The Correlation Between Highway Transportation and Regional Economic Development in Inner Mongolia

Lichen Zeng

Abstract This paper analyzes the development of highway transportation in Inner Mongolia, comprehensively analyzes the correlation between highway transportation in Inner Mongolia and regional economic system by using research methods such as transportation economic elasticity analysis and gray correlation analysis, establishes a quantitative analysis model between economic development indicators and highway transportation development indicators in Inner Mongolia, points out the problems existing in the development of highway transportation in Inner Mongolia, and puts forward relevant policy suggestions.

Keywords Highway transportation · Economic development · Economic elasticity analysis of transportation

1 Introduction

With the rapid development of national economy and urbanization, highway transportation has become an important driving factor in regional economic development due to its advantages of wide coverage, relatively low construction cost and high transportation flexibility. Inner Mongolia is located in the north of China, adjacent to Mongolia in the north and bordering Russia in the northeast. It has unique geographical features and advantageous location in the communication area. Inner Mongolia is the key area of the "the belt and road initiative" strategy. It has the advantage of connecting Russia and Mongolia and is the window for China to open to the north. Highway transportation is the dominant mode of transportation in Inner Mongolia.

With the implementation of the national development strategy, Inner Mongolia's economic development momentum has increased and higher requirements have been put forward for the development of road transportation in Inner Mongolia. This paper

L. Zeng (✉)
School of Economics and Management, Beijing Jiaotong University, Beijing, China
e-mail: 17120539@bjtu.edu.cn

M. Li et al. (eds.), *IEIS2019*,
https://doi.org/10.1007/978-981-15-5660-9_17

discusses the relationship between highway transportation and economic development in Inner Mongolia by using research methods such as transportation economic elasticity analysis and gray correlation analysis, and provides policy suggestions for highway transportation development in Inner Mongolia.

2 Literature Review

The research on the correlation between transportation and regional economic development put forward by foreign researchers originated from the first half of the 19th century. Weber and other scholars regarded transportation as the prerequisite factor affecting the economy from the perspective of location. Adam Smith and others studied transportation and industrial layout. Rostow and other scholars have combined the unbalanced development of transportation and economy, demanding to realize the vigorous development of transportation.

Domestic scholars mainly study the impact of highway transportation on regional economy from the perspective of space and time. At the same time, some scholars study from different stages of traffic development and economic development. Among them, the main representative views are "alternate push-pull relation theory", "interaction theory" and "external effect theory" [1].

While carrying out qualitative research on the relationship between highway transportation and regional economic development, quantitative analysis is also carried out. Liu uses input-output method to analyze the impact of unit output value of transportation industry on national economic growth [2]. Chen and others adopted the data envelopment analysis method, and selected the total transportation routes, passenger transportation and turnover volume, and freight transportation and turnover volume as indexes, and concluded that the development degree of transportation and economic development are generally coordinated with each other [3]. Ding established the submodels of transportation, economy and the relationship between transportation and other industries to quantitatively analyze the non-linear relationship between transportation and economy, and proposed the concept of transportation reaction factor and its estimation equation [4].

Based on the summary of the research on the relationship between transportation and regional economy by Chinese scholars, it can be found that most of the research results on the relationship between transportation and economic development are from the macro perspective or from the perspective of transportation promoting economic development unilaterally. However, there is little research on the relationship between highway transportation and economic development in underdeveloped areas, especially in Inner Mongolia, which has great development potential.

3 The Present Situation and Existing Problems of Highway Traffic Development in Inner Mongolia

3.1 Current Situation of Highway Traffic Development in Inner Mongolia

According to the Inner Mongolia Statistical Yearbook, by the end of 2018, a total of 55.4 billion yuan had been invested in fixed assets for highway transportation, 16,000 km of highway construction had been started, 3,200 km of new highways had been added, and the total mileage of highways in the whole region had exceeded 200,000 km, of which 6,630 km were expressways and 7,790 km were first-class highways, with 1.6 billion tons of commercial freight volume and 298.56 billion tons of freight turnover volume completed, up 8.5% and 8% respectively year on year.

