

The influence of industrial Synergy Agglomeration on economic resilience: Based on the comparison between Yangtze River Delta Urban Agglomeration and Central Yunnan Urban Agglomeration

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Abstract: Economic resilience is a balance between economic growth and risk, and an important guarantee for sustainable economic development. The more resilient an economy is, the more likely it is to recover as soon as possible and change its growth path in a timely manner after encountering external disturbances and shocks, so as to achieve high-quality economic transformation and development. The agglomeration of industries in a certain space can effectively reduce the production cost of enterprises. Deepening the industrial division of labor and the extension of the value chain; High-end production factors are promoted to concentrate in this region, and the knowledge spillover effect formed by the agglomeration can improve the level of innovation, which is conducive to the adjustment of industrial structure and the enhancement of regional innovation ability, so as to improve the resilience level of regional economy. In view of this, the panel data of prefecture-level cities of Yangtze River Delta city cluster and Central Yunnan City cluster in China from 2005 to 2020 are selected in this study to deeply explore the influence mechanism of industrial collaborative agglomeration on the economic resilience of city clusters. The results show that the level of industrial cooperation can improve the level of economic resilience of urban agglomerations.

Keywords: Industrial collaborative agglomeration; Economic resilience; Central Yunnan city cluster; Yangtze River Delta urban agglomeration.

1. Background

To a certain extent, the construction of urban agglomerations in China can form a synergistic effect to promote economic development, improve the level of urban governance and support capacity, form the long-term potential for stable urban development, and enhance regional economic resilience. Economic resilience refers to the concept of physics used by economics to describe the development ability of a country or economy that is not broken but indomitable when it is hit by crisis. It is the sum of economic immunity, development potential, governance ability and economic competitiveness of a country or economy. For a long time to come, economic resilience will play a key role in determining whether regional economies can recover quickly and pass the test of the pandemic. Therefore, combined with economic resilience and the development of urban agglomeration, the economic resilience of urban agglomeration is particularly important in the long-term development of epidemic prevention and control. Judging from the current world situation, the recovery of the global economy in the post-COVID-19 period will be a protracted battle. Especially for the small and medium-sized cities in the region, it is very difficult to recover the economy quickly due to the shortcomings such as single industrial structure, inadequate infrastructure, resource and population restriction. With the development of urban agglomeration, cities are no longer isolated from each other. According to the geographical advantages of each city, the free flow and optimal allocation of production factors under the law of the market, and the mutual promotion of industrial development, the productivity can be greatly improved.

In 2020, in the face of the impact of COVID-19 and the complex international situation, the major economic indicators of Chinese cities declined significantly in the first quarter and changed greatly. However, as the epidemic was further brought under control, the economy showed a positive trend in the second half of the year. Coastal city clusters such as the Yangtze River Delta and Pearl River Delta, due to their high dependence on trade, suffered a greater impact on the manufacturing sector and saw a sharp decline in export orders. By contrast, inland cities such as Chongqing, Chengdu and Kunming have suffered relatively little in terms of exports. In terms of economic aggregate growth, in 2020, the total GDP of the three provinces and one municipality in the Yangtze River Delta City Cluster reached 24.5 trillion yuan, an increase of 3% over the previous year; The total GDP of the central Yunnan city cluster reached 1.5 trillion yuan, an increase of 6.9% over the previous year. However, in general, the economic development of the Yangtze River Delta urban agglomeration still withstood the test of the epidemic. The main reason is that the Yangtze River Delta has formed a large scale of production capacity in several industrial fields, and these industries have a high degree of industrial chain agglomeration. In addition, from the perspective of government cooperation and co-construction, the functions of various governments in the Yangtze River Delta have been effectively divided and the cooperation has been strengthened in depth. Therefore, such a city cluster with a high level of economic resilience can ensure the rapid economic recovery under the impact of the epidemic. Compared with the Yangtze River Delta urban agglomeration, the industrial driving force of the cities with a higher first degree in the central Yunnan urban agglomeration is not strong, the cluster effect and synergy effect of the other industries are weak, and the joint

