Path Evaluation of Land-Sea Intermodal Transportation between China and South Korea

Tianzhen Zhao*, Haixing Zhou, Xiaoyu Kong, Yan Zhang, and Xichen Zhu

Shandong Xiandai University, Jinan, Shandong, 250104, China

*Corresponding author's e-mail: 1977863013@qq.com

Abstract. With the deepening trade between China and South Korea, it is imperative for China and South Korea to carry out land and sea multimodal transportation. This paper takes the path of multimodal transportation between China and South Korea as the research object, analyzes its development status, and determines the path evaluation of land-sea intermodal transportation between China and South Korea through the path evaluation model.

Keywords: land-sea intermodal transportation; China-Korea trade; multimodal transportation corridor; path evaluation； analytic hierarchy process

1 Introduction

Since the establishment of diplomatic relations between China and South Korea in 1992, trade between China and South Korea has been increasing and developing rapidly [1]. Since the reduction of transportation costs directly improves the price competitiveness of products, many companies are striving to build up logistics infrastructure and come up with optimal solutions using multimodal transportation. It seeks to integrate different modes of transportation, is also known as "one-stop" transportation.

2 Construction of the Model

Assume that an existing shipment of goods is to be shipped from China to South Korea. Starting from the characteristics and realistic constraints of container multimodal transportation, the following modeling assumptions are made:

(1) Each node can be transported between the three modes of waterway, highway and railroad.

(2) Only 1TEU standard ordinary container is considered, and other sizes and types of containers are not considered for the time being.

(3) Goods can only be changed at transit stations and at most once at each transit station.

After analyzing the general situation of transportation routes in the eastern coastal area of China, there are now four routes to choose from. As shown in Tab.1.

G. Zhao et al. (eds.), *Proceedings of the 2024 7th International Symposium on Traffic Transportation and Civil Architecture (ISTTCA 2024)*, Advances in Engineering Research 241,
https://doi.org/10.2991/978-94-6463-514-0_25

Table 1. Transportation routes table

Route	Transportation routes	Transportation program
Route 1	Weihai Dashubo Airport--Weihai Port--Incheon Port--Incheon International Airport	Road--Waterway--Road--Air transportation
Route 2	Mainland China--Longyan Port / Rizhao Port / Yantai Port --Pingze Port	Public railroads --Waterways
Route 3	Nanning--Qinzhou Port--Hainan Port--Korea	Public railroads --Waterways
Route 4	Mainland China—Lianyungang--Pyeongtaek Port, Incheon Port	Public railroads --Waterways

Route 1: Weihai Dashuipo Airport - Weihai Port - Incheon Port, Korea - Incheon International Airport, Korea. The main transportation modes are road, waterway and air transportation.

Route 2: Jinan City - Longyan Port / Rizhao Port / Yantai Port - Pyeongtaek Port, South Korea. The main transportation modes are road, railroad and waterway transportation.

Route 3: Nanning City - Qinzhou Port - Haikou Port - Haikou Meilan International Airport - South Korea's Incheon International Airport. The main modes of transportation are road, railroad, waterway and air transportation.

Route 4: Jinan City - Lianyungang - Pyeongtaek Port and Incheon Port of South Korea. The main transportation modes are railroad, road and waterway transportation.

3 Rationale and Steps for Pathway Evaluation

3.1 Principles of Path Evaluation

The basic principle is to use mathematical models and methods to quantitatively analyze and evaluate the paths of multimodal transport corridors on the basis of evaluation indexes [2], so as to ensure the scientificity and reliability of the evaluation results.

3.2 Steps in Pathway Evaluation

The steps of evaluation mainly include the following.

(1) Define evaluation objectives and evaluation indicators. In the path evaluation, the evaluation objective is to determine the optimal path of China-Korea land-sea intermodal transportation, and the evaluation indexes include transportation cost, time, safety, reliability and so on.

(2) Establishing a path evaluation model. The path evaluation model chosen in this thesis is the hierarchical analysis method. Since the AHP method is simple and easy to implement, and can do a combination of quantitative and qualitative, this method is chosen for path analysis [3].

(3) Data collection and data processing. The aim is to obtain valid information on

the basis of which an appropriate analysis can be made.

(4) Determine the weights. Weight refers to the importance of the evaluation indicators in the evaluation, and different indicators account for different weights.

(5) Conduct path evaluation and draw evaluation conclusions.

The model that needs to be used for the evaluation of the land-sea intermodal transportation path between China and South Korea under study is the hierarchical analysis method, and certain basic principles and steps should be followed to ensure the scientificity and reliability of the evaluation results.

