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Research on Coupling and Coordination of Rail Demand Market

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***Abstract*—Under the new pattern of "double cycle", promoting the quality development of railway infrastructure construction has become an important support point for the sound development of the economy and society. However, under the new pattern, there is still no accurate direction on how to build railway infrastructure under the background of double circulation to achieve better two-way development. Therefore, in this study, we collected relevant data on the railway track development status from 2012 to 2020, judged the current railway track industry development status through the compertz curve model, and established an index system to comprehensively evaluate the coupling degree of the railway track industry demand market, So as to get practical conclusions and provide directions for the development of the railway track industry.**

Keywords—Double cycle; industrial development status; demand market; coupling and coordination;

I. INTRODUCTION

With the rapid development of my country's high-speed railways and the steady improvement of people's living standards, high-speed railways are quietly changing people's lifestyles[1].Railway stations serve as a basic and strategic resource to enhance the competitiveness of cities[2].

At the same time, as the link between the urban agglomeration regions, the intercity railway is the foundation of the rapid social and economic development. Studying the influence mechanism of intercity railway passenger transport demand has very important practical significance for grasping the distribution characteristics and changing laws of intercity railway passenger transport volume. By analyzing the impact of potential variables such as transportation facilities, transportation costs, and economic conditions on the demand for intercity railway passenger transportation[3].

In order to promote the matching and coordination of high-speed railway passenger transport demand and market resources, and promote the dual-cycle development of the railway track industry, through the analysis of the components of the railway track demand market, the closed-loop feedback path between the various subsystems is revealed, and the mechanism of the railway track demand market coupling and coordination is explored to construct the subsystems. The development level evaluation index system, the calculation method of coupling coordination degree is proposed, and the empirical analysis with the relevant data of China's railway track industry as an example, it is concluded that the railway track demand market has been transformed from barely coordinated to well-coordinated edge, while verifying the coupling of the railway track demand market Coordination can fully reflect the level of system coordination, help to explore the limiting factors that hinder the sustainable development of the system, and provide a theoretical basis for the development of the railway infrastructure industry and efficient configuration[4].

II. SELECTION OF RESEARCH MODELS FOR RAILWAY INFRASTRUCTURE INDUSTRY

In this research, we obtained fitting data of various research indicators through channels such as the China Statistical Yearbook and the official website of China Railway Corporation.

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In practice, the commonly used method to predict market development is the Compertz model. The accuracy of the model's prediction is very high, especially when the test rounds exceed 1/3 of the total rounds. We use the data obtained to establish a Compertz curve model. This model can show the stage of the development of China's railway infrastructure industry through the development of these years. There will be different evaluation results for different stages of development.

Then an index system is established to evaluate the railway infrastructure demand market, and the coupling coordination degree model is used to analyze the level of coordinated development of things. Coupling degree refers to the interactive influence between two or more systems to achieve a dynamic relationship of coordinated development, which can reflect the degree of mutual dependence and mutual restriction between systems. Coordination degree refers to the degree of benign coupling in the coupling interaction relationship, which can reflect the quality of coordination. By selecting the corresponding index data, four systems of railway transportation volume demand, railway development status, economic development status and population status have been established. The degree of coordination of the development of these four systems has played a role in the development of China's railway infrastructure market to a certain extent. critical use.

The above are the models selected in this research and the reasons for the selection.

III. Analysis of Railway Infrastructure Market Model

A. Compertz Curve Model of Railway Infrastructure Industry

Based on the preliminary observation of the data of this research, it is judged that the railway infrastructure industry has become saturated and will soon enter the mature period of the industry. The compertz curve model belongs to the growth curve regression prediction method, which is mostly used for product development stage analysis. In order to better judge the development status of the railway infrastructure industry, the compertz curve model is used to analyze the development stage of the railway infrastructure industry.

The form of the compertz curve model is:

$$\hat{y} = ka^{b^t} \tag{1}$$

The form of the compertz curve depends on the values of parameters k, a, and b. K, a, and b are undetermined parameters used to describe the laws of industrial life.

Select the railway industry growth rate data for a total of 9 years from 2012 to 2020, divided into three groups, each group has 3 data points, and t represents the sequence of time and takes t1=0.

The specific values of the corresponding k, a, and b can be calculated, and the fitting model is obtained as:

$$y = 1.23 * 0.74^{(-0.86)^t} \tag{2}$$

Draw a scatter plot according to this fitting model as shown below:

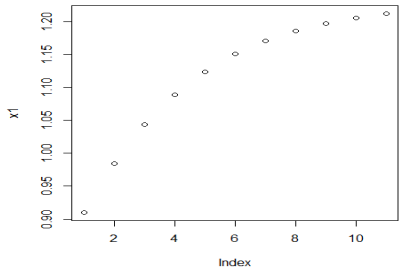

Figure 1. Scatter diagram of the fitting status of the compertz curve model

From this, it can be judged that the current railway infrastructure industry market development has become saturated. According to the industry life cycle theory, from 2021-2032, the growth rate of China's railway infrastructure industry will be relatively stable, and the development of China's railway infrastructure industry will enter a mature period.