There are expressways in 12 cities in Inner Mongolia, and the number of expressways in county towns has reached 94, including 51 expressways. The major thoroughfare that runs through the eastern and western parts of Inner Mongolia has been completed according to expressway standards. Fourteen expressways and 16 first-class expressways have been completed. Manzhouli and Erlianhaote and other major ports are connected by first-class expressways, forming an open pattern of connecting the south with the north and connecting the east with the west.

The completion of 30 out-of-area access roads has solved the problem of poor export between Inner Mongolia and other provinces and autonomous regions. Inner Mongolia is organically integrated with the port highway networks of North China, Northeast China, Northwest China and neighboring countries. It has unblocked the economic trunk lines from all parts of Inner Mongolia to the major markets in the mainland and to the sea in Xinjiang. It has effectively promoted the transformation of Inner Mongolia's resource advantages and location advantages into economic advantages. It is of great significance to the county economic development, industrial structure adjustment and economic development mode transformation in the areas along the line.

3.2 Problems Existing in the Development of Highway Transportation in Inner Mongolia

The Inner Mongolia has achieved great-leap-forward development in road transportation, supply capacity and service level. However, from the perspective of developing a comprehensive transportation system, highway transportation there are still some problems and deficiencies in development.

Firstly, the total amount of transportation infrastructure is still insufficient and structural contradictions are still prominent. Highway network density is only 1/3

of the national average, with high-grade highways accounting for only 14.7% of the total mileage, and ordinary national and provincial highways with thousands of routes. There are still 7,625 km of middle and fourth grade roads, other roads and unconnected roads, accounting for more than 20% of the total mileage. There are still 6,884 km of unconnected sections in the expressway network, and the whole expressway skeleton network has not yet been established. There are obvious differences in the regional development of the highway network in the whole region, and the development of the highway transportation facilities in each alliance city is unbalanced. Due to the slowdown of macro-economic development, difficulties in credit financing for highway construction, land, resources, environment and other factors, the expressway construction process in the whole region is slow.

Secondly, the contradiction between the demand for and supply of funds for transportation development is more prominent, the protection of public finance is obviously insufficient, the credit financing policy has bottlenecks, and the environment for attracting social capital to enter needs to be improved. With the transformation of economic development and the reduction of coal demand, the economic development of the autonomous region has been obviously impacted, the financial revenue of governments at all levels has been reduced, and the pressure of raising supporting funds for highway construction has become prominent. The rising cost of highway construction, the falling traffic volume and the poor efficiency of highway toll collection have affected the investment of social capital. With the deepening of reform, the investment policy environment for long-term support for highway construction has changed dramatically, and the contradiction between the demand and supply of funds for transportation development has become more prominent.

Thirdly, the service level of highway transportation needs to be improved, and there is insufficient effective connection and interaction with other modes of transportation. The general public transportation service has not yet been effectively met. The development of the comprehensive transportation system in the whole region is still in the initial stage. The transportation development between regions and urban and rural areas is uncoordinated. The effective connection between various modes of transportation is still not smooth. The level of transportation service needs to be further improved. The development of integrated transportation is slow. There is still a certain gap between the basic public services for urban and rural passenger transportation and the expectations of the people. The unreasonable organization of freight transportation structure has not been fundamentally reversed. The proportion of transportation costs in logistics costs is still high.

Fourthly, the highway maintenance management system is not smooth, the capital investment is insufficient, and the maintenance technology content is low. The division and multi-head management of the highway management industry in the whole region are serious, which affects the exertion of the management functions of the industry and the overall benefits of the road network. The investment in highway maintenance funds is insufficient, preventive maintenance cannot be followed up in time, and maintenance projects such as large and medium-sized maintenance and reconstruction of dangerous bridges cannot be arranged and implemented in time. Highway maintenance in rural and pastoral areas has not yet established a stable

and reliable financial guarantee system. The scientific and technological content of highway maintenance in the whole region is still at a relatively low level compared with similar regions in the country. Highway maintenance technology is single and backward, and advanced highway maintenance technology and technology have not been applied and popularized.

4 Data Comes from Research Methods

4.1 Data Sources

This paper selects GDP, highway mileage and passenger and freight transportation turnover to analyze the correlation between economic development and various data of highway transportation. The data in this paper are mainly from the statistical yearbook of inner Mongolia from 2000 to 2017.

