



Research on the Relationship between Railway Passenger Volume and Tourism Development in China

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Abstract. To enhance railway construction in the "14th Five-Year Plan" and expedite modern infrastructure, optimizing railway passenger flow deployment is crucial. This study analyzes the interplay between railway passenger volume and tourism development using 2005-2022 monthly data. It considers economic, transportation, and other travel modes as control variables, and innovatively analyzing the interplay between railway passenger volume and tourism. For the long-term relationship, cointegration analysis and error correction models were employed to analyze the impact and dynamic adjustments of tourism development and other factors. For the local analysis, this paper focuses on the classical linear regression from 2019 to 2022, and deeply analyzes the development status and construction direction of the influencing factors by comparing them with the long-term relationship. The study finds that there is a long-term cointegration relationship between railway passenger volume and the above variables, and there is also a significant relationship between tourism and passenger volume in the short term. However, railway passenger volume is not the Granger cause of tourism development, and the interaction mechanism between the two needs to be optimized. In view of the above empirical results, the policy implications of this paper are as follows: railway construction should give consideration to interaction and coordination, and actively promote the industrial integration development of "tourism+", so as to realize the quality improvement and upgrading of the deep integration.

Keywords: Railway passenger volume, tourism, time series, error correction model

1 Introduction

With the vigorous development of China's economy and the improvement of people's quality of life, tourism has become a key pillar of the national economy. Currently, China's tourism industry is in the transition period from extensive to intensive. However, the supply of high-quality tourism products is still insufficient, while the supply of low-quality and ineffective products is excessive. Transportation, as an important part of tourism system, is not only an important way to measure the level of tourism

development, but also a bridge connecting tourist destinations and tourists. Among them, railway transportation plays a pivotal role in tourism travel. National policies attach great importance to the development of tourism. "The 14th Five-Year Plan for the Development of Tourism Industry" points out that tourism industry should focus on transformation and upgrading, improving quality and efficiency. The Ministry of Transport and several departments jointly issued the "Several Opinions on Promoting the Integrated Development of Transport and Tourism", which promoted the integration of transport and tourism to an industry hot spot. In particular, the issuance of "The Outline of Building a Transport Power" points out the direction for the integrated development of transport and tourism.

By the end of 2023, China's railway operating mileage has exceeded 159,000 kilometers. With wider network coverage, faster operating speeds, and lower costs, the railway has deeply integrated into the daily lives of Chinese residents, becoming an important choice for travel. High-speed railways, with their "time-space convergence" and "organization-space coordination" effects brought by their speed advantages, are reshaping the spatial structure of regional tourism and enhancing its gateway effect, further highlighting the intrinsic connection between the railway and the tourism industry.

Therefore, this paper uses railway passenger volume as the dependent variable and the number of travel agencies as the key explanatory variable. It constructs a cointegration and error correction model to explore the interactive relationship.

Domestic research on railway construction and tourism development mainly focuses on the role of opening and construction of high-speed trains on tourism economy and space. In terms of tourism economic development, such literature focuses on the analysis of the impact of high-speed trains on tourism economy. Firstly, from the perspective of promoting urban tourism economy. Campa et al. (2016) [1] used the multivariate panel analysis method to prove that the construction of high-speed rail network in Spain promoted the increase of tourism income. However, Gao et al. (2019) [2] made a conclusion that the impact of high-speed rail connectivity on tourism revenue per capita is negative. Combined with the analysis of urban tourism resources, Cao and Hou (2024) [3] further confirmed the decisive factors of tourism resources, that is, Cities with poor economic development but rich tourism resources have a strong promotional effect, while those with good economic development but poor tourism resources are the opposite. At the same time, the region has a great impact on the relationship between railway and tourism economy.

Secondly, from the perspective of promoting regional tourism economy, Yang et al. (2018) [4] made a comparative analysis of the strength of railway accessibility and tourism economic links in the Beijing-Tianjin-Hebei region and the Yangtze River Delta region. Prideaux (2005) [5] further proved that transportation infrastructure is an important factor affecting regional tourism economy. Pagliara et al. (2017) [6] proved that high-speed trains have a positive impact on regional economic growth.

