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How to Use a Curve to Represent the Development Path of the Three Industrial Structure Optimization —— A Case Study of 16 Cities in Yunnan Province

Hanyuan Zhang [1], Wuwei Zhang [2, *]

[1]School of Economics and Management; Beijing University of Technology, China

[2] School of Management and Economics, Chuxiong Normal University, China.

Abstract. Research objective: To use a curve to represent the optimal development path of the tertiary industrial structure. Research methods: Based on the triangular midline, the change path of the three industrial structure was studied, and the development path was optimized clockwise and counterclockwise. The results show that the change path of the tertiary industrial structure in 16 cities in Yunnan Province is as follows: the cities with clockwise optimization development account for 43.75%, and the cities with counterclockwise optimization development account for 50%; The change path of the tertiary industrial structure in 129 counties and urban areas of Yunnan Province is as follows: clockwise optimized development of 41.09% of counties and urban areas, counterclockwise optimized development of 34.88% of counties and urban areas; There are great differences in the efficiency of the three industrial structure changes. Research innovation: The triangle center line is used to study the change path of the three industrial structure, and the clockwise and counterclockwise optimization development path of the industrial structure is proposed. Research value: Study regional industrial structure from multiple perspectives.

Keywords: Yunnan City, industrial structure, transition path, economic growth.

1. Introduction

Economic development, in a sense, is the history of industrial structure change. In recent years, the CPC Central Committee and The State Council have regarded growth and structural adjustment as important tasks in our economic work. All states, cities and counties regard the optimization and upgrading of industrial structure, economic growth and regional development as important tasks in their economic work. Since the founding of the People's Republic of China, the development of Yunnan city has gradually accelerated, especially since the reform and opening up, the economic aggregate has grown by leaps and bounds. In 1952, the maximum GDP of the 16 cities and cities in the province was only 156 million yuan, and the tertiary industrial structure of the 16 cities and states: 13 is 132, and 3 is 123. In 2021, the average economic scale of each city in Yunnan Province is more than 100 times that of 1978, and the economic growth rate has maintained a high speed for a long time. Through hard work, the industry of the city has become stronger and bigger, and the economy has grown steadily and rapidly for a long time. Especially since the reform and opening up, the GDP of the province has increased by an average annual rate of more than 9% from 1978 to 2021, which is rare in the history of Yunnan for more than 40 years. With the rapid economic growth, the economic strength of the city has been significantly enhanced. In 2021, the GDP of 16 cities and municipalities in the province exceeded 23 billion yuan, among which 14 exceeded 50 billion yuan, 10 exceeded 100 billion yuan, 4 exceeded 200 billion yuan and 1 exceeded 700 billion yuan. After the founding of New China, the industrial structure adjustment in Yunnan Province has achieved remarkable results. The industrial structure of Yunnan Province has been transformed from low level to high level, from unreasonable to reasonable, and constantly optimized. In 2021, the province's GDP reached 2,714.676 billion yuan, an increase of 7.3% over the previous year. The value added of the primary industry was 387.017 billion yuan, up by 8.4%; The added value of the secondary industry was 958.937 billion yuan, up by 6.1%; The added value of the tertiary industry

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was 1.368722 trillion yuan, up by 7.7%. The tertiary industrial structure of 16 cities and states: 1 is 312, and 15 is 321, indicating obvious optimization of industrial structure. According to the data since the founding of New China, it is of great practical significance to study the changing path of industrial structure and its impact on economic growth in Yunnan Province.

2. Literature review

In recent 100 years, many scholars have conducted a lot of research on the change path, evolution law or optimization development of industrial structure [1]-[9]. There are various definitions of rationalization or optimization of industrial structure in the academic world, and the differences of these definitions reflect the different views of different scholars on the rationalization of industrial structure. Match the first from William (W.P etty), (AFisher), Arthur c. lark, S.K uznets, E.V.B oventer, J.H.V on Thunen, aleem walji eber,, To Kongsamut, Rebelo, Xie, Foellmi, Zweimuller, Ngai, Pissarides, Fan, Zhang, Robinson, Lin, Jiandong Ju, Acemoglu and Guerrieri, Dietrich, Najeb Masoud, Liu Wei, Wu Guobao, Li Shaorong, Gan Chunhui, Zheng Ruogu, Yu Xiaoxiang, Liu Yuanchun, Zhang Hui, Li Chunsheng, Zhang Liancheng, Huang Kainan, Shi Benzhi, Yang Xianming, Wang Rong, Zhu Li, Xu Xinchang, Liu Qiongfang, Xie Junjun, Zhao Xuejun, Guo Xuhong, Mushui, Wang Haidi, Guo Xu, Sun Xiaohua, Zhai Yu and so on have conducted very useful research on the change of industrial structure. It promotes the development of industrial structure theory and provides a good help to our research.