system of long-term mechanism is not formed among the governments of various cities. All these may affect the resilience of the urban agglomeration. Therefore, the study on how to restore the economy of various cities under the coordinated development through the urban agglomeration and the key factors affecting the economic recovery can provide the theoretical basis and implementation suggestions for the urban development and industrial coordinated layout of Yunnan Province. Based on the above analysis, this paper will analyze the relationship between industrial collaborative agglomeration and economic resilience of urban agglomerations. In addition, based on the demonstration and leading role of the establishment of the Yangtze River Delta Urban Economic Coordination Committee in the Yangtze River Delta urban agglomerations to the central Yunnan urban agglomerations without the establishment of economic coordination organizations, In order to improve the economic resilience of central Yunnan city agglomeration policies and agreements and other aspects to provide a decision basis for development layout and structural adjustment.

2. Literature review

2.1. Industrial collaborative agglomeration

Ellison and Glaeser (1997) first proposed the concept of collaborative agglomeration when studying the geographical concentration of heterogeneous manufacturing industry in the United States. Industrial collaborative agglomeration refers to the geographic spatial concentration of heterogeneous industries with horizontal or vertical correlation, among which, Vertical correlation refers to the material connection and direct economic synergy between the upstream and downstream industries of the industrial chain, while horizontal correlation refers to the immaterial connection and indirect economic synergy between adjacent or homogeneous industries on the industrial chain, such as explicit and implicit knowledge spillover, shared factor market, etc. Then, Hu et al. (2015) clearly put forward the connotation of industrial agglomeration: industrial agglomeration is neutral, and the industries in almost all cities present the characteristics between complete diversification and complete specialization. With the deepening of the research, scholars have formed a basic consensus on the concept of collaborative agglomeration. They agree that collaborative agglomeration refers to the process in which many enterprises with horizontal and vertical correlation gather in the same geographical location in the process of industrial development, and induces industrial capital elements to converge continuously in the spatial scope. That is, the phenomenon of increasing specialization of a specific industry in a certain region (Gao and Liu, 2008; Wang, 2013).

2.2. Regional economic resilience

The concept of toughness comes from physics and represents the resistance of a material to deformation caused by force. On the definition of the connotation of economic resilience, the academic community has not yet formed a unified consensus. Some scholars believe that economic resilience is mainly an ability of the economic system to recover to the original level of development after external shocks (Hill, 2008), while others believe that economic resilience is mainly an ability of the economic system to resist or cope with external shocks (Su, 2015). In general, neither is comprehensive. The former sees economic resilience as

primarily the resilience of an economic system in the face of shocks, while the latter sees it as primarily the system's resistance to shocks. Economic resilience should therefore include both resistance and resilience. However, since it is difficult to distinguish between resilience and resilience, some scholars proposed on this basis that economic resilience should include the ability to cope with and resist external disturbances and shocks, adapt to the new environment, and change the development momentum of innovation (Martin et al., 2015).

2.3. Industrial synergy and economic resilience of urban agglomerations

According to the literature review, few scholars have studied the relationship between industrial synergistic agglomeration and economic resilience at present. However, because a high level of industrial development will directly affect its resilience, that is, economic resilience, many scholars have confirmed the relationship between industrial synergistic agglomeration and economic development, and also proved the correlation between industrial synergistic agglomeration and economic resilience to be studied in this paper. In the existing researches, scholars have studied the relationship between them mainly in two aspects: industrial synergistic agglomeration, regional economy and economic resilience.

Research on the relationship between industrial synergy agglomeration and regional economy. Hao et al. (2021) found that industrial collaborative agglomeration improves the rationalization level of regional industrial structure through resource allocation and input-output correlation, which is an important approach to industrial optimization and upgrading. Based on knowledge sharing, industrial synergy agglomeration has a significant positive impact on the growth of regional economic aggregate. Zhong and Liu extended their research perspective to the collaborative agglomeration of multi-industries and held that the collaborative agglomeration of producer services and manufacturing within the scope of urban agglomeration would also play a positive role in promoting the improvement of economic production efficiency (Zhong, 2021; Liu, 2020). When studying the effect of industrial agglomeration on regional production efficiency, Sveikauskas et al. (1975) found that industrial collaborative agglomeration had a threshold effect on regional economic growth, so the agglomeration scale should be controlled within a reasonable range in the development process of industrial agglomeration.

