Optimization of Railway Express Freight Trains Operation Plan under the Competition of Highway and Railway

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Abstract—In recent years, China's economy has developed rapidly, especially in the Internet industry and e-commerce. These have led to the rapid growth of the express industry. The express delivery industry has a huge demand for transportation. However, due to the speed and convenience of highway, the high-speed transportation occupies a large market share. Due to relevant policies and the inadequate transportation capacity resource allocation, a large number of medium and long-distance freight flows that are suitable for railway transportation choose highway transportation. This not only greatly reduces the profits of the railway transportation department, increases the carbon emission of the transportation system, but also makes the load of some road sections higher than expected. Therefore, in order to protect the environment and enhance the market competitiveness of the railway department, the optimization of the railway express freight train schedule is an urgent task.

On the basis of previous research results, this paper first calculates the generalized cost of highway and railway from the perspective of the cargo owner, and finds out whether the cargo owner will choose railway, that is, which freight flow will be attracted to the railway. Then, with the maximization of the profits of the railway transportation department as the objective function, the 0-1 integer programming model is established under the constraints of railway transportation capacity, freight transportation time and decision variable value restrictions, etc. Finally, a small-scale example is designed. After put the data into the model, the optimized operation plan of railway express freight trains is obtained.

1. LITERATURE REVIEW

The railway freight transportation gradually moves from the goal of full loaded trains to the goal of fixed time trains, not only to ensure that goods are delivered on time, but also to promote the convenience and reliability. Since the 1990s, Europeans Dejax [1] and Eva Savesberg [2] have confirmed the feasibility of the railway express freight transportation. Using specific train services to complete integration at marshalling stations according to the railway schedule can greatly reduce time consumption, making it possible for immediate freight transportation to replace highway transportation. Plotkin [3] also studied the feasibility of operating the railway express train to transport high-value-added goods from the perspective of technology and economy. In terms of frequency service network design issues, Magnanti Tl[4] proposed an optimized fixed-cost network service model based on the traditional transportation network design model. Braklow J.W[5] creatively took the transportation service quality as the objective function, and constructed the corresponding model and algorithm to effectively study the design of express service network. On the basis of the dual ascent algorithm, the descendants have carried out more in-depth research on the design of freight transportation service networks. Kim[6] paid more attention to the large-scale transportation service network problems.
including express freight transportation. Heuristic algorithms were used to obtain the minimum cost of goods transportation under the conditions of service constraints and capacity constraints. Seung-Ju [7] comprehensively considered the impact of transportation time and transportation cost on the total cost, constructed the corresponding model and algorithm, and optimized the service network. In the study of the design of dynamic service networks incorporating time factors, Crainic TG [8] used Canadian Railways as an example to conduct a comprehensive analysis of the freight trains schedule, route selection, and the assignment of operation content at each station. And a general model is proposed. Andersen J. [9] based on the spatio-temporal network model with the minimum cargo transportation time as the objective function, using the branch and bound algorithm to solve the optimization model, in order to solve the problem of railway express freight train coordination and service network design problem. Pazour J.A [10] conducted a multi-faceted study on railway freight transportation from an economic perspective, constructing a mathematical model from the perspective of reducing costs and shortening transportation time, and pointed out that the use of railway express freight train services can bring considerable economic benefits.

