

# Study on the Coupled Coordination of Transportation, Regional Economy and Population in Chengdu-Chongqing Economic Circle

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## Abstract

**Based on the panel data of transportation, regional economic and population indicators of Chengdu-Chongqing Economic Circle from 2010-2019, with 16 urban units in the economic circle as research objects, the coupling coordination model is used to conduct the coupling and coordination analysis of transportation, regional economy and population development of two cities economic circle of Chengdu-Chongqing from 2010 to 2019. The research shows that the coordination degree of Chengdu-Chongqing two cities economic circle is on the rise in time sequence, the surrounding cities are seriously siphon by core cities, and the radiation driving effect of central cities is not obvious. Therefore, it is necessary to strengthen the infrastructure construction, release the power of economic development, continuously promote the coordinated development of transportation, regional economy and population in the Chengdu-Chongqing two cities economic circle, and promote the coordinated and sustainable development of the western region.**

## Keywords

**Chengdu-Chongqing Urban Agglomeration; Transportation; Regional Economy; Population; Coupling and Coordination.**

## 1. Introduction

The Chengdu-Chongqing two cities economic circle is an important platform and key support for the development of western China and the construction of the Yangtze River Economic Belt. In 2011, The State Council approved the National Development and Reform Commission, the Chengdu-Chongqing Economic Zone and the Development Plan, and in 2016, the national urban agglomeration with economic vitality, good living quality and beautiful ecological environment by 2020, the Chengdu-Chongqing Urban Group with Beijing-Tianjin, Yangtze River Delta and Guangdong-Hong Kong-Macao in 2019. In January 2020, Xi Jinping presided over the sixth meeting of the Financial and Economic Commission of the CPC Central Committee, and pointed out that "Promoting the construction of the Chengdu-Chongqing twin-city economic circle is conducive to forming an important growth pole for high-quality development in the western region and building a strategic highland of inland opening-up, which is of great significance to promoting high-quality development". In October 2021, the Chengdu-Chongqing economic circle construction planning outline, shows that the country aims to drive by Chengdu and Chongqing, make Chengdu-Chongqing region with the economic center and science and technology innovation center, and gradually grow into a new growth pole driving the development of the national economy.

In conclusion, in order to fully explore and clarify the real situation of the coordinated development of two cities economic circle, this paper adopt the coupling coordination model to analyze the coupling coordination level between the traffic-city economic circle, and further propose the corresponding countermeasures and suggestions to promote the development of two cities economic circle.

## 2. Study Design

### 2.1. The Construction of the Index System

The study of the economic development of Chengdu-Chongqing economic circle is inseparable from the analysis of the development status of the transportation system in this region. As the demand side of transportation, the scale and distribution of population determine the investment scale and construction direction of the transportation system. The quality of regional economic development should be based on the perfection of the transportation system. The regional transportation system can not only directly affect the industrial layout and industrial structure of the region, but also provide a channel for the spatial spillover effect and industrial technology diffusion effect of the central city of the regional urban agglomeration. At the same time, the change of industrial distribution and the adjustment and optimization and upgrading of the structure will inevitably cause the flow of the population in the urban agglomeration, leading to the change of the urban population size, and then will have a certain impact on the urban transportation system.

The evaluation index of regional coordinated development is the premise of empirical research. Only by building a reasonable index system can we improve the effectiveness of the measurement. At present, scholars at home and abroad do not have a unified definition of regional development, so it is difficult to construct evaluation indicators directly. On the basis of summarizing the existing literature, combining with the actual situation of Chengdu-Chongqing two cities economic circle, and following the principles of comprehensiveness, scientificity and rationality, 25 evaluation indicators are selected to evaluate the regional development. Three sub-systems of transportation, regional economy and population development are constructed.

