

The Draft Strategy of Freight Trains in China

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Abstract: This paper proposes a draft strategy of driverless freight trains in China for the future development from the prospective of railway company. The first step is to indicate that the current situation of freight trains at home and abroad. Then use quantitative analysis to predict the possible freight volume in ten years by using the data collected from the national bureau statistics, and briefly introduce the goal of the rail development in fifteen years. Further propose the vision of the driverless freight trains strategy in China and state the key stakeholders which have interests with the railway company. The following steps are taken to achieve the vision by divided the goal into three stages, short-term plan, mid-term plan and long-term plan, followed by the evolution, advantages, disadvantages, improvements and further study. In conclusion, summarizes the strategy of the driverless freight trains in China, and puts forward the suggestion that other intelligent operations can be applied for the freight loading and unloading, to achieve the whole process of freight transport fully-automatic. And also such technology can be used in other modes of transportation.

Keywords: Freight Trains; Second Exponential Smoothing Method; Double Moving Average Method

Glossary of Terms / List of Abbreviations

Term	Explanation / Meaning / Definition
RMB	Renmingbi (currency in China)

1. Introduction

Currently, with the rapid development of social economy, the freight transportation also comes to its opportunity period for the development. Railway, with the advantages of large volume, fast speed, low energy consumption, less pollution, safety and reliability, get a prospective development among different kinds of transportation. The rail transportation not only transfers the materials related to people's livelihood such as coal, oil, timber and so on, but also develops the new freight products suitable for e-commerce platform.

Therefore, as the railway company, aiming to achieve freight trains driverless, can make the whole transportation process more efficient, less man-labour, and cater to the high-tech eras.

1.1 Scope

Mainly discuss the strategy applying in the railway, for trains running among cities. For the urban transportation, trains such as metro and trams are not included in the proposed strategy. As metro and trams in China are designed for passenger use and the freight are transferred by road more efficient when in the city.

1.2 Methodology

Gather the data freight volume from the national bureau of statistics. Then use quantitative analysis, second exponential smoothing method and double moving average method, to make a prediction of the possible freight volume in the future.

2. Background

2.1 Current situation

2.1.1 Freight trains in the world

French rail company plans to introduce driverless trains for both passenger and freight by 2023, gradually rolling them out on the main lines in the country. (Wang, 2018) The president of French rail company said in the statement that with the driverless trains, all trains will operate in coordination and at the same speed. The rail system will be much smoother. (Guillaume Pepy, 2018) The company hopes that the introduction of the driverless trains will lead to more trains running on the busiest lines and lower energy consumption.

The American Railway Association' testing institution demonstrated an experiment in last summer, with 30 freight trains all fitted with driverless train software developed by New York's Air Braking Company, run on a 48-mile rail line. The experiment was completed successful. (CISAI, 2020)

Australia has already implemented the operation of heavy-haul freight trains. A local mining company named Rio Tinto has developed an unmanned system for transporting iron ore across hundreds of miles of rail transit. This system is called AutoHaul, combined with the technology from Australia, Japan and United States, and invested a total of 940 million Australian dollar for construction and operation. The AutoHaul system keeps trains running safely by collecting and processing data of their position, length and weight to determine the optimal speed. (Railway viewpoint, 2019)

2.1.2 Freight trains in China

Railway freight trains have played an important role in promoting economic growth. As an important mode of transportation for bulk goods, railways have promoted the flow of commodities and aromatic power. Also, it is important in the unblocking the domestic circulation channel. The main economic indicators of railway transportation, such as freight volume and freight turnover, firmly rank first in the world. (Jiang, 2023)

However, the driverless freight trains in China have not put into use currently. Though there are nine unmanned rail lines in operation in China, there are almost metro lines, for passenger use. For example, Beijing Capital Airport Line, Shanghai Rail Transit Line 10, Hong Kong South Island Line. And the Changsha Maglev line, the first medium and low speed maglev railway with fully independent intellectual property rights on China, was put into operation on May 6, 2016. Figure 1 is the Zhujiang New Town Automated People Mover, the first underground driverless system in the world, which was put into use on November 2010, and the maximum running speed is 55 km/h. (Rail Transit Network, 2020)



Figure 1 – Zhujiang New Town Automated People Mover (Rail Transit Network, 2020)

2.2 The freight volume in China

According to the results published by the national bureau of statistics, the goods transferred by rail in China increased in recent five years. With 4.03 billion tons in 2018 (National Bureau of Statistics, 2019), 4.32 billion tons in 2019 (National Bureau of Statistics,

2020), 4.46 billion tons in 2020 (National Bureau of Stastics, 2021), 4.72 billion tons in 2021 (National Bureau of Stastics, 2022), 4.93 billion tons in 2022 (National Bureau of Stastics, 2023).