2. MATHEMATICAL MODEL

2.1. Symbol definition

\( V \): Set of all stations in the network;
\( Y \): Set of all operation plans from one station to another;
\( F \): Set of all freight transportation demand;
\( D \): Set of all express freight train grades from \( i \) station to \( j \) station;
\( N_m \): The express demand, that is, how many tons of cargo needs to be transported from \( s \) station to \( t \) station; (t)
\( d \): Express freight train grades, and they are divided into 120 km/h and 80 km/h express trains in this paper;
\( c_{ij}^d \): Fixed cost of \( d \) grade express freight train from \( i \) station to \( j \) station; (yuan)
\( \theta_{ij}^d \): Per ton-kilometer cost of \( d \) grade express freight trains from \( i \) station to \( j \) station; (yuan\cdot t\cdot km\(^{-1}\))
\( f_{i,j}^{rail} \): Express freight train transportation demand from \( i \) station to \( j \) station; (t)
\( l_{ij}^d \): Mileage of \( d \) grade express freight train from \( i \) station to \( j \) station; (km)
\( C_{k}^{trans} \): Cost of reorganization of freight at \( k \) station; (yuan)
\( \lambda \): Express freight train transportation price, that is, the income of one ton of cargo running one kilometer; (yuan\cdot t\cdot km\(^{-1}\))
\( \mu \): The railway loading and unloading operation fees, that is, the income of loading or unloading one ton of cargo; (yuan\cdot t\(^{-1}\))
\( p_{s,t}^{rail} \): The railway transportation price from \( s \) station to \( t \) station; (yuan)
\( p_{s,t}^{load} \): The profit part of railway loading and unloading operation fees and short distance extended logistics service fee; (yuan)
\( T_{ij}^d \): The cycle time of the \( d \) grade express freight train from \( i \) station to \( j \) station; (h)
\( G \): Per car loading capacity; (t)
\( m_{ij}^d \): The agreed number of cars in a \( d \) grade express freight train from \( i \) station to \( j \) station;
\( t_{ij} \): The actual transportation time of the express freight train from \( i \) station to \( j \) station; (h)
\( H_{ij} \): Maximum transportation time of freight flow \( f_{i,j}^{rail} \);
\( x_{ij}^{d} \): 0-1 decision variable. Under a certain train network, if the freight flow \( f_{i,j}^{rail} \) takes \( d \) grade express freight train from \( i \) station to \( j \) station, it is 1; otherwise, it is 0.
$y_{ij}^d$: 0-1 decision variable. If the $d$ grade express freight train from $i$ station to $j$ station is provided, it is 1; otherwise, it is 0.

2.2. Model formulation

The following is the objective function:

2.2.1. The cost of railway express freight trains $Z_1$ (That is, the sum of the fixed cost of the train, the cost of the transportation, and the cost of reorganization of freight). And only when the generalized cost of the railway is less than the generalized cost of the road, $f_{ij}^{\text{rail}}$ in the formula is equal to $N_{st}$, otherwise it is equal to 0.

$$
\min Z_1 = \sum_{i \in S} \sum_{j \in S} \sum_{d \in D} \sum_{t \in T} \sum_{x \in X} \frac{2}{3} \left( e_{ij}^d + \theta_{ij}^d f_{ij}^{\text{rail}} \right) y_{ij}^d + \sum_{k \in K} C_{\text{Transfer}}^{k, ij}
$$

$$
f_{ij}^{\text{rail}} = \begin{cases} N_{st} & \text{if } \gamma T_{\text{rail}} + \Phi_{\text{rail}}^{ij} < \gamma T_{\text{highway}} + \Phi_{\text{highway}} \\ 0 & \text{Otherwise} \end{cases}
$$

2.2.2. Income of railway express freight trains $Z_2$.

$$
\max Z_2 = \sum_{i \in S} \sum_{j \in S} \sum_{d \in D} \sum_{t \in T} \sum_{x \in X} \left( P_{\text{rail}} + P_{\text{station}} \right) x_{ij}^{i, j, d}
$$

To sum up, the operating profit of railway express freight trains is the difference between income and the operating cost, so the objective function is:

$$
\max \quad Z = Z_2 - Z_1 = \sum_{i \in S} \sum_{j \in S} \sum_{d \in D} \sum_{t \in T} \sum_{x \in X} \left( P_{\text{rail}} + P_{\text{station}} \right) x_{ij}^{i, j, d} - \sum_{i \in S} \sum_{j \in S} \sum_{d \in D} \sum_{t \in T} \sum_{x \in X} \left( e_{ij}^d + \theta_{ij}^d f_{ij}^{\text{rail}} \right) y_{ij}^d - \sum_{k \in K} C_{\text{Transfer}}^{k, ij}
$$

1) Transport capacity restriction

In the transportation service network, each express freight train has a certain capacity limit.

$$
f_{ij}^{\text{rail}} \leq \sum_{d \in D} G_{ij}^d x_{ij}^{i, j, d} \quad \forall i, j, s, t \in V
$$

2) Transportation time restriction

For any freight flow, the time consumed in transportation should be less than the maximum transportation time limit required by the freight flow.

$$
\sum_{i \in S} \sum_{j \in S} l_{ij} x_{ij}^{i, j, d} \leq H_{st} \quad \forall s, t \in V
$$

