Quantitative Analysis of the Economic Impact of the Opening of High-speed Railway on Huangshi and Jiujiang

Wenkai Wang1, *, Shengyue Hao2
1School of Economic and Management, Beijing Jiaotong University
2School of Economic and Management, Beijing Jiaotong University
*Corresponding author: wangwenkai97@163.com

Abstract. Transportation has always played a pivotal role in economic development and is an important factor driving the economy along the route. This paper actually calculates and analyzes the economic benefits brought by the opening of high-speed rail to Huangshi and Jiujiang. Using the comparison analysis method, the data predicted by the model when the high-speed rail is not opened and the actual data are compared. The results show that the opening of the high-speed railway has a certain promotion impact on the economic development of Huangshi and Jiujiang. However, the research results also show that its impact on the urbanization index is not significant, which is not consistent with the urbanization impact of high-speed railway.

1. Introduction
With the rapid development of economy and the deepening of globalization, more and more attention has been paid to the concept of regional development. The development of cities no longer shows the characteristics of individuation, but is more connected with regional development. In the connection between cities and regions, transportation is often the most important link. Transportation, especially railway transportation, plays an increasingly important role in the development of cities and urban agglomerations.

Scholars have done a series of studies on the impact of high-speed rail on regional economy. In the aspect of theoretical research, Blum [1] pointed out that high-speed rail can enhance the connectivity between cities, build a mutually accessible area, and expand the functional areas of cities. Zhang Nannan [4] analyzed the regional impact of high-speed railway, and elaborated the advantages brought by the opening of high-speed railway from three aspects of time and space, transportation and economy. In the aspect of empirical research, Fang Dachun [5] took the Yangtze River Delta Urban Agglomeration as the research object, analyzed the impact of high-speed railway construction, and found that after the completion of high-speed railway, the per capita GDP growth rate has increased significantly, and the urban-rural gap has a trend of expansion, Feng Bing [6] explored the pulling impact of high-speed railway on regional industry, and found that high-speed railway has a significant role in promoting the development of regional industrial economy in Hubei Province.

The high-speed railway between Huangshi and Jiujiang has been officially opened in late 2017, but the relevant statistics of 2018 in the two regions were not released until recently. On the basis of summarizing the relevant research results at home and abroad, this paper calculates and analyzes the impact of the opening of high-speed railway on the economic development of Huangshi and Jiujiang, and provides a reference for further enhancing the regional impact of the high-speed railway.
2. Research method

2.1. Select evaluation index

The opening of high-speed railway has a comprehensive impact on the regional economy, which is mainly reflected in the following aspects:

The opening of high-speed rail can significantly improve the accessibility between regions, make transportation conditions more convenient, improve transportation efficiency, reduce transportation costs, and promote the spatial economic relationship between cities and regions in the region to become closer.

The construction of high-speed railways will drive the rapid development of energy, building materials and other related industries in the region, and provide certain support for the development of the secondary industry. The opening of high-speed railway will speed up the flow of people between regions, stimulate the development of tourism, and make the tertiary industry obtain the opportunity of development, so as to optimize the industrial structure.

As a large-scale comprehensive project, high-speed railway will have a certain impact on the employment in the region during the construction process. After the opening of high-speed railway, the travel time will be greatly shortened, providing excellent opportunities for the flow of talents between regions.

High speed railway will also greatly improve the regional accessibility. For the relatively underdeveloped areas, the time of flowing to the developed areas will be greatly shortened, and the cost will become lower, which will lead to the flow of a large number of rural population, and then improve the level of local urbanization.

Through above analysis, the economic impact of the opening of high-speed railway on Huangshi and Jiujiang will be analyzed from four aspects. The first is the degree of spatial economic connection, which can be measured by the amount of spatial economic connection calculated by gravity model. The second is the impact of regional industrial structure change, this paper selects the output value change of different industries in the region as the index. The third is the employment impact, this paper selects the number of employees of different industries in the region as the index. The fourth is the urbanization impact, which is measured by the urbanization level of the two regions. The specific index classification is shown in Table 1.

Table 1. Evaluation index system of economic impact of high speed railway on Huangshi and Jiujiang.

| Research objects | Impact aspects | Specific indicators                      |
|------------------|---------------|-----------------------------------------|
| Huangshi and Jiujiang | Spatial economic connection degree | Spatial economic connection |
|                   | Changes in industrial structure | Added value of primary industry |
|                   |                                | Added value of secondary industry |
|                   |                                | Added value of tertiary industry |
|                   | Changes in employment          | Number of employees in primary industry |
|                   |                                | Number of employees in the secondary industry |
|                   |                                | Number of employees in the tertiary industry |
|                   | Urbanization level             | Urbanization rate of Huangshi |
|                   |                                | Urbanization rate of Jiujiang |
2.2. Methods and models

The grey prediction model is used to calculate the predicted value of economic indicators of Huangshi and Jiujiang without high-speed railway. The real data and the predicted value are compared and analyzed, the difference between the two is the impact of high-speed railway on the economy of Huangshi and Jiujiang.

