qinghai and Ningxia, and is of great significance in promoting the rapid economic development of the three provinces and regions.

Comprehensive evaluation of urban freight transport can provide a reference for the construction of urban freight transport evaluation system and evaluation direction. The study of freight transport spatial network structure can provide a basis for optimising the urban freight transport spatial network structure. Provide new thinking for regional freight network layout planning and further enrich the theory of regional freight network planning and development. Provide suggestions for improving the freight network layout and reducing the total cost of freight network in Gan, Qinghai and Ningxia region of the new western land and sea corridor. At the same time, as the hub of the new western land and sea corridor in the northwest region, Ganqingning has obvious location advantages, and the optimisation of the freight network can help strengthen the connection with other countries and further enhance the opening-up level of the northwest region. Promote the upgrading of industrial chain and value chain, and accelerate industrial transformation and upgrading. It is conducive to promoting the deep economic development of Gansu, Qinghai and Ningxia, and is of great significance in promoting the rapid economic development of the three provinces.

3. Analysis of factors affecting freight network optimization scheme

3.1. Analysis of the current situation of freight transportation network in Gansu, Qinghai and Ningxia regions

As a professional term, there is a lack of clear and consistent interpretation of freight node. Relevant academic research and practical application of freight nodes usually draw on the concept of logistics nodes to understand and define freight nodes. The paper also refers to the definition of logistics node when discussing the use of freight node.

In the early stage, the concept of logistics node has experienced some confusion and ambiguity, often used interchangeably with logistics hubs, nodes and other terms, resulting in unclear concepts. However, as the research goes deeper, its concept is gradually clearer. From a broad perspective, logistics nodes cover various nodes of goods distribution, storage and transit, including but not limited to ports, freight stations, public railway hubs and other logistics nodes, as well as modern logistics parks and distribution centres. These nodes play a crucial role in the logistics network and are the key hubs connecting different modes of transport and logistics links. From the narrow level of analysis, logistics nodes mainly focus on logistics parks, logistics centres and distribution centres and other functional nodes. These nodes usually have a clear functional positioning and service scope, and are important facilities in the logistics network to achieve a variety of functions such as storage, distribution and transfer of goods. As an important part of the logistics network, the definition and concept of logistics nodes are becoming clearer and clearer. With the continuous development and progress of the logistics industry, the functions and roles of logistics nodes will be continuously optimised and enhanced, providing strong support for academic research and practical application in the field of logistics.

The research content of the paper is mainly for the regional freight transport network of Gansu, Qinghai and Ningxia, so the freight transport node is placed in the macro background of the whole freight transport network for careful consideration, especially focusing on its key role in the freight transport spatial aggregation. With reference to the definition of logistics node, the freight node is defined as the intersection of goods transport routes, and the concentration of freight transport facilities, freight transport functions of various places. Through in-depth investigation of the layout and functional characteristics of the nodes, it helps to optimise the structure of the freight network in the Gansu, Qinghai and Ningxia regions, and then improve the efficiency of freight transport and service quality.

The current status of the cargo network in the Gan, Qinghai and Ningxia region of the new western land and sea corridor is as follows.

1) Ningxia Hui Autonomous Region

The goods transported through the new western land and sea corridor in Ningxia Hui Auto- nomous Region mainly include more than 30 kinds of goods, such as methionine, plate, wheat, etc. In 2020, the freight volume will reach 42,850 tons, and the freight turnover will reach 69.8 billion tons· kilometers, and the two cities of Yinchuan and Shizuishan have a strong degree of attracting sources of goods. Provincial cargo transportation by Shizuishan, Guyuan and other cities in Yinchuan assembly and sent to Lanzhou.

2) Gansu Province

Lanzhou, Jiayuguan, Zhangye, Wuwei, Tianshui and other cities in Gansu Province have a large amount of freight, taking into account both import and export of goods, the main export goods are asbestos, aluminum and other industrial products and agricultural products such as apples, and the main imports of fruits, chilled aquatic products and petroleum coke, etc. In 2020, the freight volume reaches 67,239 tons, freight turnover reaches 2,517, hundred millions tons· kilometers. Among them, Lan- zhou city freight volume reached 141.21 million tons, export freight volume is great while the import freight volume is also increased year by year, 2020 accounted for 1/4. provincial cargo transportation are assembled in Lanzhou and then sent to Chongqing via Longnan.

