

Research on the Rule of Railway Network Expansion in the Northwest Region Based on GIS

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Keywords: GIS ; railway network destiny ; correlation analysis ; northwest region ; geographic economy.

Abstract. With the implement of the 13th Five-Year Plan and the Belt and Road Initiative, there will be a new railway construction cycle. Considering the influence that the density of railway network and population have on regional economic, a reasonable arrangement of the railway expansion gains its' necessity. To meet the demands of social development and the railway network expansion law it needed, the northwestern region was taken as an example in studying the development law of each province by doing correlation analysis on the railway density, the population density and the Per Capita GDP. A corresponding formula was thus put forward through the analysis, the density of railway network in 2020 was analyzed adaptively, and the change graphs of railway density were drawn by way of GIS. After taking into account the policy, economic and other factors together as a whole, the result shows that the 13th Five-Year Plan of the railway of Northwest provinces is coincident with the basic rule with a little ahead of the economy level.

Overview

The northwestern region which occupies about 30% of total land area is restrained by economic, geographical, historical conditions, its' overall development of traffic is seriously lagging behind the developed areas in the east. With the development of west regions and the gradual implementation of the Belt and Road Initiative, railway network density in western region has been improved, but it is still low as a whole. Railway can bring enormous economic benefits, while the newly-built high-speed rail network can even make a new space impact between two cities [1]. Therefore, research on the law of railway network expansion combining with western region's economic development and population so as to analyze the rationality of railway network planning is essential for a reasonable arrangement of the construction of the railway project cycle and the scale.

At present, there are many standpoints to the study of this problem. Some scholars studied the influence that the density of railway network may have on regions from the perspective of accessibility[2-4] by analyzing the degree of fusion between cities. Huang Jie points out that according to the level of social development, the freight cost has less impact on people travel choice, while the convenience of traffic and the efficiency of time is playing an increasingly important role, so railway development promotes the flow of factors of production between regions to a greater degree. Feng Changchun, Feng Xuebing and Liu Sijun [6] studied the inter-provincial accessibility and spatial pattern of high-speed rail in China by way of the weighted average travel time. Additionally, some scholars have analyzed the density of some regional railway from the perspective of economy and population. Nowadays, the existing problems in the research on the density of railway in the northwest area mainly derive from aspects such as unreasonable sample range selection, lacking of policy factors, lacking of intuitive expression and so on, whereas GIS offers a better solution towards those issues.

Analysis of Railway Scale in Northwest China

road network development history

The railway development in the northwestern region has been lagging behind in the whole country. From 1978 to 2008, the railway density in the northwest region increased from 19.25 km/hm² to 27.55 km/hm² with a growth rate of 48%, there was a great gap compared with the modern standard of 120 km/hm² proposed by the World Bank; At about the same time, the density of railway increased from 42 km/hm² to 164 km/hm², with a growth rate of 290%. Passenger and cargo volume had restricted the development of regional economy for a long time with the only main lines such as Lanxin, Longhai, Baocheng, Bao Lan ect. We can import the data of each province [9] into the ArcMap attribute table and then make use of the connecting function of GIS, thus, the growth of railway density in northeastern area is obtained(Fig. 1, Fig. 2, Fig. 3).

