Research on Demand Analysis and Development Prospect of High-Speed Railway Express Market

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Abstract. With the rapid development of e-commerce, the demand for express delivery industry has grown rapidly. Compared with other modes of transportation, the high-speed railway's "high speed, high safety, high punctuality rate" and other characteristics ensure the rapid delivery of goods on time. In order to accurately predict the demand of the high-speed railway express delivery market, this paper collects a large amount of data extensively and processes the data through SPSS software. The extrapolation method and the proportional method were used to predict the demand of the national express delivery market and the national off-site express market demand in 2025. On this basis, the four indicators of safety, reliability, rapidity and economy are selected to construct Logit model for characteristic variables, and MATLAB software is used to calculate the market share of high-speed railway transportation. Finally, calculate the forecast value of China's high-speed rail express business, analyze the prospects of China's high-speed railway express market, and determine the future development direction of the railway industry to achieve efficiency gains and market-oriented reforms, which have certain reference value and practical significance.

1. Introduction

On July 13, 2016, the National Development and Reform Commission, the Ministry of Transport and the China Railway Corporation jointly issued the \textit{Medium and Long-term Railway Network Plan}: It is estimated that by 2020, the total mileage of China's high-speed railway lines will reach 30,000 kilometers, and more than 80% of large and medium-sized cities will be connected. With the rapid development of China's high-speed railway and the comprehensive construction of the high-speed railway network, the transportation speed and transportation efficiency of the railway system have been greatly improved. Under the premise of satisfying passenger capacity, railway transportation enterprises with traditional bulk goods as the main market need to further adjust their development methods, develop new transportation products that meet the needs of the current transportation market, and promote the rapid development of railway enterprises. Therefore, the transportation of high value-added goods has become the market with the highest profit margin and the highest competition in the transportation industry. Based on China's current market environment, the potential market demand and competitiveness of China's high-speed railway expressway need to be studied and analyzed in depth.

Since the 1980s, the research and practice of transporting goods on high-speed railways in some European countries has provided valuable experience for the development of high-speed railway
express transportation in China. At the same time, foreign countries have conducted a lot of research on traffic forecasting. Dejax et al. 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 and better meet the requirements[1]. Gerhard Troche defines high-speed rail freight transport, analyzes the feasibility of high-speed rail freight handling, transit and vehicle technology for high-speed rail express, and also exemplifies rail transport systems in Sweden, Denmark, France and other countries[2]. Guelat et al. applied the balanced distribution method to study the problem of cargo flow distribution and solved the established multi-category cargo flow distribution model[3].

In recent years, China has also conducted a lot of research on high-speed railway freight transportation and railway traffic forecast. Zhang analyzed the status quo of China's railway express cargo transportation, and used the gravity model to predict the freight volume of the freight, and gave a solution to the model of the driving plan[4]. Lin et al. analyzed the feasibility of high-speed railway to carry out express cargo transportation from railway lines, loading and unloading facilities, and rolling stock, and put forward relevant suggestions[5]. Tao used BP neural network and grey neural network (GNN) learning algorithm process to introduce hybrid intelligent algorithm combining artificial neural network and improved particle swarm optimization algorithm into the field of railway traffic forecasting[6]. At present, domestic research is mostly focused on the reform of the passenger transport mode of high-speed railways and the plan for the passenger line. The high-speed railway express delivery market has a short development time, the research problems are not deep enough, and there are few studies on the potential market demand and development prospects of high-speed railway express delivery.

2. High-speed railway express market demand forecast

This paper first analyzes the national express market demand, and predicts the national express market demand and the off-site express market demand in 2025. At the same time, the Logit calculation model of the distributing rate of various transportation modes was constructed, and the predicted value of the high-speed rail express business volume in 2025 was finally obtained.

2.1. National express market demand forecast

According to the collection of historical data, the use of extrapolation method to forecast the national express market demand. Through SPSS software, the time series prediction of express volume is obtained. The results of China's express market demand from 2019 to 2025 are as follows: the R-square of the model is 0.990, which is higher goodness of fit; the significance is 0.991, which is higher. Therefore, the forecast results of the national express delivery market based on historical data using extrapolation are shown in Table 1.

| Years | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|-------|------|------|------|------|------|------|------|
| Predictive value | 590 | 692 | 798 | 909 | 1024 | 1144 | 1269 |
| Speed increase | 20% | 17% | 15% | 14% | 13% | 12% | 11% |

Combined with other research reports on the forecast of express delivery business, such as the National Thirteenth Five-Year Plan for Postal Development, it is pointed out that the business volume of China's express delivery market will reach 70 billion in 2020. This paper predicts that the express delivery volume in 2020 will reach 69.2 billion. The growth rate is 27.6%. Considering that the growth rate of express delivery has started to decline since 2017, it is considered that the growth rate of the express delivery market predicted by this paper is more realistic. Therefore, it is predicted that the national express delivery market will reach 126.9 billion pieces in 2025.
2.2. National off-site express market demand forecast
If in the same city, consumers usually choose road transport instead of high-speed rail when sending couriers. Therefore, this article assumes that the high-speed rail transportation method is only applicable to express delivery services between different cities. After collecting and processing a large amount of historical data from the State Post Bureau, this paper uses the proportional method to analyze the data through Excel tools, and predicts the proportion of the national express delivery volume and the express delivery volume as shown in Table 2.

