Analysis on the Coupling Effect of Xi'an-Yinchuan High Speed Railway and Economy Development in Shanxi-Gansu-Ningxia District Railway and Economy Development in Shanxi-Gansu-Ningxia District

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Abstract: Rail transit has been playing a vital role in comprehensive transportation system, there goes without saying that rail transit will stimulate economic growth of the regions alongside railway lines, its coverage and development pattern will exert widespread and far-reaching impact on the area where railway travels through. In Xi'an-Yinchuan High-speed Railway construction setting, firstly, building an accessibility model based on the GIS platform and comparing analysis of traffic accessibility changes in the study area before and after the opening of the high-speed rail. Secondly, relying on the railway network and economic relations to establish comprehensive indicators System, build a coupling model of rail transit and regional economy in Shanxi-Gansu-Ningxia. Finally, predicting the coupling relationship between economy and transportation after the opening of high-speed rail. The experimental results show that the accessibility of cities along the line changes greatly before and after the completion of the high-speed rail. The high-speed rail line obviously promotes the economic development of the old revolutionary areas and surrounding cities along the line, and provides guiding suggestions for further improving the rapid railway network.

1. Introduction
Railway is a main mode of transportation in the comprehensive transportation system, which promotes the development of national economy and tourism. By the end of 2020, Chinese railway operating mileage will reach more than 120,000 kilometers, and the high-speed railway network will reach more than 50,000 kilometers, connecting all provincial capitals and cities with a population of more than 500,000. Implemented from “the Medium and Long-term Railway Network Plan”[1]Since then, railways, especially high-speed railways, have ushered in a new climax of construction and have become a new business card of "Made in China". High-speed railway has the characteristics of fast, safe, punctual and stable, which can reduce people's travel time cost and expand the scope of travel space[2]. Due to the imperfect rail transit system from the old revolutionary area to the surrounding major cities, the economic development of cities along the route is greatly restricted. Further changing the relatively backward economic outlook of the old area has become an urgent problem in the Shanxi-Gansu-Ningxia region. Therefore, studying future Xi'an-Yinchuan high-speed rail traffic time
and space changes in surrounding cities and old revolutionary areas, and analyzing red tourism and economic development changes in cities along the line under the action of high-speed rail are of great significance to driving the development of old revolutionary areas.

In recent years, the current researches on railways and regional economy at home and abroad have focused on the relationship between rail transit and economic development represented by high-speed railways. Peter MJ[3] and Hao Zhou[4] believe that high-speed railways can promote economic development. Analysis by Nakamura and Amano[5], Murayama Y[6] and Komei Sasaki[7] found that the high-speed rail has a greater impact on the economic development, population growth rate and employment level of the administrative region. Javier Gutierrez et al. studied the changes in accessibility before and after the implementation of the European high-speed rail network policy[8-9].

Therefore, under the support of the GIS platform, this paper uses the spatial network analysis methods to calculate the urban accessibility. Starting from the coordination of rail transit and regional economic development, this paper proposes a calculation model for the coupling coordination degree, and then integrates the Xi’an-Yinchuan high-speed rail and the regional economy. Comparing with the coupling situation of the two under the expected coupling situation of the two under the target situation in the future, the analysis is conducted under the guidance of the "Guiding Opinions on Implementing the Regional Development Strategy and Promoting the Coordinated Development of the Region"[10]. The impact and extent of the impact will provide guiding suggestions for improving the railway rapid network.

2. Research Area and Method

2.1. Overview of Xi’an-Yinchuan High Speed Rail

The Xi’an-Yinchuan High-speed Railway is an important part of the "Baotou-Yinchuan-Haikou Channel" in the vertical and horizontal arteries of Chinese railway network planning high-speed railway passages. It starts from Yinchuan and arrives in Xi’an, passing through five cities including Yinchuan, Wuzhong, Qingyang, Xianyang, and Xi’an. It connects Guantian Economic Zone, Longdong area and the urban belt along the Yellow River, and travels through the entire Loess Plateau. It starts in 2016, Yinchuan to Wuzhong section will be put into operation by the end of 2019, and the whole line will be completed and open to traffic by the end of 2020. The total length is about 618 kilometers, including about 182 kilometers in Ningxia, about 273 kilometers in Gansu, and about 163 kilometers in Shanxi. After the completion and opening to traffic, it will become a link between the urban belt along the Yellow River with Yinchuan as the center and the Guanzhong urban agglomeration centered on Xi’an. It is imminent to grasp the opportunity of "The Belt and Road Initiative" construction. The research area is shown in Figure 1.

![Figure 1. Overview of the study area.](image)

2.2. Overview of Regional Economy

In terms of regional GDP, the economic development level of the three provinces is extremely unbalanced. Among the five cities in the route, Xi’an and Yinchuan, as sub-provincial cities, have GDP
that is 10 times that of the old revolutionary areas Wuzhong and Qingyang. From the perspective of per capita GDP in the cities and prefectures of Shanxi-Gansu-Ningxia (see Figure 2), the uneven economic development of the cities has once again been reflected.