As for the research on the industrial structure of Yunnan Province, CNKI found that there are more than 2,100 articles on the topic of Yunnan Province and industrial structure, with no more than 5 articles per year before 1994, no more than 13 articles per year before 2000, and more than 60 articles per year after 2006. The maximum number of articles in 2015 was 176. Shi Benzhi, Duan Wanchun, Wu Youde, Zhang Hong, Luo Huasong, Wu Yingmei, Chen Changyao, Lin Xiuqun, Ming Qingzhong, Pan Yujun, Li Jun, Zhang Xuebo, Li Xuelin, Luo Hongxiang, Zhao Jing, Huang Yi, Yang Wangzhou, Zhang Meifen, Liu Dianchen, Yan Caihong, Zhang Wuwei, Wang Xiaoqin, Guo Xiangyang, Xiong Liran, Wang Zhiyong, Li Xingxu, Meng Yanju, Lu Zhenghui, Dozens of experts and scholars such as Yang Shuqi and Lin Xiuqun have published several papers and monographs on the industrial structure of Yunnan Province.

3. The curve of industrial structure change in 16 cities of Yunnan Province

3.1 Text description of the transformation process of Yunnan's industrial structure

In 1949, the province had a population of 15.95 million, of which 92 percent was agricultural population. The total agricultural output value was 925 million yuan, with a per capita grain output of 493 jin and a total industrial output value of 186 million yuan. Commodity economy is extremely backward. Light industrial consumer goods in cities are mostly supplied by coastal provinces and cities, and rural areas are basically self-sufficient in natural economy. In 1949, the GNP of the primary industry, the secondary industry and the tertiary industry was 6.26, 0.97 and 170 million yuan respectively, the ratio of the three industries was 70.1∶10.9∶19.0, showing a "132" structure; In 1952, the GNP of the primary industry, the secondary industry and the tertiary industry was 727, 182 and 269 million yuan respectively, the ratio of the three industries was 61.7∶15.5∶22.8, showing a "132" structure. In 1957, the GNP of the primary industry, the secondary industry and the tertiary industry was 12.47 million yuan, 543 million yuan and 463 million yuan respectively, the ratio of the three industries was 55.3∶ 24.1:20.6, showing a "123" structure. In 1978, the GNP of the primary industry, the secondary industry and the tertiary industry was 29.46, 27.58 and 1.201 billion yuan respectively, the ratio of the tertiary industry was 42.7∶39.9∶17.4, still showing a "123" structure, and the secondary and tertiary industries lagged behind seriously. After the Third Plenary Session of the Eleventh Central Committee of the Communist Party of China, Yunnan

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Province has changed its industrial structure significantly by adjusting the investment structure and vigorously developing the production, and is moving towards a more reasonable direction. In 1987, the secondary industry exceeded the primary industry for the first time. The GNP of the primary industry, the secondary industry and the tertiary industry was 84.06, 84.30 and 6.067 billion yuan respectively. The ratio of the three industries was 36.7∶36.8∶26.5, showing a structure of "213". In 1992, the proportion of tertiary industry also exceeded the primary industry. The GNP of primary industry, secondary industry and tertiary industry was 186.80, 219.03 and 21.286 billion yuan respectively. The ratio of three industries was 30.2∶35.4∶34.4, showing a "231" structure. By 1995, the GNP of the primary, secondary and tertiary industries had reached 305.27, 536.63 and 36.478 billion yuan respectively, and the ratio of the tertiary industries had been adjusted to 25.3:44.5:30.2, showing a "231" structure. The development of the tertiary industries in the province was gradually coordinated, and the industrialization process was further accelerated. In 1998, the ratio of tertiary industries has been adjusted to 23.4∶45.1∶31.5 (the ratio of tertiary industries nationwide in 1998 was 18∶49∶33). In 2000, the ratio of the three industries was adjusted to 22.31∶43.13∶34.56. During this period, the development of the tobacco processing industry slowed down due to the implementation of the dual control of "two cigarettes" by the state. The proportion of industry in the secondary industry of the province decreased from 39.91% to 35.69%, and the service industry grew rapidly due to the development of tourism. In 2005, the ratio of the three industries was adjusted to 18.9∶41.7∶39.4, showing a "231" structure. In 2010, the GNP of the primary industry, the secondary industry and the tertiary industry was 1,105.81, 3,233.93 and 289.040 billion yuan respectively, the ratio of the three industries was 15.3∶44.7:40.0, still showing a "231" structure. In 2013, the GNP of the primary industry, the secondary industry and the tertiary industry was 1860.80, 4939.21 and 503.230 billion yuan respectively. The tertiary industry exceeded the secondary industry, and the ratio of the tertiary industry was 15.73∶41.74∶42.53, showing a "321" structure. In 2021, the GNP of the primary industry, the secondary industry and the tertiary industry in Yunnan Province will be 3870.17, 9589.37 and 1368722 billion yuan respectively, with the ratio of the three industries being 14.26∶35.32∶50.42, and the structure of "321" will be further stabilized. The structure of "321" will continue to be adjusted and optimized in the future.

