A Multiojective Programming Model for Container Shipping of Sea-Carriage

Bin Wang and Hao Hao

ABSTRACT

The paper uses multiobjective programming to build the modal of optimization of choosing shipping container routing. In the model, the first objective function is to maximize the profit of container transport. The second objective function is to minimize the shortage cost of laden container. And the constraints to the model include meeting the need of containers, the limit to transport ability and the number of empty container supported. We transfer the multiobjective model into a linear programming. Then the linear model is solved by Lingo9.0. The loss produced by choosing unreasonable route can be reduced effectively by use of the method in the paper. The aim of the paper is to provide a reasonable project of choosing shipping container route, so the profit of a shipping company can be maximized.1

KEYWORDS

Line; container; container route; fuzzy programming; simulation.

INTRODUCTION

In the late 1960s, Regular ship transportation are divided into grocery and container ones. Because of numbers of superiority of the container transportation, it becomes the most important transport manner in the world trade.

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MATHEMATICAL MODEL

\[ x_{ij}^{zh} : \text{numbers of heavy containers that will be loaded from port } i, \text{ shipped by line } h \text{ and be transported to and unloaded in port } j. ((i, j) \in (S_z, D_z), h_i \in H). S_z \text{ is the set of origination of heavy container, } D_z \text{ is the destination of heavy container. } H \text{ is the set of lines.} \]

\[ x_{ij}^{kh} : \text{shortage numbers of heavy containers of } ((i, j) \in (S_z, D_z)) \]

\[ x_{ij}^{zh} : \text{numbers of empty containers that will be loaded from port } i, \text{ shipped by line } h \text{ and be transported to and unloaded in port } j. ((i \in S_k, j \in D_k, h_i \in H) S_k \text{ is the origination of empty containers and } D_k \text{ is the destination of empty containers.} \]

\[ x_{j}^{k} : \text{numbers of empty containers which are rented by port } j. (j \in D_k) \]

Max\{ \sum_{(i,j) \in (S_z,D_z)} \sum_{h \in H} d_{ij}^{zh} x_{ij}^{zh} - \sum_{(i,j) \in (S_z,D_z)} \sum_{h \in H} (C_{ij}^{L} x_{ij}^{zh} + C_{ij}^{h} x_{ij}^{zh} + C_{ij}^{L'} x_{ij}^{zh} ) + \sum_{(i,j) \in (S_z,D_z)} C_{ij}(i,j) x_{ij}^{zh} \}

- [\sum_{i \in S_j} \sum_{j \in D_k} \sum_{h \in H} (C_{ij}^{L} x_{ij}^{kh} + C_{ij}^{h} x_{ij}^{kh} + C_{ij}^{L'} x_{ij}^{kh}) + \sum_{j \in D_k} C_{j}^{k} x_{j}^{k} ] \}

Min \sum_{k \in D_j} x_{j}^{k}

(1)

Turn multi objective function into a linear programming.

- Max \[ \sum_{k \in D_j} x_{j}^{k} \]

Max \( \lambda_1 \) (1) + \( \lambda_2 \) (2)
\[
\sum_{i \in S_k} \sum_{j, h \in H} x_{ij}^{kh} + x_j^k = D_j^k
\]  
(5)

\[
\sum_{(i, j) \in (S_z, D_z) \in H} x_{ij}^z + x_{i, j} = D_{i, j}^z
\]  
(6)

\forall i \in S_k, \sum_{j, h \in H} x_{ij}^{kh} = S_i^k
\]  
(7)

\forall h_i \in H, \sum_{i, j \in D_z} l x_{ij}^{zh} + \sum_{(i, j) \in (S_z, D_z)} l x_{ij}^{zh} \leq L_i^h
\]  
(8)

\forall h_i \in H, \sum_{(i, j) \in (S_z, D_z)} m_i x_{ij}^{zh} + \sum_{i, j \in S_z} m_j x_{ij}^{zh} \leq M_i^h
\]  
(9)

\[x_{ij}^{zh}, x_{i, j}^z, x_{ij}^{kh}, x_j^k\] are integers
\]  
(10)

\(I\) : set of ports. \(S_k\) : set of ports that provide empty containers \((S_k \subseteq I)\), \(D_k\) : set of ports that require empty containers \((D_k \subseteq I)\). \((S_z, D_z)\) : set of ports pair that provide and require heavy containers. \(S_z\) shows the ports that supply heavy containers. \((S_z \subseteq I)\), \(D_z\) shows the ports that need heavy containers. \((D_z \subseteq I)\).