### 2.2. Weight Calculation

The research data involve a wide range of areas and lack unified quantitative indicators. Therefore, the treatment methods of previous scholars, and the extreme standardization method is used to normalize each index, so as to obtain comparable and direct dimensionless values. After normalization, the larger the value, the better the index is. The formula is as follows:

$$\text{Positive normalization: } N_{ij} = \frac{x_{ij} - \min x_j}{\max x_j - \min x_j}$$

$$\text{Negative normalization: } N_{ij} = \frac{\max x_j - x_{ij}}{\max x_j - \min x_j}$$

In the formula,  $x$  is the index variable value, and  $N_{ij}$  is the normalized value,  $i$  is the city,  $j$  is the index category.

After data standardization, the entropy method is used to calculate the index weight, and the results are shown in Table 1:

**Table 1.** Economic-population-transportation system indicators of Chengdu-Chongqing two cities Economic Circle

System	Index	Indicator nature	Entropy weight method
Economic System	Per capita GDP(yuan)	+	0.1791
	GDP(ten thousand yuan)	+	0.1888
	The proportion of added value of the secondary industry in GDP(%)	+	0.1772

	The proportion of added value of tertiary industry in GDP(%)	+	0.1371
	Number of industrial enterprises above designated size(piece)	+	-0.0025
	Total industrial output value above designated size(100 million)	+	0.0025
	Investment in the fixed assets (million)	+	0.1851
	Urbanization rate(%)	+	0.1326
<b>Population System</b>	The population density(people/km <sup>2</sup> )	+	0.1687
	Year-end population(thousands of people)	+	0.1445
	The population of permanent residents(thousands of people)	+	0.1564
	The birth rate(%)	+	0.1757
	Mortality rate(%)	-	0.1746
	Natural growth rate(%)	+	0.1800
<b>Traffic System</b>	Total road mileage(km)	+	0.0980
	Highway density(ten thousand kilometers)	+	0.1373
	Highway passenger volume(thousands of people)	+	0.0980
	Highway freight volume(ten thousand tons)	+	0.0963
	Waterway mileage(km)	+	0.1214
	Waterway passenger volume(ten thousand person-time)	+	0.1172
	Waterway freight volume(ten thousand tons)	+	0.0670
	Railway passenger volume( thousands of people)	+	0.0798
	Railway cargo volume(ten thousand tons)	+	0.1055
	Civil air passenger volume(people)	+	0.0457
	Civil air cargo volume(t)	+	0.0340

### 2.3. Model Establishment

This research focuses on the coordinated development relationship of transportation, regional economy and population system in Chengdu-Chongqing economic circle. Therefore, the three-way system coupling and coordination model is established as follows:

$$C = 3 \left[ \frac{U_1 \times U_2 \times U_3}{(U_1 + U_2 + U_3)^3} \right]^{\frac{1}{3}}$$

Development degree calculation formula:

$$T = 0.5u_1 + 0.5u_2$$

Coordination degree calculation formula:

$$D = \sqrt{C \times T}$$

**Table 2.** Evaluation criteria for coupling coordination degree

D	[0-0.3]	(0.3-0.4]	(0.4-0.5]	(0.5-0.7]	(0.7-0.8]	(0.8-1]
Degree	Severe disorder	Moderate disorder	Mild disorder	Barely coordination	Moderate coordination	Highly coordinated

