

# Analysis of the Temporal and Spatial Characteristics of Coupling and Coordination Between Manufacturing Industry and Service Industry of China

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**Abstract**—Based on constructing the system of system evaluation index of the coupling and coordination degree of manufacturing industry and service industry, 31 province-level units in China are taken as research objects, and the coupling coordination degree model is used to measure the coordinated development degree of China's manufacturing industry and service industry from the perspective of time and space. And the regional differences between the two are systematically discussed. The main conclusion is: from the perspective of time series, it is analyzed that the coupling coordination degree of China's manufacturing industry and service industry has been increasing year by year from 2007 to 2016. The relationship between the two has been transformed from running-in to adaptive coordination; from the perspective of space, the coupling degree of the two shows obvious regional differences. The development level of the manufacturing industry generally shows the "east-middle-west" decreasing distribution pattern, while the development level of service industry generally shows "V-shaped" of lower in the northeast and northwest. From the perspective of coordination level, the provincial pattern of the coupling degree of manufacturing and service industry is "pyramid type", which means the number of provinces with intermediate coordination to those facing imbalance is decreasing, and the coordination state in the east is obviously superior to other regions.

**Keywords**—*manufacturing; service industry; coupling coordination degree; temporal and spatial characteristics*

## I. INTRODUCTION

In the past 40 years since reform and opening up, China's industrial structure has shown a trend that the proportion of the secondary industry continues to decline while the proportion of the tertiary industry continues to rise. The value added of service industry in GDP has increased year by year, reaching 51.6% as of 2017. The evolution of the three industrial structures described in Petty-Clark Theorem was realized in China. In the critical period of industrial restructuring and upgrading, to improve the competitiveness

of manufacturing industry and comprehensively improve the development level of the service industry, it is necessary to accelerate the in-depth integration of the two industries and promote the coordinated development of the two. China has vast territory and abundant resources. Due to different resource conditions, factor endowments, economic base, etc., economic development and industrial structure are extremely uneven, and the development level of manufacturing and service industries varies greatly among provinces. How should we measure the development level of China's manufacturing industry and service industry, what is the relationship between the two, and what is the difference and coordination relationship between the manufacturing industry and the service industry in each region? Is the better the development of the manufacturing industry in a certain region, the better the development of its service industry? In order to clarify these issues, it is necessary to conduct a comparative study on the level of manufacturing and service industry development at the provincial level, and provide a basis and reference for the provinces to fully optimize the industrial structure and promote the upgrading of industrial structure.

With regard to the theoretical discussion of the relationship between manufacturing and service industries, mainstream views can be summarized into four categories: demand compliance theory, supply predominance theory, interactionism, and integration theory. According to the "demand compliance theory", in the industrial relationship, the two are not equal. The service industry is in the position of demand compliance, and the manufacturing industry is the prerequisite for the development of the service industry. The "supply predominance theory" pays more attention to the role of the service industry. It is believed that the perfection of the service industry system brings up the manufacturing industry. If there is no strong service industry, it is difficult for the manufacturing industry to have a strong scale and competitiveness. "Interactionism" negates the above two viewpoints, and believes that the relationship between the two is not a simple one-way relationship, but mutual dependence, mutual causation, and coordinated development.

As a popular point in recent years, "integration theory" believes that with the acceleration of global economic integration and the development of science and technology, the boundaries between the two are no longer clear, but gradually become industrial integration. The evaluation of the coordination level between the manufacturing industry and the service industry is mainly discussed from the following three perspectives: based on input-output relationship, symbiosis degree and coordination degree. Among them, there are many research literatures on the two from the perspective of the productive service industry, while the service industry includes, in addition to this, the life service industry and the consumer service industry, so the focus of research should be on promoting the relationship of interaction, integration and coordinated development between the two.

Looking at the main literature on the research of coordination relationship between manufacturing and service industry, the construction of evaluation index system, weight

design and evaluation methods for the coordination relationship between manufacturing industry and service industry are not uniform and less existing literature is about it. Most of the literature is based on the analysis from the perspective of manufacturing and productive service industries, and the state of coordination relationship is still controversial. In view of the above discussion, this paper attempts to calculate the development level and coupling coordination degree of unit manufacturing and service industry in 31 provinces from the perspective of time and space, based on the construction of the coupling degree index system of manufacturing industry and service industry, and systematically analyzes the regional differences between the two to reveal their intrinsic links and provide a theoretical basis for formulating relevant policy recommendations.