Table 2. National off-site Express Forecast (100 million pieces).

| Years | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|-------|------|------|------|------|------|------|------|
| Predictive value | 455  | 539  | 628  | 722  | 822  | 928  | 1039 |
| Proportion       | 77.07% | 77.87% | 78.68% | 79.48% | 80.28% | 81.09% | 81.89% |

As can be seen from the data in the table, the proportion of off-site express sales to national express delivery is increasing. In 2025, the amount of express delivery in different places will account for 81.89% of the national express delivery. Combined with the forecast of 2025 national express delivery volume of 126.9 billion pieces, the predicted value of national off-site express delivery in 2025 is 103.9 million pieces.

2.3. Transportation mode distributing rate calculation
The distribution ratio of transportation mode is the distribution probability of goods flow in two or more modes of transportation, representing the market share occupied by various modes of transportation[7]. The Logit model is a more mature method in the allocation rate calculation. Since the main competitors of high-speed rail express include air transport and road transport, this paper applies the Logit model to predict the distribution ratio between high-speed rail transport and air transport and road transport in the market.

2.3.1. Logit model construction. In order to eliminate the difference in 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:

\[ P_i = \frac{\exp \left(\frac{U_i}{\bar{U}}\right)}{\sum_{i=1}^{n} \exp \left(\frac{U_i}{\bar{U}}\right)} \]  

where \( P_i \) indicates the freight distribution ratio of transportation mode \( i \); \( U_i \) indicates generalized cost function of transport mode \( i \); \( \bar{U} \) indicates average generalized cost function value for various modes of transport; \( n \) indicates type of transportation, \( n = 3 \) three types are air transport, road transport and high-speed rail transport.

2.3.2. Generalized cost function. Based on the analysis of the economic and technical characteristics of different modes of transportation, the expressions of the generalized cost function are constructed from four indicators: transportation safety, reliability, rapidity and economy. The generalized function of the mode of transport is denoted by \( U \), and the four characteristic indicators of various modes of transport are quantified as follows:

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 transport mode \( i \). Generally speaking, the loading and unloading methods, tools and times have a great influence on the integrity of the goods, but this is negligible with the improvement of the cargo handling hardware facilities. Therefore, the cargo damage rate \( D_i \) of various modes of transportation in the model can be taken as 0.

Reliability: Expressed by the punctuality rate \( Z \). The smaller the environmental impact, the higher the punctuality rate, and \( Z_i \) is the punctual rate of transport mode \( i \). According to the 2017 Civil Aviation Industry Development Statistics Bulletin, the punctuality rate of national flights in 2017 was...
71.67%; the on-time rate of road transportation was 50%; according to the data of the high-speed rail network, the high-speed railway punctuality rate was 95.4%, $Z_1=0.717$, $Z_2=0.500$, $Z_3=0.954$.

Rapidity: Expressed in total transport time $T$. $T_i$ is the total transportation time of mode $i$, in hours, which is calculated formula is:

$$T_i = t_i + \frac{l}{v_i}$$

(2)

where $t_i$ indicates average residence time at both ends of transport. After consulting the information, define high-speed rail transportation for 4 hours, road transportation for 1 hour, and air transportation for 6 hours. $l$ indicates distance between the two places, km; $v_i$ indicates transport speed of transport mode $i$, 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 300 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)

where $C_i$ indicates transportation cost of transportation mode $i$; $e_i$ indicates the freight rate of transport mode $i$; $l$ indicates distance between the two places, km. The express freight rate for air transportation is 2.85 yuan/ton km. The data comes from *China's Civil Aviation Industry Development Statistics Bulletin*. 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 the express mode are determined as follows: the rapid index weight $a_1=0.79$, and the economic index weight $a_2=0.21$. According to the principle of additive multiplication, the following relationship is used to determine the generalized cost function of the mode of transport:

$$U_i = \frac{(1 - D_i)}{Z_i} \left( a_1 T_i + a_2 C_i \right)$$

(4)

2.3.3. Transportation mode distributing rate. After the quantitative data is brought into the formula to obtain the generalized cost, the generalized cost of the three modes of transportation is obtained according to different transportation distances. Finally, the formula is used to calculate the distribution rate of the three express modes. The results calculated by MATLAB are shown in Table 3.

