Analysis on regional industries based on SNA：A case of five provinces in Southwest China

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Abstract

The input-output relationship between industries is the important foundation of industry linkage. By taking five provincial regions in southwest China as cases, this paper uses the methodology of social network analysis to measure the 42 industrial sectors networks in 2012, and calculates the overall density, clustering coefficient, average distance and graph Hierarchy of each regional industrial network. At the same time, 42 industrial sectors are studied by calculating nodes centrality, nodes betweenness and nodes influence. The results show that Sichuan province has the highest industrial coupling degree, while Xizang is the lowest. Each province has similar industrial center in its industrial system, but also has respective competitive industry. The industrial structure of each province is not reasonable enough. Industry is still the leading industry and service industry is relatively backward. It is necessary for the provincial governments to make active adjustments according to their own industrial structure. They should strengthen industrial cooperation, learn from each other and seek win-win results.

Keywords

Industry Linkage, SNA, Centrality, Betweenness.

1. Introduction

Since the reform and opening up, China's economy has developed rapidly. But, with the economic aggregate increasingly, the industrial structure has become a bottleneck and restricts sustainable economic growth. In the past, China's economic growth was mainly driven by the secondary industry. But with the arrival of Service Economy Age, the national economy is increasingly dependent on the tertiary industry, and the past industrial structure has not adapted to the current economic development. Therefore, by analyzing existing industrial structure and exactly grasping industrial linkage, it will help each region to upgrade industrial structure and to achieve complementary advantages. Southwest China has five provinces. They are Sichuan, Chongqing, Guizhou, Yunnan and Xizang. The area of five provinces are 250 square kilometers, accounting for 24.5% of China's land territory. Their resident population are more than 200 million (2017), accounting for 14.5% of the total population. And GDP in 2017 amounted to 8763.304 billion yuan, accounting for 10.3% of the country. Although southwest China accounts for a small proportion of the total economy, the economic growth rate of each provinces is the highest in China. Especially Guizhou, Xizang and Chongqing, they still maintained double-digit economic growth rate. Therefore, by studying the industrial structure of southwest China, it is helpful for us to realize the industry advantages of each region, and find out an optimal path for each province to optimize industrial structure.

2. Review

Industrial structure means that various kinds of proportional relations between each industry according to some certain economic and technological relations. Industrial structure is a concentrated reflection of the level of economic development. Optimized industrial structure and efficient industry linkage are necessary conditions for all-round economic and social development. Input-output relationship is the most basic content in industry linkage. So, making a quantitative analysis on industry input-output relationship and revealing the industrial network structure are the basis of promoting regional economy sustainable development. Traditional industrial structure researches generally carry out it from three perspectives. Firstly, from the perspective of industrial economy, researchers link the proportion of a single industry's GDP and other economic indicators, and build economic models. Secondly, from the perspective of input and output, researchers expound the interrelationship between single industrial sector and industry globally by constructing indicator systems. Thirdly, from the network perspective, researchers construct industrial networks and study complexly direct or indirect links between each industry [1,2,3]. The existing researches on industrial networks mostly focus on network characteristics and network structure [4,5,6]. Research objects are mainly countries or regions [7,8]. Less attentions are given to a specific individual sector. In order to understand the degree of industry linkage between industries in southwest China, this paper uses social network analysis method depending on existing researches, and makes a quantitative analysis of industry linkage. Besides, we calculate position, influence and resource control ability of each province's industrial sector in the industrial structure network, and explore their regional industrial structure characteristic and industrial transformation advantage. We put forward some specific policy recommendations, finally. UCINET software was used for the calculation of all data in this paper.

3. Research Design

3.1 Data sources

The data mainly comes from input-output table of various provinces and cities in China in 2012[9], which contains data of 42 departments. The codes of each department are listed in the following table.