4 Path Evaluation of Land-Sea Multimodal Transportation Corridor between China and South Korea

With the development of globalization and rapid economic growth, containerized intermodal transport is receiving more and more attention in the logistics industry. As the first pilot province of China-Korea land-sea intermodal transportation, Shandong Province has carried out the first phase of dumping transportation, which has played an active and irreplaceable role in China-Korea trade exchanges [4]. Therefore, this paper simulates the delivery of goods from the Chinese mainland to the Korean mainland, and lists a total of four routes. The route maps are shown in Fig.1.

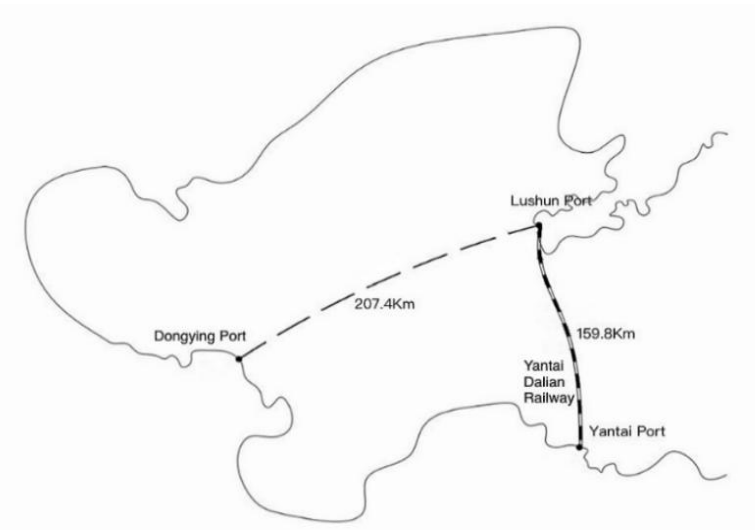

Fig. 1. Wiring diagram.

4.1 Basic Information on the Status of the Paths

The total transportation cost and time for each route can be obtained as shown in Tab. 2.

Table 2. Total transportation costs and schedules for each route.

	Transportation costs (yuan/TEU)	Transportation time (h)
Route 1	8570	17
Route 2	10040	22.5
Route 3	9228	52
Route 4	10234	30.5

4.2 Calculation Process and Results

①Quantification *of qualitative indicators.* Combined with the actual situation in Shandong, the paths were scored and the results are shown in Tab.3.

Table 3. Qualitative indicator evaluation score table.

	Transportation costs	Transportation time	Security	Rational use of resources	Impact on integrated transport systems
Route 1	9	9	4	4	9
Route 2	6	8	9	9	4
Route 3	7	5	5	5	9
Route 4	4	7	7	7	6

② Calculation of the weight of each index. Using the hierarchical analysis method, the comparison matrix of the weights of qualitative indicators of shipper satisfaction can be obtained. Constructing the comparison matrix C, according to formula (1), the results can be obtained as shown in Tab.4.

$$C_{ij} = \begin{cases} 0 & \text{i is more important than j} \\ 1 & \text{i is as important as j} \\ 2 & \text{j is more important than i} \end{cases} \quad (1)$$

Table 4. Comparison matrix of weights of qualitative indicators of shipper satisfaction.

	Transportation costs	Transportation time	Security
Transportation costs	1	2	2
Transportation time	0	1	2
Security	0	0	1

The elements of the judgment matrix are then obtained based on calculating the importance ranking index of each element. According to equation (2) (3), the results are shown in Tab.5.

ri=i=1nCij , (i=1,2,3,…,n) (2)

$$b_{ij} = \begin{cases} \frac{r_i - r_j}{r_{max} - r_{min}}(b_m - 1) + 1, & \text{when} r_i \geq r_j \\ 1, & \text{when} r_{max} = r_{min}\ i \\ \left[\frac{r_i - r_j}{r_{max} - r_{min}}(b_m - 1) + 1\right]^{-1}, & \text{when} r_i < r_j \end{cases} \quad (3)$$

included among these, retrieve $b_m = {r_{max}}/{r_{min}}$.

Table 5. Cargo owner satisfaction qualitative index weight judgment matrix.

	Transportation costs	Transportation time	Security
Transportation costs	1	3	6
Transportation time	1/3	1	4
Security	1/6	1/4	1

Then calculate the eigenvalue eigenvectors of the judgment matrix.