4.2 Research Methods

- Correlation coefficient

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{1}$$

$$r = \frac{\sum_{i=1}^{n} x_i y_i - n\overline{xy}}{\sqrt{\sum_{i=1}^{n} x_i^2 - n\bar{x}^2} \cdot \sqrt{\sum_{i=1}^{n} y_i^2 - ny^2}} \tag{2}$$

Where, $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$, $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$ are the mean values of samples x and y, generally x is the independent variable and y is the dependent variable; $i(i = 1, 2, 3, \ldots, n)$ is the number of samples.

- Analysis on Economic Elasticity Coefficient of Transportation

The elastic relationship between transportation and economic growth refers to the comparative relationship between the growth rate of transportation volume and the growth rate of GDP, which is usually defined as the ratio of the growth rate of transportation volume to the growth rate of GDP. Obviously, if the transportation supply of a country or region can meet the demand of transportation, the elasticity coefficient calculated on the basis of the actual transportation volume of the transportation system can reflect the elasticity relationship between transportation and economic

growth. For a given two departments (represented by variables x and y respectively) with a certain relationship in the economic and social system, the elastic relationship between them can be expressed by digital relationship, and its calculation equation is:

$$e = \frac{d_x}{x} / \frac{d_y}{y} \tag{3}$$

Among them, e the economic elasticity coefficient of highway transportation, x is the total amount of highway transportation, d_x is the growth amount of highway transportation, y is the total amount and d_y is the GDP growth amount. In the equation, $e = 1$ shows that the highway transportation and GDP in Inner Mongolia are increasing simultaneously. $e > 1$ shows that the growth of highway transportation in Inner Mongolia is faster than that of GDP. $e < 1$ shows that the growth of highway transportation in Inner Mongolia is slower than that of GDP.

- Grey Correlation Analysis

The general abstract system, such as social system, economic system, agricultural system, ecological system, etc., contains many factors, and the development trend of the system is determined by the result of the combined action of many factors. Among the numerous factors, which are the main factors, which are the secondary factors, which have a great impact on the system development, which have a small impact on the system development, which have a promoting effect on the system development, which need to be strengthened, which have an hindering effect on the system development and need to be suppressed, these are all issues that people are generally concerned about in system analysis. This paper will use grey correlation analysis to calculate which factors in Inner Mongolia highway transportation system have great influence on the development of regional economy and play a driving role in the development of regional economy, while which factors are restricting the development of Inner Mongolia regional economy and need to be strengthened.

Including economic development sequence group (X_i) and transportation sequence group $\left(Y_j\right)$. Among them, X_i including 5 indicators, Y_j including 4 indicators.

The initial value transformation is adopted for dimensionless treatment, and the calculation equation is as follows:

$$f(X_i(k)) = x_i(k)/x_i(1) \qquad X_i(1) \neq 0 \tag{4}$$

$$f\left(Y_j(k)\right) = y_j(k)/y_j(1) \qquad Y_j(1) \neq 0 \tag{5}$$

The correlation coefficient is the premise for calculating the correlation degree, and its calculation equation is:

$$\xi_{ij} = \frac{i^{min} j^{min} \left| X_i'(k) - Y_j'(k) \right| + \rho_i^{max} \rho_j^{max} \left| X_i'(k) - Y_j'(k) \right|}{\left| X_i'(k) - Y_j'(k) \right| + \rho_i^{max} \rho_j^{max} \left| X_i'(k) - Y_j'(k) \right|} \tag{6}$$

Among them, $\xi_{ij}(k)$ is the correlation coefficient between the first economic development index and the first transportation index in Inner Mongolia. The sum $X_i'(k)$ is the normalized value between Inner Mongolia's first economic development index and $Y_j'(k)$ the first transportation index, which ρ is the resolution coefficient, with a general value of 0.5.

Since there are many correlation coefficients, which are inconvenient to compare, it is necessary to centralize the correlation coefficients into one value, and its calculation equation is:

$$\gamma_{ij} = \frac{1}{n} \sum\nolimits_{N=1}^{1} \xi_{ij}(k) (\mathrm{N} = 1, 2 \ldots \mathrm{n}) \tag{7}$$

Among them, γ_{ij} is the degree of correlation, N is the number of indicators, that is, the Inner Mongolia economic development indicators or transportation indicators selected in this paper.