3) Qinghai Province

The development of freight transport in Qinghai Province is relatively late, and the cargo transport is mainly concentrated in Xining City and Delingha region of Haixi Mongol and Tibetan Autonomous Prefecture, and the goods transported through the new western land and sea corridor mainly include steel, coal, soda ash, etc. In 2020, the freight transport volume will reach 14,512 tons, and the freight transport turnover will reach 42,4 hundred millions tons· kilometers. Cargo transportation in the province is sent from Haixi to Xining, where it is assembled and sent to Lanzhou.

To summarize, Gansu, Qinghai and Ningxia provinces goods are assembled in Lanzhou, and then through Lanzhou - Longnan - Chongqing sent to the Beibu Gulf to the sea, constituting a land and sea channel, the western land and sea new channel

Gansu, Qinghai and Ningxia regional freight network sketch shown in Figure 1.
As can be seen from Fig.1, while the cargo revenue of Gan, Qinghai and Ningxia region of the new western land and sea corridor increases year by year, there are irrationalities in its cargo network. Such as Zhangye-Lanzhou cargo tran- sportation line for Zhangye-Wuwei-Lanzhou, Tianshui-Longnan cargo transportation line for Tianshui-Lanzhou-Longnan, the increase in transportation distance improves the cost of transportation. There are problems such as poor freight connection and unreasonable layout structure. Therefore, it is very important to carry out node selection to build a more reasonable freight transportation network.

3.2. Analysis of factors affecting the siting of freight nodes

When the freight node location modeling is carried out, the node economy, transportation conditions and freight volume factors are considered, and the major urban areas in Gansu, Qinghai and Ningxia provinces are selected as alternative nodes, while the urban areas with zero export freight volume are excluded. In the freight network structure, (Tong, H., et al., 2022)alternative node selection is mainly considered from the follow- ing factors.

1) Socio-economic attractiveness

Socio-economic attractiveness indicates that the channel involves the role of social and econo- mic radiation transmission of nodes, the greater the socio-economic attractiveness, indicating that the node is closer to the center node, and then through the role of inter-node connectivity relay to drive the regional economic development role is greater. The factors affect- ing the socio-economic attractiveness of a node are summarized in six aspects: the size of the node, the level of economic development, the level of science and education, the level of socio-cultural development, the level of re- sources and infrastructure development and the level of environmental quality development.

2) Cargo volume

Freight volume refers to the amount of goods completed or to be completed by a freight node, usually in tons. Node freight volume is generally reflected by cargo throughput, node throughput capacity intuitively reflects the size of the node and its impact on the regional economy. Which "swallow" refers to the arrival of the node cargo volume, through the arrival of the node cargo type and quantity to reflect the regional economic characteristics and this region to other regions to supply the type and quantity of products. "Spit" refers to the type and quantity of cargo originating at the freight node, reflecting the delivery of goods by the regional transportation industry, which is directly related to the scheduling of means of transportation.

3) Network topology

Network topology refers to the physical or spatial connectivity of a network. In the context of transportation and logistics, (Yang. et al., 2018)network topology refers to the spatial structure of the freight transportation network and the spatial layout of the different modes of transportation used at different volumes. In the selection of hub nodes, the focus is on the degree of topological importance of freight nodes in the freight transportation network. Freight network topology can indicate the degree of direct access between nodes, reflecting the interactive relationship between nodes and the spatial structure of the freight network, and at the same time can measure the degree of nodes attracting cargo sources. Two indicators, connectivity and accessibility, are used to describe this factor. The degree of connectivity reflects the degree of direct access between nodes and the interaction between nodes and the spatial structure of the freight network; the degree of accessibility indicates the degree of attraction of nodes to sources of goods, directly reflecting the degree of convenience of nodes in transporting goods inward and outward. The degree of accessibility indicates the degree of attraction of nodes to cargo sources, which directly reflects the convenience of nodes to transport cargo inward and outward.

4) Costs

Including node logistics transportation costs and node construction costs. Whether the node site selection is reasonable is mainly reflected in the transportation cost, expressed through the alternative node geographic location and the distance between the geographical location of the demand for nodes; node construction cost is the construction of nodes must be considered as an economic indicator, which is directly related to the node size, operating costs and payback period and other issues, and at the same time affected by the level of regional economic development and logistics demand and other factors.

