High-Speed Rail Express Business Forecast Based on Improved Logit Model for Analyzing the Market Prospect of High-Speed Rail Express Business in Hub Cities

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Abstract. The mileage of China's high-speed railway network has grown rapidly, and the total amount of express delivery nationwide has also increased rapidly. Firstly, the GM (1, 1) model is used to predict the express market demand of high-speed railway hub cities in 2025; then the share-sharing model is constructed to calculate the market share of high-speed rail transport using MATLAB software to predict the market demand of high-speed rail express; and finally based on forecast data, analyze the market prospects and prospects of the high-speed rail express business in hub cities.

1. Introduction
In recent years, China's high-speed railway network has grown rapidly, and now it has surpassed the total number of miles in other countries around the world. The domestic coverage area is expanding. It is estimated that the total mileage of high-speed railway will reach 30,000 kilometers in 2020. According to the annual "Public Industry Development Statistics Bulletin" issued by the State Post Bureau, the number of express delivery in 2018 has exceeded 50 billion. Most of China's high-speed rail lines have large surplus capacity, and there are economies of scale in sharing fixed facilities. Although the average passenger load factor of the high-speed rail is high, the operation is busy, and one ticket is hard to find, there is also a certain capacity surplus during the off-peak period. This provides basic facilities for the express delivery business on the high-speed rail line. Based on the current market environment, how much potential market demand for high-speed railway express delivery in China is and how competitive with other modes of transportation, the future of the high-speed rail express market in the main node cities connected by the "four vertical and four horizontal" high-speed railway network in-depth research and analytical arguments are needed.

Forecast of express demand:
Li Yanzhi (2015) constructed two sets of combined forecasting models to predict the express demand of Hangzhou, respectively, and combined the time series and causal relationship, and compared the prediction results. Finally, a more reasonable combination of models was selected. The volume of express delivery is forecasted [8]. Shang Fengrui (2016) used the time series SARIMA model to eliminate the influence of seasonal changes on the demand for express delivery. Analyze and simulate all monthly express data from 2003 to 2015 in China. After comparing the parameters, determine SARIMA (0,1,1) (0,1,1) is the final prediction model with high accuracy [9]. Xu Rongbin, Wang Yeguo, Wang Futian et al. (2018) proposed a combination of particle swarm optimization
algorithm with improved inertia weight and backpropagation neural network (IPSO-BP) to predict the daily express delivery volume of logistics companies [5].

The calculation of the sharing rate of different modes of transport: Deja x et al. (1991) studied the situation of cargo transportation in French railways, compared the two methods of railway transportation and road transportation, analyzed the advantages of railway transportation, and considered that the speed of railway transportation is fast, which can improve the speed of express delivery. Good to meet the high timeliness requirements expected by shippers, with good reliability and safety.

By reading relevant literature, there are many methods for forecasting express demand, but there is no targeted forecasting model. Therefore, there is still some difficulty in selecting the forecasting model of express delivery traffic. Mathematical models must match the actual data to guide the actual work. Role, this paper combines the characteristics of high-speed rail express itself to select G M(1,1) and improved logit model to predict the volume of express delivery.

2. Forecast of express shipments in high-speed railway hub cities

2.1. Choice of high-speed railway hub cities

With the increasing demand for express delivery timeliness, the express delivery volume of cities across the country, especially as the “four vertical and four horizontal” high-speed rail backbone network nodes, is growing rapidly, and the intersection of four vertical and four horizontal lines is 13. Each hub city has a place in the top 50 cities in the 2018 national express delivery volume. The annual express delivery volume of each node city has exceeded 100 million, including those in Beijing, Shanghai, Hangzhou, Shenzhen and other cities. The scale has exceeded 2 billion. In the “four vertical and four horizontal” high railway network is basically completed, the high-speed railway line crisscross node city has become the hub city of express transport channel. Therefore, this paper selects the “four vertical and four horizontal” high railway network as the research foundation, and selects the hub cities where the four vertical and four horizontal lines intersect as the representative city.

2.2. Forecast results of remote express shipments in high-speed railway hub cities

Grey prediction models are often used to predict data with small samples and missing information. According to the data of off-site express delivery of high-speed railway hub cities in China from 2014 to 2018, the GM (1,1) model is used to predict the amount of express shipments in each high-speed railway hub city.

