Research on the Influence of Shanghai-Kunming High-speed Railway on the Economics of Cities along the Line Based on Optimized Gravity Model

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Abstract: With the continuous growth of the demand for inter-regional personnel exchanges between modern social and economic development, high-speed railways, as a modern means of transportation that combines various high-tech, play an important role in meeting the high demand for mobility among regions and promoting social development. Among them, Shanghai-Kunming high-speed railway, as an important part of China's high-speed railway network, deserves in-depth study. In this paper, the city quality is obtained by comprehensive evaluation of cities along the line by entropy method. The time distance is used to replace the spatial distance. The gravitational model of the city is optimized, and the gravitational change between cities along the line before and after the opening of the Shanghai-Kunming high-speed railway is more scientifically described. Finally, the paper proposes that the opening of the Shanghai-Kunming high-speed railway can effectively promote the economic development of cities along the line, especially the rapid rise of western cities.

1. Introduction
Transportation economics theory believes that transportation has always been an important location influencing factor. When industrialization reaches the stage of high-tech development, a full and efficient transportation system has become the background condition for further economic growth, that is, the level of transportation is somewhat restrict the level of economic and technological development of a country or region.

With the development of high-speed railways, the influence of high-speed rail on urban economic relations has been widely concerned by scholars. The performance is as follows: Wang Jiaoyu [1] used GIS network analysis tools, it is concluded that the construction of high-speed railways has widened the difference in the intensity of economic linkages between cities; Wang Yufei and Ni Pengfei [2] believe that the construction of high-speed railways reduces transportation costs and time costs. Breaking the restrictions on space, accelerating the flow of factors, improving the efficiency of resource allocation, and promoting regional economic growth; Miao Changhong and Wang Haijiang [3] believe that although the passenger line has improved the level of economic linkages between cities, it has affected The direction of economic linkages between cities.

The second is the study of typical high-speed rail lines. Jin F [4] found that the high-speed railway network greatly improved the accessibility by studying the accessibility evolution mechanism of high-speed railway. There are many researches in this field in China. For example, Zhang Li [5] used a
variety of models to empirically analyse the improvement of the accessibility of Shanghai-Nanjing intercity high-speed rail and the strengthening of economic linkages along the line. Zhao Juan [5] believes that after the opening of the Beijing-Tianjin inter-city railway, it has become an important passenger passage between the two places, speeding up the integration process of the area and realizing the sharing of resources between the two major cities.

This paper starts with the optimization of the city gravity model, and empirically compares the gravitational changes of the provincial capitals and municipalities along the line before and after the opening of the Shanghai-Kunming high-speed railway. On the basis of the results, this paper analyse the impact of Shanghai-Kunming high-speed railway on regional economic development and inter-regional accessibility along the line.

2. Research objects and impact analysis

2.1. Basic overview of Shanghai-Kunming high-speed rail and areas along the route
Shanghai-Kunming High-speed Railway (Shanghai-Kunming High-speed Railway) is one of the “eight vertical and eight horizontal” rapid passenger transportation channels in the national “medium and long-term railway network planning”. Shanghai-Kunming high-speed rail routes include six provincial capitals and municipalities in Shanghai, Hangzhou, Nanchang, Changsha, Guiyang and Kunming. It is the longest route in China's east-west route and the highest-speed highway in most provinces. The schematic diagram of the route and the passing area is shown below.

![Shanghai-Kunming high-speed rail line diagram](image)

2.2. Analysis of the mechanism of urban economic development affected by Shanghai-Kunming High-speed railway
The impact of high-speed railway on regional economic development can be divided into direct impact and indirect impact. The direct impact includes improving regional rail transport capacity and improving regional accessibility. Indirect impacts include promoting regional economic development, optimizing regional industrial structure, promoting tourism development, influencing regional employment, influencing urbanization, and environmental protection effects. The Shanghai-Kunming high-speed rail has the following three aspects to the economic impact of cities along the route.

2.2.1. Improve transportation capacity. At present, the growing demand for railway passenger transport needs to be resolved, and the smooth opening of the Shanghai-Kunming high-speed railway is undoubtedly effectively alleviating the problem of insufficient transportation capacity along the cities along the route, especially for Guizhou and Yunnan provinces. At the same time, it can effectively help improve the traditional transportation structure, rational resource allocation and improve transportation structure. At the same time of improving transportation efficiency, the overall network layout of railway lines along the province has become more complete and optimized.

2.2.2. Improve accessibility. The opening of the Shanghai-Kunming high-speed railway connects the six provincial capitals and municipalities of Shanghai, Hangzhou, Nanchang, Changsha, Guiyang and Kunming, greatly shortening the travel time between each other and improving accessibility. As a result, the commuting time of a large number of residents has been saved, the pace of social and economic operations has been accelerated, and economic benefits have been greatly improved.
2.2.3. Improve the links between regional economies. The high-speed railway can connect cities along the line to form a traffic corridor or an overall economic corridor. The development of high-speed railways has shortened the time distance between various industrial zones and cities, promoted exchanges and cooperation between cities, and promoted the development of regional economy as a whole. The entire line of Shanghai-Kunming high-speed rail is opened to connect the three economic regions of the upper, middle and lower reaches of the Yangtze River more closely.