Thirdly, from the perspective of promoting the tourism economy of cities along the route, Pagliara et al. (2015) [7] argued that high-speed trains greatly enhanced the tourism attractiveness of cities along the route. However, Ma and Hao (2020) [8] took the Guangdong-Guizhou-Guizhou high-speed railway economic belt as an example to prove that the operation of high-speed trains has significantly promoted the tourism

development of regions along the economic belt, but has a negative impact on the growth rate of tourism development of cities along the belt. Similarly, Wu and Zhang (2020) [9] studied the differences in tourism development caused by different development bases of cities along the belt.

Jia and Zhang (2023) [10] explored the spatial distribution characteristics of tourism accessibility along the Guangdong-Hong Kong-Macao Greater Bay Area, and analyzed the connection between accessibility and tourism economy. Han et al. (2018) [11] used the visualization platform to analyze the evolution characteristics of the spatial pattern of accessibility in Yanbian area, which pointed out the problems that aggravated the imbalance of accessibility of tourism resources. On this basis, Yin et al. (2019) [12] analyzed the spatio-temporal evolution of tourism space, which further proved that the spatial influence increases year by year and the domestic tourism center moves from southeast to southwest.

From the above review, it can be seen that the research on railway construction and tourism development mainly takes tourism development as the analysis object, while the research on railway development by taking tourism development as the core variable is relatively few. Therefore, based on the Granger causality test, cointegration analysis and error correction model, this paper makes an empirical analysis on the role of tourism in the influencing factors of railway passenger volume in China from 2005 to 2022. The cointegration relationship analysis is used to understand the long-term trend and mutual influence, and to judge the impact of tourism on railway construction on the whole. The error correction model is used to combine the long-term relationship and short-term dynamic characteristics to reveal the short-term dynamic adjustment process, so as to have a more comprehensive understanding of mutual adaptation state.

2 Sample Description, Model Specification and Variable Description

2.1 Sample Description and Model Specification

In order to reflect the promotion effect of tourism on railway construction, railway passenger volume is used to reflect the status of railway construction. The official data of railway passenger volume, the explained variable, has been published since 2005, so the sample data from 2005 to 2022 are selected. According to the convention, the sample is processed as follows: (1) for a small amount of missing data, the near mean value is used to supplement; (2) winsorize continuous variables at the level of 1% and 99%; (3) In order to reduce the autocorrelation and heteroscedasticity, the data were logarithmized. After the above processing, the sample size of this paper is 216, and the data are all from the National Bureau of Statistics.

This paper establishes an error correction model (ECM), which can be used to study fluctuations after exploring long-term equilibrium through cointegration test when the data are not stable but satisfy the same order of single integration in macroeconomic research. For example, the model is as follows:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^n \alpha_i \Delta Y_{t-i} + \sum_{j=1}^m \beta_j \Delta X_{j,t} + \lambda ECM_{t-1} + \varepsilon_t \quad (1)$$

Where j and t represent variable and time respectively, Y represents railway passenger volume, core X is the level of tourism, β_j is the influence coefficient of tourism level on railway passenger volume, λ is the correction coefficient of error correction term ECM, both of which are the core parameters concerned in this paper; ε_t is the error term. The error correction model not only pays attention to the long-term equilibrium relationship but also pays attention to the short-term dynamic adjustment process. This paper introduces error correction to capture the short-term change and long-term trend of railway passenger volume to better understand its dynamic change process.

2.2 Description of Variables

This paper uses time series data and selects data samples from 2005 to 2022. Railway passenger traffic is taken as the explained variable. Tourism development level is the core explanatory variable, and the number of travel agencies is its proxy variable. Wang and Chen (2020) [13] used the number of travel agencies (agency) to reflect the stock of tourism facilities, which directly reflects the construction of tourism services, as well as the development trend of tourism.

This paper also controls the characteristic variables of economy, railway transportation and travel mode to minimize the error of omitted variables. The data are from the National Bureau of Statistics. For example:

As a representative indicator of economic development, gross domestic product (GDP) is directly related to the development of railway industry, thus affecting passenger traffic.

Railway operating mileage (length) reflects the development level of railway transport infrastructure, and Tan et al. (2016) [14] regarded it as a significant factor affecting passenger traffic. Railway passenger turnover (turnover) measures the workload of passenger transport and is an important basis for evaluating railway service quality and market competitiveness.

In terms of travel modes, high-speed trains have a strong substitution effect on aviation (aviation) in overlapping networks (Wang et al., 2019) [15]. Private car travel (car), as a flexible and free mode of travel, has a certain impact on railway passenger transport in short-distance tourism.