In the face of the constantly changing global market and frequent financial crisis, technological innovation and policy adjustment in various economies, scholars have conducted in-depth discussions on the relationship between industrial synergy and economic growth, and believe that industrial synergy can not only achieve the "quantity" growth of economy, but also promote the "quality" improvement of economic growth. Economic resilience is moving into the realm of economics. Relevant scholars point out that industrial collaborative agglomeration can help regional economic system respond to shocks in time, stimulate innovation to enable enterprises to adapt to crises, adjust industrial structure, and enter a new stage of development as soon as possible, so as to obtain more lasting economic resilience (Wu, 2022). Specifically, when the region is impacted by market factors, the multi-level and multi-core network economy formed by agglomeration effect and

diffusion effect superimposed by industrial division of urban agglomeration has stronger resilience (Zhang, 2021). Different types of industrial agglomeration within urban agglomerations also have different impacts on regional economic resilience, including specialized agglomeration and diversified agglomeration. On the one hand, specialization agglomeration forms MAR externality through spatial agglomeration of the same industries (GLAESER, 1992), which provides a good external environment for enterprise innovation in urban agglomeration. The internal competition generated by the agglomeration of the same or similar industries within urban agglomerations provides external impetus for enterprises to carry out innovation (Li, 2006). On the other hand, diversified industrial agglomeration increases the types and quantity of enterprises and expands the production range within industrial clusters, which helps manufacturers to quickly obtain production capacity from the surrounding areas to maintain the stability of the industrial chain when they are affected by external shocks, thus improving the resilience of regional economy (Zhang, 2020).

Based on the above summary, it is not difficult to find that there is a positive correlation between industrial collaborative agglomeration and economic resilience of urban agglomerations. As urban agglomeration has become the main bearing form of industrial spatial structure, it is more consistent with the economic development law of industrial agglomeration to study regional economic resilience with urban agglomeration as the research object. Based on this, this article put forward a hypothesis to explain the influence mechanism of industrial synergistic agglomeration on the economic resilience of urban agglomerations and to study the influence of industrial synergistic agglomeration on regional economic resilience.

3. Research design

3.1. Data sources and variables

In view of the fact that the Yangtze River Delta Urban Agglomeration established a normative local government cooperation mechanism in 1997, namely the Yangtze River Delta Urban Economic Coordination Council, during which cities joined in different years, but the 16 cities that joined before 2010 are recognized as the core cities of the Yangtze River Delta urban agglomeration. Therefore, based on the timeliness and availability of data, the study period of samples is set as 2005-2020. Among them, prefecture-level cities in Yangtze River Delta city cluster and Central Yunnan City cluster are the research samples. The Yangtze River Delta city cluster includes 27 prefecture-level cities such as Shanghai, Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yangzhou, Zhenjiang, Yancheng, Taizhou, Hangzhou, Ningbo, Wenzhou, Huzhou, Jiaxing, Shaoxing, Jinhua, Zhoushan, Taizhou, Hefei, Wuhu, Ma'anshan, Tongling, Anqing, Chuzhou, Chizhou, Xuancheng, etc. The central Yunnan city cluster includes Kunming, Qujing and Yuxi prefecture-level cities. Since the index system of economic resilience of the explained variable is to calculate the average value of prefecture-level cities in urban agglomerations using the entropy method, the difference in the number of prefecture-level cities in the Yangtze River Delta urban agglomerations and the central Yunnan urban agglomerations does not affect the calculation results. The data in this paper are from China City Statistical Yearbook and provincial statistical yearbook, and some missing values are supplemented by linear interpolation

method.