3.2 The three-line description of the three changes of industrial structure

The graphical representation of the change of the tertiary industrial structure is generally shown in the figure below, in which three broken lines represent the change course of the tertiary industrial structure. The three changes of industrial structure in Yunnan Province from 1949 to 2021 are shown in Figure 1.

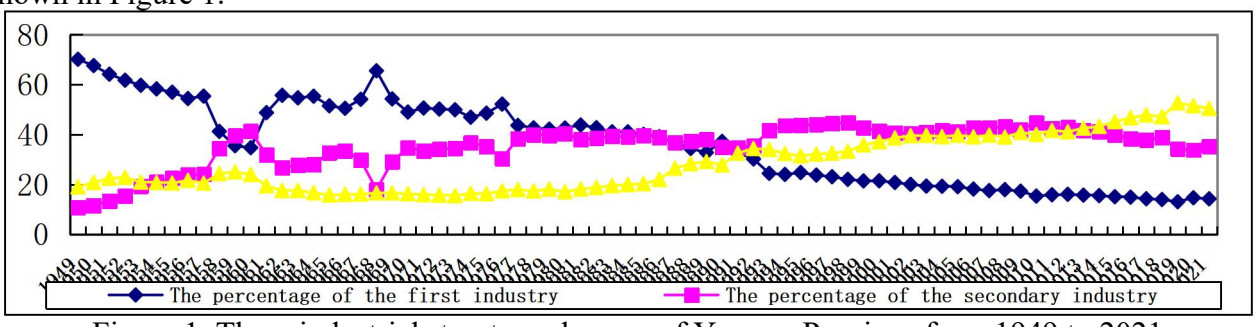

Figure 1. Three industrial structure changes of Yunnan Province from 1949 to 2021

How to express the various forms of the tertiary industrial structure and their changing process succinctly and effectively with plane graphics? Can we use a broken line to represent the changing process of the tertiary industrial structure? After years of hard work, we finally got what we wanted.

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3.3 First-line description of three industrial structure changes based on triangular midline

Next, we use the middle line of the triangle and try to use a broken line to represent the change process of the three industrial structures. The middle line of the triangle has a good property. We use the three middle lines of the triangle to divide the six forms of the three industrial structure. The six forms and their changes can be expressed succinctly and effectively in the triangle. Since 0< xi <1 (i=1,2,3) (Note: if we set 0< xi <100, we can also get the corresponding conclusion), we construct the Cartesian Cartesian coordinate system X2OX3, as shown below. Let the coordinates OF A and B be (1,0) and (0,1) respectively, AE, BD and of be the three midlines of △AOB respectively, and C be the intersection point of the three midlines of △AOB respectively. According to the properties of the midlines of the triangle, the coordinates of C are (1/3, 1/3), and the coordinates of D, E and F are (1/2, 0), (0, 1/2), (1/2, 1/2); △AOC, △BOC, and △ACB are equal in area.

S△AOC=S△BOC=S△ACB =S△AOB /3; △ACD, △OCD, △OCE, △BCE, △BCF and △ACF are equal in area, that is, S△ACD=S△OCD=S△OCE =S△ BCE=S△BCF=S△ACF =S△ACF = S△AOB./6.

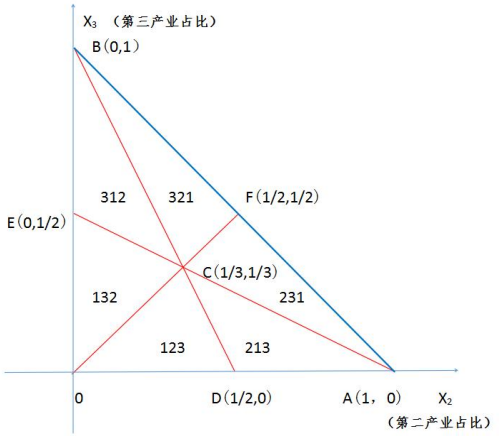

FIG. 2 Relationship between triangle centerline and tertiary industrial structure

