

Research on Industrial Symbiosis Development in Ethnic Areas Based on Symbiosis Model

Taking Three Ethnic Autonomous Prefectures in Sichuan Province as an Example

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Abstract—Based on the symbiosis model, this paper studied the industrial symbiosis degree, symbiosis relationship and symbiosis stable point of three national autonomous prefectures in Sichuan Province. The results show that the industry in ethnic areas is in a positive asymmetric mutualism mode. The symbiotic system constructed by the two and three industries first achieves the symbiotic stable state, followed by the first and second industries, and finally the first and third industries. The distribution proportion of industrial symbiotic benefits is respectively two, three and one from the large to the small.

Keywords: ethnic areas, industrial symbiosis, symbiosis model

I. INTRODUCTION

China's ethnic areas are not only ecologically fragile areas, but also backward areas of economic development. Under the two strategies of targeted poverty alleviation and rural revitalization, industrial prosperity is the primary task of stable poverty alleviation and rural revitalization in the new era. Abundant resource reserves and a large number of factor inputs are the guarantee of rapid industrial prosperity, and a good industrial symbiosis mode is the quality guarantee of industrial prosperity. China's ethnic areas are not only ecologically fragile areas, but also backward areas of economic development. Under the two strategies of targeted poverty alleviation and rural revitalization, industrial prosperity is the primary task of stable poverty alleviation and Rural Revitalization in the new era. Abundant resource reserves and a large number of factor inputs are the guarantee of rapid industrial prosperity, and a good industrial symbiosis mode is the quality guarantee of industrial prosperity. According to the research of Xiao Zhongdong [1] and other scholars, the industrial symbiosis system can be divided into leading industry, transmission industry and end industry. According to their own development needs, economic regions can create a symbiosis system with agriculture as the core or industry as the core. Of course, the emergence and long-term operation of this system need policy, financial and social support [2]. Specifically, service industry and manufacturing industry, logistics industry and manufacturing industry, logistics industry and regional

industry can form symbiosis through certain evolution process [3], and even take "industrial symbiosis" into account in product development [4]. Moreover, once the industrial symbiosis system based on the standard of ecological efficiency is realized, it can achieve huge economic, ecological and social benefits [5]. More importantly, by improving the efficiency of technology exchange in symbiosis system, we can not only promote the development of existing industrial symbiosis network, but also establish a new industrial system [6]. Through market output or sharing "symbiotic achievements" in the system, global production efficiency will be improved, industrial symbiosis will become "profitable", attracting more enterprises to join [7].

To sum up, at present, the domestic research on industrial symbiosis mainly focuses on the theoretical aspect, empirical research is less and lack of strict measurement methods, and the research on industrial symbiosis in ethnic areas is even less. Therefore, this paper takes three national autonomous prefectures in Sichuan Province as an example, through the establishment of industrial symbiosis model, in-depth analysis of the symbiotic development status and trend of primary, secondary and tertiary industries in ethnic areas, in order to provide a new path for industrial development in ethnic areas.

II. THEORETICAL ANALYSIS

Traditional economic theory divides industry into one, two and three industries. The first industry is mainly agriculture, forestry, animal husbandry and fishery. The second industry is mainly industry. The third industry is mainly service industry. This kind of industry division with limitation makes the industries launch a cruel competition with their own interests as the center, and ignores the economic relevance among the three industries. In order to realize the rapid development of national economy and meet the increasing material demand of the people, industry has been the primary task of industrial development for a long time. With the arrival of the bottleneck of industrial development, the tertiary industries such as finance and real estate have risen rapidly and become the new pillar

industries of national economy. With the development of economy and the improvement of openness, the proportion of the first industry in the industrial structure has been decreasing year by year, and the industrial structure has been fixed in "two three one" for a long time. It is worth pondering that industrialization has indeed created unparalleled material wealth, but the excessive consumption of resources, the serious destruction of ecological environment and other issues are constantly compressing the industrial development space, which not only violates the concept of sustainable development, but also damages the material foundation of the industrial symbiosis system. Secondly, although the rise of the tertiary industry conforms to the international industrial structure optimization standards, once the economic virtualization is separated from the real economy, it will bring serious economic crisis. In the end, China is a country with a large population, and we must keep the rice bowl in our own hands at all times. The primary industry is not only the composition of GDP, but the most important thing is to ensure national food security. In order to achieve certain short-term development goals, too much emphasis on the proportion of an industry in the economy will cause a double imbalance in the quantity and quality of industrial development.

"Industrial symbiosis" as an extension of the biological concept in the economic field has created a new industrial development concept. Industrial symbiosis is different from previous industrial relations, such as industrial interaction, industrial association, industrial integration, and industrial coordination. Industry interaction requires government or market regulation, and industry interactions lack autonomy. Industrial association emphasizes the technical and economic connection between industries, and the improvement of technological level is the prerequisite for the correlation between industries. According to the classic definition of industrial integration, industrial integration is the integration of industrial boundaries, and eventually forms a new industrial format. Quantity coordination and quality coordination constitute industrial coordination, that is, production value coordination and development capacity coordination are the two basic levels to achieve coordinated industrial development. It can be found that, whether it is interaction, association, integration or coordination, the focus is on economic benefits, and "symbiosis" is committed to the full realization of industrial economic, ecological and social benefits. Industrial symbiosis includes the characteristics of interaction, relevance, fusion and coordination. The interaction, association, fusion and coordination among industries are the basis of industrial symbiosis.