3.2. Model selection and variable description

In order to verify the impact of industrial collaborative agglomeration on the economic resilience of urban agglomerations, empirical regression equation is used in this paper for demonstration. The specific formula is as follows:

$$\text{Resi}_{i,t} = c + \alpha_1 \text{Cogg}_{i,t} + \text{Control}_{i,t} + \varepsilon_{i,t}$$

Among them, $\text{Resi}_{i,t}$ refers to the economic resilience level of urban agglomeration i during the period t . $\text{Cogg}_{i,t}$ is the industrial collaborative agglomeration of urban agglomeration i in the period t ; $\text{Control}_{i,t}$ is the control variable. According to the research needs, the total industrial output value, population, freight volume, urban fixed assets are selected as the control variables. c is the constant term, $\varepsilon_{i,t}$ is the random perturbation term.

Explanatory variable. Industrial collaborative agglomeration (Cogg). The specific calculation can be referred to the research of Yang Renfa (2013), Chen Guoliang and Chen Jianjun (2012). The calculation steps are as follows: Firstly, the location entropy index of manufacturing and producer services is calculated, and then the industrial collaborative agglomeration is calculated.

Explained variable. urban agglomeration economic resilience (Resi). According to the connotation characteristics of economic resilience, this paper constructs a multidimensional measurement system by referring to the reference indicators of several scholars, and comprehensively considers the economic resilience of urban agglomerations from three dimensions of resilience, resilience and renewal through entropy method. The details include per capita gross regional product, GDP, the number of registered unemployed people in urban areas, the loan-to-deposit ratio of financial institutions, the proportion of total imports and exports in GDP, the ratio of fiscal revenue and expenditure, total retail consumption, total fixed asset investment, the number of people covered by unemployment insurance, the expenditure on science and technology, the number of patents obtained, the number of college students per 10,000, and electricity The proportion of credit business in GDP.

Dummy variable. Government cooperation (Gov). As one of the most mature urban agglomerations in China, the Yangtze River Delta urban agglomerations have the historical basis of regional linkage development. Considering that the 16 cities that joined the Yangtze River Delta Urban Economic Coordination Committee before 2010 are recognized as the core areas of the Yangtze River Delta urban agglomeration, the economic ties and cooperation between cities are relatively mature. On the one hand, although the Yangtze River Delta City Economic Coordination Committee also experienced expansion after 2010, the newly included cities on the other hand, due to the short time of joining, may not have established the cooperation path between cities. On the other hand, the newly included cities belong to the periphery of the Pan-Yangtze River Delta, and the cooperation with the core area has not yet reached the cooperation standard formed by the core area. Based on this, this paper takes 2010 as the time point of government cooperation, and assigns the value of 1 to the first year and subsequent years of government cooperation, and 0 to the previous year, so as to better identify the influence effect brought by joining the dummy variable of government cooperation.

Control variables. urban fixed assets (fixed), population (people), freight volume (freight) and industrial gross output

value (industrial) are taken as control variables.

4. Empirical results and analysis

4.1. Descriptive analysis

Descriptive statistics of the data are shown in the table above. According to the analysis results, the mean value, standard deviation, minimum value and maximum value of the explained variable economic resilience (Resi) are 0.342, 0.092, 0.198 and 0.53. The mean value, standard deviation, minimum value and maximum value of explanatory variable

Cogg were 2.045, 0.274, 1.594 and 2.573. Government cooperation is a dummy variable with a minimum value of 0 and a maximum value of 1. All control variables are treated logarithmically. The mean value of urban fixed assets (fixed) is 15.028, the minimum value is 12.803, and the maximum value is 16.525. The mean value of people is 6.165, the minimum value is 6.075, and the maximum value is 6.261. The mean value of total freight is 7.782, the minimum value is 6.648, and the maximum value is 9.031. The mean value of industrial output value is 17.108, the minimum value is 15.592, and the maximum value is 18.23.