For \(\forall (i, j) \in (S_z, D_z)\), it shows that heavy containers shall be loaded from port \(i\) and transported to port \(j\). In port \(j\), the heavy containers shall be unloaded. \(H\) : the set of lines. \(C_L^i\) : loading cost of one container from port \(i\) \((i \in (S_k \cup S_z))\). \(C_h^i\) : the cost of transporting one container from port \(i\) to port \(j\) by line \(h_i\) \((i \in (S_k \cup S_z), j \in (D_k \cup D_z), h \in H)\). \(C_U^i\) : unloading cost of one container from port \(i\) \((i \in (D_k \cup D_z))\). \(d_{ij}^{zh}\) : profit of transporting one heavy container from port \(i\) to port \(j\) by line \(h_i\) \(((i, j) \in (S_z, D_z), h_i \in H)\). \(C_{i, j}\) : cost caused by shortage of one heavy container between ports pair \((i, j) \(((i, j) \in (S_z, D_z))\).
NUMERICAL EXAMPLES

Figure. 1 Structure of Routing Network.

\[ S_k = \{1, 2, 12, 6\} \quad D_k = \{17, 5, 16\} \quad (S_k, D_k) = \{(1, 5), (1, 17), (6, 11), (12, 16), (13, 11)\} \quad H = \{h_1, h_2, h_3, h_4, h_5\} \quad h_i = (1 \to 2 \to 3 \to 4 \to 5 \to 17) \quad h_2 = (1 \to 2 \to 3 \to 10 \to 11 \to 17) \quad h_3 = (1 \to 6 \to 7 \to 8 \to 9 \to 10 \to 11 \to 17) \quad h_4 = (1 \to 12 \to 13 \to 10 \to 11 \to 17) \quad h_5 = (1 \to 12 \to 13 \to 14 \to 15 \to 16 \to 17) \quad \lambda_1 = 0.4, \quad \lambda_2 = 0.6 \quad C^L_1 = 15, \quad C^L_2 = 15, \quad C^L_6 = 14, \quad C^L_{12} = 14, \quad C^L_{13} = 16, \quad C^U_5 = 15, \quad C^U_6 = 15, \quad C^U_{12} = 16, \quad C^U_{13} = 81, C^h_{117} = 112, C^h_{217} = 121, C^h_{116} = 134, C^h_{117} = 99, C^h_{115} = 141, C^h_{117} = 141, C^h_{1217} = 177, C^h_{1311} = 99, C^h_{15} = 89, C^h_{117} = 132, C^h_{1217} = 165, C^h_{217} = 121, C^h_{117} = 111, C^h_{217} = 89, C^h_{617} = 121, C^h_{611} = 97, d^zh = 423, d^zh_{15} = 407, d^zh_{611} = 411, L^h = 1600, L^h = 1900, L^h = 1850, M^h = 990, M^h = 1100, D^k_{16} = 88, D^k_{1(17)} = 78, D^k_{(12,16)} = 67, D^k_{(13,11)} = 69, S^k_{1} = 171, S^k_{12} = 136.\]

Solving result is shown in the following table.

<table>
<thead>
<tr>
<th>(x^zh_{15})</th>
<th>(x^zh_{117})</th>
<th>(x^zh_{611})</th>
<th>(x^zh_{1216})</th>
<th>(x^zh_{1311})</th>
<th>(x^zh_{15})</th>
<th>(x^zh_{217})</th>
<th>(x^zh_{1216})</th>
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REFERENCES