The formation of the industrial symbiosis system is self-organizing, driven by self-interest, and forms a primary symbiosis network through material exchange. By integrating the reuse of by-products or waste from the other party, one party reduced the factor input cost, saved the cost of pollution control and waste treatment, and brought additional benefits to the symbiotic parties. This benefit can

be seen as an economic benefit due to industrial symbiosis. The nature of capital chasing interest will attract more and more related industries to shift to the symbiotic system. After a long period of selection, a large and stable symbiotic industrial group will be formed. Ecological benefit is not the direct goal pursued by industrial symbiosis, but it is the product of industrial symbiosis. The recycling of resources and energy, in particular, improves the comprehensive utilization of non-renewable resources and reduces the amount of pollutants emitted, which has a positive external effect on the ecological environment. A complete and efficient industrial symbiosis system encompasses a wide variety of enterprises, involving all walks of life. During the development process, the industrial chain was gradually extended and the business scope was expanded to meet the new needs in the system, which provided more jobs for the society and maintained social stability. But it needs to be clearly understood that the production of symbiotic benefits must be highly matched in the symbiotic unit. Although the symbiotic system is rigid, the self-organizing nature of the symbiotic system will make the system spontaneously adjust, eliminating redundant and unrelated units, or forcing individuals to self-adjust, so that the symbiotic system evolves in a more vital direction. Therefore, parasitic, symbiotic, and asymmetric reciprocal symbiosis modes cannot exist in the industrial symbiosis system for a long time. Only the symmetric reciprocal symbiosis model with the same symbiosis between industries can guarantee the long-term operation of the industrial symbiosis system and produce a continuous stream of symbiotic benefits.

III. INDUSTRIAL DEVELOPMENT STATUS

Taking the total GDP of 2017 as an example, Liangshan Prefecture is ranked 9th among the 21 cities and prefectures in Sichuan Province, and Aba Prefecture and Ganzi Prefecture are ranked 20th and 21st respectively. There are only five cities and prefectures in Sichuan that have not exceeded 100 billion GDP, including Aba and Ganzi. On the whole, Liangshan Prefecture has basically achieved economic leapfrogging, while the economic development levels of Aba Prefecture and Ganzi Prefecture are still relatively lagging behind. As shown in "Fig. 1", the total GDP of the three states is on the rise. But since 2002, the gap between Liangshan Prefecture, Aba Prefecture, and Ganzi Prefecture has begun to widen. Liangshan Prefecture has begun to move towards the 200 billion mark, while the total economic volume of Aba Prefecture and Ganzi Prefecture is still only 40 billion. With reference to "Fig. 2", after 2010, the economic growth rate of each state began to decline after experiencing a short-term peak after the disaster. Except for the growth rate of Ganzi Prefecture in 2015 and 2016, Liangshan Prefecture and Aba Prefecture have been in a downturn. Due to the large cumulative economic volume in Liangshan Prefecture, there has been no major fluctuation in the overall development. Aba and Ganzi Prefectures have small bases and tend to be stable as a whole.

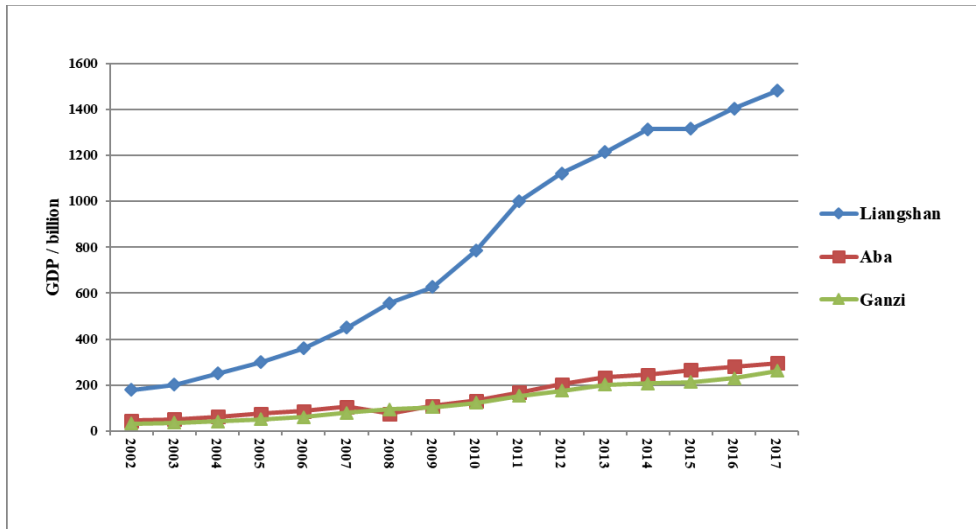


Fig. 1. Total GDP of the three ethnic autonomous prefectures from 2002 to 2017.

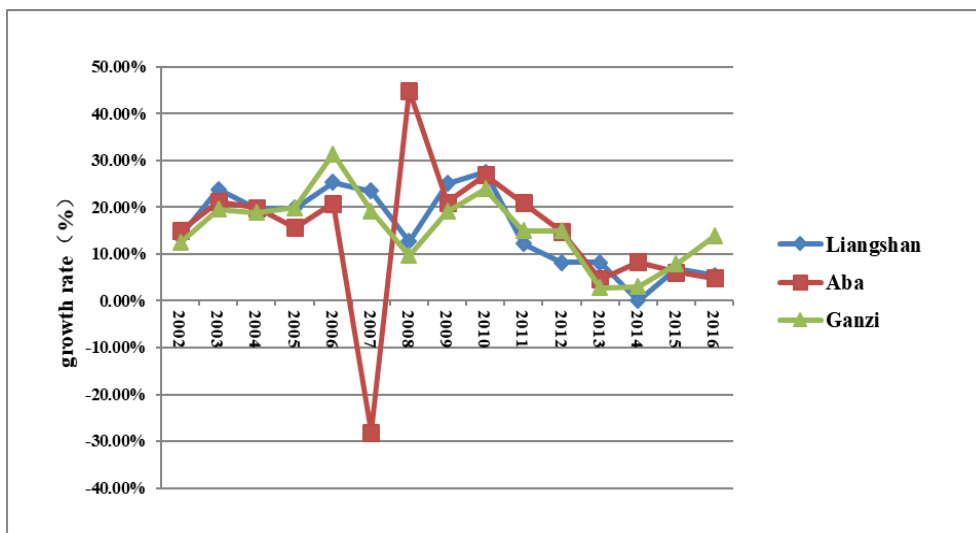


Fig. 2. GDP growth rate of the three ethnic autonomous prefectures from 2002 to 2016.

The following is a further analysis of the current status of industrial development in the three states in conjunction with "Table I", "Table II", and "Table III".