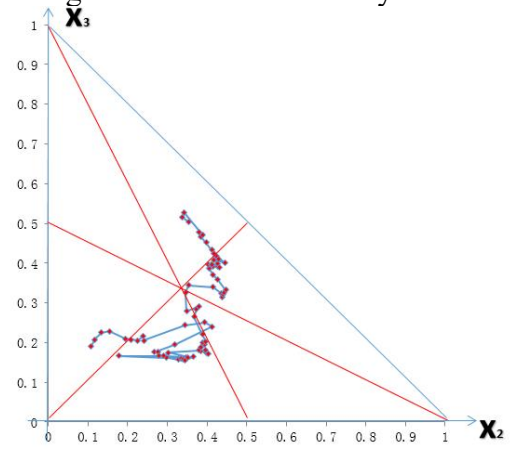

FIG. 3 Change path of tertiary industrial structure in Yunnan Province from 1949 to 2021

The six forms of the three industrial structures, 123, 213, 231, 321, 312 and 132, correspond to the points in the six triangles △OCD, △ACD, △ACF, △BCF, △BCE and △OCE divided by the three midlines of the △AOB. See [2]， [4], [7], [9] for detailed derivation.

In this way, based on the perspective of the midline of the triangle, we can use the change trajectory of n points in the triangle on the plane to represent the change process or transition path of the three industrial structures at n times (such as n years). For example, the change process or

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change path of the tertiary industrial structure in Yunnan Province from 1949 to 2021 is shown in Figure 3. The change path of the tertiary industrial structure in 73 years is clearly shown by a curve.

3.4 Multi-point description of the tertiary industrial structure of multiple countries or regions based on the triangular midline

How can the three industrial structures of multiple countries or regions in a given year be represented on a single graph? At a certain time, the tertiary industrial structure of n countries, provinces or cities can be clearly represented by n points in a graph. Based on the perspective of the center line of the triangle, for example, the distribution of the tertiary industrial structure of 16 cities and states in Yunnan Province in 1952 is shown in the left figure below, and the distribution of the tertiary industrial structure of 16 cities and states in Yunnan Province in 1978 and 2021 is shown in the middle figure and the right figure below:

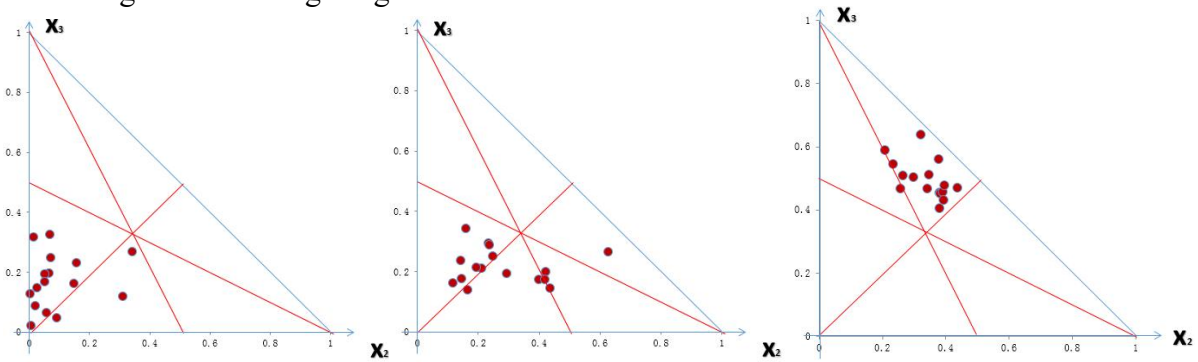

FIG. 4 Industrial structure distribution maps of 16 cities in Yunnan Province in 1952 (left picture), 1978 (middle picture) and 2021 (right picture)

The proportion distribution of the three industrial structures in 16 cities of Yunnan Province in 1952, 1978 and 2021 is shown in the following table:

Table 1 Distribution of the proportion of the three industrial structures in 16 cities of Yunnan Province in 1952, 1978 and 2021

Structure / Year	123	132	213	231	312	321
1952年	3	13	0	0	0	0
	18.75%	81.25%	0%	0%	0%	0%
1978年	3	9	3	1	0	0
	18.75%	56.25%	18.75%	6.25%	0%	0%
2021年	0	0	0	0	1	15
	0%	0%	0%	0%	6.25%	93.75%

4. Analysis of the path of industrial structure change in 16 cities of Yunnan Province

4.1 The change path between six forms of tertiary industrial structure -- the optimal development path clockwise and counterclockwise

The path of change among the six forms of tertiary industrial structure, and the possible transformation among various forms, must be gradual and cannot be crossed.When the tertiary industrial structure is at 123, there are two main paths for the tertiary industrial structure optimization change (change or evolution). One is to develop industry first, then service industry, and optimize the industrial structure along the order of 123 to 213, then to 231 and finally to 321, that is, to change along 123→213→231→321. We call it the counterclockwise optimal

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development path; Second, develop the service industry first, then the industry, and optimize the industrial structure along the order of 123 to 132, then to 312, and finally to 321, that is, change along 123→132→312→321, we call it the clockwise optimization development path; The rest belong to the hybrid optimization development path. This is shown in the figure below.