To sum up, this paper chooses the number of travel agencies to represent the level of tourism, takes the GDP as the control variable of economic level, selects the railway operating mileage and railway passenger turnover to represent the level of railway transportation, introduces the civil aviation and private car ownership as the travel mode, and takes logarithm processing. The variable definitions are shown in Table 1 below.

Table 1. Introduction of variable data.

Category	Variables	Abbreviation	Unit
Explained variable	Railway passenger volume	lnrailway	10 thousand people
Tourism	Travel agencies	lnagency	Number
Economy	GDP	lngdp	100 million yuan

Railway transport	Railway operating mileage	lnlength	Km
	Railway passenger turnover	lnturnover	100 million person-kilometers
Other means of travel	Civil aviation passenger volume	lnaviation	10 thousand people
	Private cars	ln car	10 thousand units

2.3 Descriptive Statistics

The descriptive statistics of variables are shown in Table 2.

Table 2. The descriptive statistics.

Variable	N	Mean	Sd	Min	P25	P50	P75	Max
lnrailway	216	9.717	0.392	8.222	9.408	9.701	10.045	10.542
lnagency	216	7.665	0.241	7.211	7.438	7.694	7.857	8.085
lngdp	216	11.467	0.807	9.501	10.870	11.487	12.092	12.908
lnlength	216	10.485	0.243	10.132	10.258	10.485	10.690	10.852
lnturnover	216	6.650	0.355	5.221	6.418	6.660	6.904	7.414
lnaviation	216	7.875	0.496	6.669	7.457	7.911	8.290	8.720
ln car	216	6.666	0.861	5.037	5.943	6.855	7.447	7.748

3 Long-Term Relationship Analysis.

3.1 Stationarity Test

Before the empirical analysis, in order to avoid spurious regression and spurious correlation and ensure the accuracy and validity of time series analysis, it is necessary to conduct stationarity test on relevant data. In this paper, Eviews13 was used to conduct ADF test, and the results are as follows.

Table 3. ADF test results.

Variables	ADF	5% critical value	P-value	Conclusion
lnrailway	-5.272992	-3.430864	0.0001	stationary
lnagency	1.769899	-1.942310	0.9816	nonstationary
Δ lnagency	-14.82270	-3.430963	0.0000	stationary
lngdp	-2.389710	-2.875608	0.1459	nonstationary
Δ lngdp	-3.251968	-3.432115	0.0775	nonstationary
Δ2 lngdp	-48.79474	-3.432115	0.0001	stationary
lnlength	-3.037783	-3.432115	0.1246	nonstationary
Δ lnlength	-2.363018	-2.875608	0.1536	nonstationary
Δ2 lnlength	-9.507262	-3.432115	0.0000	stationary
lnaviation	-4.121190	-3.430864	0.0068	stationary
lnturnover	-5.653903	-3.430864	0.0000	stationary
ln car	-2.159672	-2.875608	0.2219	nonstationary
Δ ln car	-1.795569	-1.942399	0.0691	nonstationary
Δ2 ln car	-96.29962	-3.432115	0.0001	stationary

It can be seen from Table 3 that at 5% confidence level, railway passenger volume, civil aviation passenger volume and passenger turnover are stationary series, while the other variables are non-stationary series, indicating that the data still have obvious statistical characteristics that change with time, such as trend. Therefore, the difference operation is used for further stationary processing.

3.2 Granger Causality Test

After passing the stationarity test, the causal relationship of variables is further investigated. In the case of railway passenger transport and tourism, the Granger test can further determine the interaction between them and provide theoretical basis for macro measures.

Table 4. Granger test results.

Causal assumption	F-value	P-value	Conclusion
lnagency does not Granger Cause lnrailway	30.8136	2.E-12	Yes
lngdp does not Granger Cause lnrailway	1.79546	0.1686	No
lnlength does not Granger Cause lnrailway	6.44433	0.0019	Yes
lnaviation does not Granger Cause lnrailway	7.01031	0.0011	Yes
lnturnover does not Granger Cause lnrailway	3.33821	0.0374	Yes
lnacar does not Granger Cause lnrailway	2.78910	0.0638	No

Table 4 shows that lnagency, lnlength, lnaviation and lnturnover Granger cause rail passenger traffic. From the perspective of tourism, the policies advocate the integration of travel and transportation to promote the high-quality development of tourism, making the railway demand of tourists a direct cause for promoting railway construction. Economy, railway network and civil aviation are related to the medium and long-term development of railway passenger transport. For the variables that have not been proved to be Granger causes of railway, GDP and private car ownership do not mean that they are not related to railway development, but that the direct relationship is more affected in a variety of influencing factors. There is a lag effect of GDP affecting the results and cars' substitution mainly focuses on short-distance flexible and convenient travel. The mode has limited impact on medium-long distance railway.