TABLE I. GDP CONTRIBUTION RATE OF THE THREE INDUSTRIES IN LIANGSHAN PREFECTURE FROM 2003 TO 2017

time	contribution rate of primary industry	contribution rate of the secondary industry	tertiary industry contribution rate
2003	12.81%	52.30%	34.89%
2004	34.98%	44.11%	20.91%
2005	18.99%	38.30%	42.71%
2006	17.00%	59.11%	23.89%
2007	31.46%	48.31%	20.22%
2008	20.52%	24.55%	54.92%
2009	13.79%	53.28%	32.92%
2010	6.27%	79.39%	14.34%
2011	9.50%	72.49%	18.01%
2012	19.72%	52.45%	27.83%
2013	16.45%	59.24%	24.31%
2014	15.76%	51.29%	32.94%
2015	189.30%	-491.00%	401.70%
2016	19.15%	38.94%	41.90%
2017	20.50%	-72.23%	151.73%

In terms of industrial structure, Liangshan Prefecture, from 2002 to 2013, reduced primary and tertiary industries and focused on developing the secondary industry. From 2014 to 2017: reduce the secondary industry, increase the tertiary industry, and promote the transformation of the industrial structure to "three two one". Several exploratory adjustments to the industrial structure indicate that there are still inconsistencies between the three industries in Liangshan Prefecture. In combination with "Table I", the secondary industries showed negative pulling rates in 2015 and 2017, respectively, and the amplitudes were large, -491.00% and -72.23%, which indicates the lack of

interaction and correlation between industries. When the secondary industry lacked new momentum and setbacks, the rapid development of the tertiary industry has not brought new blood to the secondary industry. Although the economic aggregate is still growing, the speed is much worse than before. Moreover, the maximum value of the three industrial structures and the maximum value of the contribution rate are not in the same year, on the one hand, it indicates that the formulation of industrial policies is lagging, on the other hand, it indicates that the development of the three industries is more competitive than cooperative.

TABLE II. GDP CONTRIBUTION RATE OF THE THREE INDUSTRIES IN ABA PREFECTURE FROM 2003 TO 2017

time	contribution rate of primary industry	contribution rate of the secondary industry	tertiary industry contribution rate
2003	12.56%	54.80%	32.64%
2004	19.35%	53.33%	27.32%
2005	10.70%	35.82%	53.48%
2006	8.36%	51.75%	39.89%
2007	22.06%	48.25%	29.70%
2008	-1.49%	75.07%	26.42%
2009	10.49%	56.13%	33.39%
2010	6.28%	72.57%	21.15%
2011	6.80%	60.40%	32.80%
2012	11.20%	61.82%	26.98%
2013	11.47%	61.88%	26.64%
2014	11.63%	34.32%	54.05%
2015	22.14%	29.70%	48.16%
2016	20.18%	14.35%	65.48%
2017	17.15%	59.97%	22.88%

By observing the changes in the industrial structure of Aba Prefecture over the years ("Table II"), it can be found that the focus of industrial development has always been the secondary industry, and the industrial structure is biased toward "two three one". Except for a few years, the

contribution rate of the secondary industry has always ranked first. From 2014 to 2016, ABA Prefecture reduced the proportion of the secondary industry, and the contribution rate of the secondary industry also declined sharply, but there was no negative value. While the ratio of the secondary

industry structure increased in 2017, the contribution rate also increased significantly, but the economy as a whole was still operating at a low speed. This shows that: on the one hand, the strength of Aba's secondary industry has not been fully tapped, and the adjustment of the industrial structure is

blind and follow-up; on the other hand, the early development of the secondary industry has not consolidated the primary and tertiary industries, and the three industries lack interaction.

TABLE III. GDP CONTRIBUTION RATE OF THE THREE INDUSTRIES IN GANZI PREFECTURE FROM 2003 TO 2017

time	contribution rate of primary industry	contribution rate of the secondary industry	tertiary industry contribution rate
2003	16.12%	53.14%	30.74%
2004	17.08%	57.18%	25.74%
2005	9.45%	17.64%	72.91%
2006	4.68%	58.66%	36.66%
2007	46.54%	32.11%	21.35%
2008	26.10%	38.86%	35.04%
2009	21.49%	16.76%	61.76%
2010	14.80%	55.12%	30.09%
2011	31.03%	44.20%	24.77%
2012	23.81%	44.45%	31.74%
2013	16.15%	48.32%	35.53%
2014	58.77%	-45.92%	87.16%
2015	49.55%	-12.84%	63.28%
2016	29.28%	41.75%	28.97%
2017	6.91%	65.75%	27.34%

Unlike Liangshan and Aba states, the tertiary industry in Ganzi Prefecture contributes the most to economic growth ("Table III"). The tertiary industry has been adjusted and reduced since 2015 to expand the development of the secondary industry. From 2010 to 2013, the contribution rate of the secondary industry ranked first, and the industrial structure during this period was "two three one". After three consecutive years, the industrial structure was adjusted to 321, the contribution rate of the secondary industry appeared negative, and the GDP growth rate has been below 10%. Until 2017, the industrial structure returned to "two three one", and Ganzi became the only ethnic region with a GDP growth rate of more than 10%. In addition, the development potential of the primary industry in Ganzi is greater than that of the other two states, and the industrial contribution rate was as high as 58.77%, which together with the tertiary industry promoted the development of the secondary industry.

In summary, there are some similarities in the industrial structure adjustment among the three ethnic autonomous prefectures in Sichuan Province. The proportion of the structure of the first industry is on the decline, and the second industry has gone through a process of large-scale development to reduction. Attempts have been made to make the third industry a new pillar industry. During the adjustment process, the problems of the coordination and rationality of the industrial structure are still serious, there is a lack of mutual support among industries, and the internal power source of the industrial system is outdated.

IV. METHODS AND DATA

A. Measurement of symbiosis

The symbiosis model can reflect the degree of interaction of material energy between two symbiotic units. The quality parameters reflect the intrinsic nature of the symbiotic unit. The parameter that plays the leading role is called the main quality parameter, which is the key to the formation of the symbiotic relationship. Based on previous research and the availability of data, this article selects industrial added value as the main quality parameter of the three industries.