### 3. Empirical Results Analysis

#### 3.1. Comprehensive Evaluation of Each Urban Development

As shown in Table 3, each city in the economic circle had great development in the past decade. From the perspective of development level, both in 2010 and 2019, Chongqing and Chengdu developed at significantly higher levels than other cities, which also reflects the status of these two cities in the economic circle. In terms of development speed and growth rate, Nanchong had the fastest growth rate in the decade (from 0.193 in 2010 to 0.270 in 2019 to 39.64%), followed by Mianyang (from 0.180 in 2010 to 0.251 in 2019, the growth rate reached 39.13%). The reason is that Nanchong has a superior geographical position. It is the central city in the north of Chengdu-Chongqing region, the economic city cluster of Yangtze River economy in southern Sichuan, the economic development city cluster in the northeast of Jialing River, and Nanchong is the central city in the north of Chengdu-Chongqing Economic circle. Nanchong is also the second most populous city in Sichuan province after Chengdu. The industrial development of Nanchong city is also good, among which auto parts and vehicle production is in the forefront, there are also new energy vehicle production base, economic development is also in the forefront of Sichuan. Mianyang city is the only science and technology city in China approved by the CPC Central Committee and The State Council. It is an important national defense scientific research and electronic industry production base and the second city in Sichuan. Its economic, industrial development and education are all very good in Sichuan. The territory has convenient transportation, 98 kilometers away from Chengdu, there are many railways and high-speed railways, among which Mianyang also has a civil 4D airport, the convenient transportation also makes the development of Mianyang more rapid.

**Table 3.** Comprehensive scores for urban development from 2010-2019

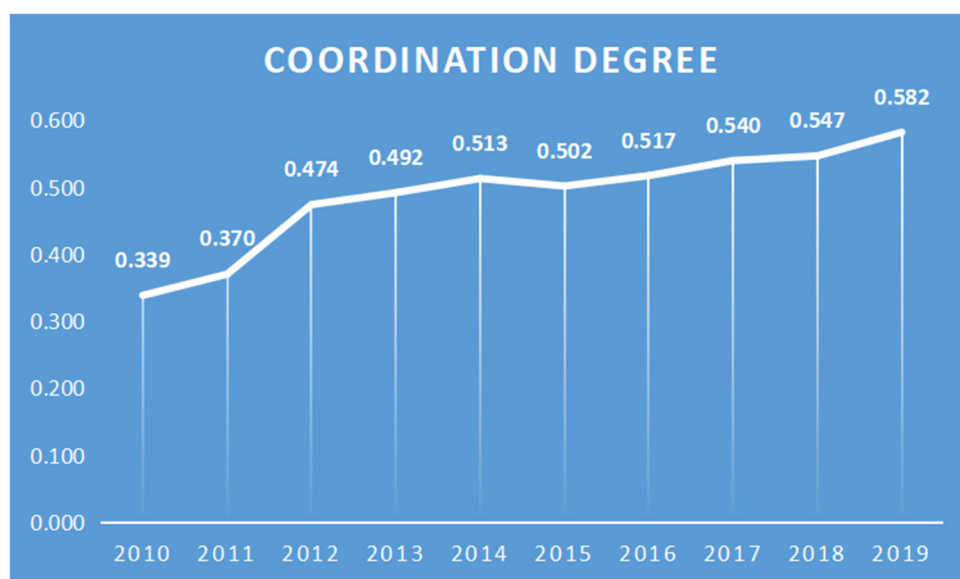
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Chongqing	0.631	0.566	0.568	0.571	0.565	0.577	0.594	0.629	0.619	0.635
Chengdu	0.401	0.375	0.411	0.416	0.405	0.429	0.468	0.500	0.507	0.515
Zigong	0.192	0.202	0.217	0.212	0.224	0.234	0.241	0.239	0.239	0.212
Luzhou	0.210	0.218	0.232	0.231	0.245	0.246	0.236	0.244	0.252	0.254
Deyang	0.186	0.207	0.218	0.220	0.227	0.230	0.235	0.268	0.252	0.250
Mianyang	0.180	0.184	0.205	0.209	0.217	0.239	0.211	0.243	0.252	0.251
Suining	0.163	0.174	0.183	0.186	0.192	0.200	0.207	0.211	0.225	0.204
Neijiang	0.215	0.213	0.225	0.214	0.235	0.264	0.219	0.269	0.243	0.240
Leshan	0.192	0.195	0.210	0.224	0.233	0.233	0.247	0.252	0.247	0.236
Nanchong	0.193	0.217	0.227	0.241	0.244	0.240	0.247	0.269	0.261	0.270
Meishan	0.187	0.194	0.210	0.198	0.227	0.235	0.228	0.231	0.214	0.214
Yibin	0.235	0.249	0.244	0.245	0.250	0.256	0.254	0.253	0.269	0.264
Guang'an	0.162	0.179	0.191	0.185	0.190	0.195	0.205	0.214	0.231	0.195
Dazhou	0.204	0.216	0.216	0.229	0.229	0.233	0.219	0.219	0.219	0.234
Ya'an	0.162	0.165	0.173	0.181	0.179	0.192	0.195	0.210	0.214	0.196
Ziyang	0.175	0.197	0.213	0.200	0.199	0.218	0.211	0.209	0.207	0.158