3) Mutual restriction of decision variables

If the freight flow $f_{st}$ takes the grade $d$ express freight train, that is, if $x_{st}^{i, j, d} = 1$, there must be $y_{ij}^d = 1$, that is to say, there must be $d$ grade express freight train from $i$ station to $j$ station. On the contrary, if $x_{st}^{i, j, d} = 0$, then $y_{ij}^d$ can be 0 or 1.

$$
x_{ij}^{i, j, d} \leq y_{ij}^d \quad \forall i, j, s, t \in V, d \in D
$$

4) Freight flow continuity restriction

For any express freight flow, it must be guaranteed that it departs from the starting station, passes through the intermediate station in the network (or has not been reorganized), and finally reaches the destination. At the same time, it must be ensured that the same express freight flow can not be split in the transportation process, that is, it can only be transported to the arrival station by the same train after it is organized at the departure station or reorganized at the intermediate station.

$$
\sum_{(d, f) : y_{ij}^d = 0} x_{ij}^{i, j, d} = \sum_{d \in D} x_{st}^{i, j, d} = 1 \quad \forall s, t \in V
$$
\[ \sum_{(d,j) \in D} x_{ij}^{d} = 1 \quad \forall s, t \in V \]

5) Variable value constraint

\[ x_{ij}^{d} \in \{1, 0\} \quad \forall i, j, s, t \in V, d \in D \]

\[ y_{ij}^{d} \in \{1, 0\} \quad \forall i, j, s, t \in V, d \in D \]

Based on the above analysis, the whole model is as follows:

\[
\begin{align*}
\text{max } Z &= Z_1 - Z_2 = \sum_{s \in S} \sum_{t \in T} (p_{i,t} + f_{i,t})x_{ij}^{d} + \sum_{s \in S} \sum_{t \in T} \sum_{j \in J} \sum_{d \in D} \sum_{(d,j) \in D} \sum_{j \in J} \sum_{d \in D} \sum_{(d,j) \in D} C_{ij}^{d} x_{ij}^{d} - \sum_{s \in S} \sum_{t \in T} \sum_{j \in J} \sum_{d \in D} \sum_{(d,j) \in D} \sum_{j \in J} \sum_{d \in D} C_{ij}^{d} y_{ij}^{d} \\
&\quad \text{subject to:} \quad f_{ij}^{d} \leq \sum_{(d,j) \in D} G_{ij}^{d} x_{ij}^{d}, \quad \forall i, j, s, t \in V \\
&\quad \sum_{i \in I} y_{ij}^{d} \leq H_{ij}, \quad \forall s, t \in V \\
&\quad x_{ij}^{d} \in \{1, 0\}, \quad \forall i, j, s, t \in V, d \in D \\
&\quad y_{ij}^{d} \in \{1, 0\}, \quad \forall i, j, s, t \in V, d \in D \\
&\quad x_{ij}^{d} \in \{1, 0\}, \quad \forall i, j, s, t \in V, d \in D \\
&\quad y_{ij}^{d} \in \{1, 0\}, \quad \forall i, j, s, t \in V, d \in D 
\end{align*}
\]

2.3. Numerical results

According to the above model, a small calculation example is designed. In this paper, it is assumed that there are 7 intermediate stations, each of which has corresponding transportation demand. The mutual location of the 7 intermediate stations on the network is shown in Figure 2.

![Figure 1. The mutual location of the 7 intermediate stations.](image)

In order to facilitate calculation, only consider the single direction, the freight transportation needs between the various stations and the freight transportation time limit is shown in Table 1.