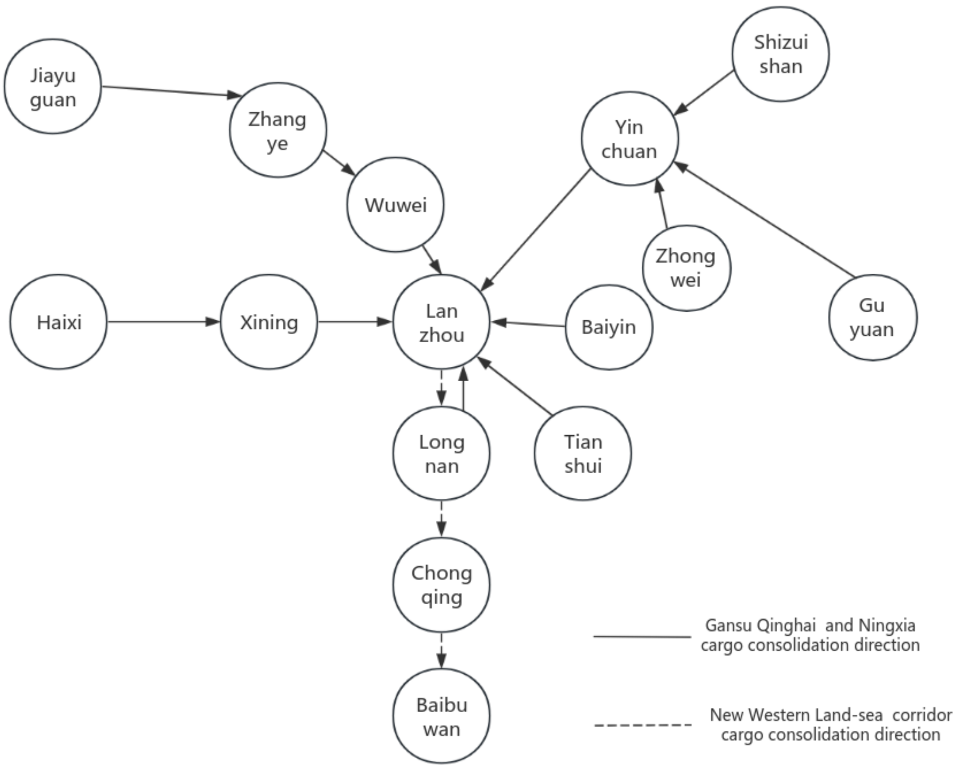

Fig.1 Schematic diagram of ganqingning regional freight network of New Western Land-sea Corridor

4. Model Construction

4.1. Socio-economic attractiveness

The node socio-economic attractiveness is expressed as the potential energy of each node under the combined effect of radiation from other nodes, and is calculated in equations (1)-(3):

$$F_p = \sum_{k=1}^{K} E_k \lambda_k \quad (1)$$

$$E_k = Z_k D_{pk}^2 \quad (2)$$

$$Z_k = \sum_{j=1}^{n} \omega_j X_{kj} \quad (3)$$

Where: F_p indicates socio-economic attractiv- eness; p indicates the$p$ th node; K indicat- es the total number of nodes; k indicates the node$k$; E_k indicates the role of radiation field strength; λ_k indicates the node influence weig- ht; D_{pk} indicates the distance between nodes; Z_k indicates the node comprehensive level index; X_{kj} indicates the comprehensive level of the city; and ω_j indicates the influence factor weight coefficient.

4.2. Topological charisma

Through comprehensive consideration, (He et al., 2023) the network topology is evaluated using two metrics, node connectivity and accessibility, and the node topology attractiveness describes the degree of node importance and attractiveness in the freight topology network. The calculation formula is shown in equation (4):

$$G_P = \omega_T T_P + \omega_D D_P \quad (4)$$

Where: G_p denotes the node topological attrac- tiveness; p denotes the p th node; T_p den- otes the node accessibility; D_p denotes the node connectivity; ω_T

and ω_D denote the we- ight coefficients of T_p and D_p , respectively.
The evaluation indicators in equation (1) are calculated as shown below.
(1) Node accessibility
The node accessibility formula is shown in equation (5):

$$T_P = \sum_{j=1}^{n} S_p \cdot (Dis_p)^{-\mu} \tag{5}$$

Where: S_p represents the total amount of tran- sportation of the alternative node p, and the total amount of goods of the node greatly reflects the importance and attractiveness of the node; Dis_p represents the distance of the line within the node area; μ represents the atte- nuation coefficient of the center's accessibility with the distance, which is calibrated according to the actual situation.
(2) Node connectivity
The node connectivity calculation formula is shown in equation (6):

$$D_p = \frac{\sum_{i=1}^{n} \frac{1}{min \sum_{i=1}^{n} \frac{L_i}{V_\beta}}}{n} \tag{6}$$

Node connectivity is expressed as the average value of connectivity of the node to the distribution point. Where D_p denotes the connectivity of the alternative node p; n denotes the number of major distribution points within the node; L_i denotes the length of the i section of the line; and V_β denotes the speed of operation when using different modes of transportation.