In the industrial symbiosis system, let A and B be two different industrial symbiosis units. x and y are their main quality parameters, then the symbiosis degree of A to B and the symbiosis degree of B to A are:

$$\delta_{AB} = \frac{dA_x/A_x}{dB_x/B_y} \quad (1)$$

$$\delta_{BA} = \frac{dB_y/B_y}{dA_x/A_x} \quad (2)$$

δ_{AB} indicates the impact of a percentage change in the B industry on the A industry, which reflects the promotion of the B industry to the A industry. δ_{AB} represents the impact of a percentage change in the A industry on the B industry, which reflects the promotion of the A industry to the B industry.

According to the scatter plot, it can be found that there is a significant linear relationship between the two main prime

parameters. Their regression equations can be found using the least squares method, expressed as follows:

$$x^t = \alpha + \beta y^t \quad (3)$$

$$\delta_{AB}^t = \frac{dx^t/x^t}{dy^t/y^t} = \frac{(x^{t+1}-x^t)/x^t}{(y^{t+1}-y^t)/y^t} = \frac{(\alpha+\beta y^{t+1}-\alpha-\beta y^t)/(\alpha+\beta y^t)}{(y^{t+1}-y^t)/y^t} = \beta \frac{y^t}{\alpha+\beta y^t} \quad (5)$$

$$\delta_{BA}^t = \frac{dy^t/y^t}{dx^t/x^t} = \frac{(y^{t+1}-y^t)/y^t}{(x^{t+1}-x^t)/x^t} = \frac{(\lambda+\mu x^{t+1}-\lambda-\mu x^t)/(\lambda+\mu x^t)}{(x^{t+1}-x^t)/x^t} = \mu \frac{x^t}{\lambda+\mu x^t} \quad (6)$$

B. Symbiosis model and symbiosis coefficient

From the behavioral mode, the symbiotic mode can be divided into: parasitic, favored symbiosis, asymmetric reciprocal symbiosis and symmetric reciprocal symbiosis. If $\delta_{AB} = \delta_{BA} > 0$, it means that the two are symbiotic and symbiotic. If $\delta_{AB} \neq \delta_{BA} > 0$, it means that the two are symbiotically asymmetric. If $\delta_{AB} = 0, \delta_{BA} > 0$ or $\delta_{AB} > 0, \delta_{BA} = 0$, it means that the two are symbiotic. If $\delta_{AB} = 0, \delta_{BA} < 0$ or $\delta_{AB} < 0, \delta_{BA} = 0$, it means that the two are symbiotic. If $\delta_{AB} = \delta_{BA} = 0$, it means that the two live together. If $\delta_{AB} \times \delta_{BA} < 0$, it means both are parasitic. If $\delta_{AB} = \delta_{BA} < 0$, it means that the two are symbiosis in opposite symmetry. If $\delta_{AB} \neq \delta_{BA} < 0$, it means that the two are symbiosis in opposite directions.

Through the comparison of symbiosis coefficient, we can judge the degree of mutual influence between two symbiosis units. The formula is as follows:

$$\delta_A^t = \frac{|\delta_{AB}^t|}{|\delta_{AB}^t| + |\delta_{BA}^t|} \quad (7)$$

$$\delta_B^t = \frac{|\delta_{BA}^t|}{|\delta_{AB}^t| + |\delta_{BA}^t|} \quad (8)$$

From the above formula, $\delta_A^t + \delta_B^t = 1$.we can determine the magnitude of the impact relationship between the A industry and the B industry based on the size of δ_A^t . If $\delta_A^t = 0$, it means that industry B has no effect on industry A. If $0 < \delta_A^t < \frac{1}{2}$, it means that the impact of the B industry on the A industry is less than the impact of the A industry on the B industry. If $\delta_A^t = \frac{1}{2}$, it means that the impact of B industry on A industry is equal to the impact of A industry on B industry. If $\frac{1}{2} < \delta_A^t < 1$, it means that the impact of B industry on A

$$y^t = \lambda + \mu x^t \quad (4)$$

By substituting the results of (3) and (4) into (1) and (2), the symbiosis degree of A industry and B industry can be obtained respectively. The formula is as follows:

industry is greater than that of A industry on B industry. If $\delta_A^t = 1$, it means that industry A has no effect on industry B.

C. Symbiotic steady state analysis

In a complex symbiosis environment, the symbiosis unit finally achieves positive symbiotic reciprocity symbiosis through internal adjustment, that is, the symbiosis steady state is reached. In order to calculate the time to reach a steady state between symbiotic units, the time series t (t = 1,2,3, ..., T) is recorded in order to indicate the year when the symbiosis between the two industries in each ethnic region is positive. Then using Eviews software for regression, we can determine the functions of δ_{AB} and δ_{BA} about t. Then make $\delta_{AB} = \delta_{BA}$, we can find the time t when the two industries have the same symbiosis with each other. By further converting it into the corresponding year, we can get the time when the two industries reach a symbiotic steady state, that is, the time to achieve positive symbiosis and symbiosis.

V. EMPIRICAL ANALYSIS

For calculation convenience, L_1, L_2 and L_3 represent Liangshan's primary, secondary and tertiary industries. A_1, A_2, A_3 in turn represent Aba's primary, secondary and tertiary industries. G_1, G_2 , and G_3 in turn represent the primary, secondary, and tertiary industries in Ganzi. The data used in this article are from the WIND database and statistical yearbooks of relevant years in ethnic regions.

A. Industrial symbiosis

First, Eviews 8.0 was used to perform regression analysis and correlation test on the two industries in ethnic areas. The results are shown in "Table IV". The $AdjR^2$ values are all greater than 0.85, indicating that the model has a high degree of fit and a linear relationship between industrial added values is established.