## II. INDEX SYSTEM AND RESEARCH METHODS

### A. Construction of the Index System

TABLE I. INDEX SYSTEM FOR THE COUPLING AND COORDINATION SYSTEM OF MANUFACTURING AND SERVICE INDUSTRIES

goal layer	system layer	criteria layer	index layer (unit)	weight
coupling and coordination system of manufacturing industry and service industry	development level of Manufacturing industry	Scale level	output value of Manufacturing industry (100 million yuan)	0.138
			quantity of employment in Manufacturing industry (town) (10,000 people)	0.140
		Structural level	Number of manufacturing companies (number)	0.163
			fixed assets investment in Manufacturing industry (ten thousand yuan)	0.121
		Growth level	proportion of Manufacturing output value in GDP (%)	0.037
			proportion of fixed assets investment in Manufacturing (%)	0.047
			Proportion of quantity of Employment in manufacturing industry in total employment (%)	0.038
			The proportion of manufacturing enterprises in the total number of enterprises (%)	0.076
			Growth rate of output value of manufacturing industry (%)	0.011
			growth rate of fixed asset investment in Manufacturing industry (%)	0.011
	development level of Service industry	Scale level	growth rate of employment of Manufacturing industry (%)	0.017
			growth rate of number of Manufacturing enterprises (%)	0.017
		Benefit level	labor productivity of Manufacturing industry (10,000 yuan / person)	0.039
			average wages of manufacturing employees (town) (yuan)	0.063
		Structural level	coefficient of effect of fixed assets investment in Manufacturing industry (%)	0.018
			proportion of total manufacturing profit in GDP (%)	0.064
			Service industry added value (100 million yuan)	0.092
			quantity of employment of Service industry (town) (10,000 people)	0.065
			Number of service companies (a)	0.085
			fixed assets investment in Service industry (ten thousand yuan)	0.067
Growth level	Structural level	Proportion of added value of Service industry in GDP (%)	0.093	
		ratio of fixed assets investment in Service industry (%)	0.073	
	Benefit level	proportion of service industry employment in total employment (%)	0.038	
		proportion of number of Service industry companies in total number of companies (%)	0.042	
		growth rate of added value of service industry (%)	0.011	
		Growth rate of fixed assets investment in service industry (%)	0.010	
		growth rate of employment in Service industry (%)	0.016	
		growth rate of number of Service companies (%)	0.045	
Benefit level	Structural level	labor productivity of Service industry (ten thousand yuan / person)	0.077	
		Average wages of employed persons (towns) in the service industry (yuan)	0.107	
	Benefit level	Effect coefficient of fixed assets investment in service industry (%)	0.009	
		Total tax revenue of service industry in GDP (%)	0.170	

<sup>a</sup>. Note: Labor productivity = added value (or output value) / average number of employees

<sup>b</sup>. Effect coefficient of Fixed asset investment = increment of total output value during the report period / fixed asset investment amount \*100%

The relationship between the development level of manufacturing industry and service industry is a unity of quantity and quality. It can not only pursue the accumulation of quantity, but the interdependence and integration between

the two is more important, so as to achieve a dynamic and coordinated development relationship. With regard to constructing index system of the development level of manufacturing industry and service industry, there are many

research results at present. From the aspects of scale, structure, growth and benefit level, this paper selects a total of 16 representative indexes based on the principles of scientific practicality, systemicity, dynamics and completeness to reflect the development level of China's manufacturing and service industries. Through the gray correlation analysis, the correlation degree between each index is above 0.5, and the average correlation degree is above 0.7, indicating that the indicator system is meaningful. Then, the relatively objective entropy weight method is used to empower the indexes at all levels and make a consistency test. The evaluation index system for constructing the coupling degree of manufacturing and service industry is shown in "Table I".

**B. Evaluation of the Comprehensive Level**

This paper is based on the time series from 2007 to 2016. During this period, the world experienced the financial crisis and subsequent economic fluctuations, which is also a key period for the adjustment and upgrading of China's industrial structure, so it has certain research value. The selected data mainly comes from China Statistical Yearbook, China Industrial Statistical Yearbook, China Third Industry Statistical Yearbook and statistical yearbooks of provinces and cities. Some missing data are predicted by interpolation method and analogy.