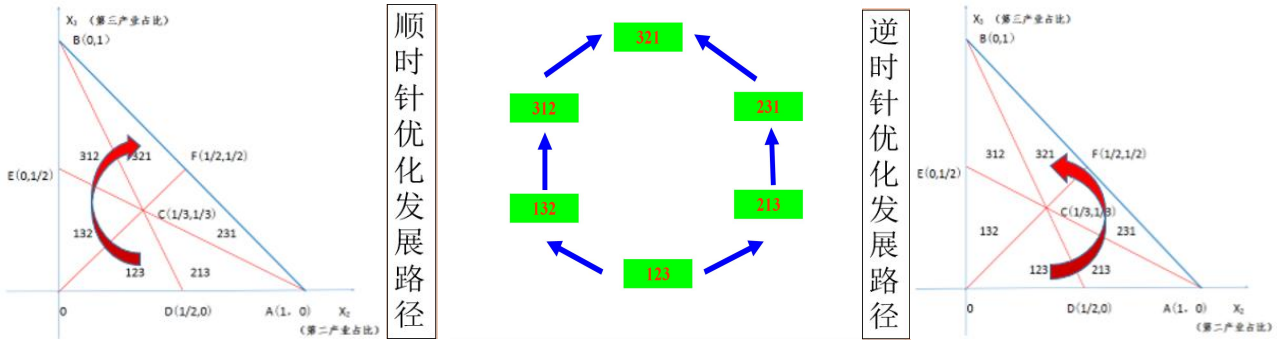

Figure 5. Change path of the three industrial structure optimization

If we regard the six forms of industrial structure as six nodes in dynamic programming, the shortest path from any node, namely various forms of industrial structure, to 321 can be obtained by applying the principle of dynamic programming, as shown in the figure below.

231→213→123→132→312→321；213→123→132→312→321；123→132→312→321；132→312→321；312→321。

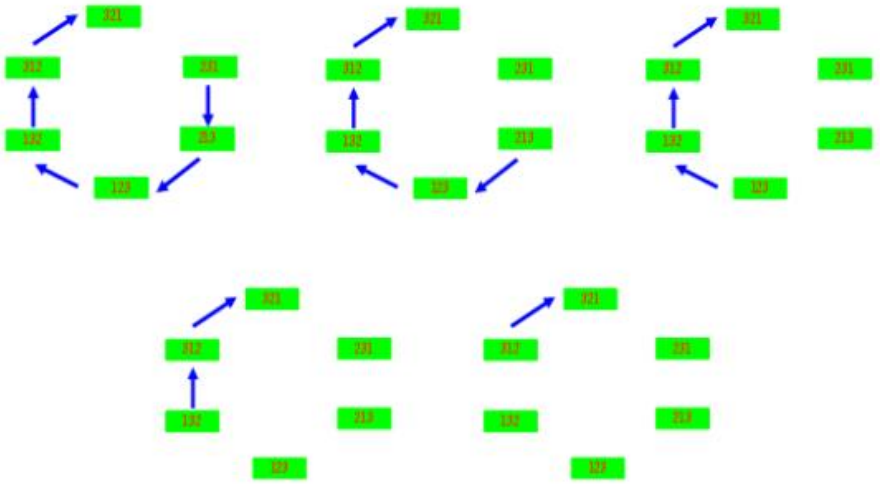
Figure 6. The shortest path diagram of clockwise optimization development

312→132→123→213→231→321；132→123→213→231→321；123→213→231→321；213→231→321；231→321；

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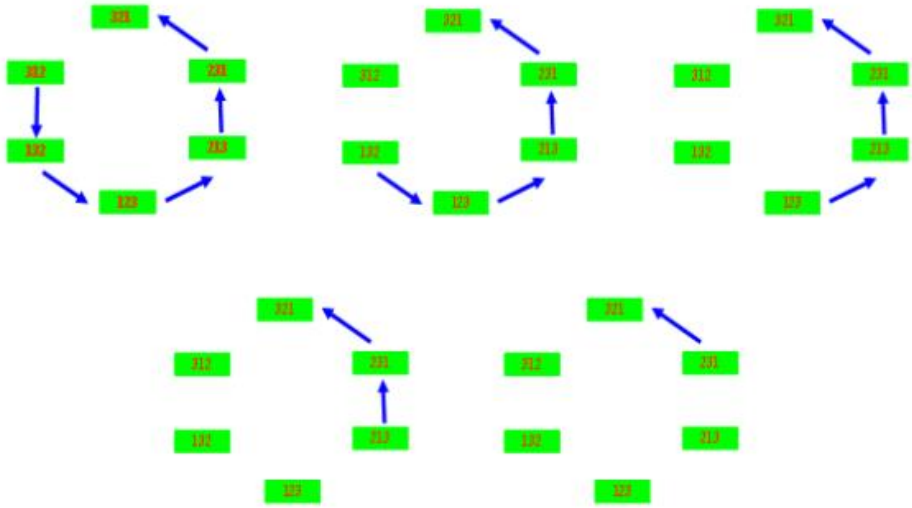