Table 1. Descriptive statistical results of variables

Variable type	Variable code	Variable name	Observed value	Mean value	Standard deviation	Minimum value	Maximum value
Dependent variable	Resi	Economic resilience	32	0.342	0.092	0.198	0.53
Argument	Cogg	Industrial collaborative agglomeration	32	2.045	0.274	1.594	2.573
Dummy variable	Gov	Government cooperation	32	0.6875	0.471	0	1
	fixed	Urban fixed assets	32	15.028	1.134	12.803	16.525
	people	Population	32	6.165	0.05	6.075	6.261
Control variable	freight	Freight volume	32	7.782	0.526	6.648	9.031
	industrial	Gross industrial output value	32	17.108	0.688	15.592	18.23

4.2. Regression analysis

Table 2. Results of regression analysis

	(1) Population sample Resi	(2) Central Yunnan city cluster Resi	(3) Yangtze River Delta urban agglomeration Resi
Cogg	0.104*** (3.11)	0.167** (3.09)	0.0474* (1.94)
fixed	-0.0423*** (-5.66)	0.00684 (0.97)	-0.156*** (-4.30)
people	-0.691** (-2.19)	-0.266 (-1.56)	-0.569* (-2.09)
freight	0.0640*** (5.17)	0.0365*** (5.05)	0.156*** (3.76)
industrial	0.0392 (1.53)	0.121*** (10.03)	0.0961*** (3.34)
t2010	0.0483*** (3.15)	-0.00434 (-0.27)	0.0389* (2.12)
_cons	3.822** (2.48)	-0.742 (-0.71)	3.291** (2.43)
N	32	16	16
adj. R ²	0.904	0.971	0.859
F	49.40	153.0	29.99

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

In order to verify the influence of industrial synergy agglomeration on the economic resilience of urban agglomerations, this paper conducts regression analysis on the central Yunnan City agglomeration and the Yangtze River

Delta City agglomeration. As shown in the above table, the results of basic regression are reported in columns (1) - (3), and the t statistic is in parentheses. (1) Regression results of the overall sample, (2) regression results of the "central Yunnan" urban agglomeration model, and (3) regression results of the "Yangtze River Delta" urban agglomeration. In order to verify the influence of government cooperation behavior on the economic resilience of urban agglomerations, control variables such as gross industrial output value, population, freight volume and urban fixed assets were added to the model. It can be seen from (1) that, under the overall sample, industrial collaborative agglomeration has a positive impact on the economic resilience of urban agglomerations. Each additional unit of industrial collaborative agglomeration can improve the economic resilience of urban agglomerations by 0.104 units, which is significant at the 1% significance level. Similarly, it can be seen from equation (2) that, in the central Yunnan city cluster, industrial collaborative agglomeration still has a positive impact on the economic resilience of the city cluster. Each additional unit of industrial collaborative agglomeration can improve the economic resilience of the city cluster by 0.167 units, which is significant at the 5% significance level. Equation (3) can be seen that in the Yangtze River Delta city cluster, Each additional unit of industrial cooperative agglomeration can improve the economic resilience of urban agglomeration by 0.0474 units, which is significant at the 10% significance level.

In order to verify the impact of government cooperation behavior on the economic resilience of urban agglomerations, this paper introduced dummy variables to comparative analysis of the impact of government cooperation on the economic resilience of urban agglomerations before and after

2010. Through the model, it can be seen that in the overall sample (1) and the Yangtze River Delta urban agglomeration (3), after 2010, Government cooperation can significantly improve the economic resilience of urban agglomerations, but not in the sample of central Yunnan urban agglomerations. The reasons are mainly due to the low level of economic resilience of central Yunnan urban agglomeration, which has the following problems in terms of government cooperation and industrial coordination. First, the degree of industrial division of labor and cooperation is low, and there is excessive competition among industries in different regions. Secondly, there are still local market barriers and administrative barriers in urban agglomerations. The flow of production factors such as information, technology and talents is blocked, and resources are not properly allocated. Third, as the city with a high degree of priority in urban agglomeration, Kunming is still faced with a series of problems such as very serious urban traffic congestion, inadequate infrastructure and resource flow blockage caused by excessive agglomeration of production factors. Although the city cluster in central Yunnan can still show a good trend of economic development, due to problems such as the low degree of cooperation among the cities and the unreasonable allocation of resources, the urban system has not formed a pattern of regional industrial coordinated development and lacks the ability to withstand the external impact. As a cross-region cooperation organization spontaneously and voluntarily established by local governments under the market mechanism, the Yangtze River Delta Urban Economic Coordination Committee breaks local protectionism and provides a platform for local governments to exchange from competition to cooperation, which is conducive to realizing the free flow and optimal allocation of factors between regions and industries, thus promoting the industrial collaborative agglomeration of urban agglomerations. The economic resilience of the Yangtze River Delta city cluster has been further strengthened. Decentralization among regions is the biggest barrier to the economic resilience of urban agglomerations. Information sharing and communication among governments break administrative barriers, enabling neighboring regions to learn relevant industrial technologies from regions with higher economic development level and flood more knowledge and technical talents, thus realizing the coordinated development of economic resilience of various regions within urban agglomerations. In the context of regional integration, local measures and differentiated policies are crucial. Urban agglomerations can establish a network regional system with clear center and smooth communication by relying on inter-local government cooperation, which can abandon blind reform. Scientific decision-making and reasonable guidance through consultation between governments are conducive to improving the economic resilience of urban agglomerations. Moreover, based on Marshall's externality theory, industrial collaborative agglomeration promotes information flow and knowledge spillover among enterprises, thus stimulating regional innovation vitality, which to some extent enhances regional ability to find new economic development paths when affected by external interference or impact, thus improving regional economic resilience. Through policy regulation and financial support, cooperation among local governments can improve product quality and technology upgrading in an industry within the city cluster, thus promoting the joint development of quality and technology in the upstream and downstream of the industrial chain, and