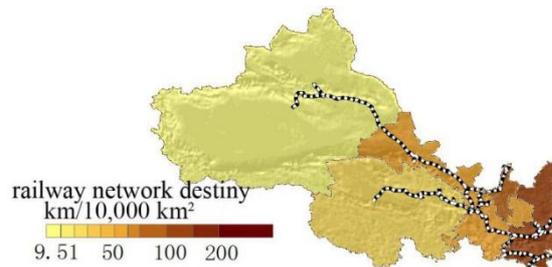


Fig.1 The northwest railway traffic map in 1984

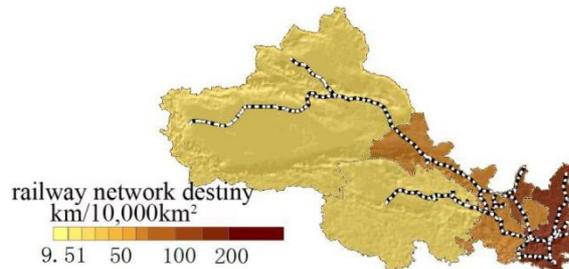


Fig. 2 The northwest railway traffic map in 2004

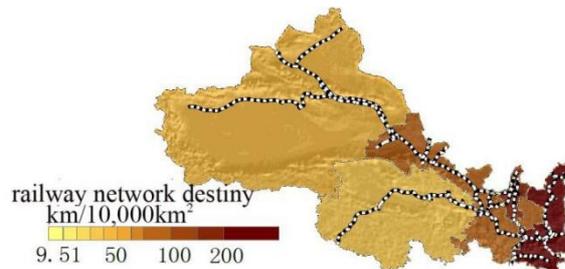


Fig. 3 The northwest railway traffic map in 2014

Population density, per capita GDP on the impact of road network density

Northwest region is located inland China where the transportation function is more significant. The density of the railway directly affects the population mobility and the turnover of goods, thus affecting the regional economic level. When the railway network density is insufficient, the cargo turnover is small, in turn the economic development is restrained; whereas a too advanced railway network will not only take up a lot of social resources, but the investment is difficult to recall in a rather short period, it is also a waste of transport capacity. So the density of railway network in a region should be moderately ahead of the local economic situation so as to promote the development of economy. The growth of railway density, per capita GDP and population density in Northwest China are demonstrated as Fig. 4, Fig. 5:

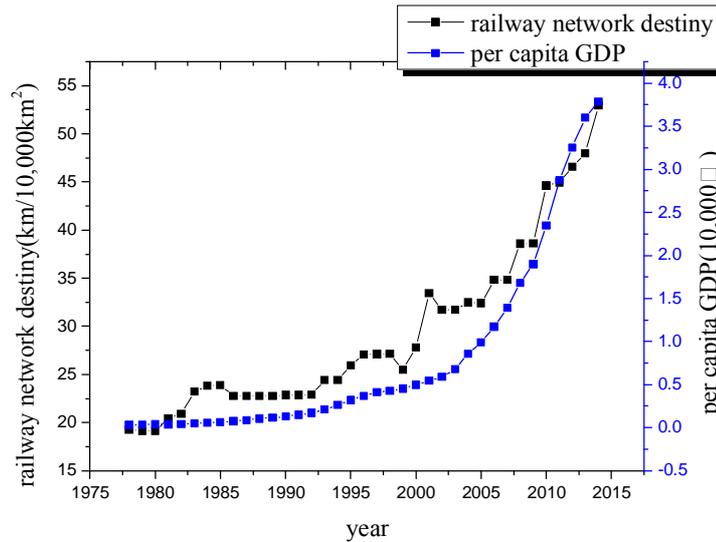


Fig. 4 Northwestern region road network density and per capita GDP growth trend chart

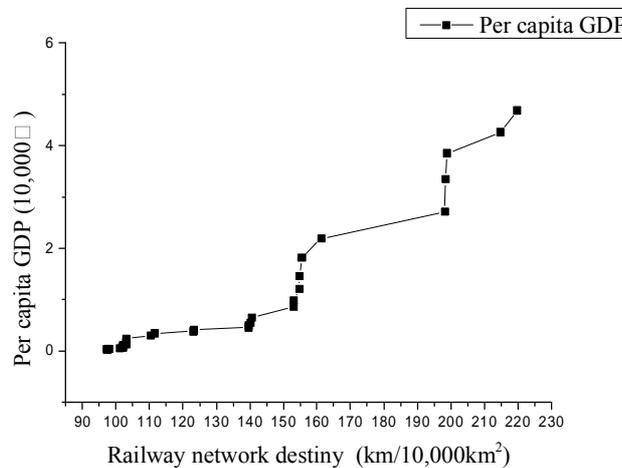


Fig. 5 Northwestern region road network density and per capita GDP diagram

It is illustrated in the picture that the development of railway presents the obvious phases. In order to test whether the density of railway road network is suitable for economic development, the SPSS software here is introduced to analyze the correlation among population density, railway network density and per capita GDP in the northwest region. Then the Pearson simple correlation coefficient is applied to measure the linear correlation among variables. The results of the analysis are shown in Table 1.

Table 1 The provinces network density Pearson correlation tables

parameter	province			
	Shaanxi	Gansu	Qinghai	Xinjiang
Per capita GDP and road network density correlation	0.951	0.9	0.882	0.972
Correlation between road network density and population density	0.765	0.853	0.828	0.922

From the table above we can see that there is a strong positive correlation among the three. Then set the road network density and population density as independent variables, and per capita GDP as a

dependent variable to map a picture, find out the inflection point of economic development curve or fallen overlap in year interval. By calculating the derivative, the year intervals that economic growth slowed down can be drawn, the railway growth rate in these years is relatively slow, while the growth rate of the other years is faster(Fig.6).

