Coupling Coordination Analysis of Multidimensional Transportation and New Urbanization--Taking Twelve Provinces and Cities in Western China as The Example

Da Cheng, Yongsheng Qian, Junwei Zeng, Xiaoping Guang

School of Traffic and Transportation,Lanzhou Jiaotong University,Lanzhou 730070,China

Keywords: Coupling coordination analysis; Multidimensional Transportation System; New Urbanization; Entropy weight method; Scissors difference method

Abstract: New urbanization is an inevitable outcome of China's social and economic development. And the comprehensive development of multi-dimensional transportation system is the key means to accomplish new urbanization. Taking twelve provinces and cities in western China as the example,this paper presents a coordinated development evaluation system for multi-dimensional transportation system and new urbanization, and uses entropy method and coupling coordination analysis method to study the degree of coupling and coordination between them. The results show that the comprehensive evaluation index of new urbanization and multi-dimensional transportation system as well as the coupling coordination degree between them show arise trend, but have not reached the optimal state yet. Based on the result, the suggestions for improving the coupling coordination between them are proposed accordingly.

1. Introduction

In recent years, China's rapid development of new urbanization effectively supported the urban industrial structure adjustment and the utilization of rural surplus labor.Meanwhile,the development of multi-dimensional transportation system greatly alleviate the increasingly prominent urban traffic congestion and inefficiency, and make people's work and life more convenient than ever. The coupling study of the two systems can quantitatively analyze the promotion effect of multi-dimensional transportation system on new urbanization and then provide enough reasonable suggestions for the development of new urbanization.

At present, the researches on the transportation system and urbanization by many experts and scholars in the related fields, most of them mainly starts with specific methods, establishes different evaluation models, and analyzes the degree of coordination between them.To measure the development level of the new urbanization, Wang etal, found that the weight of index worked out with the entropy method can improve the objectivity and reliability.[1]; Wang studied the spatial pattern of new urbanization showed a decreasing trend from east to west, continuously expanded to the inland area.[2]; Jiang revealed such as environmental degradation, damage of rural culture, homogeneous competition of tourism, the low level quality overall, etal.[3]; Zhang etal studied the rail transit of the Tokyo metropolitan area System development and explored the impact of rail transit development on urban development [4]; Jiang created a coordination degree model, evaluated the degree of coordination, and analyzed the relevant trends [5];Zhao studied the scissors difference between the trends of EF an EC time series had been decreasing until 2000,and began to rise after the year.[6]; Delgado A Found the results revealed that for the groups urban population, rural population and specialists, the project would have a positive, negative and normal social impact, respectively. [7]; Zhu explored the relationship between the development of the rail transit system and the tourism economy by studying the relationship between tourism and railway development [8]. In the above studies, only static analysis is made on the relationship between transportation and economic development, but no further studies are made on the impact of dynamics.

Under the background of western development strategy and the rapid development of new urbanization, the key deployment areas of the multi-dimensional transportation system gradually

transfer from eastern to the central and western of China during the “13th Five-Year Plan” period. The relationship between the economic development and various transportation modes are becoming closer and closer, and the mutual promotion between the multi-dimensional transportation system and the new urbanization is gradually beginning to manifest. Therefore, this paper combines the model with the example of development status of multi-dimensional transportation system and new urbanization in 12 provinces and cities in the western China, and studies the development relationship between them based on the coupling coordination analysis approach.

2. The Model

2.1 Functional equation

The general function of multidimensional traffic (abbreviated as MT) and new urbanization (abbreviated as NU) is given as:

$$f(MT) = \sum_{i=1}^{n} a_i x_i \qquad i=1,2,...,n \tag{1}$$

$$f(NU) = \sum_{j=1}^{m} b_j y_j \qquad j=1,2,...,m \tag{2}$$

Where a_i , b_i denote the weight corresponding to x_i , y_i respectively,and x_i , y_i represent multi-dimensional transportation system indicator and new urbanization system indicator. According to the connection and role between the two system, it is assumed that there is a large system covering the two systems, then we can get the following:

$$A = df(MT)/dt = \alpha_1 f(MT) + \alpha_2 f(NU) \tag{3}$$

$$B = df(NU)/dt = \beta_1 f(MT) + \beta_2 f(NU) \tag{4}$$

According to (3) and (4), it can be concluded that in the whole system, whether there is a small change of multi-dimensional transportation system or a change of new urbanization indicators, it will eventually have an impact on the results. Therefore, the evolution process of the whole system can be regarded as the result of the joint action of the multi-dimensional transportation system and the new urbanization system.

$$V = g(V_A, V_B) \tag{5}$$

$$V_A = dA/dt \tag{6}$$

$$V_B = dB/dt \tag{7}$$

where, V is the evolution speed of the whole system; V_A, V_B are the evolution speed of the two systems under the condition of no external influences and with external influence respectively. If we consider V_A, V_B as a variable, we can learn more about the multidimensional transportation system and the new urbanization system through research V changes.