TABLE IV. THE REGRESSION EQUATION BETWEEN THE TWO INDUSTRIES IN THE THREE ETHNIC AUTONOMOUS PREFECTURES

Liang shan	$L_1 = 0.302139L_2 + 60.98617 \cdot L_2 = 3.091225L_1 - 164.2026 \cdot (AdjR^2 = 0.929263)$
	$L_1 = 0.511947L_3 + 47.17298 \cdot L_3 = 1.892430L_1 - 81.65270 \cdot (AdjR^2 = 0.966597)$
	$L_2 = 1.549360L_3 - 10.27125 \cdot L_3 = 0.559787L_2 + 38.17559 \cdot (AdjR^2 = 0.857835)$
Aba	$A_1 = 0.247326A_2 + 8.458376 \cdot A_2 = 3.823341A_1 - 28.48875 \cdot (AdjR^2 = 0.941727)$
	$A_1 = 0.386875A_3 + 4.475286 \cdot A_3 = 2.55410A_1 - 10.77022 \cdot (AdjR^2 = 0.987269)$
	$A_2 = 1.507373A_3 - 12.94587 \cdot A_3 = 0.643747A_2 + 9.980160 \cdot (AdjR^2 = 0.968250)$
Ganzi	$G_1 = 0.626104G_2 + 1.447313 \cdot G_2 = 1.555965G_1 - 1.017169 \cdot (AdjR^2 = 0.972353)$
	$G_1 = 0.674136G_3 - 1.835016 \cdot G_3 = 1.469312G_1 + 3.163861 \cdot (AdjR^2 = 0.989839)$
	$G_2 = 1.056847G_3 - 4.262692 \cdot G_3 = 0.926884G_2 + 4.958241 \cdot (AdjR^2 = 0.978116)$

Make the following analysis based on the results in "Table V":

In Liangshan Prefecture and Aba Prefecture, the symbiosis degree of the first industry to the second industry is less than that of the second industry to the first industry. The symbiosis degree of the first industry to the second industry is rising in the fluctuation, while the symbiosis degree of the second industry to the first industry is declining in the fluctuation. The symbiosis degree of the first industry to the third industry is smaller than that of the third industry to the first industry. The symbiosis degree of the first industry to the third industry is rising in the fluctuation, and the symbiosis degree of the third industry to the first industry is declining in the fluctuation. The symbiosis degree of the second industry to the third industry is greater than that of the third industry to the second industry. The symbiosis degree of the second industry to the third industry is declining in the fluctuation, and the symbiosis degree of the

third industry to the second industry is rising in the fluctuation.

The change of the symbiosis degree of the primary, secondary and tertiary industries in Ganzi is the same as that of Liangshan and ABA, but the primary and tertiary industries are the opposite. In Ganzi Prefecture, the symbiosis degree of the primary industry to the tertiary industry is greater than that of the tertiary industry to the primary industry. The symbiosis degree of the primary industry to the tertiary industry is declining in the fluctuation, and the symbiosis degree of the tertiary industry to the primary industry is rising in the fluctuation.

In the time range of the study, the three industries of the three national autonomous prefectures are currently in the stage of positive asymmetric mutualism, and gradually approach to positive symmetric mutualism with the passage of time.

TABLE V. SYMBIOSIS BETWEEN THE TWO INDUSTRIES IN THE THREE ETHNIC AUTONOMOUS PREFECTURES

Area	Liangshan					
time	$\delta_{L_1L_2}$	$\delta_{L_2L_1}$	$\delta_{L_1L_3}$	$\delta_{L_3L_1}$	$\delta_{L_2L_3}$	$\delta_{L_3L_2}$
2002	0.218	6.544	0.390	3.207	1.127	0.452
2003	0.253	4.932	0.423	2.837	1.109	0.500
2004	0.306	2.757	0.459	2.073	1.093	0.566
2005	0.349	2.364	0.520	1.882	1.071	0.613
2006	0.415	2.086	0.553	1.733	1.062	0.678
2007	0.480	1.688	0.592	1.495	1.052	0.732
2008	0.514	1.535	0.674	1.395	1.036	0.758
2009	0.559	1.509	0.699	1.377	1.032	0.790
2010	0.648	1.447	0.723	1.335	1.028	0.845
2011	0.722	1.376	0.754	1.285	1.024	0.885
2012	0.744	1.321	0.774	1.246	1.021	0.896
2013	0.761	1.294	0.786	1.226	1.020	0.904
2014	0.775	1.271	0.801	1.209	1.018	0.910
2015	0.763	1.252	0.814	1.196	1.017	0.905
2016	0.772	1.233	0.827	1.182	1.015	0.909
2017	0.755	1.218	0.859	1.170	1.012	0.901
Area	Aba					
time	$\delta_{A_1A_2}$	$\delta_{A_2A_1}$	$\delta_{A_1A_3}$	$\delta_{A_3A_1}$	$\delta_{A_2A_3}$	$\delta_{A_3A_2}$
2002	0.333	3.527	0.602	1.682	1.964	0.524
2003	0.376	2.916	0.631	1.592	1.769	0.571
2004	0.435	2.232	0.664	1.454	1.600	0.629
2005	0.473	2.028	0.720	1.402	1.405	0.664
2006	0.518	1.908	0.749	1.369	1.331	0.704
2007	0.570	1.616	0.776	1.275	1.272	0.745
2008	0.401	1.584	0.738	1.264	1.359	0.596
2009	0.558	1.479	0.790	1.225	1.247	0.736
2010	0.631	1.422	0.809	1.202	1.212	0.791