The maximum eigenvalues and eigenvectors of the judgment matrix are calculated in the AHP method as in equation (4). Finally normalization is also done as in equation (5)

$$\overline{w_i} = \sqrt[n]{\sum_{j=1}^{n} b_{ij}}\ ,\ \ i = 1,2, \ldots., n \quad (4)$$

will be normalized, i.e., computed:

$$\overline{w} = \frac{\overline{w_i}}{\sum_{i=1}^{n} \overline{w_i}}\ ,\ \ i = 1,2, \ldots., n \quad (5)$$

receive $\overline{w} = (w_1, w_2, \ldots, w_n)^T$, finally, (0.248, 0.228, 0.189) can be obtained as the approximation of the eigenvectors. On this basis, according to formula (6) (7) (8), then calculate the maximum eigenvalue of the judgment matrix, and finally the consistency test of the judgment matrix.

Compute the maximum eigenvalue of the judgment matrix λ_{max}。

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(A\overline{w})_i}{n\overline{w_i}} \quad (6)$$

Among these $(A\overline{w})_i$ is the ith element of the vector Aw.

Consistency test for judgment matrices.

$$C.I = \frac{\lambda_{max} - n}{n-1} \quad (7)$$

The larger the n of the judgment matrix the worse the consistency of the judgment, so the correction value R.I is introduced and taken to be

$$C.R = \frac{C.I}{R.I} \quad (8)$$

To measure the judgment matrix consistency index, the values of R.I are shown in Tab. 6 below.

Table 6. the value of R.I.

Dimensionality	1	2	3	4	5	6	7	8	9
R.I	0.00	0.00	0.58	0.96	1.12	1.24	1.32	1.41	1.45

When $\lambda_{max} = n$, CR=0, For complete consistency, generally as long as CR ≤ 0.1, the consistency of the judgment matrix is considered acceptable, otherwise the comparative judgment should be repeated. So after calculation, it can be learned that CR = 0.051 < 0.1, which satisfies the consistency test.

The same way and method were used to derive the comparison matrix and judgment matrix for the qualitative indicators of social satisfaction as shown in Tab.7 and Tab.8.

Table 7. Comparison matrix of qualitative indicators of social satisfaction.

	Rational utilization of resources	Impact on integrated transport systems
Rational resource utilization	1	2
Impact on integrated transport systems	0	1

Table 8. Qualitative indicator judgment matrix of social satisfaction.

	Rational utilization of resources	Impact on integrated transport systems
Rational resource utilization	1	6
Impact on integrated transport systems	1/6	1

It is calculated as (0.34, 0.12), which is the approximation of the eigenvectors. Then calculate the maximum eigenvalue of the judgment matrix, and finally the consistency test of the judgment matrix. After a rough calculation of this process, it can be learned that CR = 0.023 < 0.1, which satisfies the consistency test.

The evaluation results show that China-South Korea land-sea intermodal transportation is overall more perfect, but there are still deficiencies. For example, there are some logistics parks and the development of multimodal transportation enterprises in Shandong and other regions[5], the overall degree of intensification of logistics enterprises still needs to be improved, which affects the efficiency and scale of multimodal transportation.

Comprehensively evaluating the results of the four paths, the optimal path is Path 1: Weihai Dashuipo Airport → (public railroad) Weihai Port → (waterway) Incheon Port of Korea → (highway) Incheon International Airport of Korea.

We consider that in the construction of China-Korea land-sea intermodal transport, we should focus on balancing the indicators of various aspects and optimizing the path selection

5 Conclusion

Through the analysis of the indicators, it can be learned that in terms of resource utilization, purely by inland transport is the most unselectable, the existing public railroad lines and sea shipping channels are not reasonably used at present, China and South Korea are accelerating the vehicle through the preparation of matters [6]. After the trial operation of the project, to further reduce the cost of trade between China and South Korea, improve the circulation efficiency, the resilience and stability of the international supply chain between China and South Korea to better serve the domestic and international double-cycle new development pattern to provide strong support.

References

1. "Multimodal Transportation Route Selection Considering Dynamic Transshipment Time under Uncertain Demand" Journal: Natural Science Edition
2. "Optimization of Multimodal Transportation with Dual Objectives Considering Inventory and Disruption" Journal: Frontiers of Engineering Management Science and Technology
3. "Multimodal Transportation Network Construction of Integrated Vehicle Logistics at Home and Abroad" Journal: China Logistics and Purchasing
4. "Multi-objective Optimization Research on Emergency Material Supply Based on Multimodal Transportation" Journal: China Journal of Safety Science
5. "Analysis of the development status quo and countermeasures of multimodal transport between China and South Korea" Journal: Shandong Transportation Science and Technology 2021-05
6. "Large space for the development of multimodal transportation" Journal: World Rail TransportationHome and Abroad" Journal: China Logistics and Purchasing