ISSN: 2414-1895 DOI: 10.6919/ICJE.201911_5(12).0023

Research on Optimization of Container Route Network in Xiamen-ASEAN Area

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Abstract

In order to successfully undertake the rapid growth of container transportation volume between China and ASEAN region brought by the "One Belt, One Road" policy, this paper analyzes the specific composition of shipping cost based on the previous research on the optimization of container route network, and uses the mathematics of mixed integer programming. The method is to establish a container route network optimization model with the minimum total transportation cost as the target, and use MATLAB software to solve the problem. Finally, taking the route network between Xiamen Port and the five important ports of ASEAN countries as an example, the feasibility of the model and solution method is verified. The results show that the model constructed in this paper and the solution method used can solve the practical problems better, and can solve the more reasonable and efficient China-ASEAN container transport route network through software solution calculation.

Keywords

Xiamen-ASEAN; Route network; Mixed integer programming; MATLAB programming; Optimization.

1. Introduction

At present, there are different degrees of development on the optimization of container route networks at home and abroad, mainly in terms of class density and ship type distribution. The mainstream method of constructing the optimization model is to use dynamic programming, linear programming and other methods to construct complex dynamic or linear models, and select sailing time, traffic volume, capacity and other conditions as restrictions, set the minimum total cost, total revenue, or total transportation. The largest objective function is operated, especially the linear method. The research at home and abroad has been in-depth and has been successfully applied in practice.

Xu Zhao [1] proposed a mathematical model for network planning and layout optimization of container ports, in order to optimize the allocation of ports and navigation resources; Lifen Chen, Xinlian Xie [2] and other issues for the selection of transportation modes in the Bohai Rim region, a negative index was constructed. Network distribution model;Zijian Guo [3] and so on to solve the problem of container route network nonlinear programming, introduced the ant colony algorithm and applied to the minimum cost flow problem involved in the regional study of container route network, and solved the port route network On the optimization issue. Qiang Meng [4] and so on the design of the axial-width container route network, by analyzing the multi-stakes method and considering various types of containers, the balanced network design constraint model is constructed and programmed, and the model is constructed. The cost function is proposed to embed a diagonal hybrid genetic algorithm in the mixed integer linear programming model to solve the model, and use this

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model to study the empty container transportation problem in the container route network.Wang Bin, Tang Guochun [5] based on the opportunity-constrained planning to construct the container route network optimization model, the original objective-constrained programming model was transformed into an integer with the maximum profit as the objective function and the number of heavy boxes and empty containers as variables Planning model.

In order to successfully undertake the “One Belt, One Road” policy, the rapid growth of container traffic in China and the ASEAN region. In the following, the modeling solution is mainly analyzed from the perspective of shipping cost, so as to seek the optimal container shipping network under the minimum transportation cost, and select the existing Xiamen-ASEAN container shipping network for instance optimization.

2. Shipping cost analysis

Usually, the transportation cost of a container is determined by the sum of various transportation costs. In general, the cost of shipping a container is determined by five cost factors:

(1) Capital cost

The cost of capital is a fixed cost. The calculation of the ship's ship purchased or built, including the size of the cargo ship's capacity, is a factor that affects the overall price. The cost of capital is included in the cost calculation and is based on the payment of interest and return on capital, depending on how the ship is financed.

(2) Maintenance cost

Maintenance and repair costs include the following three categories, according to company policy and ship inspection requirements: classified inspection costs, periodic maintenance costs, and maintenance costs.

(3) Operating cost

The operational aspects of the ship generate operating costs. These costs include crew, shops, groceries, insurance and management. In some cases, maintenance costs are also included in operating costs.

(4) Voyage cost

The voyage cost is the variable cost incurred by a particular voyage. The components of these costs mainly include fuel and port charges. Fuel costs depend on several variables such as ship size, hull shape and condition, speed, weather (waves, currents and winds), type and capacity of main and auxiliary engines, and fuel type. Therefore, fuel costs depend on fuel prices and daily fuel consumption. Port charges are fees charged using port facilities such as tugs, moorings, moorings, harbors and other facilities, depending on ship capacity and ship capacity (total tonnage and net tonnage).

(5) Cargo handling cost

The cost of cargo handling also affects transportation costs. These costs occur at ports associated with loaders and container storage charges. Typically, storage charges are based on container type, empty container or fully loaded container, with or without container or warehouse transfer. Another cost is the cost of the warehouse, which costs the warehouse every day.