Area	Aba					
time	$\delta_{A_1A_2}$	$\delta_{A_2A_1}$	$\delta_{A_1A_3}$	$\delta_{A_3A_1}$	$\delta_{A_2A_3}$	$\delta_{A_3A_2}$
2011	0.700	1.365	0.840	1.178	1.164	0.837
2012	0.749	1.309	0.858	1.154	1.140	0.868
2013	0.779	1.270	0.871	1.137	1.124	0.886
2014	0.784	1.259	0.879	1.132	1.114	0.889
2015	0.792	1.223	0.891	1.115	1.100	0.893
2016	0.795	1.204	0.900	1.106	1.090	0.896
2017	0.805	1.191	0.903	1.100	1.087	0.901
Area	Ganzi					
time	$\delta_{G_1G_2}$	$\delta_{G_2G_1}$	$\delta_{G_1G_3}$	$\delta_{G_3G_1}$	$\delta_{G_2G_3}$	$\delta_{G_3G_2}$
2002	0.809	1.083	1.265	0.798	1.449	0.647
2003	0.836	1.076	1.236	0.810	1.394	0.687
2004	0.870	1.067	1.202	0.829	1.332	0.743
2005	0.878	1.063	1.139	0.837	1.221	0.757
2006	0.907	1.060	1.117	0.843	1.184	0.808
2007	0.926	1.034	1.098	0.902	1.153	0.843
2008	0.937	1.028	1.083	0.917	1.127	0.866
2009	0.938	1.026	1.068	0.922	1.104	0.867
2010	0.951	1.023	1.059	0.930	1.089	0.894
2011	0.961	1.018	1.050	0.946	1.076	0.915
2012	0.967	1.015	1.045	0.952	1.067	0.927
2013	0.972	1.014	1.039	0.956	1.058	0.938
2014	0.971	1.013	1.036	0.960	1.054	0.935
2015	0.970	1.012	1.034	0.962	1.051	0.934
2016	0.973	1.011	1.032	0.965	1.048	0.939
2017	0.978	1.011	1.029	0.966	1.044	0.951

B. Industrial symbiosis coefficient

According to the calculation results of the symbiosis degree, the symbiosis coefficient between industries can be further calculated. Since the two industries have a great correlation with each other's symbiosis, the general environment for rural revitalization and the trend of industrial structure adjustment are also considered. This article focuses on the symbiosis of the primary industry to the secondary and tertiary industries and the tertiary industry to the secondary industry in ethnic areas.

According to “Fig. 3”, “Fig. 4” and “Fig. 5”, on the whole, except for the positive promotion effect of the tertiary industry on the primary industry in Ganzi Prefecture, the positive impact of secondary and tertiary industries on the primary industry in Liangshan Prefecture and Aba Prefecture is constantly increasing. The positive promotion effect of the secondary industry to the tertiary industry in each region is gradually increasing, but due to the differences in the overall economic strength of the region, the effect of the impact between industries is slightly different.

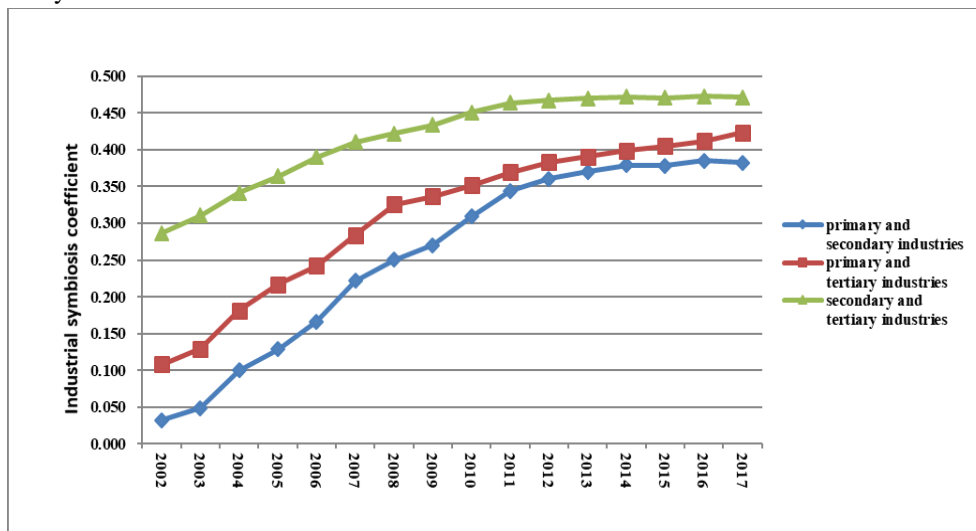


Fig. 3. Coexistence coefficient of three industries in Liangshan Prefecture.

As shown in “Fig. 3”, in Liangshan Prefecture, the symbiosis coefficient of the tertiary industry to the secondary industry is gradually close to 0.5, indicating that although the

impact of the secondary industry on the tertiary industry is smaller than that of the tertiary industry, the impact of the secondary industry on the tertiary industry continues to rise,

and the symbiosis system formed by the secondary and tertiary industry is close to steady state. The symbiosis coefficient of the primary industry to the tertiary industry is gradually approaching 0.45 in the rise, and the symbiosis coefficient of the primary industry to the secondary industry is gradually approaching 0.4 in the rise. This shows that the

current impact of the tertiary industry on the primary industry is greater than the impact of the secondary industry on the primary industry. Compared with the primary industry, the secondary industry has more impetus to the tertiary industry.

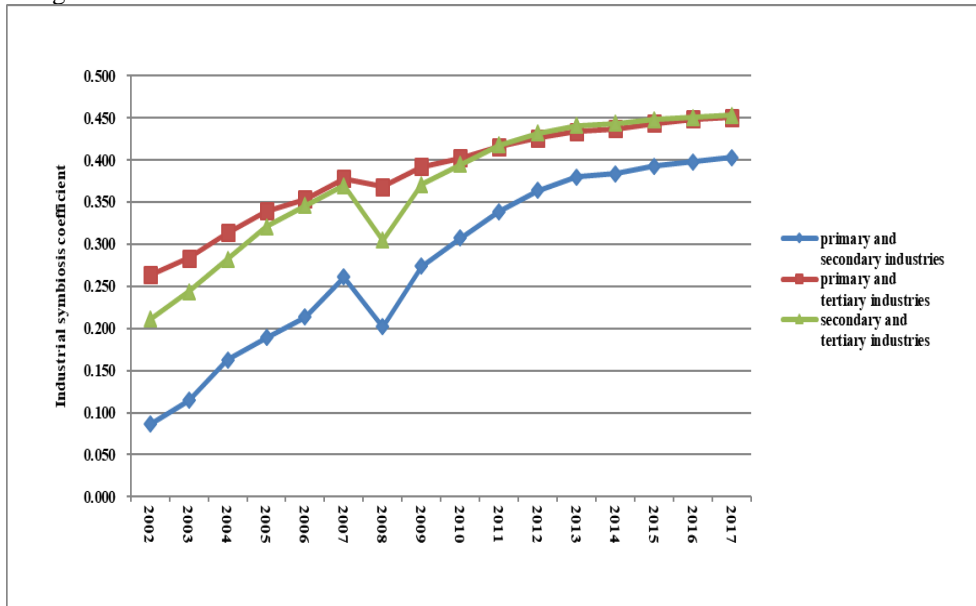


Fig. 4. Coexistence coefficient of three industries in Aba Prefecture.