In order to measure the comprehensive development level of the manufacturing and service industries, the initial data should be standardized, and the interference caused by different dimensions and orders of magnitude should be excluded. The formula is  $u_{ij}' = \frac{u_{ij} - \min u_{ij}}{\max u_{ij} - \min u_{ij}}$ , where  $u_{ij}'$  represent standardized data,  $j$  represent initial data,  $i$  represent different regions,  $u_{ij}$  represent different indicators,  $\max u_{ij}$ ,  $\min u_{ij}$  represents the maximum and minimum values for different years or regions. The entropy weight method is used to assign weights to the standardized indexes as follows:

First, to eliminate the impact of the index logarithmics on the calculation, the  $u_{ij}'$  is translated into  $A$  units, which means  $v_{ij} = u_{ij}' + A$ . The closer  $A$  is to  $\min u_{ij}$ , the better the effect is. (Here we take  $A = 10^{-4}$ ) Then we normalize the translated data, with the formula, and the standardized matrix  $P_{ij} = (p_{ij})_{m \times n}$  can be obtained.

Second, the entropy  $e_j$  of index  $u_j$  and redundancy  $d_j$  is calculated. The entropy is  $e_j = -K \sum_{i=1}^m p_{ij} \ln p_{ij}$ ,  $K = \frac{1}{\ln m}$  and redundancy  $d_j = 1 - e_j$ .

Finally, the weight  $w_j$  of index  $u_j$  is calculated, and the formula is  $w_j = \frac{d_j}{\sum_{j=1}^n d_j}$ .

The graded weighted summation of each standardized index can obtain the development level scores of the manufacturing and service industries, namely  $u_i = \sum_{j=1}^m w_{ij} u_{ij}'$ ,  $\sum_{j=1}^n w_j = 1$ , where represents the development level of manufacturing or service industry,  $u_{ij}'$  represents standardized index, and  $w_{ij}$  represents weights for each index.

**C. Coupling Coordination Model**

On the basis of evaluating the development level of manufacturing and service industry, the system model of capacity coupling in physics is used to calculate the coordination level of the two by constructing the coupling coordination degree model. The formula is as follows:

$$T = \alpha u_1 + \beta u_2 \quad C = 2\sqrt{u_1 \times u_2} / (u_1 + u_2) \quad D = \sqrt{C \times T}$$

Among them,  $C$  indicates the degree of coupling, and  $D$  indicates the comprehensive coordination index,  $T$  reflecting the contribution of the respective development level of two systems to the coordination degree. The  $u_1$  and  $u_2$  indicates the coupling degree of the manufacturing industry and the service industry;  $\alpha$  and  $\beta$  indicate the development level of manufacturing and service industries respectively; indicates the role of manufacturing in coordinated development and indicates the role of service industry in coordinated development. Considering the development scale of service industry at this stage plays greater the role in the overall industry upgrade, this article gives weight,  $\alpha = 0.4$  and  $\beta = 0.6$ .

Regarding the classification of coupling coordination degree, there is no unified standard at present. In order to objectively reflect the coordinated development level of manufacturing industry and service industry, based on the research results of predecessors, this paper combines the system development theory and uses the uniform distribution function method to grade the coupling coordination degree as shown in "Table II".

TABLE II. CLASSIFICATION STANDARD COUPLING COORDINATION DEGREE

Coupling coordination	0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5
<i>Coordination degree</i>	extreme imbalance	severe imbalance	moderate imbalance	mild coordination	close to coordination
<i>Coupling coordination</i>	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
<i>Coordination degree</i>	narrow imbalance	primary coordination	intermediate coordination	fine coordination	quality coordination

### III. TIME AND SPACE COUPLING ANALYSIS OF MANUFACTURING AND SERVICE INDUSTRIES

#### A. Time Series Coupling of China's Manufacturing Industry and Service Industry

From the perspective of time series, the phased characteristics of the coordinated development of manufacturing and service industry can be clearly revealed. As shown in "Table III", during the period of 2007~2016,

except for the slight decrease caused by the global financial crisis in 2008, the coupling coordination degree of China's manufacturing industry and service industry continued to rise, from 0.463 in 2007 to 0.858 in 2016. The coordination level is also gradually transitioned from close to coordination to fine coordination. It shows that the development of China's manufacturing and service industries has maintained a benign interaction since 2007, and the two have been coordinated from the initial running-in period.