4.3. Nodal export shipments

The western land and sea new corridor Gansu, Qinghai and Ningxia region is mainly exported goods, so the node export freight volume is selected as one of the comprehensive utility maximization model indicators. The formula for calculating the node export freight volume is shown in equation (7):

$$S = \sum_{v \in V} \delta_v \cdot s_v \tag{7}$$

Where: S represents the export cargo volume of alternative nodes; $\delta_{\square}$ represents the total volume of cargo; s represents the weighting coefficient of exported cargo, which is calculated based on the ratio of the amount of exported cargo to the total amount in each city (state); and V represents the set of exported cargo.

4.4. Costs

Node selection prioritizes the geographic location of the demand place, while node selection should be carried out in close proximity to industrial areas. In order to shorten the transportation distance, reduce the transportation cost and improve the freight revenue.

1. Unit logistics and transportation costs

(Paweł D et al., 2017)The formula for calculating the unit logistics and transportation cost is shown in equation (8):

$$C_t = \sum_{u \in U} c_u \cdot d_u \tag{8}$$

Where: c_u indicates the unit price of the trans- portation mode (dollar/ton. km); d_u indicates the transportation distance when using the transportation mode; u indicates the trans- portation line (national highway, provincial highway, railroad, etc.); U indicates the collection of transportation lines.

2. Hub construction costs

(He Y et al., 2017)The hub construction cost formula is shown in equation (9):

$$C_s = \sum_p (a_0 + c_p \cdot \lambda_p \cdot S_p) \tag{9}$$

Where: a_0 represents the fixed construction cost of the node; c_p represents the unit land price of the node p; S_p represents the freight volume of the node p; and λ_p represents the conversion factor of the node's land area and freight volume.

4.5. Utility maximization model construction

Due to the inconsistency of the function value magnitude target, the different meanings and objectives of the magnitude mapped to the [0, 1] interval, so that the function value magnitude unity, while the use of the Delphi method for the assignment of the indicators to the multi-objective optimization problem into a single-objective optimization problem, (Zhu Y et al., 2023)the optimal optimization model established is shown in Eq. (10):

$$max\, W = \sum_i^n \left(\phi_f F' + \phi_g G' + \phi_s S' + \phi_{cs} C_s{}' + \phi_{ct} C_t{}'\right) x_i \tag{10}$$

Where: $F^{'}$, $G^{'}$, $S^{'}$, $C_s{}^{'}$,$C_t{}^{'}$ denote F , G , S, C_s, C_t (Zong. et al., 2022)standardized uniform dimensionless values (see (4.2) for data standardization); ϕ_f, ϕ_g, ϕ_s, ϕ_{cs}, ϕ_{ct} denote the weighting coefficients of $F^{'}$, $G^{'}$, $S^{'}$, $C_s{}^{'}$,$C_t{}^{'}$, respectively.
The constraints are shown in Eqs. (11)-(13):

$$\sum_i^n x \leq X^* \tag{11}$$

$$\sum_i^n (C_s + C_t)\, x_i \leq C^*_{\square} \tag{12}$$

$$\sum_i^n S\, x_i \leq S^* \tag{13}$$

Where: X^* denotes the maximum number of selected nodes; C^* denotes the maximum investment cost consumed when using the node; S^* denotes the total regional freight volume. Among the constraints, Eq. (11) is the total number of nodes constraint; Eq. (12) is the maximum investment cost limit; and Eq. (13) is the node freight volume limit. After normalization, the specific expression of the integrated utility maximization function model is shown in Eq. (14):

$$max\, W = \sum_i^n \begin{pmatrix} \phi_f \sum_p \left(\sum_{k=1}^{K} \lambda_k \cdot \sum_{j=1}^{n} \frac{\omega_j X_{kj}^{'}}{D_{pk}^2} \right) \\ +\phi_g \sum_p (\omega_T T_P + \omega_D D_P)^{'} + \\ \phi_s \sum_p \left(\sum_{v \in V} \delta_v \cdot s_v \right)^{'} - \\ \phi_{cs} \sum_p \left(\sum_{u \in U} c_u \cdot d_u \right)^{'} - \\ \phi_{ct} \sum_p [\sum_{p \in P} \left(a_0 + c_p \cdot \lambda_p \cdot S_p \right)]^{'} \end{pmatrix} x_i \tag{14}$$