Table 1 Codes of 42 industrial sectors

01 Agriculture, forestry, animal husbandry and fishery products and services	22 Other manufactured products
02 Coal mining products	23 Scrap waste
03 Oil and gas production products	24 Metal products, machinery and equipment repair services
04 Metal mineral products	25 Production and supply of electricity and heat
05 Non-metallic minerals and other mineral products	26 Gas production and supply
06 Food and tobacco	27 Water production and supply
07 textile	28 building
08 Textile clothing shoes and hats leather down and its products	29 Wholesale and retail
09 Wood work and furniture	30 Transportation, warehousing and post
10 Papermaking, printing, culture, education and sporting goods	31 Accommodation and catering

11 Petroleum, coking products and nuclear fuel processed products	32 Information transmission, software and information technology services
12 Chemical products	33 financial
13 Non-metallic mineral products	34 The real estate
14 Metal smelting and calendering products	35 Rental and business services
15 Metal products	36 Scientific research and technical services
16 General equipment	37 Management of water conservancy, environment and public facilities
17 Special equipment	38 Resident services, repairs and other services
18 Transportation equipment	39 Education
19 Electrical machinery and equipment	40 Health and social work
20 Communications equipment, computers and other electronic equipment	41 Culture, sports and entertainment
21 Instrument and meter	42 Public administration, social security and social organizations

3.2 Methods

Social Network Analysis (SNA) is a kind of theory or method, which analyze social relations structure and social attribute. SNA mainly analyzes social relationship structure and social attributes formed by different actors (individuals, groups or societies). In 1998, Watts & Strogatz put forward Six Degrees of Separation theory. Since then, SNA has been widely applied in the fields of management and economics, and has become a new paradigm in the study of social relations.

3.3 Network Construction

Social networks consist mainly of nodes and ties. In the industrial network, each industrial sector is a network node, and the connection between industrial sector is a tie. Therefore, we use the data of various industrial sectors in the input-output table. And a 42-by-42 industry correlation coefficient matrix can be constructed, as shown in equation 1.

$$A = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,42} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,42} \\ \vdots & \vdots & \vdots & \vdots \\ a_{42,1} & a_{42,2} & \cdots & a_{42,42} \end{bmatrix} \tag{1}$$

In some network structure analysis, dichotomized matrix is needed. Theoretically, the threshold of dichotomy can be selected freely, and different thresholds represent different research perspectives. This paper studies the major industries in different regions, so we choose the average correlation coefficient as the threshold. "1" represents that the correlation coefficient is greater than the mean, and "0" represents that the correlation coefficient is less than the mean.

3.4 Network Structure Index

(1) Density

It reflects the degree of closeness between various departments in the industry linkage network. The higher the density is, the closer the nodes will be. The calculation principle is that the actual number of relations of each node in the network is divided by the theoretical maximum number of relations.

(2) Graph Hierarchy.

Hierarchy degree of network expresses to what extent different nodes can be reached asymmetrically. The higher the hierarchy degree of the graph, the more hierarchical the network is, and the central node may exist in the network.

(3) Small-World.

Small-World mainly includes two indexes, which are clustering coefficient and average distance. The former reflects the efficiency of information transfer, and the latter reflects the convenience of link. Small-World requires the network to have higher clustering coefficient and lower average distance.

3.5 Network Node Index

(1) Centrality.

Centrality reflects the degree to each node in the network is located in the center. This characteristic is mainly measured by degree centrality or closeness centrality. A higher degree centrality indicates that a node has more connections with other nodes, while a higher closeness centrality indicates that a node is closer to other nodes, and it may be located in the center of the network.

(2) Betweenness.

In a network, if a node is on the shortcut of many other node pairs, we say that the node has a high betweenness centrality. This node may play an important intermediary role, and have more structure holes.

(3) Influence.

Each node in the network, selects to build different relationships. Some nodes are "looked after" by many other nodes and get more help, while others may choose to "look after" others more and give help more. If a node has few out and in relationships. It means that this node is "lonely" and has no influence. This paper mainly studies the outward influence.