The forecast results are as follows:

| City          | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---------------|------|------|------|------|------|------|------|
| Shijiazhuang  | 5.17 | 6.05 | 6.98 | 7.96 | 8.98 | 10.05| 11.17|
| Shenyang      | 3.66 | 4.27 | 4.91 | 5.60 | 6.33 | 7.09 | 7.86 |
| Beijing       | 32.78| 38.34| 44.09| 50.25| 56.79| 63.61| 70.61|
| Zhengzhou     | 7.06 | 8.28 | 9.50 | 10.85| 12.14| 13.72| 15.24|
| Wuhan         | 10.11| 11.82| 13.59| 15.51| 17.53| 19.62| 21.78|
| Changsha      | 4.77 | 5.59 | 6.43 | 7.33 | 8.27 | 9.26 | 10.29|
| Tianjin       | 7.23 | 8.46 | 9.74 | 11.09| 12.53| 14.05| 15.57|
| Jinan         | 4.35 | 5.10 | 5.85 | 6.68 | 7.53 | 8.45 | 9.38 |
| Xuzhou        | 3.08 | 3.60 | 4.14 | 4.71 | 5.34 | 5.97 | 6.62 |
| Nanjing       | 9.13 | 10.70| 12.28| 14.00| 15.84| 17.72| 19.67|
| Hangzhou      | 33.48| 39.21| 45.08| 51.37| 58.06| 65.02| 72.17|
| Shanghai      | 44.86| 52.46| 60.34| 68.80| 77.74| 87.10| 96.66|
| Shenzhen      | 37.38| 43.75| 50.23| 57.29| 64.81| 72.57| 80.56|
The accuracy of most of the calculated values is controlled within 10%. It is calculated by MATLAB software that the model passes the accuracy test and the prediction accuracy reaches one level, which is suitable for medium and long-term prediction.

3. Based on the share ratio of high-speed rail express market demand forecast

3.1. Logit model construction

In order to eliminate the widening of the results caused by exponential growth in the general form of the Logit model, the model needs to be improved. After the generalized cost function is averaged, the improved model is:

\[ P_i = \frac{\exp\left(\frac{U_i}{\bar{U}}\right)}{\sum_i \exp\left(\frac{U_i}{\bar{U}}\right)} \]  

(1)

\( P_i \) represents the freight volume sharing rate of transportation mode \( i \).

\( U_i \) represents the generalized cost function of the \( i \)-th transport mode.

\( \bar{U} \) represents the average generalized cost function value for various modes of transport.

\( n \) means that there are \( n \) kinds of transportation modes to choose from, \( n=3 \) in this paper, which are air transportation, road transportation and high-speed rail transportation.

3.2. Generalized cost function

Safety: It is expressed by the cargo damage rate \( D \). The smaller the cargo damage rate, the higher the safety. \( D_i \) is the cargo loss rate of the \( i \)-th transport mode. Let \( i \) be taken as 0.

Reliability: expressed by the punctuality rate \( Z \). According to the 2017 Civil Aviation Industry Development Statistics Bulletin, the punctuality rate of national flights in 2017 is 71.67%; the on-time rate of road transportation is 50%; according to the high-speed rail network, the high-speed railway punctuality rate is 95.4%. Therefore, \( Z_1 = 0.717, 2 = 0.500, \) and \( 3 = 0.954 \).

Rapidity: expressed in total transport time \( T \). \( T_i \) is the total transportation time of the \( i \)-th mode, \( h \) hours, which is calculated as:

\[ T_i = t_i + \frac{l}{v_i} = T \]  

(2)

Among them, \( t_i \) is the average transportation time at both ends of transportation, that is, the loading and unloading time at both ends and the time spent on technical stoppage. It can take high-speed rail for 4h, highway for 1h, and aviation for 6h [6]. \( l \) is the distance between the two places, km; \( v_i \) is the transport speed of the \( i \)-th transport mode, km/h. The whole journey speed of air transport is about 800km/h; the whole road transport speed is about 70 km/h; the high-speed rail express speed takes the travel speed of the train section, which is about 250 km/h.

Economical: The transportation cost \( C \) indicates economics, and the cost is lower and the economy is better. Its calculation formula is:

\[ C_i = e_i l \]  

(3)

Among them, \( C_i \) is the transportation cost of the \( i \)-th transportation mode, \( e_i \) is the freight rate of the \( i \)-th transportation mode, \( l \) is the distance km between the two places. The express freight rate for air transportation is 2.85 yuan/ton kilometer [10]. Taking into account the volatility of highway freight rates, this paper selects the average of the freight index of the LTL freight from Guangzhou to Shanghai from 2013 to 2017. The road transport price of this paper is 0.45 yuan/ton. High-speed rail express freight rate data is relatively small, refer to the current high-speed rail express freight rate announced by China Railway Express, about 2.7 yuan / ton km.
The determination of the generalized cost weight index coefficient has an important impact on the model results. The commonly used methods include Delphi method and AHP method, all of which are qualitative judgments. In this paper, by referring to the relevant data, the weighting coefficients of the generalized cost of express transportation are determined as follows: the weight of the rapid index is 0.79, and the weight of the economic index is 0.21 [7]. The calculation of the generalized cost value uses the following relationship to determine the generalized cost function of the mode of transport,

\[ U_i = \frac{(1 - D_i)}{Z_i} (\alpha_i T_i + \alpha_i C_i) \]  

(4)

3.3. Determination of transport sharing rate

Bring the above data into the formula to find the generalized cost, and obtain the generalized cost of the three modes of transportation according to different transportation distances, then bring into the formula to calculate the sharing rate of the three modes of express transportation. The results calculated by MATLAB are shown in Table 2 and Figure 1.