Where:x_i is 0-1 integer decision variable, taking 1 means selecting the node, taking 0 means not selecting the node. (Pawlowski S D. et al., 2005) Using the Delphi method on the coefficients $\phi_f, \phi_g, \phi_s, \phi_{cs}, \phi_{ct}$ for the assignment. Fifty experts and scholars in the field of transport were selected: 47 per cent were from professional scholars, i.e., experts related to the transport industry, who possessed the appropriate professional knowledge to make the evaluation results professional and scientific; 40 per cent were from the on-site staff and managers of the freight yards, who had a more detailed and precise understanding of the implementation of railway freight transport to make the evaluation results more targeted and representative. The rest of the personnel from the shippers, they start from their own interests, can take into account the other personnel cannot consider the issue of the overall evaluation of a more comprehensive.
According to the actual situation of the discussion and analysis to determine the indicator selection range [1, 5] and weights leap value 0.25, by experts and scholars independently of the F, G, S, C indicators for the impact of the integrated utility scoring, scoring by the weighted average of the results of the processing is shown in Table 1.
As can be seen from Table 1, socio-economic attractiveness has the greatest impact on the comprehensive utility and is the most important factor to be considered in node selection, with its importance being 3.4 times that of the node's topological attractiveness, and the node's freight volume and unit cost are of similar importance, second only to the node's topological attractiveness.

5. Model solving

5.1. Node Selection

Gansu, Qinghai and Ningxia provinces are located between 97-108 degrees east longitude and 34-40 north latitude, with a total area of 1,214,500 square kilometers, and the transportation conditions and freight traffic survey and analysis of the cities in the three provinces are carried out for the preliminary selection of freight network nodes. After the basic conditions screening, excluding the nodes with 0 export freight volume, 24 cities (states) of Lanzhou, Baiyin, Wuwei, Jinchang, Zhangye, Jiuquan, Jiayuguan, Dingxi, Longnan, Tianshui, Pingliang, Qingyang, Linxia, Yinchuan, Zhongwei, Wuzhong, Guyuan, Shizuishan, Xining, Haidong, Huangnan, Haibei, Golog, and Haixi are selected as the initial alternative nodes. The location of the nodes and the sketch of the route network of transportation modes between the nodes are shown in Figure 2.

Tab. 1. Table of weighting factors

Norm	Socio-economic attractiveness	Topological attractiveness	Volume of freight	(manufacturing, production etc) costs
weighting factor	4.25	3.25	2.75	1.25

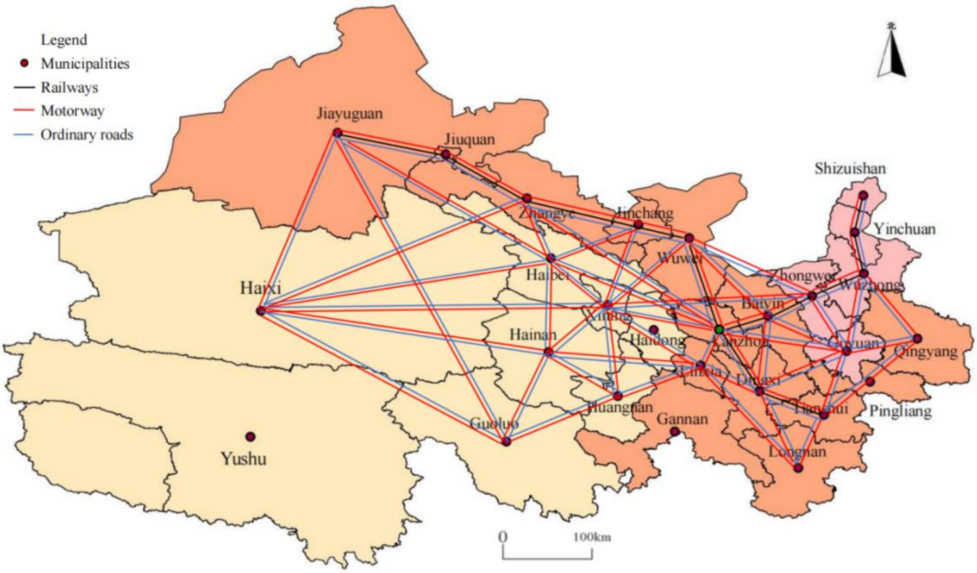

Fig.2 Schematic diagram of the line network of the traffic mode between the nodes

5.2. Data processing

Due to the inconsistency of the data units, the data were processed for ease of computation and were processed as follows.

1) Data standardization

The initial data were first standardized and the processing equation is shown in equation (15):

$$a_p^{j'} = \frac{a_p^j}{\frac{[\sum_{k=1}^{n}(a_j^k)]}{n}} \tag{15}$$

Where: a_p^j denotes the j th indicator of the initialized p th node.