2.3 Possible futures

2.3.1 The possible freight volume transferred by railway in 30 years

Based on the data published on the National Bureau of Statistics, the freight volume transferred by railway from 2013 to 2022 can be seen as follows.

Table 1 –Freight volume transferred by railway in China from 2013 to 2022

No.	Year	Freight Volume (billion tons)
1	2013	3.97
2	2014	3.81
3	2015	2.53
4	2016	3.33
5	2017	3.69
6	2018	4.03
7	2019	4.32
8	2020	4.46
9	2021	4.72
10	2022	4.93

(Figure from *National Bureau of Stastics of China*)

Then, make a line graph according to the railway freight volumes.

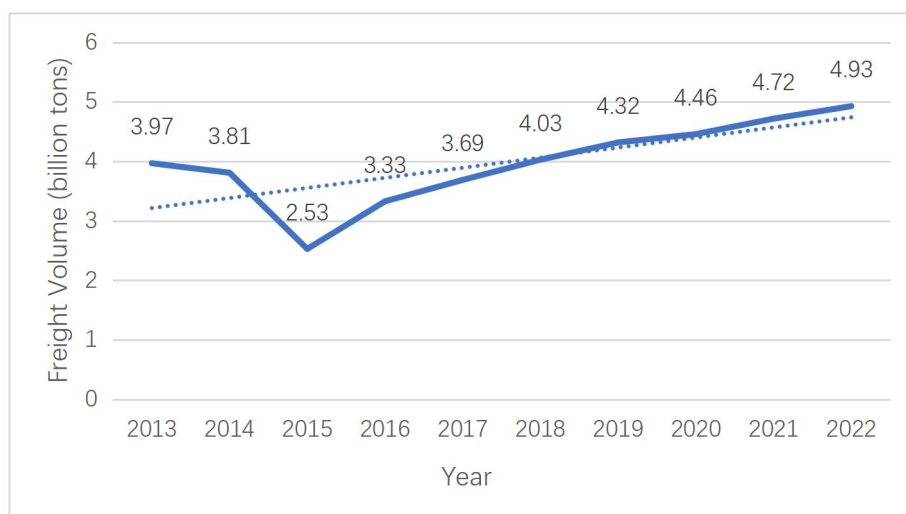


Figure 2– Freight volume transferred by trains in China from 2013 to 2022 (Fei Wang, 2023)

In terms of the possible freight volume in the future, make a prediction by using second exponential smoothing method proposed by Robert G..Brown and double moving average method.

It shows that the figures have a fluctuation bewteen the year 2014 and the year 2016, but the overall trend is increase. Therefore, assume the weighting coefficient α values 0.3 while using second exponential smoothing method.

The calculation results of second exponential smoothing method are in *Table 2*.

Table 2 –Calculation results of the second exponential smoothing method (Fei Wang, 2023)

No.	Year	Freight Volume	$F_t^{(1)}$	$F_t^{(2)}$
1	2013	3.97	3.97	3.97
2	2014	3.81	3.92	3.96

3	2015	2.53	3.50	3.82
4	2016	3.33	3.45	3.71
5	2017	3.69	3.52	3.65
6	2018	4.03	3.68	3.66
7	2019	4.32	3.87	3.72
8	2020	4.46	4.05	3.82
9	2021	4.72	4.25	3.95
10	2022	4.93	4.45	4.10

$$a_7 = 2 F_{10}^{(1)} - F_{10}^{(2)} = 4.8$$

$$b_7 = [\alpha \div (1 - \alpha)] [F_{10}^{(1)} - F_{10}^{(2)}] = 0.15$$

$$y_{10+10} = 4.8 + 0.15 \times 10 = 6.3 \text{ billion tons}$$

Therefore, in the year 2033, there will be 6.3 billion tons of freight transferred by railway under the calculation of second exponential smoothing method.

In a similar way, the double moving average method results are in *Table 3*.