2.2 Coupling coordination degree and scissors difference analysis

The degree of coupling coordination between the two systems is the angle that satisfies the following relationship:

$$\tan\alpha = V_A / V_B \tag{8}$$

$$\alpha = \arctan(V_A / V_B) \tag{9}$$

In which, α denote the degree of coordination, by constantly changing it, the degree of coordination between multi-dimensional traffic and new urbanization can be quantified and contrasted, which is helpful to understand the relationship between them better.

$$\beta = \arctan\left|(V_A - V_B)/(1+V_A V_B)\right| \tag{10}$$

In this equation: β is the scissors; the larger the value, the greater the difference in the trend between the two system.

3. Coupling analysis

3.1 The index system

In the process of building the actual index system, it is necessary to constantly improve the coordination between MT and NU, and constantly improve the benefits of multi-dimensional transportation by using scientific means and advanced technology. All the index data listed here came from <The Provincial Statistical Yearbooks> and <The China Statistical Yearbooks>.

Table 1 Index system between multidimensional transportation and new urbanization

Composite system	subsystem	Indicator	
The Coordinated Development Level of Multidimensional Transportation--New Urbanization Composite System	Multidimensional transportation system	Passenger traffic	
		Freight volume	
		Passenger turnover	
		Cargo turnover	
		Operating mileage	
	New urbanization system	social urbanization	per capita disposable income of urban residents
			Number of health technicians per 10,000 people
		Economic urbanization	per-capita gross domestic product
			The proportion of output value of the second and third industries
		Population urbanization	Urban population
			The proportion of the third industry population
		Spatial urbanization	Urban population density
			Urban built-up area

3.2 Comprehensive evaluation model

In this paper, the two methods, Principal Component Analysis (PCA) and Entropy method, are used for research.

Dimensionless data and entropy method processing:Dimensionless data: $x_{ij} = \left|(X_{ij} - \min)/(\max - \min)\right|$ Where: X_{ij} is the index value of the system; $\max$ is the maximum value of the sample; $\min$ is the sample minimum. The proportion of one province in the index: $p_{ij} = x_{ij} / \sum_{i=1}^{n} x_{ij}, i = 1, \cdots, n, j = 1, \cdots, m$; The entropy value is: $e_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij})$; And $d_j = 1 - e_j$ is the information entropy redundancy; $w_j = d_j / \sum_{j=1}^{m} dj$ is the weight of each province.

(2)The coordinated development level can be obtained by the comprehensive evaluation index: $F = \sum_{i,j=1}^{m} F_i p_j$,in which, F_i is the evaluation value of a certain indicator, p_j is the weight of the indicator.

Through principal component analysis, the indexes which have the main influence on the two systems are obtained, and the comprehensive evaluation value of their performance level is obtained, which reflects the change trend of the system.

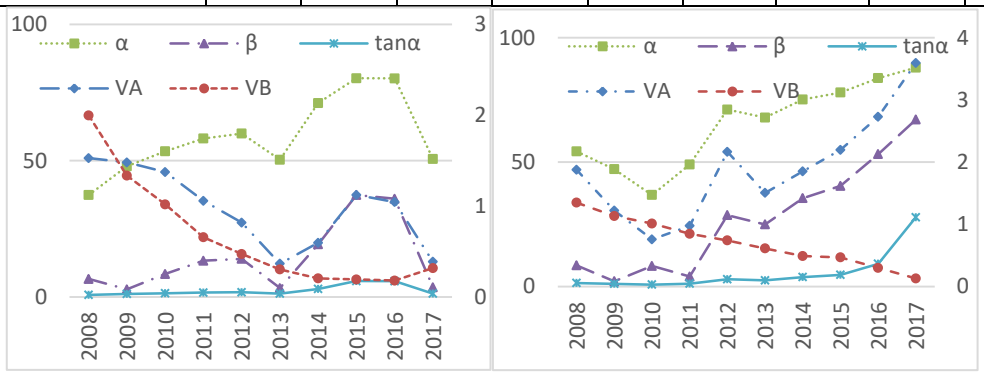
4. Coupling coordination degree analysis