Figure 7 Counterclockwise optimization development shortest path diagram

4.2 Path analysis of the three industrial structure changes in 16 cities of Yunnan Province

In reality, most countries or regions take a counterclockwise optimization development path during the transformation or evolution of the tertiary industrial structure. For example, China's tertiary industrial structure transformation from 1949 to 2021 takes a counterclockwise optimization development path of 132→123→213→231→321. From 1949 to 2021, the three industrial structure changes in Yunnan Province followed a counterclockwise optimization development path of 132→123→213→231→321.

The transformation paths of the three industrial structures in all 16 cities and cities of Yunnan Province are shown in the figure below. Some of them are optimized clockwise and some are optimized counterclockwise.

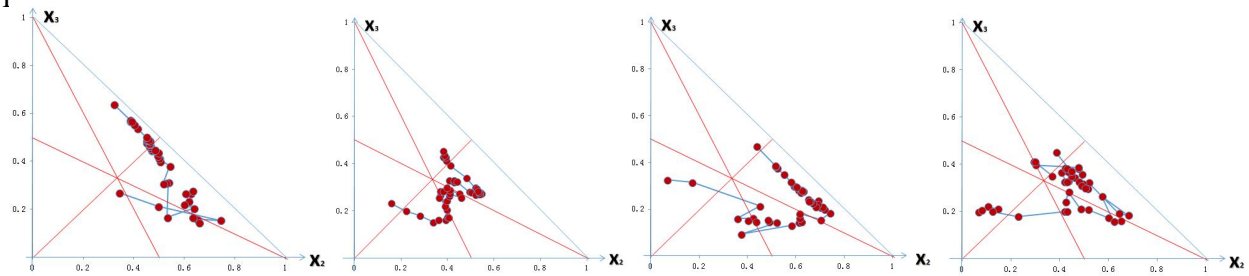

Figure 8 Map of three industrial structure changes in Kunming, Qujing, Yuxi and Zhaotong from 1952 to 2021

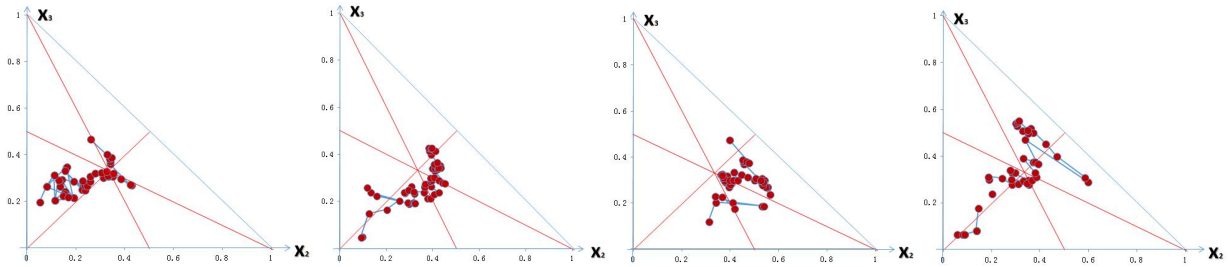

FIG. 9 Map of three industrial structure changes in Lincang City, Chuxiong Yi Autonomous Prefecture, Honghe Hani Yi Autonomous Prefecture and Nujiang Lisu Autonomous Prefecture from 1952 to 2021

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The above eight cities and cities have three counter-clockwise optimization development paths of the three industrial structure changes, accounting for 50% of the 16 cities and cities in Yunnan Province.