As shown in "Fig. 4", In Aba Prefecture, regardless of the special time point of "Wenchuan earthquake" in 2008, the symbiosis coefficient of the primary industry to the tertiary industry gradually increases to close to 0.45, the symbiosis coefficient of the primary industry to the secondary industry gradually increases to close to 0.4, and the symbiosis coefficient of the tertiary industry to the

secondary industry gradually increases to close to 0.45. This shows that the influence of the tertiary industry on the primary industry is greater than that of the secondary industry on the primary industry, and the influence of the secondary industry on the primary and tertiary industry is relatively balanced.

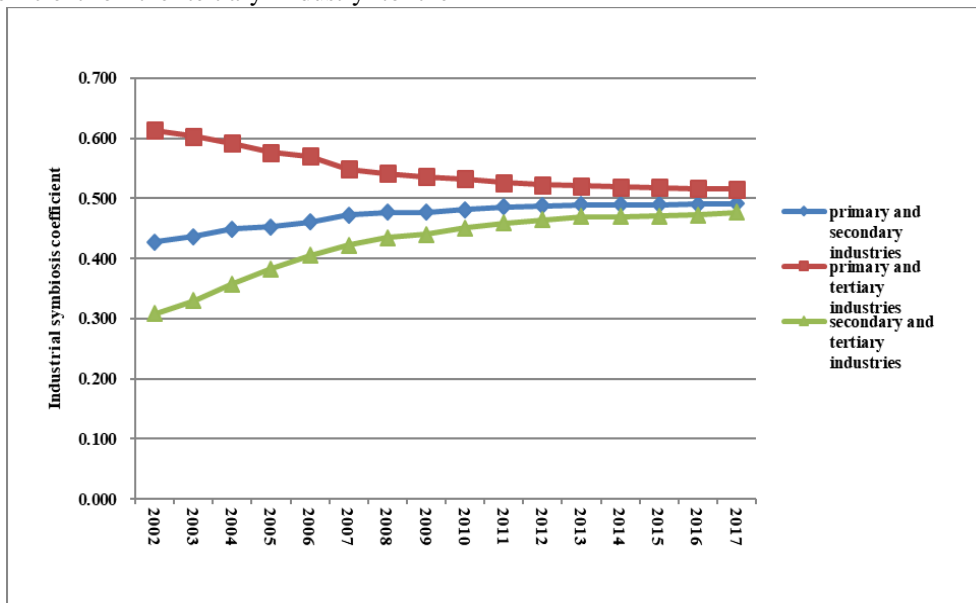


Fig. 5. Coexistence coefficient of three industries in Ganzi Prefecture.

As shown in “Fig. 5”, in Ganzi Prefecture, the symbiosis coefficient of the primary industry to the tertiary industry is approaching 0.5 in the decline, the symbiosis coefficient of the primary industry to the secondary industry is approaching 0.5 in the rise, and the symbiosis coefficient of the tertiary industry to the secondary industry is approaching 0.5 in the rise. This shows that: the influence of the tertiary industry on the primary industry is gradually decreasing, and the influence of the primary industry on the tertiary industry is gradually increasing; the promotion effect of the secondary and tertiary industries on the primary industry is relatively small; compared with the tertiary industry, the secondary industry has more influence on the primary industry.

To sum up, the industrial symbiosis system of Ganzi Prefecture is the best of the three regions, which has basically reached the stable point of industrial symbiosis, and the industrial development is more special. The industrial symbiosis of Liangshan and Ganzi is close, and the key to the problem lies in the primary and secondary industries.

C. Stable time point of industrial symbiosis

The following research data ranges from 2002 to 2017. In view of the fact that the industrial development of Aba Prefecture was severely affected by the earthquake disaster in 2008 and the data was abnormal, it was selected for empirical calculation. Liangshan Prefecture and Ganzi Prefecture were not affected, and all the data was retained. According to the results in "Table VI", the time for realizing industrial symbiosis in the three ethnic autonomous prefectures is different.

The three industries of Liangshan Prefecture, the symbiotic system composed of secondary and tertiary industries first achieved positive symbiotic reciprocity and symbiosis (2019-2020), followed by the primary and secondary industry system (2020-2021), and finally the primary and tertiary industry system (2023-2024). The symbiosis between the first industry and the second and third industries has delayed the time for the entire industry symbiosis system to achieve a symbiosis steady state, especially the primary and tertiary industry system.

The overall situation in Aba Prefecture is similar to Liangshan, but the time to reach the symbiotic steady state point is relatively late. The secondary and tertiary industry system is 2021-2022, the primary and secondary industry system is 2023-2024, and the primary and tertiary industry system is 2026-2027.

The time for the two industries to achieve symbiosis and stability lies in the middle of three regions. The time for the primary and secondary industry system and the secondary and tertiary industry system to achieve symbiosis and stability is basically the same (2020-2021). The primary and tertiary industry system is 2022-2023. It shows that in Aba Prefecture, the secondary industry has good symbiosis and integration, and can establish symbiosis relationship with other industries quickly in the symbiosis system, while the primary and tertiary industries lack dependence on other industries.