| No. | OD pair | demand/t | mileage /km | time limit /h |
|-----|---------|----------|-------------|--------------|
| 1   | 1-2     | 600      | 500         | 48           |
| 2   | 1-3     | 1200     | 950         | 72           |
| 3   | 1-4     | 1080     | 1100        | 72           |
| 4   | 1-5     | 660      | 1625        | 72           |
| 5   | 1-6     | 840      | 2350        | 120          |
| 6   | 1-7     | 1260     | 3100        | 144          |
| 7   | 2-3     | 600      | 450         | 48           |
| 8   | 2-4     | 1440     | 600         | 48           |
| 9   | 2-5     | 720      | 1125        | 44           |
| 10  | 2-6     | 840      | 1850        | 96           |
| 11  | 2-7     | 600      | 2600        | 120          |
| 12  | 3-4     | 1000     | 150         | 24           |
| 13  | 3-5     | 900      | 675         | 48           |
| 14  | 3-6     | 1020     | 1400        | 72           |
| 15  | 3-7     | 660      | 2150        | 96           |
| 16  | 4-5     | 540      | 525         | 42           |
| 17  | 4-6     | 660      | 1250        | 72           |
| 18  | 4-7     | 660      | 2000        | 96           |
| 19  | 5-6     | 1080     | 725         | 48           |
| 20  | 5-7     | 540      | 1475        | 88           |
| 21  | 6-7     | 960      | 750         | 48           |
According to the freight transportation demand of each node, the corresponding express freight train is designed, as shown in Figure 3. For the convenience of research, only a single direction is considered. The first picture shows all direct express trains. Dark blue means departing from station 1. Red means departing from station 2. Yellow means departing from station 3. Green means departing from station 4. Purple means departing from station 5. Light green means departing from 6 stations. The second picture shows all express freight trains that need to be reorganized on the way. The same color lines indicate the same express freight train. The starting point of the arc indicates the departure station. The arrow finally points to the destination station of the reorganized express freight train. An arc without an arrow indicates an intermediate station. For example, the red line in the figure means departing from station 1, then reorganizing at station 3, and finally reaching station 7.

The detailed information of each express freight train, including the departure and arrival stations of the train, the stop, mileage, speed, the cycle time, etc., is shown in Table 2. Railway transportation price is determined in accordance with the "Railway Freight Tariff Rules", "Railway Freight Loading and Unloading Role Billing Method" [2005] and the latest railway freight rate. The freight charges are calculated using the freight rate of No. 5, which is 0.21 yuan/(ton·km). The marked load of railway freight cars is 60 tons, and the number of cars is 50, so the maximum capacity of each train is 3000 tons. The fixed cost is 100,000 yuan. For each additional reorganization station, the cost is 3,500 yuan, the reorganization time is 6 hours, and the freight time value is 3.47 yuan/(ton·hour). It is considered that the railway express freight train requires 24 hours for loading and unloading. It is believed that the mileage of highway and railway transportation is the same, the highway transportation price is 0.35 yuan/(ton·km), and the average speed of the highway transportation is 60km/h.

| No. | Train departure and destination | the stop | mileage/km | speed/(km/h) | cycle time (h) |
|-----|--------------------------------|---------|-----------|--------------|---------------|
| 1   | 1-2                            | -       | 500       | 120          | 48            |
| 2   | 1-3                            | -       | 950       | 120          | 48            |
| 3   | 1-4                            | -       | 1100      | 120          | 48            |
| 4   | 1-5                            | -       | 1625      | 120          | 48            |
| 5   | 1-6                            | -       | 2350      | 120          | 48            |
| 6   | 1-7                            | -       | 3100      | 120          | 48            |
| 7   | 2-3                            | -       | 450       | 120          | 48            |
| 8   | 2-4                            | -       | 600       | 120          | 48            |
| 9   | 2-5                            | -       | 1125      | 120          | 48            |
| 10  | 2-6                            | -       | 1850      | 120          | 48            |
| 11  | 2-7                            | -       | 2600      | 120          | 48            |
First of all, according to the previous formula for calculating the generalized cost of highway and railway, we can know which freight flow will choose railway. Taking the first OD pair as an example, according to the formula \( \gamma T_{st} + \phi_{st} \), the first OD pair is the freight transportation demand between 1 station and 2 station. Then the generalized cost of the railway is calculated as follows: \( 3.47 \times 500 \div 120 \times 24 \times 600 + 0.21 \times 500 \times 600 = 121643 \) yuan. And the generalized cost of highway is calculated as follows: \( 3.47 \times 500 \div 60 \times 600 + 0.35 \times 500 \times 600 = 122350 \) yuan. Because the generalized cost of railway is less than the generalized cost of highway, the freight flow will finally choose railway. After calculation, the selection results of the 21 OD pairs are shown in the following table.