Set \( x^{(0)} \) as the original data sequence, as shown in formula (1). According to formula (2), \( x^{(0)}(t) \) is accumulated (AGO) to obtain \( x^{(1)}(t) \) sequence, and then whitening differential equation is established for \( x^{(1)}(t) \) sequence through formula (3).

\[
x^{(0)}(t) = \{ x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), \ldots, x^{(0)}(n) \} \tag{1}
\]

\[
x^{(1)}(t) = \{ x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \ldots, x^{(1)}(n) \} \tag{2}
\]

\[
\frac{dx}{dt} + ax = u \tag{3}
\]

In formula (3), \( a \) and \( u \) are respectively undetermined constants. In order to obtain the estimated values of \( a \) and \( u \) in GM (1,1) model, data matrices \( B \) and \( Y \) are constructed. By using the principle of least square method, parameters \( a \) and \( u \) are calculated according to formulas (4) and (5), and then the sequence is restored by using formula (6), the original sequence fitting sequence is shown in formula (7).

\[
B = \begin{bmatrix}
\frac{1}{2} [x^{(0)}(1)] + x^{(0)}(2) \\
\frac{1}{2} [x^{(0)}(2)] + x^{(0)}(3) \\
\vdots \\
\frac{1}{2} [x^{(0)}(n-1)] + x^{(0)}(n)
\end{bmatrix},
Y = \begin{bmatrix}
x^{(0)}(2) \\
x^{(0)}(3) \\
\vdots \\
x^{(0)}(n)
\end{bmatrix},
\left( \begin{array}{c}
\hat{a} \\
\hat{u}
\end{array} \right) = (B^T B)^{-1} B^T Y \tag{4}
\]

\[
\hat{x}^{(0)}(t+1) = x^{(0)}(1) - \frac{u}{a} e^{-at} + \frac{u}{a} \tag{5}
\]

\[
\hat{x}^{(1)}(t+1) = \left[ x^{(0)}(1) - \frac{u}{a} \right] (1 - e^a) e^{-at} \tag{6}
\]

In this paper, posterior-variance-test is used to test the accuracy of the model. The test indexes are the ratio of mean square error \( C \) and small probability error \( P \), the calculation formula is as follows, \( S_1 \) is the variance of the sequence \( x^{(0)} \), \( S_2 \) is the variance of the residual error, and the discrimination standard is shown in table 2.

\[
C = \frac{S_2}{S_1} \tag{8}
\]

\[
P = \{|e^t - \bar{e}| < 0.6745S_2\} \tag{9}
\]

| Model accuracy level | \( C \) | \( P \) |
|----------------------|-------|-------|
| Level 1 (Excellent)  | \( C \leq 0.35 \) | \( P \geq 0.95 \) |
| Level 2 (Qualified)  | \( 0.35 < C \leq 0.5 \) | \( 0.95 > P \geq 0.8 \) |
| Level 3 (barely qualified) | \( 0.5 < C \leq 0.65 \) | \( 0.8 > P \geq 0.7 \) |
| Level 4 (unqualified) | \( 0.65 < C \) | \( 0.7 > P \) |
3. Results & Discussion

3.1. Spatial economic connection
With the advancement of transportation, the economic connection between regions is constantly strengthened. The gravity model can be used to measure the spatial economic connection between cities, the calculation formula is shown in (10). In this formula, \( R_{ij} \) means the degree of economic connection between city \( i \) and city \( j \), and \( P_i \) means the number of non-agricultural population in city \( i \); \( P_j \) means the number of non-agricultural population in city \( j \); \( G_i \) means the economic status of city \( i \), expressed by the local GDP; \( G_j \) means the economic condition of city \( j \), expressed by the local GDP; \( D_{ij} \) means the distance between two cities, which is expressed by the single track mileage between two cities.

\[
R_{ij} = \frac{\sqrt{P_i G_i} \sqrt{P_j G_j}}{D_{ij}}
\]  

(10)

According to the requirements of gravity model formula, the GDP and urban population data of Huangshi and Jiujiang from 2013 to 2017 are collected, and then the data sequences are tested. The results show that all data sequences pass the test and can be used for prediction. The prediction results are shown in table 3.

Table 3. Calculation results of spatial economic connection.

| Year | The spatial economic connection strength between Huangshi and Jiujiang |
|------|---------------------------------------------------------------|
| 2018 (If the high-speed railway is not opened) | 19.27 |
| 2018 (Actual data) | 30.08 |

Assuming that the high-speed rail is not opened, the spatial economic connection strength between Huangshi and Jiujiang in 2018 will be 19.27, while the real spatial connection strength between Huangshi and Jiujiang in 2018 was 30.08, and the real data was 1.56 times of the predicted data. The analysis shows that the opening of the high-speed railway shortens the "time distance" between the two cities, and expands the scope of entertainment, shopping and travel of the people in the two cities, It has accelerated the circulation of business people, service personnel and other personnel, expanded the scope of employment of the people in the two regions, accelerated the rapid circulation of high-tech and related market information, and made the economic connection between the two regions closer.