4. Results

4.1 Visualization

The structure diagram of the industrial network is generated according to node's degree centrality and the distribution of ties. Each node represents an industry (the industry code is marked on the upper corner). The larger the node area is, the greater degree centrality is in the whole network. Through comparison, it found that the network structure of Sichuan, Yunnan and Guizhou are relatively close, while Chongqing and Xizang are loose.
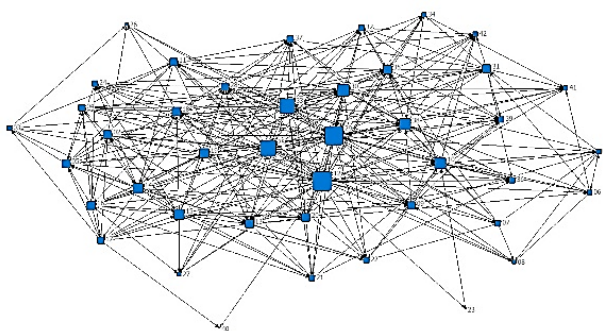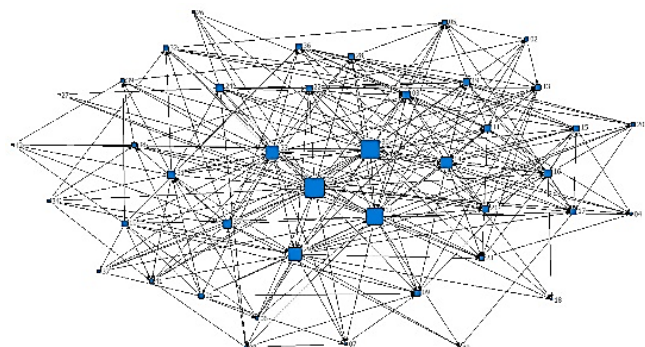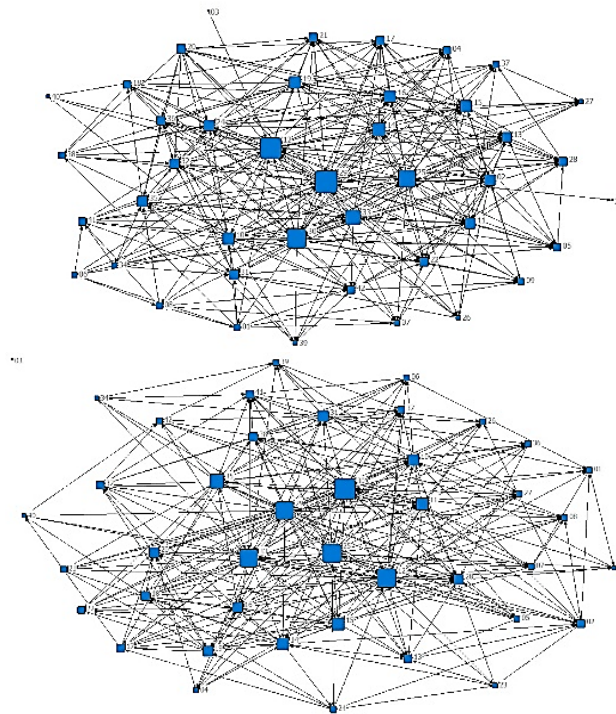