#### 3.2. Time Series Analysis

According to the formula of coupling degree and coupling degree, the coupling coordination degree of urban economy-population-transportation in two cities economic circle from 2010 to 2019 is calculated. Due to the limited space, only the results of 2010, 2015 and 2019 are listed, and the coupling coordinated development trend of the whole Chengdu-Chongqing economic circle with time series. (Table 4, Figure 1).

**Table 4.** Coupling and coordination of three cities in Chengdu-Chongqing two cities Economic Circle

	2010		2015		2019	
	Coordination degree	Coordination level	Coordination degree	Coordination level	Coordination degree	Coordination level
Chongqing	0.7862	M C	0.7588	M C	0.7915	H C
Chengdu	0.6144	B C	0.5823	B C	0.6782	B C
Zigong	0.3617	M D	0.4052	Mild D	0.3929	M D
Luzhou	0.4342	Mild D	0.4612	Mild D	0.4820	Mild D
Deyang	0.3439	M D	0.3952	M D	0.4138	Mild D
Mianyang	0.3962	M D	0.4669	Mild D	0.4797	Mild D
Suining	0.3706	M D	0.3936	M D	0.4112	Mild D
Neijiang	0.4236	Mild D	0.5064	B C	0.4605	Mild D
Leshan	0.4187	Mild D	0.4638	Mild D	0.4646	Mild D
Nanchong	0.4287	Mild D	0.4822	Mild D	0.5131	B C
Meishan	0.4079	Mild D	0.4574	Mild D	0.4029	Mild D
Yibin	0.4496	Mild D	0.4862	Mild D	0.4869	Mild D
Guang 'an	0.3590	M D	0.4000	Mild D	0.4148	Mild D
Dazhou	0.4384	Mild D	0.4726	Mild D	0.4634	Mild D
Ya'an	0.3885	M D	0.4213	Mild D	0.4297	Mild D
Ziyang	0.3909	M D	0.4338	Mild D	0.3811	M D



**Figure 1.** Coupled and coordinated development trend of the three systems in Chengdu-Chongqing Two Cities Economic Circle in 2010-2019

From the above results, we can see that the coupling and coordination degree of transportation, regional economy and population in Chengdu-Chongqing economic circle were on the rise, while only the coordination degree of Ziyang city and Meishan city decreased slightly. Although Chengdu-Chongqing region shuangcheng economic circle coupling coordination rising, but in addition to Chongqing in 2019, the rest of the cities are still at a low level of coupling coordination stage, mainly due to Chengdu-Chongqing region shuangcheng economic parts economic development is slow, system development lag between, thus showing low coupling coordination development. During the decade, the fastest coordination improvement was in

Mianyang city, rising to 1.21 times that in 2010, ranging from moderate to mild disorder. Seven of the 16 cities in the economic circle have changed their coordination levels, namely Chongqing, Deyang, Mianyang, Suining, Nanchong, Guang 'an and Ya' an, while the coordination levels of the other cities have not changed. From the perspective of time sequence characteristics, the overall coordination level of Chengdu-Chongqing economic circle has increased significantly in the past ten years, from 0.339 in 2010 to 0.582 in 2019, up by 1.71 times, and the increase is still very large.