B. Coupling and Coordination Model of Railway Infrastructure Industry Development

The degree of coupling and coordination can fully reflect the strength of the coupling effect between the systems and the overall coordination performance. Drawing lessons from the model of coupling and coordination in physics, based on the use of the optimal sequence diagram method to calculate the comprehensive development level of each subsystem, the track traffic demand, Rail development status, economic development status, and population status build a model of coupling coordination degree of rail demand market, and evaluate the overall coordinated development status based on the evaluation criteria of coordination degree. The construction steps of the coupling coordination degree model are as follows.

1)Calculate the development level of each system

Use the function to calculate the development level of the four major systems of railway transportation volume demand, railway development status, economic development status and population status. The function formula is:

$$U_i = \sum_{j=1}^{n} u'_{ij} \lambda_{i_j} \tag{3}$$

2)Calculate the comprehensive evaluation index of the system

The coordination index T value represents the development level of the system. The larger the T value, the higher the system development level. The system development status is related to the construction of four major indicators. The calculation formula is:

$$T = \beta_1 U_1 + \beta_2 U_2 + \cdots \tag{4}$$

3)Calculate the degree of system coupling

Coupling degree refers to the interaction between the elements of the four major systems of rail transportation volume demand, rail development status, economic development status, and population status. The calculation formula is:

$$C = 4 \times \left[\frac{U_1 \cdot U_2 \cdot U_3 \cdot U_4}{(U_1+U_2+U_3+U_4)^4}\right]^{\frac{1}{4}} \quad (5)$$

4）Calculate the degree of system coupling and coordination

Coupling coordination degree focuses on describing the degree of coupling development between systems, and the calculation formula is:

$$D = \mathrm{sqrt}(C^{*}T) \quad (6)$$

In order to better analyze the coupling and coordination of road passenger transport demand, railway development status, economic development status, and population status from a quantitative perspective, the coupling coordination level is divided, and the results of the division are shown in the following table:

Table 1 Classification standard of coupling coordination degree

D value range	Degree of coupling coordination
[0.5~0.6)	Barely coordination
[0.6~0.7)	Primary coordination
[0.7~0.8)	Intermediate coordinate
[0.8~0.9)	Good coordination

Calculate the weight of each indicator element through the optimal sequence diagram method and bring the weight of each indicator element into the coupling coordination model to calculate the coupling coordination degree result. Compared with the coupling coordination degree classification standard, the coupling coordination degree of each year can be judged.

The calculation results show that the overall coordination degree of rail demand market coupling between 2014 and 2020 has shown an upward trend, from 0.547 in 2014 to 0.805 in 2020. The maximum value is 0.848 in 2018 and the minimum value is 0.547 in 2014. The state of coordination ranges from barely coordinated to well coordinated to intermediate coordination and finally to good coordination. The analysis of the changes in the degree of coupling and coordination at different stages is as follows:

TABLE 2 CALCULATION RESULTS OF COUPLING COORDINATION DEGREE

year	C value	T value	D value	Degree of coupling coordination
2014	0.852	0.351	0.547	Barely coordination
2015	0.819	0.416	0.583	Barely coordination
2016	0.703	0.504	0.596	Barely coordination
2017	0.986	0.697	0.829	Good coordination
2018	0.946	0.761	0.848	Good coordination
2019	0.678	0.876	0.77	Intermediate coordinate
2020	0.887	0.73	0.805	Good coordination

From 2014 to 2016, the coupling and coordination status of the rail demand market was barely coordinated. China’s huge population base and vast territory have determined the prosperous rail demand in China. However, at this stage, the railway development status is poor and the overall track construction level is low. To meet China's strong transportation demand, from a macro perspective, China's economic development level is lower than the average at this stage, and it has not yet formed a backfeed to the rail infrastructure industry. It can be seen that the interaction between railway traffic demand, railway development status, economic development status, and population status is weak at this stage, and the benefits of coordinated development are at a relatively low level.

From 2017 to 2018, the coupling and coordination status of the rail demand market was well coordinated. In 2017, China’s “four horizontal and four vertical” high-speed rail network was officially completed. Under this background, the railway development situation has fully adapted to the demand situation, and the overall coupling and coordination level has been continuously improved.

From 2019 to 2020, due to the impact of the new crown epidemic, demand has been hit. Under such a background, the reduction in demand has had an impact on the degree of coupling and coordination of the rail demand market in the initial stage. Therefore, the overall coupling level will drop slightly in 2019 and become a mid-level coordination. However, in 2020, under China's effective epidemic prevention work, China's track development status, economic development status, and population status are all affected on a large scale, so the degree of coupling coordination has returned to good coordination.

IV. CONCLUSION

As the research institute surfaced, the development of China's railway track infrastructure industry has entered a mature stage. Based on the analysis of coupling and coordination, we can see that China's railway track demand market has a good degree of coordination. China’s huge territory and population are also important factors influencing China’s railway track demand market. In recent years, China’s economic construction has achieved remarkable results, neutralizing the pressure on the railway track industry to a certain extent, but the development of the railway industry and the development of demand are not synchronized. Objectively, this will be an issue that the Chinese government needs to pay attention to in the next step.

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