**Table 2. The Sharing Rate Prediction Result of Different Ways of Express with the Variation of Distance**

| Distance/Km | Air Express | Road Express | High-speed rail express |
|-------------|-------------|--------------|------------------------|
| 100         | 0.2309      | 0.4227       | 0.3463                 |
| 500         | 0.2631      | 0.3729       | 0.3639                 |
| 800         | 0.2673      | 0.3673       | 0.3654                 |
| 1000        | 0.2688      | 0.3654       | 0.3659                 |
| 1500        | 0.2708      | 0.3627       | 0.3665                 |
| 2000        | 0.2718      | 0.3614       | 0.3668                 |
| 2500        | 0.2724      | 0.3606       | 0.3670                 |
| 3000        | 0.2728      | 0.3601       | 0.3671                 |

**Figure 1. The Sharing Rate Prediction Result of Different Ways of Express with the Variation of Distance**
It can be seen from the above results that with the increase of the distance, the sharing rate of aviation and high-speed rail is on the rise, and the sharing rate of road transportation decreases with the increase of distance.

Since the general transport cost considers the price to be the average price, the average price of air transport in real life is the average price of the medium and long distance. When the distance is short, the air traffic is zero and the situation cannot be counted when calculating the average price. When transporting in medium and long distances, the price advantage of air transportation is obvious. Therefore, the proportion of long-distance transport aviation in reality is higher than that of the model. The proportion of air transport in short-distance transport is lower than that of the model.

According to the above data, it can be seen that the high-speed rail express has obvious advantages in distance of more than 500km, occupying an average of 36.36% of the express market.

### 3.4. Potential Market Forecast Results of High-speed Rail Express in National High-speed Railway Hub Cities

Multiply the predicted off-site shipment data by the share rate of the high-speed rail, and obtain the potential market volume of express delivery that can be transported by high-speed rail, that is, high-speed rail express. The forecast results are as follows,

| City       | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|------------|------|------|------|------|------|------|------|
| Shijiazhuang | 1.88 | 2.20 | 2.54 | 2.89 | 3.27 | 3.65 | 4.06 |
| Shenyang    | 1.33 | 1.55 | 1.79 | 2.04 | 2.30 | 2.58 | 2.86 |
| Beijing     | 11.92| 13.94| 16.03| 18.27| 20.65| 23.13| 25.67|
| Zhengzhou   | 2.57 | 3.01 | 3.45 | 3.95 | 4.45 | 4.99 | 5.54 |
| Wuhan       | 3.68 | 4.30 | 4.94 | 5.64 | 6.37 | 7.13 | 7.92 |
| Changsha    | 1.73 | 2.03 | 2.34 | 2.67 | 3.01 | 3.37 | 3.74 |
| Tianjin     | 2.63 | 3.08 | 3.54 | 4.03 | 4.56 | 5.11 | 5.66 |
| Jinan       | 1.58 | 1.85 | 2.13 | 2.43 | 2.74 | 3.07 | 3.41 |
| Xuzhou      | 1.12 | 1.31 | 1.51 | 1.71 | 1.94 | 2.17 | 2.41 |
| Nanjing     | 3.32 | 3.89 | 4.47 | 5.09 | 5.76 | 6.44 | 7.15 |
| Hangzhou    | 12.17| 14.26| 16.39| 18.68| 21.11| 23.64| 26.24|
| Shanghai    | 16.31| 19.07| 21.94| 25.02| 28.27| 31.67| 35.15|
| Shenzhen    | 13.59| 15.91| 18.26| 20.83| 23.56| 26.39| 29.29|
| Total       | 73.83| 86.4 | 99.33| 113.25|127.99|143.34|159.1 |

### 4. Conclusions and prospects

In 2019, the total potential market of high-speed rail express delivery in road network hub cities has reached 7.4 billion pieces, and will exceed 16 billion pieces in 2025. The express shipments of cities will also increase by 2-3 times in the next five years.

This paper only takes the high-speed railway hub as the research object. The next step is to select the research objects according to different scopes, and even to study all high-speed rail cities, so as to predict the potential demand market of small-scale and even China's high-speed rail express.

### Acknowledgments

This work was financially supported by the alumni fund and Century ray.

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