2) Socio-economic attractiveness model ω Empowerment values

The socio-economic attractiveness of nodes takes into account various factors and comprehensively reflects the importance of nodes. The weight of each factor determines the accuracy of the solution results, and in order to increase the objectivity of the solution results and reduce ambiguity and uncertainty, the entropy weight method is used to solve the weight of each indicator. The solution formula is shown in equation (16)-(20):

$$X_{ij}' = \frac{X_{ij} - min(X_i)}{max(X_i) - min(X_i)} \tag{16}$$

$$e_j = -\theta \sum f_{ij} \ln f_{ij} \tag{17}$$

$$f_{ij} = \frac{X_{ij}'}{\sum X_{ij}'} \tag{18}$$

$$\theta = \frac{1}{\ln m} \tag{19}$$

$$\omega_j = \frac{1 - e_j}{n - \sum e_j} \tag{20}$$

Where:see 4.1 for the meaning of each indicator.

3) Topological charisma attractiveness model ω Weighting values

In order to make the data more objective, the topological charm attractiveness ω was weighted using two methods , (Huang. Et al., 2022)which are described in Eqs. (21)-(22).

$$\omega_j^c = \frac{s_j}{\sum_{k=1}^{m} s_k}, \quad s_j^2 = \frac{1}{n}\sum_{p=1}^{n}\left(a_j^p - \overline{a_j}\right)^2, \quad \overline{a_j} = \frac{1}{n}\sum_{p=1}^{n} a_j^p \tag{21}$$

Where: ω_j^c denotes the weight of the j th indicator, s_j and $\overline{a_j}$ denote the sample varia- nce and sample mean of the a_j th indicator, respectively.

$$\omega_j^g = \frac{\overline{a_j}}{\sum_{j=1}^{m}\overline{a_j}} \tag{22}$$

Where: ω_j^g represents the weight of the first j indicator determined using a "function driven" approach.

4) Data integration

The values obtained from the assignment are integrated and the value of k_1, k_2 is also determined so that equation (23)

$$\sum_{p=1}^{n}\sum_{j=1}^{m}(k_1\omega_j^c + k_2\omega_j^g)\, a_j^p \tag{23}$$

The maximum value is taken when the condition $k_1 > 0$, $k_2 > 0$, $k_1 + k_2 = 1$ is satisfied. The integration method is shown in equation (24):

$$\omega_j = k_1\omega_j^c + k_2\omega_j^g \tag{23}$$

When using the above methods for data processing, the best expectation is to obtain balanced values to optimize the overall effect. The "difference-driven" empowerment emp- hasizes balance, and the more average the evaluation result, the better; the "function driven" empowerment method pays more attention to the average value of the indicators. The comprehensive evaluation method describ- ed above can combine the advantages of the "difference-driven" and "function-driven" methods, so that all indicators are balanced and close to the optimum.

5.3. Model solving

1) Indicator weights

The factors affecting the socio-economic attractiveness of the nodes were summarized in the previous section into six aspects: the size of the nodes, the level of economic development, the level of science and education, the level of socio-cultural development, the level of resource and infrastructure development and the level of environmental quality development. The indicators and weights of each influencing factor are shown in Table 2.

Tab. 2. Weighting coefficients of factors influencing the level of integration of nodes

Causality	Norm	Weight (%)
Nodal ballpark	Total population(million)	4.69
	Area(km^2)	11.44
Level of economic development	GDP(billion dollars)	4.62
	Value added of secondary industry(billion dollars)	5.42
	Value added of tertiary industry(billion dollars)	6.80
	Share of output in secondary and tertiary industries	8.05
	Investment in fixed assets(billion dollars)	5.64
	Total retail sales of consumer goods/total	10.69
	Local revenue(billion dollars)	5.15
	Year-end savings of the population(billion dollars)	3.29
Level of science education	Number of students per 10,000 population	2.54
	Investment in science education(billion dollars)	6.13
Level of social development	Average wage of employees($)	7.79
	Disposable income per capita($10,000)	5.18
	Electricity consumption per capita(kmh)	1.07
	Number of hospital beds per 10,000 persons	0.57
	Number of physicians per 10,000 persons	1.02
Level of resources and infrastructure development	Urban road area per capita(m^2)	0.81
	Per capita daily domestic water use(L)	2.35
	Gas penetration rate	7.02
	Total electricity consumption(kwh)	1.36
Level of development of environmental quality	Greening coverage(%)	4.69
	Green space per capita(m^2)	9.82

2) Nodal socio-economic attractiveness and topological attractiveness

According to the factors such as the network topological location between nodes and the distance between each node, the socio- economic attractiveness and topological attractiveness of each alternative node are calculated based on Eqs. (1)-(8) and are shown in Table 3.