TABLE VI. PREDICTION TIME POINT OF INDUSTRIAL SYMBIOSIS IN THREE ETHNIC AUTONOMOUS PREFECTURES

area	regression equation	x value	AdjR ²	stable time point
Liangshan	$\ln\delta_{L_1L_2} = 0.538279\ln x - 1.681168$	19.736	0.961280	2020-2021
	$\ln\delta_{L_2L_1} = -0.630958\ln x + 1.806014$		0.952290	
	$\ln\delta_{L_1L_3} = 0.319882\ln x - 1.049287$	22.7728	0.965933	2023-2024
	$\ln\delta_{L_3L_1} = -0.39417\ln x + 1.182532$		0.968974	
	$\ln\delta_{L_2L_3} = -0.042804\ln x + 0.126535$	18.647	0.976334	2019-2020
	$\ln\delta_{L_3L_2} = 0.289676\ln x - 0.846198$		0.971094	
Aba	$\ln\delta_{A_1A_2} = 0.369717\ln x - 1.203716$	22.5042	0.962832	2023-2024
	$\ln\delta_{A_2A_1} = -0.431211\ln x + 1.290135$		0.984620	
	$\ln\delta_{A_1A_3} = 0.168205\ln x - 0.553760$	25.693	0.977681	2026-2027
	$\ln\delta_{A_3A_1} = -0.174153\ln x + 0.557615$		0.979583	
	$\ln\delta_{A_2A_3} = -0.236206\ln x + 0.690507$	20.2277	0.982491	2021-2022
	$\ln\delta_{A_3A_2} = 0.224034\ln x - 0.693458$		0.974753	
Ganzi	$\ln\delta_{G_1G_2} = 0.074130\ln x - 0.218702$	19.589	0.979944	2020-2021
	$\ln\delta_{G_2G_1} = -0.030169\ln x + 0.091585$		0.922132	
	$\ln\delta_{G_1G_3} = -0.084367\ln x + 0.250982$	21.045	0.970043	2022-2023
	$\ln\delta_{G_3G_1} = 0.084027\ln x - 0.262058$		0.919225	
	$\ln\delta_{G_2G_3} = -0.133708\ln x + 0.393267$	19.5889	0.968588	2020-2021
	$\ln\delta_{G_3G_2} = 0.152063\ln x - 0.456891$		0.979323	

VI. CONCLUSION AND RECOMMENDATION

A. Conclusion

Judging from the time required for the three industries to reach the symbiosis steady state point, there is a significant difference in the time for the three industries to form a positive symmetrical reciprocal symbiosis mode. On the whole, areas with faster economic development or areas with slower economic development but high industrial coordination will achieve positive symbiotic symbiosis earlier in the industry. The industrial development in the regions with strong economic strength is relatively mature, and they can adapt to the changes of the symbiosis system at a faster speed, and form a symbiotic pattern of equality and mutual benefit with other industries. In areas with relatively backward economy and balanced industrial development, although the overall benefit of the industrial symbiosis system is not high, a fair symbiosis environment can keep the entire system growing at a low rate for a long time. In terms of symbiotic benefits, the secondary industry is still benefiting the most from the industrial symbiosis system in ethnic areas, followed by the tertiary industry, and finally the primary industry. In terms of time, the symbiotic system formed by the secondary and tertiary industries in ethnic areas can take the lead in reaching the symbiosis steady state point, followed by the primary and secondary industrial systems, and finally the primary and tertiary industrial systems. The symbiosis of primary and tertiary industries is the key to the formation and stable operation of the industrial symbiosis system in ethnic areas.

B. Recommendation

It is suggested to optimize the industrial symbiosis environment and provide the basic conditions for the realization of the stable state of the industrial symbiosis system. The first is the institutional environment. The formation and operation of the industrial symbiosis system is accompanied by the transfer of industrial clusters. The overthrow of the old system and the establishment of a new system require corresponding institutional support and regulation. The second is the market environment. A good market environment will not only promote efficient industry competition and cooperation, but also improve the efficiency of resource allocation and guide the industry into a symbiotic circle. The last is the technological environment. The formation of industrial symbiosis is based on technological fusion, which blurs the industrial boundaries, promotes the establishment of industrial supply-demand relationships, and the cooperation of business modules, thereby promoting the establishment of industrial symbiosis.

Further, it is to coordinate the three industrial developments and tap the development potential of the tertiary industry in mature economic development areas and the secondary industry in economically underdeveloped areas to improve the overall efficiency of the industrial symbiosis system. At present, the secondary industry in the fast-developing ethnic regions has basically reached saturation. We should make full use of our unique tourism

resources and unique national culture to make the tertiary industry a new driving force for economic growth. Although the strength of the primary and tertiary industries in the relatively backward ethnic regions is relatively strong, the overall economic level is not high because they have not enjoyed the economic benefits brought by industrialization in the early stage. Therefore, while continuing to stabilize the development of the primary and tertiary industries, we can use resources such as minerals to develop heavy industries. At the same time, we can use the light processing industries such as pharmaceutical processing and dairy processing to jointly promote the development of the secondary industry.

Moreover, it is to strengthen the correlation, interaction and integration of the primary and tertiary industries. How to build a symbiotic system of the primary and tertiary industries is the key to accelerating the symmetry and mutual symbiosis of the three industries in ethnic areas. At present, the influence of the tertiary industry on the primary industry in ethnic regions must be further enhanced. Bring into play the advantages of agriculture, forestry, animal husbandry and other industries in ethnic areas, combine local ecological and environmental resources, extend the primary industry industrial chain, and expand the development mode of the primary industry. Combining the rich and diverse service industry with modern agriculture, innovating the operation mode of the rural complex, and improving the overall layout of the agricultural industry. Make the development of the primary industry in line with the secondary and tertiary industries, fully participate in the symbiosis circle formed by the secondary and tertiary industries, and actually shorten the time for the industrial symbiosis system to reach a steady state.

According to the different stages of industrial symbiosis, formulate appropriate industrial policies. Industrial symbiosis is a value-added process, and there is a complete value chain between industries. For industries in different positions and stages of the value chain, different implementation policies are needed. For ethnic regions with relatively mature economic development, a more autonomous module-relational governance can vertically connect industries and strengthen the stability of the symbiotic system. For ethnic regions with low levels of economic development, a leadership-market governance model is needed. On the one hand, large enterprises can give play to their leadership role and stabilize the development of small enterprises. On the other hand, the introduction of competitive factors through the market can promote the improvement of small enterprises' own capabilities. For ethnic regions with backward economic development, it is necessary to adopt strict bureaucratic governance, give priority to the development of the main industries, and take into account the development of new industries to the extent permitted by resources.

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