TABLE III. COUPLING COORDINATION LEVEL OF CHINA'S MANUFACTURING INDUSTRY AND SERVICE INDUSTRY FROM 2007 TO 2016

Years	2007	2008	2009	2010	2011
<b>Coupling coordination</b>	0.463	0.405	0.495	0.560	0.572
<b>Coordination degree</b>	close to imbalance	close to imbalance	close to imbalance	narrow coordination	narrow coordination
<b>years</b>	2012	2013	2014	2015	2016
<b>Coupling coordination</b>	0.629	0.720	0.772	0.812	0.858
<b>Coordination degree</b>	primary coordination	intermediate coordination	intermediate coordination	fine coordination	fine coordination

#### B. Provincial Pattern of China's Manufacturing and Service Industry Development

1) *The spatial distribution characteristics of the development level of manufacturing industry:* Since 2010, the overall scale of China's manufacturing industry has ranked first in the international market for years, and has become the world's largest manufacturing industry. However, the inter-regional development is extremely uneven and has great differences. From "Fig. 1", from the perspective of China's regional manufacturing development level, the eastern coastal areas are significantly higher than the northeast, central and western regions<sup>1</sup>, showing overall distribution pattern of "East-Mid-West" declining. From the average score of regional manufacturing development level, it can be seen that the eastern region is 0.434, the northeast region is 0.245, the central region is 0.344 and the western region has the lowest average score of 0.193. Among the top

10 provincial units ranked according to the level of manufacturing development from high to low, the eastern region occupies 6 seats and the west occupies 4 seats. Among them, the top three provinces are Jiangsu, Shandong and Guangdong, reaching 0.837 and 0.709 and 0.708 respectively. The spatial distribution of the manufacturing development level is characterized by uneven distribution, and the level of development varies among different provinces.

<sup>1</sup> According to the dividing method of National Bureau of Statistics to scientifically reflect the social and economic development in different regions of China in 2011, China's economic region is divided into four regions: the eastern part includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. The central part includes Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan; the western part includes Inner Mongolia, Guangxi, Sichuan, Chongqing, Guizhou, Yunnan, Tibetan, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang; the northeast part includes Liaoning, Jilin and Heilongjiang.



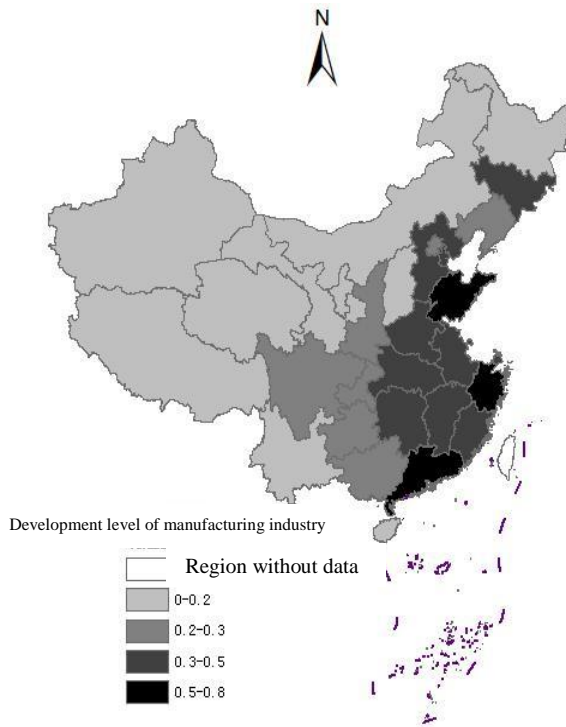


Fig. 1. Spatial distribution pattern of China's manufacturing industry in 2016.