3. Optimize the urban space gravity model and case checking

3.1. Optimization of Urban Space Gravity Model Method
The urban space gravity model is constructed according to the law of gravity and the principle of distance attenuation. It is used to measure the closeness of the economic relationship in the affected areas. The expression is as follows:

\[ F_{ij} = K \frac{G_i^a G_j^\beta}{d_{ij}^\lambda} \]

Among them: \( F_{ij} \): the size of space gravitation between i city and j city; \( G_i, G_j \): the city quality of i city and j city, generally expressed by the population or GDP of the city; \( d_{ij} \): the spatial distance between two cities; \( K \): constant, also known as gravitational coefficient; \( \alpha, \beta \): elastic coefficient, used to adjust the influence of each factor on gravity; \( \lambda \): distance friction coefficient.

3.2. Analysis of the cities along the Shanghai-Kunming high-speed railway
According to the 2017 index data of the cities along the Shanghai-Kunming high-speed railway, the above-mentioned entropy method is used to calculate the comprehensive quality \( G \) of each city. The results of each evaluation index are shown in the following table.

| Primary indicator | Primary indicator | Weights | Weights | Weights |
|-------------------|-------------------|---------|---------|---------|
| City size         | Urban Infrastructure | 0.1006 | population | 0.0192 |
|                   |                   |         |          |         |
| Urban quality G   |                   | 0.4897  | Urban production value | 0.0329 |
|                   |                   |         | Per capita GDP | 0.0017 |
|                   |                   |         | The proportion of the tertiary industry to GDP | 0.0062 |
|                   |                   |         | Fixed assets investment | 0.0012 |
|                   |                   |         | Per capita fixed assets investment | 0.0017 |
|                   |                   |         | Local fiscal revenue | 0.0576 |
|                   |                   |         | Local fiscal expenditure | 0.0801 |
|                   |                   |         | Per capita disposable income of urban residents | 0.0068 |
|                   |                   |         | The total retail sales of social consumer goods | 0.0288 |
|                   |                   |         | Value added of industrial enterprises above designated size | 0.0307 |
|                   |                   |         | Total import and export | 0.1796 |
|                   |                   |         | Actual use of foreign capital | 0.0624 |
|                   |                   |         | Total passenger traffic | 0.0183 |
|                   |                   |         | Shipping weight | 0.0874 |
|                   |                   |         | Number of mobile phone users | 0.0201 |
|                   |                   |         | Internet user | 0.0152 |
|                   |                   |         | Per capita living water consumption | 0.0055 |
|                   |                   |         | Per capita green area | 0.0041 |
According to the weight of urban quality indicators, the city's comprehensive quality G can be measured. The use of distance between cities to replace space distances can better reflect the impact of the development of high-speed railways on accessibility and attractiveness between cities.

Table 2. Urban gravity after (before) the opening of the high-speed railway

|                | Shanghai | Hangzhou | Nanchang | Changsha | Guiyang | Kunming |
|----------------|----------|----------|----------|----------|---------|---------|
| Shanghai       | —        | 1064.120 | 126.031  | 96.569   | 45.388  | 37.767  |
| Hangzhou       | 1064.120 | —        | 43.150   | 29.348   | 12.389  | 10.068  |
| Nanchang       | (798.090)| (13.648) | —        | (29.771) | (2.721) | (1.923) |
| Changsha       | 96.569   | 29.348   | 39.897   | —        | 16.285  | 10.095  |
| Guiyang        | (43.399) | (13.648) | (29.771)| (4.449)  | (3.056) | (1.238) |
| Kunming        | 37.767   | 10.068   | 7.118    | 10.095   | 21.984  | —       |

Calculate the mutual gravitational coefficients between the municipalities directly under the Central Government and the provincial capitals before and after the opening of the Shanghai-Kunming high-speed railway. The opening of the Shanghai-Kunming high-speed railway has greatly increased the spatial gravitation between the municipalities directly under the central government and the provincial capitals. Taking Shanghai and Kunming as examples, the analysis compares the inter-city gravity and growth multiples before and after the opening of the Shanghai-Kunming high-speed railway, as shown in the following figure.
Figure 3. Comparison of urban gravity with Kunming as a reference.

By comparison, it can be concluded that the opening of Shanghai-Kunming high-speed rail has a greater effect on Kunming than Shanghai. As Kunming is located in the western part of China, geographical factors and economic development have led to poor accessibility in the region. The opening of the Shanghai-Kunming high-speed railway has greatly increased the number of passengers who choose to travel by railway and enhance the communication ability between Kunming and other regions. At the same time, through the above calculation of the inter-city gravity, it is further illustrated that the opening of the high-speed railway has a more obvious effect on the central and western regions, which can greatly increase the attractiveness of the western cities.

4. Conclusion
This paper analyzes the mechanism of Shanghai-Kunming high-speed railway on the economic development of cities along the line, and concludes that the opening of Shanghai-Kunming high-speed railway has effectively stimulated the potential railway passenger transport market along the line, promoted the flow of people along the line, improved the traditional transportation structure, and greatly improved the city accessibility along the route. At the same time of improving transportation efficiency, the overall network layout of railway lines along the province has become more complete and optimized.

Through the establishment of the index evaluation system, the entropy method is used to calculate the comprehensive city quality, and the time distance is used instead of the spatial distance to optimize the inter-city gravity model, and the gravitational change between cities along the Shanghai-Kunming high-speed railway is more scientifically described. It can be concluded that the gravity between cities has increased by 1-3 times; the impact of western cities is even higher. The opening of high-speed railways can effectively promote the economic development of cities along the line, especially the rapid rise of western cities, most obviously in terms of accessibility, mode of travel and passenger route selection. In the future, Shanghai-Kunming high-speed railway will promote the flow of talents, funds, labor and materials between regions, minimize the duplication of corresponding projects, promote the faster development of the economy and improve the quality of life. At the same time, it will also promote the social and economic talents and material flows among cities in the region and promote the economic development in the region.

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