The value range of correlation degree is 0–1 ($0 \leq \gamma_{ij} \leq 1$), the greater the value, the greater the correlation, when $0 < \gamma_{ij} \leq 0.35$ it is low correlation degree; For $0.35 < \gamma_{ij} \leq 0.65$ moderate correlation; When $0.65 < \gamma_{ij} \leq 0.85$ is higher correlation; When $0.85 < \gamma_{ij} \leq 1$, the correlation is high.

5 Empirical Analysis on the Correlation Between Economic Development and Highway Transportation in Inner Mongolia

5.1 Correlation Analysis Between Economic Development and Highway Transportation

Based on relevant data, Pearson correlation coefficient matrix can be obtained by using equation and SPSS software calculation. Through the matrix, the correlation coefficients of GDP and highway passenger turnover, highway freight turnover and highway mileage are 0.851, 0.919 and 0.931, the correlation coefficient of highway mileage and highway passenger turnover is 0.745, and the correlation coefficient of highway mileage and highway freight turnover is 0.879, all of which are significantly correlated on the confidence level of 0.01. It can be seen that the correlation coefficient with passenger turnover, freight turnover and highway mileage has reached above 0.7, indicating that the relationship between them meets the significant correlation requirements of statistics, and the correlation is relatively significant (Table 1).

Table 1 Correlation coefficient matrix of economic development and highway transportation indicators in inner Mongolia

Indicators	GDP	Highway passenger transport turnover	Highway freight turnover	Highway mileage
GDP	1.000	0.851	0.919	0.931
Highway passenger turnover		1.000	0.789	0.745
Highway freight turnover			1.000	0.879
Highway mileage				1.000

5.2 Analysis on Economic Development and Elastic Coefficient of Highway Transportation

In order to simplify the calculation process, this paper selects GDP as the measurement index of inner Mongolia's economic development, selects inner Mongolia's highway passenger turnover and highway freight turnover as the measurement index of inner Mongolia's highway transportation, and calculates the economic elasticity coefficient of Inner Mongolia's transportation through equation that can be seen Table 2.

The development of economic elasticity coefficient of highway cargo transportation in Inner Mongolia basically shows an upward trend from 2000 to 2015, and a downward trend from 2015 to 2018. From 2001 to 2018, the GDP of Inner Mongolia and the transportation economic elasticity coefficient of road transportation freight turnover are basically positive, which shows that the economic growth and the growth of road transportation are positively correlated. The economic elasticity coefficient of transportation is more than 1 in most cases after 2007, and the growth rate of road freight transportation is faster than the economic growth rate. With the rapid development of Inner Mongolia's economic base, road cargo transportation is well adapted

Table 2 Inner Mongolia transportation economic elasticity coefficient from 2000 to 2018

Year	Economic elasticity coefficient of passenger transport	Economic elasticity coefficient of cargo transportation
2000	0.65	0.61
2003	−0.28	0.20
2006	0.43	0.71
2009	0.71	1.03
2012	0.89	1.94
2015	−1.90	18.80
2018	−1.93	1.09

to the requirements of economic development. Road transportation has increased investment and accelerated the pace of development.

From 2001 to 2018, the elasticity coefficient of passenger transport turnover volume and GDP in Inner Mongolia gradually showed a downward trend, especially from 2012 to 2018, showing a significant year-on-year decline, basically below 0.6 and showing negative values, indicating that the growth rate of passenger transport seriously lags behind the economic growth rate. With the increase of per capita income, the travel demand of passengers is continuously increasing. The supply of passenger transport in Inner Mongolia cannot meet the demand of passenger transport. The passenger transport industry restricts the economic development of Inner Mongolia.

5.3 Grey Correlation Analysis of Economic Development and Highway Transportation

- *Construction of Index System*

In this paper, the economic development system of Inner Mongolia and the transportation system are analyzed by grey correlation degree, and the economic development system is constructed by using 4 indexes including the GDP of Inner Mongolia from 2000 to 2017 and the GDP of primary, secondary and tertiary industries. The statistical data of 5 indexes such as road mileage, road passenger turnover, road freight turnover and road network density are used as comparison series shown in Table 3.