2) *The spatial distribution characteristics of the development level of service industry:* Different from the development level of the manufacturing industry, the overall distribution pattern of China's regional service industry development level is not uniform, and it does not show the pattern of “east-mid-west” decline. From the average score of the development level of regional service industry, the average score of the eastern region is 0.411, and the score gap of average scores in other regions is small. The scores of northeast, central, and west region are 0.194, 0.267, and 0.242, respectively. The eastern region is significantly higher than other regions. Among them, the top three regions are Beijing, Shanghai and Jiangsu, reaching 0.715, 0.595 and 0.527. Among the last ten provinces, the central part occupies one seat, the northeast occupies three seats, and the western part occupies six seats. The service industry in the northwest and northeast regions has the lowest level of development, and the overall distribution pattern is “V-shaped”. At the same time, it can be found that in areas with high level of service industry development, the level of manufacturing development is not necessarily high, and vice versa, such as Beijing and Henan, which means the spatial distribution pattern of service industry and manufacturing industry shows a certain mismatch.

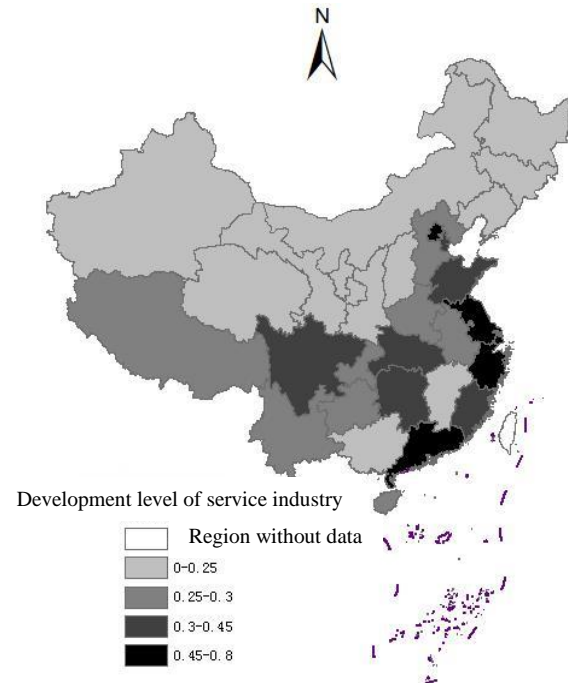


Fig. 2. Spatial distribution pattern of China's service industry development level in 2016.

In general, the development level of service industry in the various provinces is extremely uneven. The eastern region with a higher economic level took the lead in starting industrial restructuring, and the development of the service industry was much higher than other regions in terms of scale, structure, growth, and efficiency. The eastern region should continue to play a dominant role. At the same time, it is necessary to further optimize the economic structure and promote the adjustment and upgrading of industrial structure in the central and western regions. The central and western regions should also make full use of their advantages in resources and labor, attach great importance to the leading role of the service industry in accelerating the mode of economic development, and realize the doubling of the service industry as soon as possible as shown in "Fig. 2".

3) *Type of relationship between the development level of manufacturing and service industry:* The manufacturing development level index (MLI) and the service industry development level index (SLI) are standardized by the Z-score method, to generate two new series of ZMLI and ZSLI, indicating that the deviation degree of development level indexes of manufacturing and service industry of each province from the central location of the 31 provincial units MLI and SLI, where the sign indicates the synergy of deviation degree between the two. In the rectangular coordinate system with ZMLI as the horizontal axis and ZSLI as the vertical axis, the quadrant maps of the manufacturing and service industry development levels in different provinces are drawn, as shown in "Fig. 3".