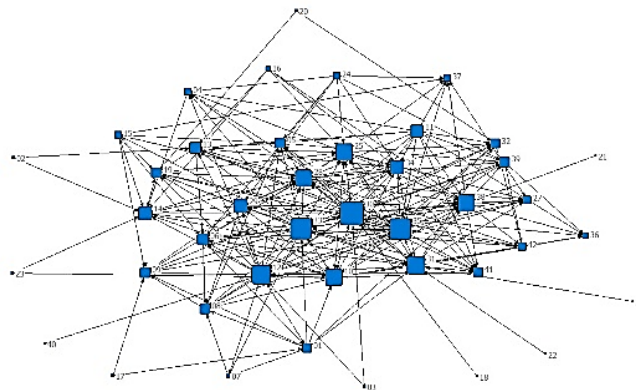
Fig. 1 Sichuan   Fig. 2 Chongqing

Fig.3 Yunnan　　　　　　　　　　Fig.4 Guizhou

Fig.5 Xizang

4.2 Network Characteristic

From Table 2, we see that the network density of all the five provinces in southwest China did not exceed 0.2, indicating that the industrial and economic links of all the provinces and cities in southwest China were not close enough, and most of the industrial links were weak. Specifically, Sichuan's industrial network density is the highest, reaching 0.194, while Xizang is the lowest, only 0.1475. It means that the economic exchanges between various industries in Sichuan are the closest, and the coupling degree of industrial sectors is the highest. Xizang has the lowest industrial contact degree, and has great potential to rise the coupling degree of industrial sectors. Five provinces all have the characteristics of Small-World, including higher clustering coefficient and short average path between nodes. It shows that information transmission between industries is efficient and accurate. On average, each industrial department can transmit information through less than 2 other departments. Industrial communication is convenient. Specifically, Small-World of Guizhou and Sichuan is the best, and Small-world of Xizang is the worst. About graph hierarchy, only Guizhou reach 0.5873, and other provinces are no more than 0.4. Xizang is even only 0.3022. It means that Guizhou have obvious single industry center, industry have a rigid hierarchy. On the contrary, Xizang have several industry centers, every industry is relatively equal.

In general, the five southwest provinces's industrial linkage closeness are still relatively low, and do not give full play to superiority in industrial network convenience. Because of lacking direct links and strong links between industries, industrial structure cannot meet the requirements of upgrade and optimization. Compared with the developed provinces, five southwest provinces have a lot of room for improvement.

Table 2 Industrial network structure of five provinces in southwest China

	Sichuan	Chongqing	Guizhou	Yunnan	Xizang
Tie	334	283	322	331	254
Density	0.194	0.1643	0.187	0.1922	0.1475
Clustering Coefficient	0.613	0.579	0.634	0.609	0.565
Average Distance	1.659	1.711	1.65	1.677	1.927
Graph Hierarchy	0.394	0.3661	0.5873	0.4031	0.3022

4.3 Centrality Analysis

According to Patore's 80/20 law, the top nine industrial sectors can be considered as important sectors. After calculation of UCINET, nine departments with the largest point centrality in each province are sorted out, and the results are as follows. From the table, it find that among the five provinces, retail wholesale and (except Tibet), chemical products, production and supply of electricity and heat, finance and transportation, warehousing, postal service all entered the top 9. The reason is that, in industrial chain, Wholesale and Retail is the phase for all products into market; Electric power, Heat production and Supply is basic inputs and safeguard of all production; Chemical products provide industry's and agriculture's production and daily consumption with important raw materials; Transportation, Storage and Post is the basic need of products circulation; Financial guarantees the normal operation of the economy.

In addition to the above five sectors, each province also has some own leading industries. Such as Residents Services, Repair and Other Services, Paper Printing and Cultural and Educational Sports Supplies in Sichuan; General Equipment in Chongqing; Oil and Gas Production Products, Petroleum, Coking Products and Nuclear Fuel Processed Products in Guizhou; Electrical Machinery and Equipment, Metal Products in Yunnan; Accommodation and Catering, Architecture in Xizang. In general, these industries are at the center of the industrial network in their respective provinces, which belong to the leading industries, and should be given priority to development.

Table 3 TOP 9 Centrality Sectors

	Top9 Point Degree
Sichuan	1.Chemical products 2. Wholesale and retail 3. Production and supply of electricity and heat 4. Financial 5. Transportation, warehousing and postal services 6. Resident services, repairs and other services 7. Papermaking, printing, culture, education and sporting goods 8. Metal smelting and calendering products 9. Metal products
Chongqing	1. Production and supply of electricity and heat 2. Transportation, warehousing and postal service 3. Chemical products 4. Financial 5. Wholesale and retail 6. Metal smelting and calendering products 7. Rental and business services 8. General purpose equipment 9. Wood processed goods and furniture; Petroleum and natural gas production products
Guizhou	1. Transportation, warehousing and postal service \

	2. Production and supply of electricity and heat 3. Chemical products 4. Wholesale and retail 5. Financial 6. Leasing and business services
	7. Metal smelting and calendering products 8. Metal products
	9. Petroleum, coking products and nuclear fuel processed products
Yunnan	1. Wholesale and retail 2. Chemical products 3. Transportation, warehousing and postal service
	4. Production and supply of electricity and heat 5. Financial
	6. Metal smelting and calendering products 7. Electrical machinery and apparatus
	8. General equipment 9. Metal products
Xizang	1.Transportation, warehousing and postal service 2. Financial
	3. Rental and business services 4. Chemical products 5. Accommodation and catering
	6. Production and supply of power and heat
	7. Paper, printing, culture, education and sporting goods 8. Building
	9. Resident services, repairs and other services