3.3 Serial Correlation - Cross Correlation

Cross-correlation analysis is used to detect the correlation between two time series. This paper uses cross-correlation analysis to determine the appropriate number of lags, which provides a reference for the model establishment. Figure 1 is an image of the correlation between lnrailway and lnagency, using the CCF function to calculate the inter-relationship. It is determined by image analysis that when the lag order is 0, the explanatory variable has the greatest correlation with railway passenger volume.

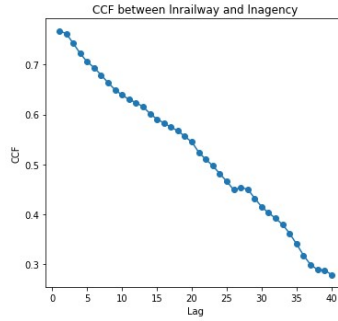


Fig. 1. Cross-correlation diagram of lnrailway and lnagency.

Table 5. Results of CCF values.

Variables	CCF	lag
lnagency	0.7340	0
lngdp	0.5750	2
lnlength	0.6260	0
lnturnover	0.9287	0
lnaviation	0.8569	0
lnacar	0.4419	0

The correlation between lnrailway and other variables is shown in Table 5 above. The analysis shows that most of the variables are strongly correlated with the volume in the current period, the lag of GDP and the lowest correlation of private car ownership all prove the above conjecture.

3.4 Cointegration Test

Using the original data of lnrailway as the explained variable and the other variables as the explanatory variables, the OLS multiple regression model was established by Stata16, and the residual series of the model was used for ADF test. When the residual model contained the constant term and did not contain the trend term, the stationarity test showed that there was a cointegration relationship between lnrailway and the explanatory variables. The results of OLS regression are shown in Table 6.

The model is as follows:

$$lnrailway_t = \beta_0 + \beta_1 lnagency_t + \beta_2 lnrevenue_t + \beta_3 lnaviation_t + \beta_4 lntourist_t + \beta_5 lnhotel_t + \beta_6 lnhighway_t + \beta_7 lnpopulation_t + \mu \quad (2)$$

Table 6. Results of multiple regression models.

Variables	Coefficient	T-value	P-value
C	-5.808908	-9.27	0.000
lnagency	0.1130285	2.44	0.016
lngdp	0.0286973	5.09	0.000

<i>lnlength</i>	0.899181	13.73	0.000
<i>Inturnover</i>	0.6007141	25.24	0.000
<i>lnaviation</i>	0.3135318	13.54	0.000
<i>lnicar</i>	-0.2338392	-10.62	0.000

$$\begin{aligned} \ln railway_t = & -5.808908 + 0.1130285 \ln agency_t + 0.3135318 \ln aviation_t + \\ & 0.0286973 \ln gdp_t + 0.899181 \ln length_t + 0.6007141 \ln turnover_t - \\ & 0.2338392 \ln icar_t + \mu \end{aligned} \quad (3)$$

Table 7. Results of residual stationarity test.

Variables	ADF	5% critical value	P-value	Conclusion
residual	-9.493403	-3.430963	0.0000	stationary

The ADF test of the residuals is shown in Table 7 above, which proves that the residuals are stationary. According to the analysis results, tourism development has a significant effect on railway passenger traffic. For example, a 1% increase in the number of travel agencies will increase railway passenger traffic by 11.3%, which indicates that they can have a positive impact on railway passenger traffic.