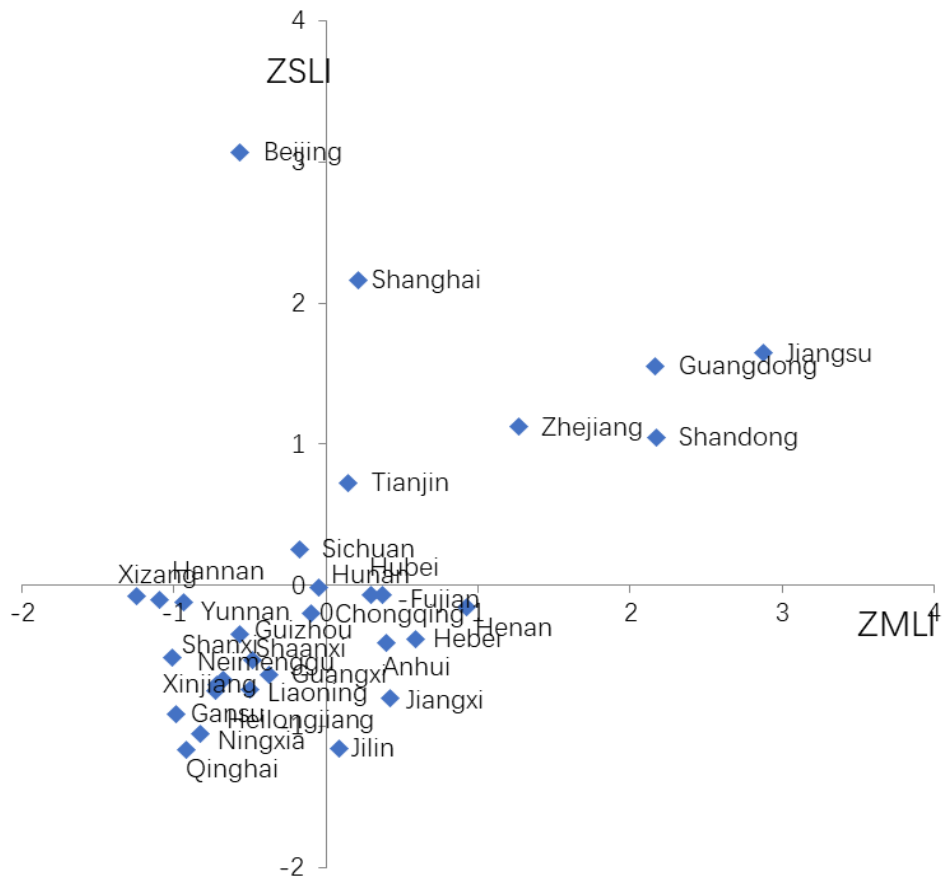


Fig. 3. ZMLI and ZSLI quadrant maps of each province in China.

In the ZMLI and ZSLI quadrant diagram, the relationship between the manufacturing and service industry development levels of the 31 provincial units is divided into four types: the first quadrant is the advanced coordinated development type; the second quadrant belongs to the service industry level; the third quadrant is a low-level coordinated development; the fourth quadrant is horizontal transitional type of manufacturing industry. As can be seen from the quadrant map, there are 22 provinces in the first and third quadrants, which means the development levels of manufacturing industry and service industry of most provincial units are matched, and the level of service industry is higher in the places with higher level of manufacturing industry development. The development level of the service industry is lower in the regions with low level of manufacturing development. Compared with the high-level coordination type, the proportion of areas with low-level coordination is higher, reaching 16 and most of them

are western provinces. The reason for the mismatch between the manufacturing industry and the service industry is mainly due to the different industrial structure in each region. The higher the per capita income is, the faster the industrial structure adjustment is, and the lower the per capita income is, the slower the industrial structure adjustment is.

*C. Spatial Coupling of Development of Manufacturing Industry and Service Industry in China*

Due to the different stages of economic development, development status and adjustment of industrial structure, the development level of manufacturing and service industries in different provinces is quite different. Based on the calculation of the development level of manufacturing and service industries in 31 provincial-level unit in 2016, the coupling coordination degree model is used to further measure the coordinated development between the two, and the spatial distribution characteristics are drawn.

