Construction of Logistics Joint Transportation Cost Model

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Keywords: Transportation time; Transportation cost; Constraints; Decision model

Abstract: The decisive factors of logistics joint transportation include transportation time, transportation cost and constraint variables. In the transportation time factors, the in transit time and transit time are considered, and the time window constraint to meet the task is considered. The in transit time and transit time mainly include the transportation time of a certain transportation mode on a certain trunk line and the road transportation time from the starting point to the loading point The time from the starting point to the loading point of road transportation; the transportation cost mainly considers the cost of road transportation, railway transportation and air transportation; the decision-making model is established based on the comprehensive consideration of the time cost and cost of logistics combined transportation.

1. Transportation time

In the process of joint transportation of goods, the transportation time includes transit time and transit time. At the same time, the time window of the task is considered in the constraint conditions of the model according to the amount of tasks, so that the goods can be delivered to the designated area within the time required by the task. The time window can be delivered within a period of time or at a specified point in time. In the actual transportation process, there are many unpredictable factors affecting the transportation time, such as weather and natural conditions, vehicle failure, detention time of transit hub center, etc. In this paper, the fuzzy time window analysis method with time window is adopted. [1] Specifically, the whole transportation time is fuzzified to make the transportation meet the triangular fuzzy membership function $T^1=\left(T^{L^1},T^{M^1},T^{U^1}\right)$. The formula is as follows:

$$\mu\left(T^1\right)=\begin{cases}\dfrac{T^1-T^{L^1}}{T^{M^1}-T^{L^1}},T^{L^1}\le T^1\le T^{M^1}\\ 1,T^1=T^{M^1}\\ \dfrac{T^{M^1}-T^1}{T^{U^1}-T^{M^1}},T^{L^1}\le T^1\le T^{M^1}\\ 0,\text{other}\end{cases}$$

In the formula, when the time of goods transportation to the destination is greater than the earliest time that can be accepted by the task, and is less than the most satisfactory transportation time specified in the task, the membership level is $\dfrac{T^1-T^{L^1}}{T^{M^1}-T^{L^1}}$; when the goods are delivered at the most satisfactory time of the task[2], the membership level is 1; when the time of goods transportation to the destination is greater than the most satisfactory transportation time of the task, and is less than the latest transportation time acceptable by the task, the membership level is ab The level is $\dfrac{T^{M^1}-T^1}{T^{U^1}-T^{M^1}}$.

1.1 Transportation time of a certain mode of transportation on a section of trunk line

In order to facilitate decision-making and maximize the transportation effect, it is necessary to

  DOI: 10.25236/icbsis.2020.045

calculate the operation time of different vehicles in the same section by considering the usability of different vehicles. The running speed of the vehicle has a direct impact on the transportation time, and the shorter the transportation time of the same line, the better the timeliness requirement of the product can be met. The calculation method of transportation time between transfer points is shown in the formula [3].

$$T_{ij}^{m_1} = \frac{l_{ij}^{m_1}}{v_{m_1}}$$

Where: $T_{ij}^{m_1}$ represents the transportation time from transfer point i to transfer point for mode j transportation m_1; A $l_{ij}^{m_1}$ is the shortest distance from transfer point i to transfer point j for mode m_1

1.2 Connection time of transportation mode

Record the time of each connection as T_{xi}^1, then the total time of convergence

$$T_x^1 = \sum_{i=0}^{n} T_{xi}^1$$

T_x^1 is the total time for the connection of goods transportation, T_{xi}^1 is the total time for each mode of transportation, where $i = 0$ represents the initial loading time of goods.

1.3 Total transportation time

In the process of joint transportation of goods, the transportation time includes the transit time and the transit time

$$T^1 = \sum T_{ij}^{m_1} + T_x^1$$

Where $T_{ij}^{m_1}$ is the transportation time from transfer point i to transfer point j for transportation mode m_1, represents the transportation time from transfer point i to transfer point j for transportation mode $m_1 = \{K | K \in (k_1, k_2, k_3)\}$,$T^1$ is the total time of transportation.