3. Construction of Container Route Network Optimization Model

The optimization model proposed in this section is based on transportation cost, in which we assume that the trunk transportation is carried out, and the ship is sailing under normal navigation conditions, the loaded containers are 20 feet, and the speed, route status, port average Indicators such as handling efficiency have been determined.

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3.1 Parameter introduction

C:Total cost of the route network;

Cr:Fixed daily fixed cost of the route;

V:Representing the collection of ports;

Xij:When the ship travels from port i to port j, the value is 1, otherwise it is 0;

Yi:When the ship serves i port, the value is 1, otherwise it is 0;

K:Total number of ships;

k:Running the ship number on the route;

Oij:The total fuel consumption per day of the ij segment is combined with the fuel consumption of the ship on the day of navigation;

tij:The sailing time of the ij segment;

H:The port fee is assumed to be the same as the port charges of the ports studied, which is the product of the port capacity of the port and the port usage rate;

Qi:The demand for containers in port i;

wi:Loading and unloading rates for each port.

3.2 Modeling

Based on the above assumptions and parameters, establish a container route network cost optimization model:

Objective :

$$\min C = \sum_{i}^{n}\sum_{j}^{n}(C_r + O_{ij}) * t_{ij} / 24 + \sum_{i}^{n}(H * i + Q_i * w_i) \tag{1}$$

Subject to:

$$\sum_{i\in V} Q_i Y_i \le Q_k, \forall k \in K \tag{2}$$

$$\sum_{i\in V} X_{ij}^{k} = Y_j^k, \forall j \in V, \forall k \in K \tag{3}$$

$$\sum_{j\in V} X_{ij}^{k} = Y_i^k, \forall i \in V, \forall k \in K \tag{4}$$

$$\sum_{k=1}^{K} Y_i^K = 1, \forall i \in V \tag{5}$$

$$0 \le \sum_{i=1}^{n} Y_i \le n, \forall k \in K \tag{6}$$

$$X_{ij} \in \{0,1\}, Y_{ij} \in \{0,1\}, \forall k \in K, \forall i, k \in V \tag{7}$$

Equation 2 indicates that the sum of container demand for each port on the route should not be greater than the rated container capacity of the carrier; Equation 3.4.5 indicates that all ports of call are visited and only visited once; Equation 6 indicates the number of ports served by the ship,not exceeding the total; Equation 7 is for the definition of variables.

4. Solution of Container Route Network Optimization Model

4.1 Example introduction

In the previous section, the container route network cost optimization model was proposed. This section solves the model by combining the example data. Selecting the container shipping network between some ports in the Xiamen-ASEAN region to investigate the overall situation of the container shipping network under the current circumstances, aiming to establish the basic data of known

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shipping vessels, the known port transportation demand and the ports of call. Under the conditions of distance and running time, a reasonable and efficient regional container transportation route network will be generated to provide optimal decision support for the Xiamen-ASEAN shipping industry.

In the example, six ports are selected, namely Xiamen Port, Manila Port, Singapore Port, Port Klang, Ho Chi Minh Port and Haiphong Port, respectively, numbered 1-6. Xiamen Port is the central port of the route network and the originating port of the container route. Singapore Port, Manila Port, Port Klang, Ho Chi Minh Port and Haiphong Port are the ports of call for the ASEAN region. The shipping network between existing ports is shown in Table 4-1 below.

Table 4-1. Existing route network between Xiamen-ASEAN ports

Serial number	Route situation	Shift (shift/week)
1	Xiamen - Manila	7
2	Xiamen-Singapore-Klang	1
3	Xiamen-Singapore	3
4	Xiamen - Haiphong	3
5	Xiamen - Ho Chi Minh - Singapore	1
6	Xiamen - Ho Chi Minh	2
7	Xiamen-Singapore-Hai Phong	1

4.2 Software solution

The model proposed in the previous section can be applied to the route network optimization of fleets of different types of ships. However, in order to facilitate the calculation and in line with the actual container liner transportation network, it is assumed that the ships in the case are all ships of the same type, and other data required in the model are also known.