3.2. Changes in industrial structure
This paper collects the data of the added value of the primary industry, the secondary industry and the tertiary industry in Huangshi and Jiujiang from 2013 to 2017, and then tests the data sequences. The results show that each data sequences has passed the test and can be used for prediction. The prediction results are shown in table 4.
Table 4. Calculation results of industrial structure change (100 million yuan).

| Year                        | Added value of primary industry | Added value of secondary industry | Added value of tertiary industry |
|-----------------------------|---------------------------------|-----------------------------------|----------------------------------|
| 2018 (If the high-speed railway is not opened) | 332.86                          | 2134.85                           | 1697.89                          |
| 2018 (Actual data)         | 284.85                          | 2292.49                           | 1710.18                          |

It can be seen from the calculation results that the added value of the primary industry has decreased compared with the predicted value, while the added value of the secondary industry and the tertiary industry has increased compared with the predicted value. The opening of high-speed railway can promote the integration and utilization of regional tourism resources, accelerate the development of tourism in Huangshi and Jiujiang, promote the exchange of information technology, capital, senior labor, commerce and trade between the two regions, and then drive the development of the tertiary industry in the two regions.

3.3. Changes in employment

This paper collects the data of employment in primary industry, secondary industry and tertiary industry in Huangshi and Jiujiang from 2013 to 2017, and then tests the data sequences. The results show that all data sequences pass the test and can be used for prediction. The prediction results are shown in table 5.

Table 5. Calculation results of employment change (ten thousand people).

| Year                        | Employment in primary industry | Employment in secondary industry | Employment in tertiary industry |
|-----------------------------|---------------------------------|-----------------------------------|----------------------------------|
| 2018 (If the high-speed railway is not opened) | 117.55                          | 160.01                            | 167.28                           |
| 2018 (Actual data)         | 116.53                          | 159.14                            | 166.93                           |

It can be seen that if the high-speed railway is not opened, the employment proportion of the primary, secondary and tertiary industries in Huangshi and Jiujiang will be 26.43%, 35.97% and 37.60% respectively, while the actual employment proportion of the primary, secondary and tertiary industries in 2018 were 26.33%, 35.96% and 37.72% respectively. The analysis shows that the opening of high-speed railway will have a certain impact on the employment of different industries in Huangshi and Jiujiang. The proportion of employment in the primary industry and the secondary industry will decrease, while the proportion of employment in the tertiary industry will increase, but the impact is relatively small.
3.4. Urbanization level

This paper collects the urbanization rate data of Huangshi and Jiujiang from 2013 to 2017, and then tests the data sequences. The results show that all data sequences pass the test and can be used for prediction. The prediction results are shown in table 6.

Table 6. Calculation results of urbanization rate(%).

| Year         | Urbanization rate of Huangshi | Urbanization rate of Jiujiang |
|--------------|------------------------------|------------------------------|
| 2018 (If the high-speed railway is not opened) | 63.42%                       | 55.43%                       |
| 2018 (Actual data) | 63.29%                       | 55.27%                       |

It can be seen from the calculation results that if the high-speed railway is not opened, the urbanization rates of Huangshi and Jiujiang will be 63.42% and 55.43% respectively, while the actual urbanization rates of Huangshi and Jiujiang in 2018 were 63.29% and 55.27% respectively, in comparison, the urbanization rates of Huangshi and Jiujiang are slightly lower than the predicted values, which is not consistent with the urbanization impact of high-speed railway. Huangshi is the vice central city of Wuhan city circle and an important member of the urban agglomeration in the middle reaches of the Yangtze River. Jiujiang is the second largest political, economic, educational and trade center in Jiangxi Province and one of the top ten port cities in the Yangtze River Basin. The urbanization level of the two regions is high, the stage of large population flow has passed, and a large number of population aggregation has also caused a series of problems, such as the rapid rise of house prices. Many residents began to choose to live in suburbs or other urban areas around them, which resulted in the loss of urban population. Therefore, the analysis shows that the reduction of urbanization rate in the two regions is not caused by the opening of high-speed railway.

4. Conclusion

Based on the analysis of the impact process of high-speed railway on regional economy, this paper establishes the analysis index system of the impact of high-speed railway on regional economic development, calculates and analyzes the economic benefits brought by the opening of high-speed railway by using the grey prediction model, and compares the data predicted by the model when the high-speed railway is not opened with the real data, it is found that the opening of high-speed railway can bring great vitality to the economy of Huangshi and Jiujiang, strengthen the spatial economic connection between the two regions, promote the upgrading of industrial structure and the continuous growth of economy. However, the research results also show that its impact on the urbanization index is not significant, which is not consistent with the urbanization impact of high-speed railway.

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