![Figure 2. Per capita GDP of cities and prefectures in Shanxi-Gansu-Ningxia in 2018.](image)

3. Research Methods

3.1. Evaluation Method of Regional Traffic Accessibility

The commonly used evaluation model based on accessibility is the traffic resistance method:

\[
AA_i = \frac{\sum_{j=1}^{n-1} T_{ij}}{n-1}
\]  

Where \(AA_i\) —— The average time cost from node \(i\) to other \(n - 1\) nodes;

\(T_{ij}\) —— The shortest travel time cost between the node \(i\) and rail transit accessibility \(j\);

This research uses a network analysis tool based on ArcGIS software platform, and uses the OD cost matrix in this tool to study the railway travel time cost between urban nodes in Shanxi-Gansu-Ningxia area.

\[
A_i = \frac{1}{n-1} \sum_{j=1}^{n} d_{ij}
\]

\[
A = \frac{1}{n} \sum_{i=1}^{n} A_i
\]

Where \(A_i\) —— The accessibility of node cities \(i\) in the railway network;

\(A\) —— The accessibility of the overall railway network in the region;

\(d_{ij}\) —— The impedance attribute between the node city \(i\) and \(j\), measured by time.

The accessibility measurement value can reflect the excellence and worseness of the accessibility of a certain city node. The smaller the value, the shorter the time for the city to reach other cities through the rail transit network, indicating that the city has better accessibility. On the contrary, it shows that the city has range accessibility.

3.2. Comprehensive Evaluation Model of Regional Economy

In accordance with the basic principles of science, operability and completeness, the comprehensive indicator method is selected and 11 indicators shown in Table 1, to construct the evaluation index system of the economic development of the study area. According to the result of factor analysis of SPSS software, three principal components are extracted from the selected indicators. Among them, the first principal component \((y_1)\) Contains 8 indicators, which mainly explain the level of economic development; the second principal component \((y_2)\) Contains 2 indicators, which mainly explain the
level of railway development, see Table 2. On the basis of the three main components, the economic development index of the research area is calculated:

\[ Y = 0.654y_1 + 0.244y_2 + 0.102y_3 \]  

(4)

**Table 1.** Evaluation indicators for the economic development of Shaan-Gan-Ning city area.

| Indicator name                                      | Indicator code |
|----------------------------------------------------|----------------|
| GDP                                                | \( x_1 \)      |
| Local budget revenue                               | \( x_2 \)      |
| Local budget expenditure                           | \( x_3 \)      |
| Financial institution deposit balance at the end of the year | \( x_4 \)      |
| Financial institution loan balance at the end of the year | \( x_5 \)      |
| GDP per capita                                      | \( x_6 \)      |
| Disposable income of urban residents               | \( x_7 \)      |
| The total retail sales of social consumer goods     | \( x_8 \)      |
| Railway Passenger Transport                         | \( x_9 \)      |
| Rail freight                                        | \( x_{10} \)   |
| Non-agricultural proportion                        | \( x_{11} \)   |

3.3. **Coupling Degree of Railway and Regional Economy**

Using the coupling coordination degree model to analyze the degree of coordinated development of the rail network and the regional economy in combination with the economic development indicators mentioned above. This model can not only reflect the interaction, but also reflect whether they have good development level. The coupling coordination formula is as follows:

\[ D_{(xy)} = (CT)^{1/2} \]  

(5)

In the formula, \( D \) is the degree of coupling coordination; \( C \) is the degree of coupling; \( T \) is the comprehensive coordination index of the railway network and the regional economy.

The comprehensive coordination index is as follows:

\[ T = \alpha F(x) + \beta G(y) \]  

(6)

In the formula, \( \alpha \) and \( \beta \) are undetermined coefficients to measure their importance. Generally, they are regarded as equally important, so \( \alpha \) and \( \beta \) are both set to 0.5.

In order to better analyze the relationship between the railway and the economy, on the basis of drawing lessons from the predecessors, the coupling coordination degree is classified as shown in the table 2. It can be seen that the greater the coupling coordination degree value, the better the coordination degree, and vice versa.
Table 2. Coupling coordination level division.

| Coupling coordination degree D value interval | Coordination level | Coupling degree       |
|---------------------------------------------|-------------------|----------------------|
| (0.0~0.1)                                   | 1                 | Serious disorder     |
| [0.1~0.2)                                   | 2                 | Moderate Disorder    |
| (0.2~0.3)                                   | 3                 | Mild disorder        |
| [0.3~0.4)                                   | 4                 | Verge disorder       |
| [0.4~0.5)                                   | 5                 | Barely coordinated   |
| [0.5~0.6)                                   | 6                 | Primary coordination |
| [0.6~0.7)                                   | 7                 | Intermediate coordination |
| [0.8~0.9)                                   | 8                 | Good coordinated     |
| [0.9~1.0)                                   | 9                 | High coordination    |

4. Result Analysis

4.1. Temporal and Spatial Changes of Regional Traffic Accessibility

Using the accessibility evaluation model. Through the ArcGIS spatial analysis method and the inverse distance weight interpolation method, the reachable time map of the cities in the study area before the opening of the high-speed rail is obtained, as shown in Figure 4.