- *Calculation of Correlation Degree*

Through equation, the correlation matrix is obtained after processing the original data of Inner Mongolia In the highway transportation system, the index with the highest correlation with GDP is the freight turnover X4, reaching 0.9307, which shows that the development of the freight transportation industry is closely related to the economic development. The average correlation degree between the turnover volume of goods and the three industries is also above 0.8, which is relatively

Table 3 Index system of grey correlation analysis between economic development and highway transportation in inner Mongolia

Highway transportation index	Indicators of economic development
X_1 highway mileage	Y_1 GDP
X_2 Expressway Mileage	Y_2 Gross Output of Primary Industry
X_3 Highway Network Density	Y_3 Gross Output Value of Secondary Industry
X_4 turnover of goods	Y_4 Gross Output Value of Tertiary Industry
X_5 passenger turnover	

Table 4 Grey correlation analysis index system of economic development and highway transportation in inner Mongolia

	X_1	X_2	X_3	X_4	X_5	Average
Y_1	0.8876	0.9142	0.8686	0.9307	0.7821	0.87664
Y_2	0.8256	0.9889	0.8458	0.8314	0.8344	0.86522
Y_3	0.8683	0.9578	0.9316	0.8615	0.7385	0.87154
Y_4	0.8482	0.9795	0.9248	0.8942	0.8104	0.89142
Average	0.8574	0.9601	0.8927	0.8794	0.7913	

high, with the development of goods transportation playing the most significant role in promoting the development of the tertiary industry. The highway mileage has the highest average correlation with economic development among all kinds of highway indexes, which shows that the highway development is the most closely related to economic development in the highway transportation system. Highway has obvious advantages to drive the circulation of goods in the region and integrate the independent economies in the region to promote the overall rapid development (Table 4).

6 Conclusions and Recommendations

Inner Mongolia highway traffic has a high degree of correlation with economy. Economic development has a positive impact on the development of highway traffic, which also greatly promotes economic development. Inner Mongolia is located inland. Highway transportation is the dominant mode of transportation in the autonomous region. After years of construction, highway traffic is at a stage of development in which it accelerates to form a network, steadily improves and integrates with comprehensive traffic, and pays equal attention to overall development. On the one hand, it is required to optimize the network layout, strengthen the connection of facilities, and vigorously improve the smooth level of infrastructure and the coverage of key cities and towns in the construction of highway transportation system.

We should speed up the construction of tourist passages and tourist highways, and strengthen the supporting and guaranteeing role of transportation in tourism. In accordance with the principle of seeking progress in stability and being moderately ahead of schedule, we should continue to improve the construction of transportation infrastructure, focus on strengthening weak links, continuously upgrade the technical level and construction standards of infrastructure, and improve the service capacity of transportation facilities. On the other hand, as the basic network of the comprehensive transportation system, highway transportation development should be based on its comparative advantages of wide coverage and close connection with public production and life, strengthen the connection with other modes of transportation,

make overall and intensive use of channel resources, and optimize the allocation of channel capacity. Strengthen the connection with railway stations, airports and other transportation hubs, and improve the connection and conversion efficiency between roads and other modes of transportation.

In areas where the total amount of highway transportation infrastructure in Inner Mongolia is still insufficient, the transportation service letter needs to be improved, and there is still a certain gap with the national advanced level, it is even more necessary to speed up infrastructure construction, speed up the improvement of infrastructure network, vigorously promote modern transportation organization methods, comprehensively improve the overall supply capacity and comprehensive service level of transportation, and increase power and reserve stamina for optimizing the structure, improving quality and increasing efficiency in stable economic growth.

References

1. Xiao, Z. (2005). Research on the interactive relationship between guangdong intercity transportation and regional economic development. *Central South University*, 5–7
2. Liu, J., & He, J. (2002). Transportation and national economic development the empirical research. *Journal of Transportation Systems Engineering and Information Technology*, *2*, 82–86.
3. Chen, D., Jiang, X., & Li, T. (2007). Study on coordinated development of regional economic system and highway transportation system. *New West*, *8*, 4–6.
4. Ding, Y. (2005). Study on the relationship between transportation and economy. *System Application of Engineering Theory and Methods*, *4*(2), 23–26.