3) Genetic algorithm solution

The model is solved using the Matlab Genetic Algorithm Toolbox, which comes with two ways of solving the model: the simple command line mode and the intuitive GUI interface mode. It should be noted that the above two ways can only solve for the minimum value of the objective function.

The parameter settings for the solution using the Matlab Genetic Algorithm Toolbox are as follows:

① Population. The population type defaults to a real number code and the population size is set to 50.

② Adaptation ordering. Use function rank ordering by default.

③ Chromosome selection. The default is to use the function random uniform.

④ Breeding. The number of elites was set to 0.05 and the proportion of cross progeny to 0.8.

⑤ Variant. Use the default value.

vi. Determine whether the algorithm termi- nation conditions are satisfied. Such as the number of stopping generations and the maximum number of evolutionary generations (both set to 100).

The results obtained from the calculation of the node's comprehensive economic attractiveness, topological attractiveness, export freight volume, unit logistics and transportation cost and node construction cost are brought into the comprehensive utility maximization model. According to the set constraints, the solution is input into the solver toolbox for solving. The results are obtained by solving using Matlab Genetic Algorithm toolbox.

Tab. 3. Indicators of economic attractiveness and attractiveness of alternative node meetings

Serial number	Name	Socio-economic attractiveness	Topological attractiveness
1	Lanzhou	402.0	59.0
2	Baiyin	43.5	30.9
3	Zhangye	48.7	18.3
4	Jinchang	135.1	15.6
5	Wuwei	39.6	13.2
6	Jiuquan	13.5	18.6
7	Jiayuguan	20.5	25.2
8	Dingxi	29.2	16.8
9	Longnan	18.2	16.8
10	Tianshui	48.4	45.0
11	Pingliang	62.2	14.1
12	Qingyang	61.0	13.5
13	Linxia	91.2	21.0
14	Guyuan	52.7	7.5
15	Zhongwei	45.4	17.4
16	Wuzhong	37.8	12.6
17	Yinchuan	189.7	52.2
18	Shizuishan	128.2	29.1
19	Haidong	28.8	22.8
20	Huangnan	54.6	21.6
21	Xining	245.5	42.6
22	Haibei	23.9	21.0
23	Guoluo	30.1	25.8
24	Haixi	5.0	38.1

4) Solution results

Combining the solution results and the actual situation, the experiment results in the optimal number of freight hub nodes selected as 9. The optimal result is obtained after 213 iterations of operation, and the maximized utility is 653.The finalized freight nodes are Lanzhou, Wuwei, Jiayuguan, Longnan, Tianshui, Yinchuan, Shizuishan, Xining and Haixi. Among them, Lanzhou city has a superior geographic location and a large export freight volume, and the node has a very high economic attractiveness of 402 and a topological attractiveness of 59, which is a great advantage in the network topology. In terms of export freight volume, Yinchuan City has a relatively large export freight volume due to its geographic location and rich regional resources, and takes a great advantage in the network topology

6. Analysis of results

In order to promote the construction of new western land and sea corridors and the economic development of the northwestern region, combining the calculation results with the geographic location of each node, and also considering the railroad projects under construction (such as Lanzhang 3-4 and Tianlong lines), (Peng, Y., et al., 2021)it is proposed to plan the south, central and east freight corridors in Gansu, Qinghai and Ningxia provinces, and the screened nodes and freight corridor planning are shown in Fig. 3.

1) Central Freight Corridor

Western land and sea new corridor Gansu, Qinghai and Ningxia middle line freight corridor mainly benefit Jiayuguan, Zhangye, Wuwei, Lanzhou, Longnan and other Gansu provinces and cities, is the western land and sea new corridor Gansu, Qinghai and Ningxia regional freight network main channel. The middle line freight corridor is important for promoting the operation of multimodal international freight train lines and boosting the high-quality development of outward-oriented economy in Gansu Province.

2) Eastern Freight Corridor

The new western land and sea corridor, the Gan-Qing-Ning East Freight Corridor, mainly benefits the Ningxia Hui Autonomous Region and the cities of Tianshui and Longnan in Gansu Province. The freight corridor will promote the economic growth of the Ningxia Hui Autonomous Region and facilitate the export of its mineral resources.