contributing to the synergistic interaction of elements in the spatial network of several related industries, that is, industrial synergistic agglomeration. Furthermore, the synergy formed by industrial agglomeration enables agglomeration enterprises not only to share various supporting public facilities and improve output efficiency, but also to gather technical and managerial personnel, which increases technology spillover and promotes the development of economic resilience of urban agglomeration.

5. Research conclusions and Enlightenment

This paper takes the Yangtze River Delta city cluster and the central Yunnan City cluster as the research object, and analyzes the influence mechanism of government cooperation and industrial collaborative agglomeration on the economic resilience of the city cluster. Based on the empirical results, this paper draws the following conclusions: (1) Industrial collaborative agglomeration can promote the economic resilience of the central Yunnan City cluster and the Yangtze River Delta city cluster. (2) The regional governance mechanism emphasizing governmental cooperation can break the boundaries of administrative divisions, and the internal division of labor and cooperation can produce a synergistic effect of $1+1>2$, which improves the economic resilience of urban agglomerations. (3) The dynamic evolution characteristics of industrial collaborative agglomeration have boosted the economic resilience of the Yangtze River Delta urban agglomeration to spiral upward, and government cooperation plays an important leading role in industrial collaborative agglomeration. This study has important enlightenment for the Central Yunnan City cluster to further strengthen inter-regional government cooperation and gradually build a resilient regional economic pattern. Specific policy recommendations are as follows:

The government cooperation organization shall be established to realize the coordinated governance of the cities in the central Yunnan city cluster. In the face of competition and deprivation among local governments, it is indispensable for each administrative body within the central Yunnan City cluster to establish a regional coordination mechanism of joint participation. On the one hand, guided by the demonstration of urban cooperative governance within the Yangtze River Delta urban agglomeration, the Central Yunnan Urban agglomeration should establish and improve the corresponding provincial economic coordination meeting and joint meeting system to promote the cooperative development of Kunming, Yuxi, Qujing, Chuxiong and other cities. After establishing the agreement of cost and profit sharing, when facing the entrance of talent introduction or major investment projects, Local governments can make overall consideration from the overall urban agglomeration, carry out reasonable division and coordination of projects, and reduce disordered competition and resource deprivation in internal industries. On the other hand, in the context of regional integration, local measures and differentiated policies are crucial. Urban agglomerations can establish a network regional system with clear center and smooth communication by relying on inter-local government cooperation, which can abandon blind reform. Scientific decision-making and reasonable guidance through consultation between governments are conducive to improving the economic resilience of urban agglomerations. For Kunming, Qujing, Yuxi and other cities, government

cooperative organizations should focus on improving the quality of industrial agglomeration and collaborative ability of the cities, avoid the phenomenon of resource flow blockage caused by excessive agglomeration of production factors, and rationally channel and divert internal resources. For Mengzi, Gejiu, Jianshui, Kaiyuan, Maitreya, Lusi and Shiping, governmental cooperative organizations should encourage them to give full play to their resource advantages, attract and retain talents through favorable supporting policies and environment, speed up the improvement of transportation facilities and industrial supporting measures, promote the dislocation development of each city and avoid duplication of construction. In addition, the policy of one-to-one assistance should be set up within urban agglomerations, and the national strategic guideline of "the first rich drive the second rich" should be implemented. The developed cities should radiate to drive the coordinated development of the surrounding less developed cities, and the cities within urban agglomerations should be guided to form close economic cooperative relations through cooperation.