2. Calculation of transportation cost

The combined transportation of goods is to transport goods from the starting point to the destination, passing through intermediate stations. In the transportation path, there are at least two or two transportation modes between two stations at random. Any transit point in the network has the ability to transfer transportation mode. As long as there are activities, there will be cost and time cost. Therefore, when the transfer operation is carried out, there will be different degrees of transit time and cost, and in the complete transportation process, the total time can not exceed the required time specified in the task. In the process of transportation, different means of transportation have different transportation time, cost and capacity because of their own characteristics. To sum up, considering various factors, the optimal transportation combination mode is determined to minimize the total freight within the time window to meet the transportation task.

The total transportation cost of combined transportation is the total cost of the process, including the transportation cost of using transportation tools, the guarantee cost of using other logistics company's related tools, and the service fee through the relevant toll station [4].

2.1 Cost calculation of highway transportation

In the road transportation, the self-provided flat transport vehicles or outsourcing logistics vehicles are generally used for commodity transportation. The transportation cost of each truck is determined by the factors such as fuel consumption and equipment allocation. The unit distance freight rate of freight cars is directly proportional to the number of vehicles used. Considering whether it is fully loaded, the freight rate of each truck is inversely proportional to the freight volume, so the cost calculation method of highway transportation is shown in the formula [5].

$$E_{ij}^{h}=\begin{cases} P_{ij}F_c l_{ij}^{h}P_{ij}Q_c=q_{ij} \\ (P_{ij}+I)F_c l_{ij}^{h}P_{ij}Q_c^{h}<q_{ij}\leq (P_{ij}+I)Q_c^{h} \end{cases}$$

2.2 Cost calculation of railway transportation

For the calculation of railway transportation cost, the formula is as follows according to China's railway freight pricing strategy [6].

$$c^{m_1}=\frac{\delta^{m_1}c^{aviation}T^{aviation}}{T^{m_1}}=\frac{\delta^{m_1}c^{road}T^{road}}{T^{m_1}}$$

$$c^{m_1}=\frac{\delta^{m_1}c^{aviation}V^{m_1}}{V^{aviation}}=\frac{\delta^{m_1}c^{road}V^{m_1}}{V^{road}}$$

2.3 Calculation of air transportation cost

For air transportation, the enterprise's transportation cost calculation method is generally adopted, and the formula is as follows:

$$E_{ij}^{air}=\sum_{k=1}^{n}\left(q^{k}-q^{k-1}\right)a^{k-1}c^{air}l_{ij}^{air} \qquad q^{n-1}<q_{ij}\leq q^{n}\leq Q_c^{air}$$

3. Model establishment

3.1 Decision variables

$P_{ij}^{k_1}$ represents the decision variable of transportation mode selection between transfer point i and transfer point j.If transport mode k_1 is selected between transfer point i and transfer point j, then $P_{ij}^{k_1}=1$, otherwise $P_{ij}^{k_1}=0$;

$P_{ij}^{k_2}$ represents the decision variable of transportation mode selection between transfer point i and transfer point j.If transport mode k_2 is selected between transfer point i and transfer point j, then $P_{ij}^{k_2}=1$, otherwise $P_{ij}^{k_2}=0$;

$P_{ij}^{k_3}$ represents the decision variable of transportation mode selection between transfer point i and transfer point j. If transport mode k_2 is selected between transfer point i and transfer point j, then $P_{ij}^{k_3}=1$, otherwise $P_{ij}^{k_3}=0$.

3.2 Correlation set

It is defined as the transportation network of $Ne=(Tr, L, K)$ combined transportation, where Tr represents the collection of all transfer points in the transportation network.L is the set of arcs in the combined transportation network, K is the set of all transportation modes in the transportation network, p_i is the transit point of the combined transportation network, and o、d is the transportation starting point and transportation terminal point respectively.