4.1 Calculation of coupling coordination degree

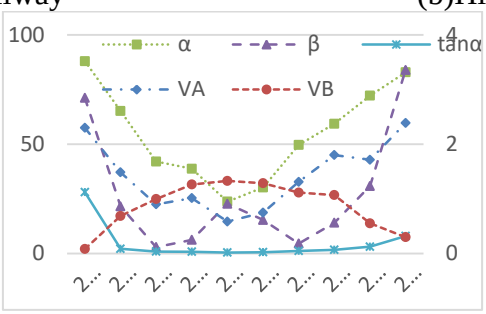
According to the above calculation, the comprehensive index values of railway transportation system, highway transportation system, air transportation and new urbanization system in the western of China from 2008 to 2017 are obtained as shown in table 3.

Table 2 Comprehensive evaluation value of multi-dimensional transportation system and new urbanization system in the western of China from 2008 to 2017

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Railway transportation system comprehensive index	-1.29	-0.90	-0.55	0.05	0.37	0.85	0.62	-0.05	0.07	0.83
Highway transport system comprehensive index	-1.33	-1.04	-0.64	-0.07	0.48	0.23	0.37	0.49	0.65	0.87
Aviation transport system comprehensive index	-1.46	-1.10	-0.72	-0.81	-0.32	0.35	0.78	1.03	0.99	1.27
New urbanization system comprehensive index	-1.60	-1.10	-0.81	-0.40	-0.13	0.21	0.54	0.60	1.08	1.59



(a) Railway (b)Highway



(c)Aviation

Fig.1 Coupling Coordination Degree between Transportation and New Urbanization in Western China from 2008 to 2017

Correspondingly according to equations (1)-(10), the degree of coupling and coordination between multi-dimensional transportation and new urbanization system indexes in western China from 2008 to 2017 are given in Figure 4.

5. Results Analysis

5.1 Multi-dimensional transportation system and new urbanization development level are gradually strengthened.

It can be concluded from the comprehensive evaluation value in the above table 3 that the development level of multi-dimensional transportation system and new urbanization system in western China shows an increasing trend year by year from 2008 to 2017. Among them, the railway transport system shows a slight decline from 2013 to 2017, but the comprehensive evaluation value of highway transport system and air transport system shows a rapid development. This means that with the national "12th Five-Year Plan" being carried out in 2013, while ensuring the steady development of the railway transport system, the air transport system and road transport system have been vigorously developed as well. From 2008 to 2014, the development rate of the new urbanization system is relatively slow, which indicates that the railway, air and highway transportation systems are developing in synergy with each other during this period.

5.2 The development of multi-dimensional transportation and new urbanizationThere is strong positive correlated.

It can be seen from the Figure 4 that the coordination and coupling degree of multi-dimensional transportation system and new urbanization system is coordinated and tends to be in a state of strong coupling and coordination during the period of 2008-2017.Since 2013, the construction of railway transportation begin to take shape, besides,the economic grows fast and steadily and which contributes to the development of multi-dimensional transportation systems. The two-coupling curve track converge, highway transportation system of the new urbanization system inhibition, begin to show the synchronous development of state.

5.3 The influence of new urbanization on the development of multi-dimensional transportation in western China is gradually strengthened.

It can be concluded from Figure 4 that the multi-dimensional transportation system and the new urbanization system showed a relatively fast speed transition to the synchronous development state from 2008 to 2012, and the collaborative development state between them begin to emerge. During the period, the western region's economy presented a rapid and stable development. With the improvement of economic situation, the gap between the evolution rate of highway transportation system and railway transportation system shorten, and the development trend of the two systems gradually converged. With the commence of the “12th Five-Year Plan, the development of the urbanization in western China increased obviously.

6. Suggestions

6.1 Strengthen the comprehensive and coordinated development of multi-dimensional transportation system and various transportation modes.

In the later period of the “13th Five-Year Plan” period, the comprehensive development of multi-dimensional transportation system should focus on the unity of scale, quality and benefits, and the changes from the isolated development of various transportation modes to the coordinated development of various transportation modes. It is urgent to update the perspectives from all levels, to further clarify the important role of traffic planning in the development of transportation, and respond to the development needs of new urbanization actively, rather than simply meet the needs of traffic planning alone. Based on a comprehensive understanding of the new urbanization construction, we should carry out in-depth exploration of the multidimensional transportation system planning, and pay attention to the connection, unification and coordinated development of various modes within the multidimensional transportation system.