This section uses Matlab to solve the problem. The order of calling the port on the route will have a profound impact on the operating cost of the entire route, and will directly affect the revenue of the route operation. It is necessary to set the generation rule limit for optimizing the route. After all possible route routes are generated, basic calculations and restrictions on these routes are required, and then the final optimized routes that meet the conditions are selected. First, it is necessary to calculate the time spent on operations between ports and the cost of the route after the route is generated. Total time. In addition, due to the time factor, it is also one of the cost factors that the shipping industry needs to consider. It is one of the important indicators for evaluating the shipping service capacity. It is also an important criterion for the cargo owner to choose the shipping company for cargo transportation. Therefore, the cargo owner often limits the arrival time of the cargo. To ensure their own income. Therefore, the maximum time limit for cargo transportation in this paper is one week (168 hours). Then, it is necessary to limit the container transportation volume of each voyage of the Xiamen ASEAN container route. The sum of the container demand of each port on the route should not be greater than the rated container capacity of the carrier.

4.3 Result analysis

Based on the current container demand of these ports in the ASEAN countries, the demand for port containers in the coming years can be predicted. Based on the historical data of the previous 5-10 years, the container demand of each port in 2020 is predicted and then input into the Matlab. In the algorithm program, the operating costs between ports in Xiamen-ASEAN region in 2020 are available, as shown in Table 4-2 below.

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Table 4-2. Operating costs between ports in Xiamen-ASEAN region in 2020

Port	Xiamen	Manila	Singapore	Klang	Ho Chi Minh	Hai Phong
Xiamen	0	824500	1539500	1649500	1127000	797000
Manila	-	0	2762125	2817125	2377125	2390875
Singapore	-	2644300	0	1764300	2066800	2520550
Klang	-	2323825	1388825	0	1760075	2213825
HoChiMinh	-	1828050	1635550	1704300	0	1676800
Hai Phong	-	2174900	2422400	2491150	2009900	0

After screening, the routes that meet the requirements are shown in Table 4-3 below.

Table 4-3. Route network between ports in Xiamen-ASEAN region in 2020 and its cost

Output route code	Specific route network	Shift (shift/week)	Route operating cost($)
1-2	Xiamen - Manila	7	824500
1-2-3	Xiamen - Manila - Singapore	1	3586625
1-4-3	Xiamen - Klang - Singapore	1	3038325
1-5-3	Xiamen - Ho Chi Minh - Singapore	1	2762550
1-6-5-3	Xiamen - Hai Phong - Ho Chi Minh - Singapore	1	4442450
1-6-4	Xiamen - Hai Phong - Klang	1	3328150
Total cost($)	22889600		

According to Table 4-1, based on the conditions assumed in this paper, the total cost of the route network operation before optimization can be calculated to be 25161400 \$. Compared with Table 4-3 above, the total cost of the optimized route network is reduced by 2271800, and the optimization effect is obvious. Explain that the proposed optimization model is effective.

From the route network composed of the six ports in the Xiamen-ASEAN region selected this time, it is possible to increase the number of flights to the routes that are growing fast enough to avoid calling unnecessary ports. According to the specific route, In 2015, the number of calls to Manila Port, Singapore Port, Port Klang, Ho Chi Minh Port and Haiphong Port was 7, 6, 3, 2, and 3; in 2020, it was 8, 4, 2, 2, 2, which is 2015. In 2020, it is necessary to increase the number of flights to Manila by one time, reduce the number of flights to Singapore by two times, reduce the number of flights to Klang and the number of flights to Haiphong once, so that the route network can reach the optimal allocation of shipping resources, thus achieving a reduction. The purpose of shipping costs throughout the shipping network.

5. Conclusion

This paper analyzes and summarizes the previous scholars' analysis of route network optimization problems, analyzes the composition of shipping costs based on the minimum total cost of airline

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operations, and constructs a container route network optimization model with minimum total cost, design optimization algorithm, and combines with Xiamen. - The shipping network between some ports in the ASEAN region was quantified using Matlab. The final result analysis shows that the optimized container shipping network operation cost is considerably less than that before optimization, which verifies the effectiveness and feasibility of the optimization model and algorithm proposed in the third section.

Although this paper has made some efforts and achievements in optimizing the Xiamen-ASEAN regional liner route network, there are still some shortcomings to be improved. First, the optimization model proposed in this paper is based on some specific assumptions, but the actual route network situation is more complicated, and the transportation ship situation is more diverse. Second, because the solution method proposed in this paper needs to be improved, some inspirations can be adopted in the future. Algorithms to improve the accuracy of calculations, or use a variety of algorithms to compare results, may get more effective results.

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