| No. | OD pair   | Railway generalized cost /yuan | Highway generalized cost /yuan | Selection result |
|-----|-----------|--------------------------------|---------------------------------|------------------|
| 1   | 1-2       | 121643                         | 122350                         | railway          |
| 2   | 1-3       | 372301                         | 464930                         | railway          |
| 3   | 1-4       | 373775                         | 484506                         | railway          |
| 4   | 1-5       | 311203                         | 437401                         | railway          |
| 5   | 1-6       | 541577                         | 805063                         | railway          |
| 6   | 1-7       | 1038141                        | 1592997                        | railway          |
| 7   | 2-3       | 114476                         | 110115                         | highway          |
| 8   | 2-4       | 326347                         | 352368                         | railway          |
| 9   | 2-5       | 253484                         | 330345                         | railway          |
| 10  | 2-6       | 441232                         | 633773                         | railway          |
| 11  | 2-7       | 422678                         | 636220                         | railway          |
| 12  | 3-4       | 119118                         | 61175                          | highway          |
| 13  | 3-5       | 220094                         | 24759                          | railway          |
| 14  | 3-6       | 426119                         | 582386                         | railway          |
| 15  | 3-7       | 393988                         | 578716                         | railway          |
| 16  | 4-5       | 112704                         | 115621                         | railway          |
| 17  | 4-6       | 252071                         | 336463                         | railway          |

**TABLE III. GENERALIZED COST COMPARISON OF RAILWAY AND HIGHWAY**
From the results in the table, we can see that only 2-3 freight flow and 3-4 freight flow, the generalized cost of railway is greater than the generalized cost of highway, and the transportation time of highway is shorter than that of railway. Based on these two reasons, it is difficult for railway to attract these two freight flow.

Based on the above data, the parameters are substituted into the previous model, and after calculation, the results are shown in the following table 4.

**TABLE IV. FREIGHT FLOW OPTIMIZATION RESULTS**

| No. | OD pair | \( x_{ij}^{d} \) value | transportation time(h) | time limit (h) | Whether the time limit is exceeded |
|-----|---------|-----------------|------------------------|----------------|-----------------------------------|
| 1   | 1-2     | 1               | 36                     | 48             | no                                |
| 2   | 1-3     | 1               | 42                     | 72             | no                                |
| 3   | 1-4     | 1               | 44                     | 72             | no                                |
| 4   | 1-5     | 1               | 38                     | 72             | no                                |
| 5   | 1-6     | 1               | 44                     | 120            | no                                |
| 6   | 1-7     | 1               | 69                     | 144            | no                                |
| 7   | 2-3     | 0               | -                      | -              | -                                 |
| 8   | 2-4     | 1               | 38                     | 48             | no                                |
| 9   | 2-5     | 1               | 44                     | 44             | no                                |
| 10  | 2-6     | 1               | 53                     | 96             | no                                |
| 11  | 2-7     | 1               | 63                     | 120            | no                                |
| 12  | 3-4     | 0               | -                      | -              | -                                 |
| 13  | 3-5     | 1               | 38                     | 48             | no                                |
| 14  | 3-6     | 1               | 36                     | 72             | no                                |
| 15  | 3-7     | 1               | 42                     | 96             | no                                |
| 16  | 4-5     | 0               | -                      | -              | -                                 |
| 17  | 4-6     | 1               | 46                     | 72             | no                                |
| 18  | 4-7     | 1               | 41                     | 96             | no                                |
| 19  | 5-6     | 1               | 39                     | 48             | no                                |
| 20  | 5-7     | 1               | 48                     | 88             | no                                |
| 21  | 6-7     | 1               | 39                     | 48             | no                                |

When \( x_{ij}^{d} = 1 \), it indicates that the freight flow \( f_{ij} \) is on the \( d \) grade express freight train from station \( i \) to station \( j \); when \( x_{ij}^{d} = 0 \), it indicates that the freight flow is not on the \( d \) grade express freight train from station \( i \) to station \( j \). As can be seen from the table 4, most of these freight flows have chosen to take the express freight train, only three freight transportation demand (2-3, 3-4, 4-5) are not satisfied, it can be seen that the optimization results satisfy most of the freight transportation demand. Comparing the time limit with the maximum time limit of freight flow transportation, it is found that the limit is not exceeded, so the model calculation in this paper is scientific and accurate.