For control variables, especially civil aviation travel, it shows a certain synergistic effect with railway. The increase of civil aviation passenger volume increases railway passenger volume by 31.35%, indicating that the development of aviation industry improves the connectivity of the overall transportation network. It can be seen that the competition between civil aviation and railway exists in the short-distance overlapping network, and the complementary effect will be significantly enhanced for long-distance travel. Private travel has a negative impact on railway passenger volume, it has a strong convenience attraction and has a significant substitution effect, but because of the limited medium and short distance, the overall impact on railway passenger volume is limited. From the perspective of GDP, the coefficient is relatively small, indicating that the growth effect of GDP is mainly reflected by the government's resource investment in railway construction, which is more inclined to the overall development of railway and the coordinated development with other transportation modes. The coefficient of railway passenger turnover is the largest, which indicates that the railway department has been effective in improving service quality, which enhances the attractiveness of railway transportation. Therefore, it is expected that the focus of railway construction is still the coordination and quality of network.

3.5 Error Correction Model (ECM)

After determining the existence of long-term cointegration relationship among variables, this paper uses ECM model to explore the correction mechanism and the equation obtained is as follows:

$$\begin{aligned} \nabla \ln railway_t = & -0.001428 + 0.244457 \nabla \ln agency_t + 0.346421 \nabla \ln aviation_t + \\ & 0.039888 \nabla \ln gdp_t + 0.632729 \nabla \ln turnover_t - 0.518244 ECM(-1) + \varepsilon_t \end{aligned} \quad (4)$$

In terms of model testing, the ECM model passed the F-test and the model was well constructed. The value of the error correction coefficient is -0.52, which reflects the negative correction process of the railway passenger volume. In addition, in terms of the impact of short-term fluctuations, the coefficient value of the difference term of \ln agency is 24.45%, which indicates that the development of tourism has promoted the development of railway passenger industry.

In order to further explore the interactive relationship, this paper conducts reverse Granger causality test.

Table 8. Granger causality test.

Causal assumption	F-value	P-value	Conclusion
\ln railway does not Granger Cause \ln agency	0.12971	0.8784	No

The Granger causality test of \ln railway and \ln agency is shown in Table 8 above. The results show that the railway passenger volume does not Granger cause the number of travel agencies, indicating that the current integration situation is not ideal, and the interaction still needs to be further strengthened.

4 Partial Analysis

After the aforementioned analysis, it is found that there is a long-term cointegration relationship between tourism and railway passenger volume, and the dynamic adjustment process is revealed by the error correction model. However, due to the exogenous intervention of the epidemic, the data fluctuated greatly after 2019. Therefore, the short-term local analysis was carried out, and the linear regression was carried out on the data in 2019 and after. The regression results are shown in Table 9 below.

Table 9. Regression results after 2019.

Variables	Coefficient	T-value	P-value
C	107.1871	1.68	0.100
\ln agency	-0.5304395	-1.39	0.172
\ln gdp	0.0599017	3.72	0.001
\ln length	-14.03992	-1.73	0.092
\ln turnover	0.608572	7.58	0.000
\ln aviation	0.3764815	4.73	0.000
\ln car	6.643214	1.87	0.069

By analyzing and comparing the two regression results, it can be found that the significance of variables decreased significantly after the epidemic, which is explained from the perspective of the impact of the epidemic on variables:

From the perspective of tourism: for the number of travel agencies, its coefficient becomes negative and insignificant after the epidemic, reflecting that business is restricted and its role is weakened due to changes in the market environment. From other perspectives, the GDP always shows a significant positive impact, indicating that economic growth is always an important factor to promote economic activities. After the

epidemic, the aviation industry has been severely impacted, but due to the importance of its infrastructure and the potential for economic recovery, its impact is still positive and significant, and the same as the turnover. Under the circumstances of external shocks, the promotion effect of them on railway passenger transport is relatively stable, which reflects the effective coordination of the railway network. All in all, many industries have been severely impacted during the epidemic, but with the epidemic under control, these industries are expected to become an important force in promoting economic recovery.

5 Research Conclusions and Policy Recommendations

5.1 Research Conclusions

The integrated development of transportation and tourism is conducive to adapting to new demands in tourism, and it serves as a vital gripper for realizing high-quality development in the tourism industry. Moreover, it is a significant driving force for achieving a powerful transportation nation and modernization. However, existing literature primarily focuses on the role of high-speed rail openings in promoting tourism development, leaving ample room for further exploration into the effects of tourism development on railway passenger transport. Meanwhile, most existing literature has focused solely on the long-term promotional effects of railways on tourism or the recovery status in the post-pandemic era, with limited research conducting comparative analysis between them. In light of this, this paper employs data such as railway passenger traffic volume from 2005 to 2022 to conduct cointegration analysis and error correction model analysis, aiming to explore the long-term relationship and analyzes the long-term variables and dynamic adjustment variables that affect railway passenger transport. Furthermore, regression analysis is conducted on data from 2019 to 2022 to explore the short-term relationship between the two, and to derive the current status and development directions of various influencing factors.