Second, improve the construction of infrastructure, strengthen the spatial economic relations among the cities within the group, narrow the regional economic differences, and promote the integrated development of urban agglomeration. Local governments should strengthen geographical connections between cities through exchanges and cooperation, play a role of inter-provincial and inter-city coordination, increase R&D investment and policy support for cities according to local economic development level and industrial structure, improve industrial development networks and transportation and other infrastructure of cities, promote inter-governmental cooperation, and then guide inter-city cooperation. Form highly connected urban groups. In recent years, although the transportation infrastructure of central Yunnan urban agglomeration has achieved great development, there are still problems such as low overall level and unbalanced development. Therefore, the industrial transfer generated in the process of industrial collaborative agglomeration will certainly increase the pressure on the transportation of the destination. If the road transportation network is not optimized and broadened, the destination of industrial relocation will be unable to meet the demand of resource circulation. Not conducive to the development of the industry locally. Therefore, infrastructure construction should be adapted to local conditions. For developed areas, attention should be paid to improving the refined management level of infrastructure construction, and for less developed areas, more efforts should be made to support the interconnection construction of infrastructure, give full play to regional advantages, improve the quality of infrastructure, and improve the ability of infrastructure to withstand disasters so as to enhance the resilience of urban agglomeration to external interference and impact. At the same time, government cooperation organizations should continue to increase investment in urban agglomeration infrastructure construction, especially in transportation, energy, scientific research and technical services, network communication and other municipal public infrastructure construction, but also actively enhance the infrastructure construction of public life. In recent years, the outbreak of the novel coronavirus epidemic, more investment should be increased in the construction of medical and health infrastructure. To ensure the safety and health of residents in urban agglomerations, and create favorable production conditions for the

improvement of economic resilience. In addition, it can also rely on the function of government cooperation and collaborative governance to establish a public service platform for the central Yunnan city cluster, promote the exchange and sharing of resources, information, technology, talents and other aspects among cities, and promote the coordinated development of the city cluster industry. Specifically, based on the authority of the executor of public power, government departments should establish regional cooperative organizations such as regional financial risk monitoring center, regional innovation platform and integrated transportation network. The second is to provide policy and financial support for specific industries and regions, which is not only conducive to the formation of "incentive effect" of industries, but also can avoid the phenomenon of resource waste caused by repeated allocation and construction within urban agglomerations. Third, a cross-regional social security system should be established to reduce the friction coefficient of economic development and improve the resilience of regional economy by promoting the mutual recognition of social management on a larger scale. In conclusion, in the process of coordinated industrial development of urban agglomeration, governments at all levels in Central Yunnan urban agglomeration should play a leading role, establish a regional coordination mechanism, promote the cooperative development among cities within the urban agglomeration, and provide institutional guarantee for the improvement of economic resilience of urban agglomeration. The fourth is to establish an efficient logistics network system for the central Yunnan urban agglomeration, and accelerate the rapid economic growth of the central Yunnan economic circle by gathering and coordinating various economic factors. In order to promote the rational allocation of logistics resources and improve the efficiency of the use of logistics resources, government cooperative organizations should take practical measures to promote the rational flow of logistics resources in central Yunnan region.