#### 4. Conclusion

This paper to Chengdu-Chongqing region twins economic circle as the research object, select 2010-2019 Chengdu-Chongqing region twins economic circle in 16 cities of transportation, regional economic system and population panel data, using the entropy method of index weight calculation, using coupling coordination model to explore the relationship on the timing, and the in-depth analysis, get the following conclusions:

First of all, from the perspective of time sequence characteristics, the overall development level of Chengdu-Chongqing twin cities economic circle is relatively low and still in the rising stage of development, with great development potential. The comprehensive development level of Chongqing and Chengdu is still far higher than that of other cities, and their leading positions in the economic circle are unshakable. The comprehensive development scores of other cities in the circle are not much different, and the highest score is Nanchong, worthy of being the second city in Sichuan. In this decade, the fastest growth rate is also Nanchong. Secondly, Mianyang. The rapid development of Mianyang reflects the obvious geographical advantages of Deyang, and it has a solid industrial foundation and convenient transportation facilities. Let's look at the coupling coordination degree. After ten years of development, the coupling and coordination degree of Chengdu-Chongqing twin economic circle has shown an upward trend, stepping from moderate imbalance into barely coordination, and the upward trend is very obvious. Looking at each city alone, Chengdu and Chongqing are still far ahead. Except for Ziyang and Meishan, the other cities are also showing an upward trend, but the development is relatively slow. Many cities have uneven development and low coordination, but the reason is that many cities are strong in a certain aspect. For example, Deyang has a relatively high economic score, but its traffic score is relatively low.

From the perspective of spatial characteristics, the core cities and the surrounding cities differ significantly, and the polarization phenomenon is more serious. The central cities are simultaneously affected by the siphon effect of Chengdu and Chongqing, and the coordination degree is low. They present the two centers of Chengdu and Chongqing in space, and then diminishes around, and the central part seriously collapses. In the past ten years, the spatial pattern of cities in the economic circle is not obvious, the spatial connection is insufficient, and the diffusion effect and trickle-down effect of Chengdu and Chongqing are not obvious.

Based on the above conclusions, the paper puts forward the following suggestions for the coupling and coordinated development of "transportation-economy-population" system in Chengdu-Chongqing economic circle.

We will continue to vigorously develop Chengdu and Chongqing with the new development concept, establish the linkage mechanism of Sichuan-Chongqing policy coordination, industrial system complementarity, transportation network co-construction and human capital sharing, and innovate the system and mechanism of the coordinated development of Chengdu-Chongqing twin cities economic circle with the principle of common progress, win-win situation and sharing. At the same time, combined with their own advantages, development and complementary advantages, and explore the boundary of economic development and administrative management within a certain scope, to strengthen the deep integration of

economic activities between cities in the Chengdu-Chongqing twin cities economic circle. Secondly, give full play to the role of Chengdu and Chongqing to jointly drive and lead the high-quality development of other cities in the two cities economic circle. With Chengdu and Chongqing as the "points" and the connection between Chengdu and Chongqing and the cities adjacent to Chongqing as the "lines", it will become the "fundamentals" of the coordinated economic development of Chongqing.

In terms of transportation, we will further strengthen and enhance the infrastructure construction and connectivity level of the Chengdu-Chongqing Twin Cities Economic Circle, comprehensively improve the service capacity and level of the regional transportation network system, and jointly build a modern comprehensive transportation network system of the Chengdu-Chongqing Economic Circle. At the same time should be established in Chengdu-Chongqing region twins economic circle is given priority to with high-speed rail, highway covering twins economic circle city land traffic link, at the same time construction and perfect in Chengdu, Chongqing airport as the international aviation hub, in Chengdu-Chongqing region twins economic circle of medium-sized city airport as the node of modern airport network.

In terms of population, China is currently entering an aging population, and the fertility rate has reached a new low. In order to promote the increase of population, on the one hand, the country needs to optimize the fertility environment, enhance the inclusiveness of the fertility policy, introduce relevant policies to encourage fertility, reduce the cost of family fertility, parenting and education, and release the potential of fertility.

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