From the perspective of long-term relationship, it can be seen from regression and residual stationarity test that there is a long-term stable cointegration relationship between railway passenger volume and tourism. By analyzing the error correction model, it is found that the change of railway passenger volume is greatly affected by the number of travel agencies, and there is a positive correlation. When the number of agencies increase by 1%, the railway passenger volume increases by 24.45%. It can be seen that the improvement of tourism service quality is conducive to the development of tourism. As for the civil aviation, it is positively correlated with the railway passenger volume, which indicates that aviation and railway are not directly competitive, but complementary modes of transportation. From the perspective of tourism, the increase of civil aviation passenger traffic means that passengers take aircraft as the main means of transportation, and choose railway to travel to tourist attractions. According to the Granger causality test, the number of travel agencies is the Granger cause of the railway passenger volume, but the reverse is not necessarily true. The reason may be that the opening of high-speed trains makes it more convenient for tourists to travel, which attracts tourists and strengthens the evacuation of passenger flow. A large number of tourists are

transferred from the station cities to the non-station cities, and the tourism resources are divided and intercepted, resulting in the original tourist destinations becoming transit destinations.

From the perspective of local analysis, the epidemic has greatly restricted the development of tourism service industry, but the turnover of air and aviation has always been significant variables, which proves that the construction and coordination of railway network are effective, and it is expected to be the future development direction. The influence direction of operating mileage and private car tourism has changed, which indicates that it is affected by a variety of factors such as policy and economy. Therefore, in the process of railway construction and optimization in the future, it is necessary to take tourism as the driving force, the interaction and coordination of railways as the development direction, and comprehensively consider various factors such as economy, so as to provide more convenient and efficient transportation support.

This paper not only enriches the literature on the reverse mechanism of the role of tourism development on railway, but also has certain guiding significance for the integration of transport and tourism. At the same time, local analysis and long-term analysis also expand the research ideas. However, there are some limitations of theoretical derivation such as mechanism analysis in this paper, and the development of the integration of transport and tourism needs to be further discussed.

5.2 Policy Suggestions

(1) Focus on improving the quality of tourism services. The increase of the number of travel agencies will promote the increase of railway passenger traffic, so it is necessary to enhance the effectiveness of travel agencies, pay attention to travel itinerary service and reception capacity, travel agencies can establish close cooperation with the railway department, reasonable development of tourism special lines and other diversified, characteristic tourism demand. At the same time, the improvement of reception quality will have a certain positive impact on the tourism service market, such as the development of tourism products, in-depth tourism, etc., to attract passenger flow and promote the development of railway passenger industry, and further improve the tourism transportation system.

(2) Improve the railway network and coordination. Aviation passenger volume and passenger turnover play a significant role in promoting railway passenger transport. Therefore, the government should strengthen the overall planning of civil aviation and railway traffic, ensure the smooth connection by optimizing the layout, highlight the synergistic effect of civil aviation and railway, and enhance the attractiveness of railway travel. Pay attention to the improvement of service quality, including ride environment and ticket purchase services, to provide economic travel solutions.

(3) Improve the interaction mechanism between railway passenger transport and tourism. Firstly, the cooperation between tourist attractions and railway departments should be strengthened to jointly formulate appropriate preferential policies and special services, such as one-stop services such as ticket purchase and turnover. Secondly, we should develop products and services of tourist attractions, attract potential railway passengers, provide management reference data for the corresponding railway ride, and

improve the convenience of railway travel ticket purchase and other services. At the same time, we should pay attention to the policy improvement and platform operation of cooperation and development, strengthen market supervision and standardize the order of competition

(4) Explore various industrial integration models of "tourism+". Tourism plays a certain role in promoting railway passenger transport. Therefore, it is necessary to give full play to the driving force and integration ability of tourism, deeply integrate with the characteristic industries of tourism destinations, enhance the comprehensive value of new business forms based on tourism platforms, further promote the high-level development of tourism through the optimization of characteristic publicity and one-stop service, and form a characteristic benign interactive development mechanism.

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