Table 3 –Calculation results of the moving average method (Fei Wang, 2023)

No.	Year	Freight Volume	$M_t^{(1)}$	$M_t^{(2)}$
1	2013	3.97		
2	2014	3.81		
3	2015	2.53		
4	2016	3.33		
5	2017	3.69		
6	2018	4.03		
7	2019	4.32		
8	2020	4.46		
9	2021	4.72	4.59	
10	2022	4.93	4.83	4.71

$$a_7 = 2 M_{10}^{(1)} - M_{10}^{(2)} = 4.95$$

$$b_7 = [2/(n-1)] [M_{10}^{(1)} - M_{10}^{(2)}] = 0.24$$

$$y_{10+10} = 4.95 + 0.24 \times 10 = 7.35 \text{ billion tons}$$

Therefore, in the year 2033, there would be 7.35 billion tons of freight transferred by railway under the calculation of double moving average method.

Combine with the current development trend, and take the natural resources demand and advantages of railway into consideration, the latter result 7.35 billion tons is more likely to be reached.

2.3.2 The goals of development of railway in China

The total length of railway will reach about 200,000 kilometres by the year 2035, including 70,000 kilometres' length of high-speed trains. Up to August,2020, the figure for the length of railway was 141,400 kilometres. (Govnet of China, 2020)

2.3.3 Overall

In the following fifteen years, the freight volume transferred by railway will over double while the rail lines would face overloaded used. As the railway company, increase the operating logarithm running trains may be a feasible way, but the cost of each trains can be expensive. Therefore, apply advanced technology as the strategy to achieve huge volume of freight transport can not only save investment, but also improve the efficiency during the whole process.

3. The goal and the support partners of the strategy

3.1 Vision

In the future, with the increase of goods, the driverless technology will be used on the freight trains. This technology will allow freight be transported day and night without interruption, reducing manual operation and improving the capability of the rail lines. More special railway lines will be built and more central control rooms will be construct for information processing and train monitoring. Also, there will be advanced artificial intelligence applied in the freight transfer, beginning with the goods scan, allocation, and ending at distribution by the robots automatically.

In terms of transport, the driverless technology can make the whole process more efficient, safer, less energy consumption, and improve the flexibility.

3.2 Commentary on the key stakeholders

3.2.1 Railway company

To achieve driverless goal, railway company need to cooperate with the technical institution and afford the basic facilities. Costs include operations cost, staff costs, building and maintenance costs, and as the haulier role, there are also insurance costs. Profits can be made via the freight fare paid by the shippers and ticket fare paid by the passengers.

3.2.2 Government

It carries out favourable policies and invest money to support railway department for both political and economic development and raises fund to the technical institutions for science development.

3.2.3 Technical department

Developing the advanced technology, generally the investment is supported by the government. Once the technology has been developed, the department can cooperate with railway company. Then railway company has the right to take advantage of the driverless operation.

3.2.4 Shipper

As the shipper, when hand the freight to the railway, there is a necessity to pay the freight fare. This is a way for the railway company to make money.

3.2.5 Bank

Railway company will get a loan from the bank as the support of the costs of operation and construction.

3.2.6 Railway station staff

Staff who work in the railway stations should guarantee the normal and save operation, including check the trains, locomotives, rail lines, signals, turnout, catenary, train circuit etc.

4. The plan for the strategy freight trains in China

4.1 The separate steps for the draft strategy

4.1.1 Short-term plan

It will take several years to develop the technology and plan the construction.

As the first unmanned railway freight marshalling station has already operated (Yutian, 2021), the technology can be shared and applied in more and more stations for freight transport.

For one thing, advance the driverless technology which can apply in the freight trains. Railway company is supposed to cooperate with technical institution, followed by learning the operation process, computer control and staff training. The driverless technology in the first step mainly refers to the simulation, testing and optimization. Also gather data including energy consuming, speed test, labour consuming. Analyse the line utilization capacity and the freight transport efficiency, in order to optimize the operation pattern, improving the overall efficiency and saving costs.

For another, design and plan the construction of stations and rail lines for the operation of the driverless freight trains, including the building of the control centres, signalling rooms, and new freight rail lines.

4.1.2 Mid-term plan

In the second step of achieving the vision, driverless freight trains should be operated in the actual operation situation. Nearly half of the freight trains will be run automatically, and the efficiency of freight transfer will be improved greatly. At that time, government will continue to support railway company to achieve freight transport at a full-automatic level, and the driverless system will be perfected to guarantee the operation running safely.