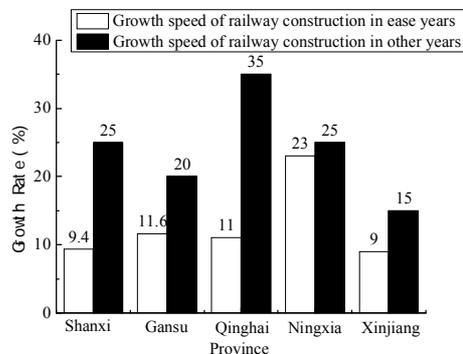


Fig.6 Northwest railway network density growth figure

Impact of major events on road network density

In addition, the railway density also depends on the policies from both national and local government . Wang Zhengming [10] proposed the layout of the domestic railway from the strategic level and programmed the domestic route way and node, but there is still less involved in the study of policy factors at present. In 2000, China began to implement the western development strategy, taking Shaanxi Province as an example, the growth rate of railway density is 11% in 1995-2000, and it rates 24% in next five years. As for Xinjiang Province, with a 4 trillion investment plan in 2008, which made its' railway density rate increased from 2% to 56% in 3 years, the policy affected the road network density in a large extent. In order to discover the macroeconomic changing law, gravity analysis with GIS was conducted, and it reflected the change of the economic trend scientifically, proved the rationality of “different scales of cities develop coordinately” Through the GDP analysis of the five provinces of northwestern region in 1984, 2004 and 2020 (forecast), conclusion can be drawn that the geometric center of gravity of the railway network in the northwest is moving from east to west. This also a verification of the "western development" strategy(Fig.7).

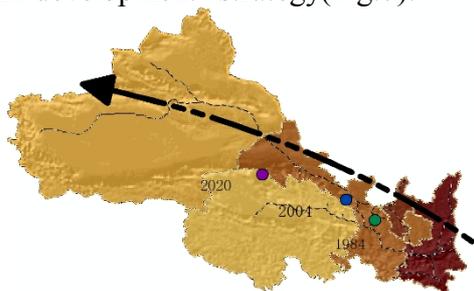


Fig. 7 The northwest railway geometric figure center of gravity moving direction

vision planning

medium and long-term road network planning

According to China’s long-term railway network planning, by 2020 the scale of China's railway network will reach 150,000 km, and by 2025, the scale of the railway network will reach 175,000 km. The new railway in the northwest includes both the international channel, such as the Kashi-Tugu section of the Zhongjiwu Railway, and the Korla-Golmud line.

provincial planning and road network adaptability analysis

Multivariate regression is a common method used in forecasting, some scholars have analyzed and predicted the railway density in terms of economic, population and other factors. According to the observation, the population growth rate in Northwest China remains stable. In 2016-2020, the population growth rate of Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang will be 0.15%, 0.75%,

0.81%, 1.22% and 1.5% respectively. The population of each province will reach 183.705 person/km², 57.33 person/km², 8.15 person/km², 100.87 person/km² and 14.04 person/km². Compare the regression equation of GNP per capita with the Cobb-Douglas function, the multiple regression index relation model among the density of railway network, the population density and the per capita GDP is obtained. Then with the SPSS software applied to fit the provinces in the northwest region, the model expressions are listed as follows:

$$R = \exp (a + b * P + c * E), \tag{1}$$

Where R is the railway network density (km/hm²), P is the population density (person/km²), E is the per capita GDP (million/person), the following formula is the railway road density regression equation of Shaanxi province:

$$R = \exp (3.678 + 0.134 * P + 0.006 * E) \tag{2}$$

the parameters of the equations obtained after the regression of the data in each province are shown in Table 2, Table 3.

Table 2 The northwest provinces regression equation parameters

parameter province	a	b	c
Shaanxi	3.678	0.134	0.006
Gansu	3.809	0.134	0.001
Qinghai	1.166	0.091	0.227
Ningxia	2.99	0.109	0.019
Xinjiang	0.796	0.107	0.159

Table 3 Northwest provincial road network density table in 13th Five-Year Plan

province indicators	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang
Road network density planning value (km/hkm ²)	315	150	44.4	301.2	65
Road network density calculated value (km/hkm ²)	304	78.42	35.2	241.3	39.57
The growth rate of road network density planning value (%)	43	68	50.6	45.1	90.2
Road network density growth rate calculated value (%)	38	16.9	19.4	24	20.2

It can be seen from the table that although there is some deviation between the calculated value and the planned value, the density growth rate of each province is basically in accordance with the railway construction and economic law, and because the Belt and Road Initiative attaches more significance to the connection with other countries in the northwestern region compared with the previous policies. In 2016-2020 is also a key period of building a well-off society in our country, the growth of road network density locates in a reasonable range, and it also indicates the complexity of railway road network density factors.

Conclusion

Through GIS we can easily query and manage data of a region, and its' development and changes can be shown vividly. The economic development varies among the northwest region, and the link

between railway and economic development is also different. However, due to the implementation of the policy of the Belt and Road Initiative, the density of the road network in the northwest will further increase. And the economic operation has a certain regularity, when the road network density benefits little to economic growth, the government should strictly control the approval of railway project to limit the density of road network to maintain about a 10% growth rate. When it comes to rapid economic growth, the growth of population or emergence of Major policy adjustments, a 30% -50% of the construction speed should be maintained according to local policy planning, so as to better adapt to economic development.

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