Third, promote the balanced development of industrial collaborative agglomeration within urban agglomerations. The central Yunnan Province city agglomerate is in southwest borderland in our country, planning for the city agglomerate starts later, therefore, the competitive power of the central Yunnan Province city agglomerate has a much bigger gap than that of the coastal city agglomerate. Compared with Shanghai, Nanjing, Wuxi, Suzhou and other cities, the core city of Kunming has a weak comprehensive strength and small urban scale, which includes the imperfect modern industrial system, especially the lack of export-oriented industries and the prominent homogeneity of industrial development. Therefore, on the one hand, each city should clarify its own core division of labor and develop local characteristics and advantageous industries. For example, Kunming should make full use of its advantages in economy, market, talent, science and technology, comprehensively promote the construction of flower, coffee and other advantageous characteristic industrial clusters, and create a new highland for industrial development. Qujing should actively cultivate high-tech industries, while focusing on the development of manufacturing, transportation, finance and public services; Yuxi is the largest tobacco industry base in Asia, so we should pay attention to the development of transportation industry, accommodation and catering industry, so as to reduce transportation costs and improve transportation benefits. Chuxiong is a city dominated by

agricultural and sideline product processing and cultural industries. It should promote the coordinated development of manufacturing, wholesale and retail, transportation, accommodation and catering industry to enhance the soft power of the city. On the other hand, under the collaborative governance of local government departments, it is necessary to plan the production chain of trans-regional industrial coordination in the central Yunnan city cluster, optimize and improve the transportation and information communication network of Kunming, Qujing, Yuxi, Chuxiong and other places, so as to reduce the range of knowledge spillover benefit decreasing with the increase of distance and the transportation cost. And then give play to the economic driving and radiation effect of core cities serving the whole city group. While paying more attention to the industry, the government departments of the central Yunnan city cluster should combine the accumulation of human resources with industrial development, so as to provide matching human resources for the high-quality development of the industry and the effective play of industrial synergistic agglomeration effect. Among them, it is necessary to strengthen cooperation and exchanges in higher education, especially vocational education, exchange employment channels and information, promote the sharing of high-quality vocational education resources, promote the continuous development of vocational education, and jointly train outstanding potential employees for enterprises in the urban agglomeration of central Yunnan. At the same time, in order to narrow the gap in the level of industrial collaborative agglomeration among cities, cities should combine geographical location, factor endowment, industrial layout and other factors to carry out professional production, and form an industrial agglomeration pattern with reasonable division of labor and complementary development within the region. For big cities, government cooperative organizations should actively promote collaborative agglomeration among industries, transfer labor-intensive industries that are excessively clustered to medium and small cities, drive regional innovation with high-tech industries, and enhance the renewal force in the economic resilience of urban agglomerations. While actively undertaking the task of industrial transfer, medium and small cities should give full play to their own industrial advantages, improve the level of professional development, and further introduce capital, projects, talents and other resources to promote the coordinated development of regional industries.

6. Research limitations and future prospects

Limited by data collection, this study still has some shortcomings. First, there is no heterogeneity analysis on the mechanism of industrial synergistic agglomeration to promote the economic resilience of urban agglomerations. Secondly, the study is only based on the prefecture-level city data of the Yangtze River Delta city cluster and the Central Yunnan City cluster. The county-level data contained in the study is missing due to the inconsistency between the statistical index and the prefecture-level city. Therefore, the data of Chuxiong Yi Autonomous Prefecture and Mengzi City, Gejiu City, Jianshui County, Kaiyuan City, Miele City, Luxi County, and Shiping County in the northern part of Honghe Hani and Yi Autonomous Prefecture are not included in the calculation of economic resilience of Central Yunnan urban agglomeration. Finally, relying only on 14 indicators to

determine a unified comprehensive measurement system of economic resilience of urban agglomerations cannot follow the same law. In view of the above deficiencies, the follow-up research can theoretically explore the influence of industrial collaborative agglomeration on the economic resilience of central Yunnan urban agglomeration, so as to further explore the mechanism of improving the level of economic resilience. In terms of the research scope, the relationship between industrial synergistic agglomeration and economic resilience in regional, sub-regional and regional urban agglomerations is deeply analyzed, so as to enhance the applicability of the research in a wider range. In terms of research indicators, combined with the actual development status of prefecture-level cities and county-level cities within urban agglomerations and specific local policies, specific evaluation indicators are selected to measure the economic development of urban agglomerations, so as to establish a sound economic resilience measurement system of urban agglomerations.

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