3) Southern Freight Corridor

The new western land and sea corridor Gan-Qing-Ning south line freight corridor mainly benefits Qinghai Province and Gansu Province Lanzhou, Longnan and other cities. Compared with Ningxia and Gansu provinces, the development of freight transport in Qinghai Province is relatively late, and the advantages of freight transport are mainly concentrated in Xining and Haixi. The new western land and sea corridor south freight corridor can accelerate the promotion of the establishment of Qinghai Province and the southwestern region to connect the fast, large capacity channel.

The results of the study show that the freight transport network composed of the south, central and east freight transport corridors in Gansu, Qinghai and Ningxia provinces can organically connect the different resources in each region of Gansu, Qinghai and Ningxia provinces with the new land and sea corridors in the west, form a cluster effect, improve the utilization rate of the resources, generate cluster benefits and promote the high-quality development of the corridor economy. It is of great significance to the construction and development of the corridor.

7. Summary

Improving the construction of transport corridors plays a key role in promoting regional economic development. Efficient and convenient freight transport corridors can reduce freight costs, improve the turnover speed of goods, and then promote the rapid development of related industries. At the same time, it helps to enhance the competitiveness of regional freight transport. Strengthening the construction of freight transport corridors in Gan, Qinghai and Ningxia areas of the new western land and sea corridors, optimising the freight transport service system and enhancing freight transport efficiency will help to promote regional economic growth, promote the rational allocation and utilisation of resource factors and realise the coordinated development of the region, and at the same time will further strengthen the trade exchanges between China and Central Asia and Europe, promote inter-regional interconnectivity, provide more opportunities for China's participation in the global economic co-operation, and promote economic prosperity and integrated development of the western region. It will also further strengthen trade exchanges between

China and Central Asia and Europe, promote inter-regional connectivity, provide more opportunities for China to participate in global economic cooperation, and promote economic prosperity and integrated development in the western region.

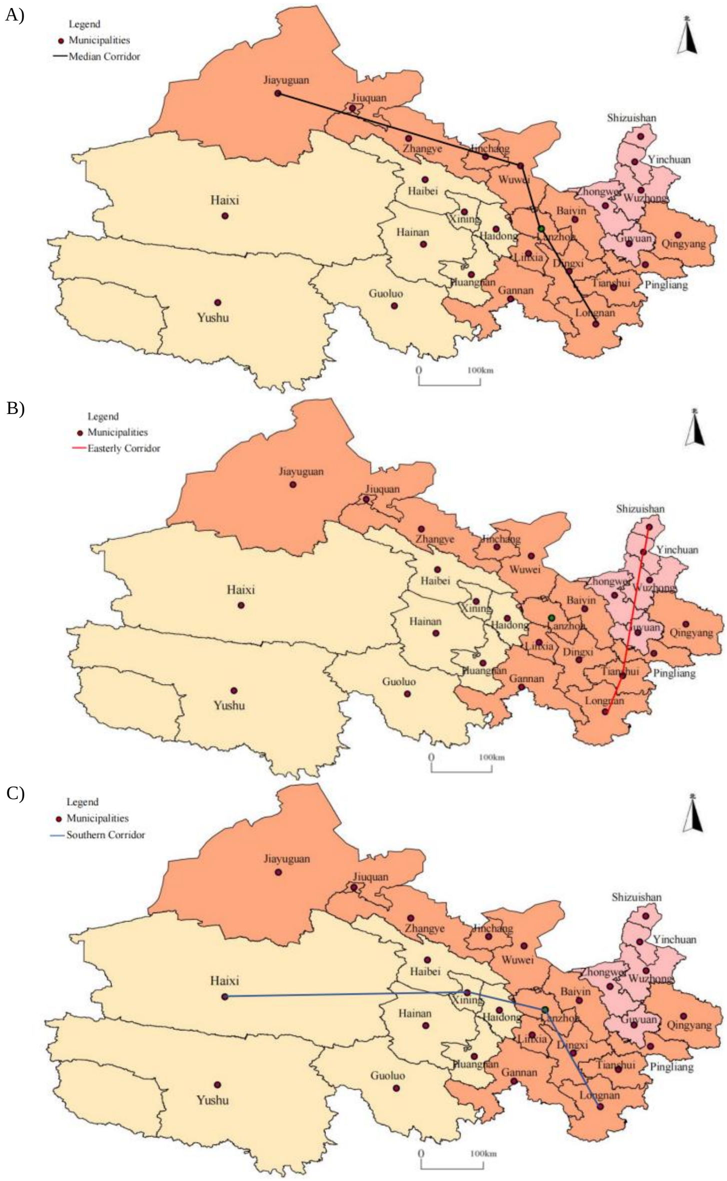

Fig.3 Node and Freight AccessPlan

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