Besides, with the freight volume increase in ten years according to the calculation, the result will be less than twice than today's transfer volume, but the railway lines' construction in the goal of the national's development cannot catch the pace with the sharp increase of freight. Therefore, it is necessary to change technically to improve the line utilization capacity, operation efficiency, and increase the pairs of the operational freight trains.

Apply the driverless freight trains can shorten the man-operated time, so as to save time to transfer more goods on the certain rail lines.

4.1.3 Long-term plan

In the long run, more than ten years from 2030, more than half or even all freight trains will be equipped with driverless system, and most work at train stations such as marshalling stations, district stations and intermediate stations refer to freight work also can be accomplished automatically. This can greatly improve the freight transportation capacity, line utilization capacity and save cost.

4.2 Analysis of the driverless strategy

In this driverless strategy, the main fund will be supported by the government and bank to encourage the advanced technology development. Especially with the development of high-speed railway, more and more intelligent technology will be applied. Government will support billions of RMB for both science research and railway construction.

Although the shippers will pay the transfer fare and passengers will pay the tickets while travelling, the money received by the railway company need to afford the basic expense, such as salaries, maintenance and insurance.

The profits of the railway company, to a great degree, depends on the freight volume and passengers flow. If the income from freight and passengers exceeds than the expenditure, then the railway company can make a money. Vice versa. However, bank will still load fund and government will make up for the loss, as the railway is the state-owned business in China.

In the prediction of the freight volume, it presents an upward trend in the future, also with the development of the railway, there will be more and more people choose to travel by trains, so it is a way for railway company to reduce losses by attracting travellers.

4.3 Strengths

The driverless freight trains do have some advantages in the strategy development.

Firstly, the driverless trains can decrease manual operation. They are high likely to be in time and stable. The technology avoids some human errors and accidents, guarantees safety for both freight and staff, and lowers the risks of paying the loss.

Secondly, improve the line utilization capacity, freight can be transferred with much higher efficiency and shorter time. At the same time, shippers will be happy to see the freight being transferred smoothly, and this can attract more stakeholders to choose railway company and bring more investment, which is beneficial for the later stage construction.

Thirdly, driverless freight trains are much more flexible, this character can reduce the impact of human involvement on operational efficiency. Trains are being controlled by the automatic system and central room, which save labour consuming and improve the flexibility of the whole railway network.

Besides, the driverless trains can force relevant industries to use more intelligent products. For example, robots to move the freight to the warehouse, automatic machines to finish the information process, make the whole transport more smart and efficient.

What is more, the advanced technology can improve the popularity and competitiveness in the world. It has positively political and economic effects.

4.3.1 Weakness and improvements

Like the coin, everything has two sides. For the driverless freight trains, the first thing will lead to is that many people will lose their job. Either the trains drivers or the general working staff like the signalling man as the trains are controlled automatically. Moreover, if the system has somewhere gone wrong, such as cracker attacking, short circuit, or equipment failure, then the consequences can be catastrophic. At least the failure system will influence the following operation.

Therefore, as the improvement, government can provide some job opportunities for the laid-off workers, or send them back in school to learn other skills for the job hunting. Strengthen the system protection and back-up plan, guarantee the system can run safely in any emergent situation.

4.3.2 Further study

The strategy only focus on the freight transport, so in the future, before the freight loaded onto the trains and after the freight unloaded from the trains, there are operations needed to be optimized. We still need to develop the science and technology to make the whole transfer process fully-automatic, from information processing to distribution.

5. Conclusions

5.1 Findings

In this strategy of driverless freight trains in China, the freight volume in the future will increase as shown in the calculation. And the foal of the railway development is to reach a total length of about 200,000 kilometres by the year 2035. As the strategy is divided into three stages, short-term step, by the year 2025, mid-term step, by the year 2030, and long-term step, different objectives should be finished for each stages. Government and bank will support the fund for the railway company to construct, and the fare the freight and passengers can be the profits to earn the money.

Overall, the driverless freight trains can decrease human errors, improve the operational flexibility and the transport efficiency. Promote the political and economic development.

5.2 Recommendations

Additional automatic operations can be developed for the freight loading and uploading. Computers, conveyor belts, robots and other high-technical equipment can do the information processing, transfer the freight in the warehouse and on the road intelligently, achieving the freight transport full-automatic.

Besides the railway, the driverless technology can apply in the road transport, and the automatic operations such as data process and distribution, can use in the air transport and water transport. For advanced technology in the whole transportation industry, promoting the political and economic development significantly.

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