| Distance(km) | Air       | Road      | High-speed Railway |
|-------------|-----------|-----------|--------------------|
| 100         | 0.0909    | 0.7227    | 0.1864             |
| 500         | 0.1631    | 0.4929    | 0.3440             |
| 800         | 0.2173    | 0.4336    | 0.3491             |
| 1000        | 0.2207    | 0.4134    | 0.3659             |
| 1500        | 0.2308    | 0.3927    | 0.3765             |
| 2000        | 0.2368    | 0.3914    | 0.3718             |
| 2500        | 0.2424    | 0.3886    | 0.3690             |
| 3000        | 0.2695    | 0.3734    | 0.3571             |
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 generalized transportation cost considers the price to be the average price, when the distance is short, the air transportation volume is zero, and the situation cannot be counted. In reality, the proportion of long-distance transport aviation is higher than that of the model, and the proportion is lower than the result 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, and the highest sharing rate is from 1500km to 2000km. Since the generalized cost model cannot fully consider all the factors in the actual situation, the result has certain discrepancies with the actual situation.

2.3.4. *High-speed railway express market demand forecast results.* Since most of the high-speed rail stops at more than 100 kilometers, the average rate of high-speed rail transportation is obtained based on the high-speed rail transportation rate of 500km-3000km. According to Section 2.3.2, the forecast value of the national off-site express volume in 2025 is 103.9 million pieces, multiplied by the average share rate of high-speed rail transport by 36.19%, and the forecast quantity of high-speed rail express delivery is 37.601 billion pieces.

3. Analysis of the prospect of high-speed railway express delivery market

3.1. *High-speed railway express delivery has broad prospects*  
According to the previous predictions, the business volume of China's high-speed railway express delivery market will reach 37.601 billion in 2025, with broad development prospects and huge market potential. At the same time, the construction of high-speed railway network provides a good transportation network foundation for high-speed rail express. At present, China Railway Express has extended the express service network to 505 cities/sites covered by all high-speed railway lines in the country, and basically achieved full coverage of municipalities, provincial capitals, prefecture-level cities in the central and eastern regions, and economically developed counties. Under the background of the “four vertical and four horizontal” high-speed railway network and the comprehensive construction of the “eight vertical and eight horizontal” road network, it is imperative to promote the development of the local express delivery industry through high-speed rail express. Under the background of the state's support for “mixed reform”, the State Railway Administration will improve its drawbacks in cooperation with private express delivery companies, continuously improve service quality, and expand supply, which is a good way to increase revenue.

3.2. *High-speed railway express market share increased*  
As the business scope of the trial operation of high-speed railway continues to expand, as a new type of express operation mode, high-speed rail express has gradually highlighted a certain degree of competitiveness. According to the demand forecast of China's high-speed railway express market and the forecast value of express delivery business of China's high-speed rail main node cities, it can be seen that there is a huge market growth space for high-speed rail express. For express delivery companies, it is their greatest appeal to deliver goods to customers on time, quickly and economically. High-speed rail transportation is basically not limited by climate, geographical location and road conditions. Compared with aviation and highways, it has high reliability and can better meet these demands. At the same time, the speed of high-speed rail express transport vehicles is generally 250km/m and above, which is three times the speed of road transport, and reaches about 1/2 of the speed of air transport. Compared with the traditional line package, it has obvious advantages in terms of timeliness. The ability of the high-speed rail in the transportation speed can be adapted to the express service time regulations, and the business realization of the day and the next day is guaranteed. It can be seen that there is still a large room for growth in the market share of high-speed rail express.
3.3. High-speed rail express business has become a trend
Driven by the growing demand for express logistics, with the continuous breakthrough of high-speed rail express transportation technology, high-speed rail express will become a trend in the future. In addition to fresh fruits and vegetables, express parcels, expensive jewelry, high-end digital products, medical supplies, etc. can open high-speed rail transport mode. The advantages of high-speed rail express network, speed, cost and reliability will have a major impact on the current domestic express and freight development pattern. Each car of the sports car with a speed of 250km/h or more is fully open, and the side of the car can be opened in a large format. The forklift can directly load and unload cargo. After the implementation of container loading and unloading, labor costs are reduced and transportation efficiency is improved. In addition, the cargo sports car group adopts virtual assembly and in-transit management system. Each container has its own fixed position on the EMU, so that the transport personnel can accurately inspect the status information of all the containers on the car in the escort room. It ensures the safe and reliable transportation of goods.

4. Conclusions
At this stage, China has built the world's most developed high-speed railway network, providing an opportunity for high-speed rail freight reform. Faced with broad development prospects, the high-speed railway department should give full play to the advantages of high-speed railway safety, rapidity, high punctuality rate and low cost, accelerate the layout of high-speed rail express service outlets, enhance the competitiveness of high-speed rail express, and improve economic efficiency. With the further optimization and improvement of the research model, factors affecting the development of the high-speed rail express market should be considered more comprehensively, and the accuracy of prediction should be improved. The research in this paper provides theoretical support for the development of China's high-speed rail express, and provides reference and reference for further promotion of high-speed rail express.

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