4.4 Betweenness Analysis

Betweenness of industrial sector is mainly measured by betweenness centrality, which reflects the extent to a sector controls the industrial links between other sectors. By measuring the betweenness centrality of each industry sector in the five provinces, we find that each industry sector often has centrality and betweenness at the same time. If one's degree centrality is higher, its betweenness centrality is higher. However, there are some cases in which the following departments only play the role of intermediary, such as Accommodation and Catering Paper Printing and Cultural and Education Sports Supplies in Guizhou; Accommodation and Catering, Leasing and Business Services in Yunnan, and Metal Smelting and Calendering Products in Xizang. In general, an industry can occupy two location advantages at the same time, but the benefits from the two advantages are not the same. The departments with higher betweenness have more control advantages and more discourse power in the industrial network.

4.5 Influence Analysis

The influence of industrial sector is mainly reflected in whether a sector plays the role of "giving orders" or "accepting orders" in the whole industrial system. Sectors belonging to the former show spillover effect in industry linkage, which can export value to other sectors and promote development of them, while sectors belonging to the latter show inflow effect, which mainly relies on the value input and is driven by other sectors. By measuring the influence of each sector in five provinces, the results are as follows. It seen that heavy industry and chemical industry are still the most influential industries, while service industry and light industry rank the second. Although the influence of each sector is similar to centrality and betweenness, there are several points worth noting. First of all, in Sichuan and Yunnan, agriculture still plays a significant role. Secondly, in Chongqing, Guizhou and Yunnan, sector about fixed asset investment plays an important role. lastly, Sichuan, Chongqing and Xizang have relatively good development of high-tech industries which show strong industrial driving capacity.

Table 4 Top5 Influence Sector

	Top5 Influence
Sichuan	1. Chemical products 2. Metal smelting and calendering products 3. Production and supply of electricity and heat 4. Agriculture, forestry, animal husbandry and fishery products and services 5. Communications equipment, computers and other electronic equipment
Chongqing	1. Metal smelting and calendering products 2. Production and supply of electricity and heat 3. Chemical products 4. Transportation, warehousing and post 5. Communications equipment, computers and other electronic equipment
Guizhou	1. Production and supply of electricity and heat 2. Transportation, warehousing and post 3. Chemical products 4. Metal smelting and calendering products 5. Coal mining products
Yunnan	1. Metal smelting and calendering products 2. Agriculture, forestry, animal husbandry and fishery products and services 3. Transportation, warehousing and post 4. textile 5. financial
Xizang	1. Metal smelting and calendering products 2. Chemical products 3. Production and supply of electricity and heat 4. Communications equipment, computers and other electronic equipment 5. Wholesale and retail

5. Conclusion

Based on input-output data and SNA, this paper analyzes the industrial structure of the five provinces in southwest China. The research indicates that the industrial economic relation degree is lower, and the industrial structure is not reasonable enough. At present, power industry, thermal industry, chemical industry, distributive service industry and finance all occupy a good position in the industrial network, while light industry and service industry are relatively weak. Sichuan has a complete industrial structure with the best development prospect, Chongqing is not far behind. Although Guizhou and Yunnan have defects in industrial structure, they both have their own leading industries. Xizang, limited by its backward industrial level, needs to rely more on the development of service industry. In general, the industrial structure of the five southwest provinces is not reasonable, and the proportion of technology-intensive industries and production-oriented services are low.

6. Policy Recommendations

In order to change this situation, it is necessary to adjust measures to local conditions, accelerate the adjustment of regional industrial structure, narrow regional gap and accelerate the process of integration. Establish a reasonable industrial hierarchy; Promote the integration of industrial network internal space integration; Collaborative integrated regional economic structure adjustment, promote

industrial reasonable layout, for the leading industry of the centricity and betweenness, government should provide resources and policy support. Highlight the radiation effect of dominant industry. Give priority to the role of industrial hubs. Increase the pulling effect that advantageous industry develops to southwest area economy. Five provinces should also strengthen industrial cooperation, complement each other and seek win-win situation.

Acknowledgements

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