6.2 Accelerate the development of new urbanization based on the multi-dimensional transportation system.

We will vigorously develop a multidimensional transportation system that will cover new urban areas, industrial agglomerations and other new areas, meet the needs of commuting, and increase the coverage of road networks in suburban areas and other areas. Different functions of transportation facilities should be utilized to guide the optimization of urban spatial distribution. With expressway ring roads, air routes and railway lines as the boundaries, the relations among ports, transportation, life and leisure should be handled comprehensively, and the agglomeration function of multi-dimensional transportation system for people flow and logistics should be utilized to drive the development of new urbanization.

7. Pay more attention to multi-dimensional transportation system planning in the process of new urbanization development.

From the current development situations of the western China, the level of economic development is increasingly mature and stable, and the construction of new urbanization is taking shape, which will bring new opportunities for the development of multi-dimensional transportation system apparently. From a new starting point, with the multi-dimensional traffic system planning in western region, we should make use of national policy support, further strengthen the coordinated unification between different modes of transport, and highlight the new route planning, especially depends on the construction of the "one belt one road", to ensure the sustainable and healthy economic growth at the same time. By following closely, the demands of the development of multi-dimensional traffic, we should work hard to prompt the multi-dimensional traffic system in the new urbanization development and enable it to develop faster and more efficiently.

8. Conclusion.

The development of new urbanization in western China needs to take the development status of multi-dimensional transportation system fully into consideration. In combination with the implementation of the national "One Belt and One Road" development strategy and the overall economic development progress, the development level of multi-dimensional transportation system can be improved a lot while promoting the construction of new urbanization. In this paper, the coupling coordination analysis method and entropy method are used to research multi-dimensional transportation system and new urbanization development. The development status of multi-dimensional transportation system and new urbanization system in western China, as well as the difference in development trend between them, are studied carefully and analyzed thoroughly hereby. The results show that the coordinated development of different modes of transportation in the multi-dimensional transportation system is an effective way to promote the development of new urbanization, and can also guide the optimization of urban spatial structure and the adjustment of road network planning to promote the balanced development of the two. This study helps to correctly understand the dynamic coupling law between multi-dimensional transportation and newurbanization, and provides scientific basis for the regional coordinated development.

Acknowledgments.

This work is supported by the National Social Science Foundation of China(Grant No. 14CJY052, No. 15BJY037) and the Natural Science Foundation of Gansu Province, China(Grant No. 1606RJZA017, No. 18JR3RA119).

References

[1] Wang Xin-yue, Song Yang, Song Fei-hong, et al. New Urbanization Measurement and Spatial Differences in Shandong Province [J]. Scientia Geographica Sinica, 2014, 34(9):1069-1076.

[2] Wang Jian-kang, Gu Guo-feng, Yao Li.Analysis of New Urbanization's Spatial Pattern Evolution and Influence Factors in China [J]. Scientia Geographica Sinica, 2016, 36(1):63-71.

[3] Huang Zhen-fang, LuLin, etal. Research and development of rural tourism under the background of new urbanization: Theoretical reflection and breakthrough of predicament [J]. Geographical Research, 2015.

[4] Zhang Yuan-hao,Rong Chao-he.Influence of Rail Transit on Tokyo Metropolis Area from Perspective of Time-space [J].Railway Transport And Economy, 2015, 37(8):78-82.

[5] Jiang Hui-feng.A Model for Evaluating and Predicting the Coordination of Transportation and Economic System [J]. Systems Engineering, 2014(1):133-138.

[6] Zhao Xiao-Lu, Gao Min-hua, Gao Jun, etal. Quantitative Analysis of Sustainable Development of Urumqi City Based on Modified Eco-footprint Model [J]. Xinjiang Agricultural Sciences, 2010, 47(4):774-779.

[7] Delgado A, Romero I. Environmental conflict analysis using an integrated grey clustering and entropy-weight method: A case study of a mining project in Peru [J]. Environmental Modelling & Software, 2016, 77:108-121.

[8] Zhu Tao-xing, Lu Jun, Zhu Zheng-guo.Study on Relationship between Railway Traffic and Tour Economic Growth in China based on Impulse Response Function [J]. Railway Transport and Economy, 2015, 37(7):54-60