Tr is the set of all transfer points, that is$Tr=(p_1, p_2, \cdots p_n)$, $p_i=\left(m_{p_i}, z_{p_i}, y_{p_i}\right)$.

K represents the set of all transportation modes in the transportation network, i.e.

k_1, k_2, $k_3 \in K$.

3.3 Objective function

The transportation of goods is relatively complex. In addition to considering the transportation cost, transportation time cost, connection time cost, safety and punctuality reduction system, more attention is paid to the timeliness, transportation effect, transportation accessibility and the feasibility of commodity guarantee in the process of transportation with the completion of tasks as the main goal In the process, the objective function based on the completion of transportation task is proposed, that is, the timeliness of the task should be paid attention to in the transportation process [7]. On this basis, the accessibility of transportation, the feasibility of transportation commodity guarantee and the accuracy of transportation time are integrated. The calculation formula is as follows:

$$minE = E^{k_1} + E^{k_2} + E^{k_3} + E^{i} \tag{4.36}$$

Where E^{k_1}: transportation cost paid by highway;E^{k_2}: transportation cost paid by railway; E^{k_3}: transportation cost paid by railway; E^{i}: transfer cost at transfer point. The cost calculation formula of each part is as follows:

$$E^{k_1} = \sum_0^{k_1} E_{ij}^{h} \tag{4.37}$$

$$E^{k_2} = \sum_0^{k_2} E_{ij}^{k_2} \tag{4.38}$$

$$E^{k_3} = \sum_0^{k_3} E_{ij}^{k_3} \tag{4.39}$$

$$E^{i} = \sum_0^{i} E^{i} \tag{4.40}$$

3.4 Constraints

Transportation mode selection constraints. It means that only one mode of transportation can be selected between any two transfer points.

$$P_{ij}^{k_1} \le 1, \ \forall i, \ j \in Tr$$

$$P_{ij}^{k_2} \le 1, \ \forall i, \ j \in Tr$$

$$P_{ij}^{k_3} \le 1, \ \forall i, \ j \in Tr$$

Transportation capacity constraints. It means that the total amount of goods transported on any arc section cannot exceed the transportation capacity limit of the arc section.

$$z\left(x^{M_1}\right) \le z_{p_i}^{M_1}$$

Transportation transfer capacity constraints. It means that at any hub point, the transit transportation volume can not exceed the transit capacity of the hub.

$$z\left(x\right) \le z_{p_i}$$

Transportation time limit. Indicates that the transportation time and transit time of the goods cannot exceed the transportation time window specified in the transportation of the goods.

$$T_1 \le T$$

Variable logic constraints.

$$P_{ij}^{k_1} = \{0, \ 1\}, \ \forall i, \ j \in Tr$$

$$P_{ij}^{k_2} = \{0, \ 1\}, \ \forall i, \ j \in Tr$$

$$P_{ij}^{k_3} = \{0, 1\}, \forall i, j \in Tr$$

The fuzzy environment combined transportation route optimization model is summarized as follows:

$$minE = E^{k_1} + E^{k_2} + E^{k_3} + E^{i}$$

$$P_{ij}^{k_1} \leq 1, \forall i, j \in Tr$$

$$P_{ij}^{k_2} \leq 1, \forall i, j \in Tr$$

$$P_{ij}^{k_3} \leq 1, \forall i, j \in Tr$$

$$T_1 \leq T$$

$$P_{ij}^{k_1} = \{0, 1\}, \forall i, j \in Tr$$

$$P_{ij}^{k_2} = \{0, 1\}, \forall i, j \in Tr$$

$$P_{ij}^{k_3} = \{0, 1\}, \forall i, j \in Tr$$

4. Conclusion

The study makes a comprehensive consideration of transportation time, customers and cost. in the aspect of time, the research model of task window is established. The general calculation method is adopted in the cost. In terms of constraints, time cost, route and transportation mode are considered comprehensively. Based on the cost, the logistics transportation model is established. The model is universal and can provide strong support for decision-making of logistics transportation.

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