Before the opening of the high-speed rail, several cities with the highest accessibility rankings, such as Tianshui, Dingxi, Lanzhou, Xianyang, and Baoji, which are all node cities along the Baoji-Lanzhou Passenger Dedicated Line. Among them, Lanzhou, as a large railway hub city, has a better accessibility ranking. The accessibility of all cities in Ningxia province has performed poorly. The reason is that there is no high-speed railway network connecting other cities in the Shanxi-Gansu-Ningxia region before the research time node (2018 year). Gannan Prefecture, Linxia Prefecture, Qingyang City, and Tongchuan City are ranked at the bottom because they have no accessibility by railway. The other cities are Jiuquan, Jiayuguan, and Yulin and so on, which have poorer accessibility. It is not difficult to find in the network diagram that most of the railway lines passing through the above-mentioned cities are single railway lines.

It can be seen from the measurement results of the accessibility of the nodes in the lower Shanxi-Gansu-Ningxia cities under the expected circumstances that the Xi’an-Yinchuan high-speed rail is opened (see Figure 5). The opening of the Xi’an-Yinchuan high-speed rail has significantly
improved the accessibility of the surrounding cities along the line, and the average degree of improvement is Up to 20%. The reachable time is reduced by an average of 1 hour, among which Shizuishan, Yinchuan, Qingyang, Wuzhong and other cities have the largest changes. The construction of the Xi’an-Yinchuan High-speed Railway has shortened the travel time between the three provinces of Shanxi, Gansu and Ningxia. The cities of Shizuishan, Yinchuan, Wuzhong, and Qingyang that were originally in a disadvantaged position have made a qualitative leap in railway accessibility. In addition, the completion and opening of the Xi’an-Yinchuan high-speed railway make Qingyang end the history of railway blank and realize the change of accessibility from scratch, and form a cluster of cities with close economic connections, which will drive the economic development of each other to a higher level.

4.2. Forecast of Regional Economic Development Level
The comprehensive economic index of each region before and after the opening of Xi’an-Yinchuan is drawn into a line chart, as shown in Figure 6. Comparing the comprehensive economic scores of the study area before and after the opening of the Xi’an-Yinchuan high-speed railway, it can be seen that Xi'an's economic development momentum is still strong. Wuzhong and Qingyang, Baoji and Xianyang and so on, which are along the line, have all improved their comprehensive economic scores. On the whole, the blessing of the Xi’an-Yinchuan high-speed railway has made cities such as Pingliang, Guyuan, Wuzhong, and Qingyang and other cities, which have experienced greater economic changes, become the new stars of regional economic development.

![Figure 5. Comprehensive economic Scores of cities in Shanxi-Gansu-Ningxia.](image)

4.3. Coupling Analysis of Railway And Regional Economy
Bringing the railway and economic index data of Shanxi-Gansu-Ningxia region in 2018 into the formula. It can obtain the coupling and coordination type of railway and regional economy in Shanxi-Gansu-Ningxia. The spatialization in ArcGIS obtains Figure 7.

Among the 29 cities in the study area (Figure 7), the provincial capital cities Xi'an and Lanzhou have a higher degree of coupling and coordination, which is a good coupling coordination. Their economic development volume is large, and they are large-scale railway hubs, and their transportation accessibility is relatively high level, so the regional economy and rail transit show a high degree of coupling coordination. While Gannan, Linxia and Qingyang City in Gansu province, the first two are mild disorder, and their adjacent cities Dingxi and Longnan are barely coordinated. The latter Qingyang in the hinterland of Shanxi, adjacent to Yan'an, Pingliang, Guyuan, etc. It is verge disorder
The opening of the Xi’an-Yinchuan high-speed railway has promoted the economic development of cities along the line, solved the railway tension in the old revolutionary areas, and promoted the development of red tourism. Statistics on the economic indicators of various regions from 2013 to 2018 predicts the various economic indicators of the city after the opening of the high-speed railway. Then the type of coordination between the railway and the economy in the Shanxi-Gansu-Ningxia region in 2021 are predicted and analyzed, as shown in Figure 8.

5. Conclusion
The opening of the Xi’an-Yinchuan high-speed railway has an important impact on the economic development of Shanxi-Gansu-Ningxia region. The following conclusions and recommendations are drawn:

1) The opening of Xi’an-Yinchuan high-speed railway has improved the traffic accessibility of Shanxi-Gansu-Ningxia area, and the accessibility of cities along the line has been greatly improved. It has a leading role in the development of the surrounding old revolutionary areas, and fills up the lack of railways in the old revolutionary areas while reducing travel costs. It acts as a core city of economic development to drive the economic development of the old revolutionary areas.

2) In the Shanxi-Gansu-Ningxia region, the coupling coordination degree between the railway and the regional economy is mostly barely coordinated. After the opening of the high-speed railway, the coupling coordination degree in cities along the line such as Qingyang and Wuzhong and so on has increased significantly, realizing the rail-driven regional economic development model.

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