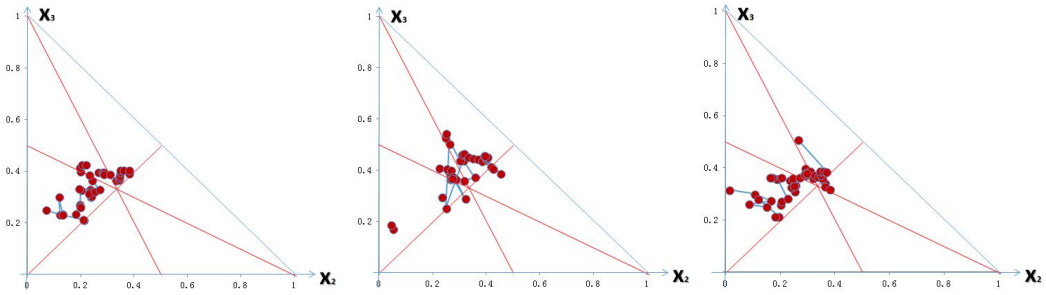

Figure 10 Map of three industrial structure changes in Baoshan, Lijiang and Pu 'er from 1952 to 2021

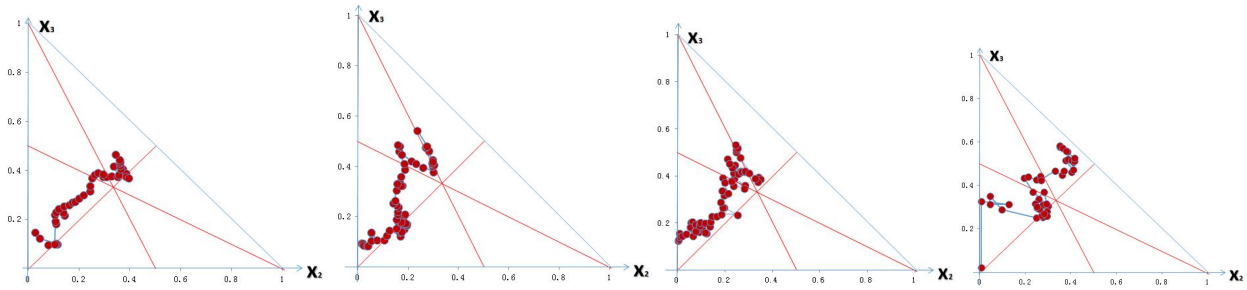

Figure 11 Map of industrial structure changes in Wenshan Zhuang and Miao Autonomous Prefecture, Xishuangbanna Dai Autonomous Prefecture, Dehong Dai Lisu Autonomous Prefecture and Diqing Tibetan Autonomous Prefecture from 1952 to 2021

Figure 10 and Figure 11 show the clockwise optimization development path of the three industrial structure changes in the above 7 cities and cities, accounting for 43.75% of the 16 cities and cities in Yunnan Province.

The three industrial structure changes of Dali Bai Autonomous Prefecture showed clockwise optimization development in one period, and counterclockwise optimization development in another period, which is called mixed optimization development path.

We analyzed the paths of the threetimes industrial structure change in 129 counties and urban areas of Yunnan Province from 1978 to 2019, and the conclusion is that 53 of the 129 counties and urban areas (41.09%) have the path of the threetimes industrial structure change is the clockwise optimization development path; In 45 counties (34.89%), the path of the three industrial structure changes is the counterclockwise optimization development path.

4.3 Efficiency measurement of three industrial structure changes

It is difficult to measure the efficiency of the change in the third-order industrial structure represented by the three-line change, but in the third-order industrial structure change represented by the first-line change based on the triangular midline, the mathematical theorem "the shortest line between two points" gives us a good inspiration. If the industrial structure changes from A2001 to A2002 to A2003 (that is, the three industrial structure of a place changes from 2001 to 2002 and then to 2003), the industrial structure of a region in 2001, 2002 and 2003 is assumed to be:

$$A_i(x_{2i}, x_{3i}) \qquad i = 2001, 2002, 2003$$

We define the efficiency of industrial structure change from 2001 to 2003 as:

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$$\frac{|A_{2001}A_{2003}|}{|A_{2001}A_{2002}|+|A_{2002}A_{2003}|}\times 100\%$$

$$=\frac{\sqrt{(x_{2,2001}-x_{2,2003})^2+(x_{3,2001}-x_{3,2003})^2}}{\sqrt{(x_{2,2001}-x_{2,2002})^2+(x_{3,2001}-x_{3,2002})^2}+\sqrt{(x_{2,2002}-x_{2,2003})^2+(x_{3,2002}-x_{3,2003})^2}}\times 100\%$$

This is the transition efficiency over three years. Similarly, when i= 1,2... n, we can define the transition efficiency for n years,

$$\frac{|A_1A_n|}{|A_1A_2|+\mathrm{L}\ +|A_{n-1}A_n|}\times 100\%$$

$$=\frac{\sqrt{(x_{2,1}-x_{2,n})^2+(x_{3,1}-x_{3,n})^2}}{\sqrt{(x_{2,1}-x_{2,2})^2+(x_{3,1}-x_{3,2})^2}+\mathrm{L}\ +\sqrt{(x_{2,n-1}-x_{2,n})^2+(x_{3,n-1}-x_{3,n})^2}}\times 100\%$$

Therefore, we can measure the efficiency of the three industrial structure changes reasonably.