Optimize each scheduled train, when \( y_{ij}^{d} = 1 \), it means to provide \( d \) grade express freight train from station \( i \) to station \( j \). When \( y_{ij}^{d} = 0 \), it means that there is no \( d \) grade express freight train from \( i \) station to \( j \) station. The values of \( y_{ij}^{d} \) for the 30 express freight trains are shown in Table 5.
### TABLE V. EXPRESS FREIGHT TRAIN OPTIMIZATION RESULTS

| No. | Train departure and destination | the stop | $y_{ij}^d$ value |
|-----|---------------------------------|----------|-----------------|
| 1   | 1-2                             | -        | 0               |
| 2   | 1-3                             | -        | 0               |
| 3   | 1-4                             | -        | 0               |
| 4   | 1-5                             | -        | 1               |
| 5   | 1-6                             | -        | 1               |
| 6   | 1-7                             | -        | 0               |
| 7   | 2-3                             | -        | 0               |
| 8   | 2-4                             | -        | 0               |
| 9   | 2-5                             | -        | 0               |
| 10  | 2-6                             | -        | 0               |
| 11  | 2-7                             | -        | 0               |
| 12  | 3-4                             | -        | 0               |
| 13  | 3-5                             | -        | 0               |
| 14  | 3-6                             | -        | 1               |
| 15  | 3-7                             | -        | 1               |
| 16  | 4-5                             | -        | 0               |
| 17  | 4-6                             | -        | 0               |
| 18  | 4-7                             | -        | 1               |
| 19  | 5-6                             | -        | 0               |
| 20  | 5-7                             | -        | 0               |
| 21  | 6-7                             | -        | 0               |
| 22  | 1-3-7                           | 3        | 1               |
| 23  | 1-4-6                           | 4        | 0               |
| 24  | 1-2-4                           | 2        | 1               |
| 25  | 2-4-6                           | 4        | 1               |
| 26  | 2-5-7                           | 5        | 1               |
| 27  | 3-4-6                           | 4        | 0               |
| 28  | 3-5-7                           | 5        | 0               |
| 29  | 4-6-7                           | 6        | 0               |
| 30  | 5-6-7                           | 6        | 1               |

As can be seen from Table 5, after the optimization, a total of 10 express freight trains were operated, including 5 direct trains and 5 transit trains, as shown in figure 5.

Figure 3. Express freight train optimization results.

Summarizing the information of these 10 express trains, the relevant elements of the departure station, arriving station, intermediate station, composition, speed, cycle time are shown in Table 6.
### TABLE VI. ELEMENTS OF OPTIMIZED EXPRESS FREIGHT TRAIN

| No. | Train departure and destination | the stop | composition       | speed (km/h) | cycle time (h) |
|-----|---------------------------------|---------|-------------------|--------------|---------------|
| 1   | 1-5                             | -       | 1-5 660t         | 120          | 48            |
| 2   | 1-6                             | -       | 1-6 840t         | 120          | 48            |
| 3   | 3-6                             | -       | 3-6 1020t        | 120          | 48            |
| 4   | 3-7                             | -       | 3-7 660t         | 120          | 48            |
| 5   | 4-7                             | -       | 4-7 660t         | 120          | 48            |
| 6   | 1-3-7                           | 3       | 1-3 1200t, 1-7 1260t | 80          | 48            |
| 7   | 1-2-4                           | 2       | 1-2 600t, 1-4 1080t, 2-4 600t | 80          | 48            |
| 8   | 2-4-6                           | 4       | 2-6 1440t, 4-6 660t | 80          | 48            |
| 9   | 2-5-7                           | 5       | 2-5 720t, 2-7 600t | 80          | 48            |
| 10  | 5-6-7                           | 6       | 5-6 1080t, 5-7 540t | 80          | 48            |

3. CONCLUSION

Under the background of the rapid development of modern logistics market, ensuring the timeliness, rapidity, safety and reliability of the express freight transportation is an important measure to improve the market share of railway transportation in freight transportation. This paper focuses on the optimization of the railway express train operation plan. Firstly, from the perspective of generalized cost, it calculates which freight flow the railway will attract, and operates the express freight train according to the transportation demand without wasting the capacity. Then, under the conditions of guaranteeing the transportation demand, the profits of the railway transportation department and various constraints, the 0-1 integer programming model is proposed to optimize the express freight train operation plan. Finally, a small-scale example is designed, with a total of 7 stations, which only considers the transportation needs in a single direction. The model in this paper is verified, and it is found that the optimization greatly increases the profit of the railway transportation department.

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