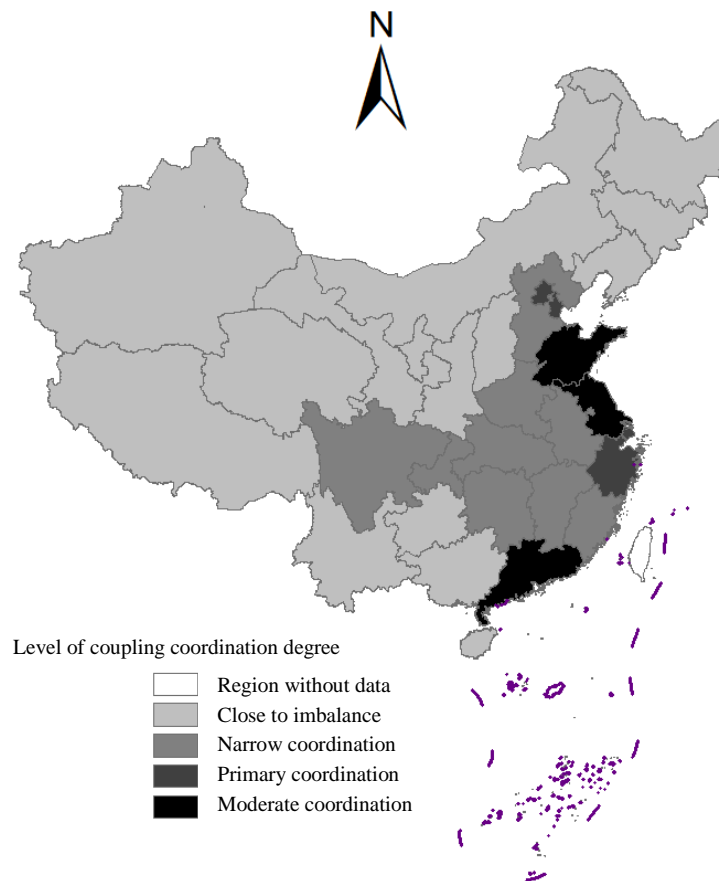


Fig. 4. Spatial distribution pattern of coupling coordination degree between China's manufacturing industry and service industry in 2016.

It can be seen from "Fig. 4" that the coupling coordination level between China's manufacturing industry and service industry shows obvious regional differences, which have the following characteristics:

First, in the eastern region, only Hainan shows moderate imbalance and Hebei is mild imbalance. Other regions have shown a coordinated development of manufacturing industry and service industry. Among them, Beijing, Tianjin, Shanghai, and Zhejiang have reached the basic coordination type, and Jiangsu, Guangdong, and Shandong have achieved fine coordination type.

Second, Heilongjiang, Jilin, and Liaoning provinces in the northeastern region are all in a state of moderate imbalance; except for the moderate imbalance of Shanxi in the central region, all other provinces shows mild imbalance; the western regions are all in the state of imbalance. Except Chongqing and Sichuan that are in the state of mild imbalance, the rest of the provinces are in a state of moderate imbalance.

Thirdly, from the perspective of coordination level, the provincial pattern of the coupling coordination degree of manufacturing industry and service industry presents a "pyramid type", which means the number of provinces of each coupling coordination type satisfies "intermediate coordination type > primary coordination type > narrow coordination type > close to imbalance type." Among them,

there are 3 provinces with intermediate coordination type, 4 provinces with primary coordination type, 9 provinces with narrow coordinated numbers, and 15 provinces with close to imbalance type. From the perspective of geographical distribution, the provinces with more than the primary coordination type are located in the eastern coastal areas, and the northeast and central and western regions are mainly coordinated and on the verge of imbalance.

#### IV. CONCLUSION

On the basis of constructing the comprehensive evaluation index system and the coupling coordination degree model, 31 provincial-level units in China are taken as research objects, and the level of coupling coordination degree of manufacturing industry and service industry and the regional differences are analyzed from the perspective of time and space, and the following conclusions are obtained.

First, from the perspective of time series, the coupling coordination degree of China's manufacturing industry and service industry showed an increasing trend from 2007 to 2016. The coupling coordination level increased from 0.463 in 2007 to 0.858 in 2016 and the coupling coordination level is also transformed from close to imbalance to fine coordination.

Second, from a spatial perspective, the regional differences in the coupling coordination level between

China's manufacturing industry and service industries in 2016 are obvious. Among them, the development level of regional manufacturing industry generally shows the “east-mid-west” decreasing distribution pattern, and the development level of regional service industry is the lowest in Northwest China and Northeast China, and the overall distribution pattern is “V-shaped”.

Third, the relationship between the manufacturing industry and the service industry in most provinces is matched, which means the higher the level of manufacturing development is, the higher the level of development of the service industry will be, but due to different stage of economic development and different speed of industrial adjustment, a small number of provinces will also show the state of mismatch.

Fourthly, from the perspective of coupling coordination level, the provincial pattern of coupling coordination degree of manufacturing industry and service industry is “pyramid type”. That is to say, the provinces of each coupling coordination type satisfies “good coordination type>basic coordination type>mild imbalance>moderate coordination type, and the provinces in the eastern coastal areas are dominated by coordination, while the provinces in the northeast, central and western regions are dominated by narrow coordination and close to imbalance type.

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