4.4 Efficiency measurement of three industrial structure changes in 16 cities of Yunnan Province

According to the above definition of efficiency measurement, we measured the efficiency of the three industrial structure changes in 16 cities and states of Yunnan Province from 1978 to 2021, and calculated the efficiency of the three industrial structure changes in 16 cities and states from 2010 to 2019 with a 5-year cycle. The conclusions are shown in the following table.

Table 1 Efficiency analysis of the three industrial structure changes in 16 cities of Yunnan Province from 2010 to 2019

Region	2014—2019 Efficiency	2013—2018 Efficiency	2012—2017 Efficiency	2011—2016 Efficiency	2010—2015 Efficiency	Maximum value	Minimum value	Mean value
Kunming	87.15%	81.36%	99.51%	99.88%	78.65%	99.88%	78.65%	89.31%
Qujing	84.03%	89.69%	92.99%	99.33%	82.05%	99.33%	82.05%	89.62%
Yuxi	99.92%	99.86%	99.82%	99.48%	82.14%	99.92%	82.14%	96.24%
Baoshan	57.36%	57.65%	78.46%	85.75%	54.08%	85.75%	54.08%	66.66%
Zhaotong	67.32%	60.57%	63.08%	54.42%	21.63%	67.32%	21.63%	53.40%
Lijiang	91.30%	73.04%	32.92%	37.53%	11.43%	91.30%	11.43%	49.25%
Pu 'er	80.14%	64.81%	52.64%	43.47%	9.85%	80.14%	9.85%	50.18%
Lincang	90.20%	92.14%	91.57%	48.25%	23.60%	92.14%	23.60%	69.15%
Chuxiong	35.93%	48.76%	83.67%	93.23%	73.83%	93.23%	35.93%	67.08%
Honghe	68.91%	62.09%	78.42%	91.11%	73.02%	91.11%	62.09%	74.71%
Wenshan	94.61%	94.54%	74.78%	53.92%	16.43%	94.61%	16.43%	66.86%
Xishuangbanna	92.40%	89.48%	94.63%	95.13%	43.45%	95.13%	43.45%	83.02%

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Dali	97.53%	91.71%	90.94%	78.38%	22.24%	97.53%	22.24%	76.16%
Dehong	94.89%	95.83%	95.76%	88.81%	77.46%	95.83%	77.46%	90.55%
Nujiang	18.46%	71.82%	82.88%	88.74%	56.45%	88.74%	18.46%	63.67%
Diqing	24.49%	7.76%	29.17%	58.73%	48.01%	58.73%	7.76%	33.63%

Yuxi City, Kunming City, Qujing City, Dehong Prefecture and Xishuangbanna Prefecture had better average efficiency of the three industrial structure changes during the measurement period. The maximum value and the minimum value of the three industrial structure change efficiency are 99.92% and 7.76%, and the difference of the three industrial structure change efficiency is relatively large.

5. Policy recommendations

First, we should strengthen planning and guidance and clarify our goals and tasks. It is necessary to adhere to the top-level design to promote the high quality economic development of Yunnan city. To perfect the organizational structure and integrate multiple regulations into practice, it is suggested to carry out comprehensive assessment on the economic development of Yunnan city every year. Second, adhere to the market orientation, clear development path. According to the resource endowment, define the industrial development path; In line with market demand, we will focus on developing leading industries and enhance our ability to drive the economy. Third, we will continue to share the people's livelihood and promote harmonious development. Promote the construction of infrastructure connectivity, improve the modernization level of the city; We will give priority to education and improve the quality of the workforce. We will comprehensively promote shared development. Fourth, support modern agriculture and improve the level of agriculture. Improve the quality of agricultural development, improve the level of agricultural production; We will strengthen rural infrastructure and lay the foundation for the development of modern agriculture. Fifth, we will strengthen green industrialization and enhance industrial competitiveness. Give full play to the role of the secondary industry to economic growth, and promote the industrial structure to rationalize and improve the direction of development; We will encourage the transformation and upgrading of traditional industrial enterprises and actively foster and develop emerging industries. Adhere to the centralization, agglomeration and intensive development of industry in the city, encourage the cross-city integrated development, and adhere to the green development, circular development and low-carbon development. Sixth, we will actively develop modern service industries and comprehensively improve their quality. We will comprehensively promote the high-quality development of the tertiary industry, actively foster and develop the modern service industry, strengthen the demand base and driving force for the service industry, leverage our resource advantages, and expand and strengthen characteristic industries with high quality.

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