Analysis of the Industrial Structure of New Structural Economics based on the Revealed Comparative Advantage Index (RCA)

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Abstract—To measure economic development, the productivity and income of people in various industries are inseparable. The improvement of labor productivity level mainly relies on technological innovation and industrial upgrading, while the power of a country is ultimately limited and cannot support each industry in equal amount. So the classification of existing industries and the implementation of corresponding policies for each type of industry can promote a country's economic development efficiently. According to the five categories of industries proposed by Professor Justin Lin's new structural economics, I selected five indicators and analyzed the industrial data of the world from 1995 to 2018, and compared the upgrading and transfer of industrial structure between China and the United States between 1995 and 2018.I found that the United States has always been leading the world in most industries, while China has achieved remarkable results in industrial transformation and upgrading compared with 20 years ago.

Keywords-new structural economics, industrial division, industrial structure, industrial leadership, industrial policy, China-US comparison

1 INTRODUCTION

The development of a country's economy cannot be separated from its industrial policy, but not every country's industrial policy can achieve good results. Therefore, the government should first classify the industries when formulating industrial policies. The author choose Professor Justin Lin's classification of industries in the new structural economics. On the one hand, it can reflect the difference of the government's role due to the situation. On the other hand, it can introduce the technical characteristics of industries and industrial structure into the analysis framework at the same time from the perspective of new structural economics. Through the comparative analysis of RCA, GDP, ILI and other indicators, we can understand the industrial development status of each country in the world, measure the strength of each country's industry and research, and accordingly help the country to formulate effective industrial policies to help economic recovery and development.

(Note: Taking into account the economic impact of the 2019 epidemic, all data are used from 1995-2018,)

ICEMME 2022, November 18-20, Nanjing, People's Republic of China

DOI 10.4108/eai.18-11-2022.2327174

2 INDUSTRIAL STRUCTURE CLASSIFICATION INDICATORS

2.1 Overview of industrial structure classification indicators

Based on the new structural economics, Professor Justin Yifu Lin classifies industries into five different types: catching-up industries, leading industries, trans-formation-type industries, bending industries, and strategic industries [1] Catching-up industries need to catch up and upgrade their industries by conducting cross-border mergers and acquisitions, attracting investment, joining hands with developed enterprises to build factories, and strengthening applied research. Leading industries need companies to strengthen basic research, encourage innovation, and continuously develop new products and technologies to maintain their advantages. The transition-formation industries need to enhance brand value, operate high value-added components such as product quality, product design and R&D, and marketing channel management, and move factories to regions with high labor endowments to reduce costs[2].The bending industry needs to focus on applied research to seize the leading position within the field of this industry, but the results of basic research also have spillover effects[3].Strategic industries, including new energy, new materials, space technology and other industries that concern a country's livelihood and international status, are very important to a country's development. It should focus on basic research, bring in world top talents, purchase patents and encourage innovation. The difference of industrial structure fundamentally comes from the difference of technology level in industrial structure, which determines the difference of R&D structure[3].For the purpose of classification, the author chose five indicators, such as the dominant comparative advantage index, gross national product, industrial complexity, industrial productivity, and patent growth rate, as parameters for measurement.

2.1.1 Calculation of indicators.

2.1.1.1 Explicit comparative advantage

The Explicit Comparative Advantage Index, also known as the Export Performance Index, is a measure often used when analyzing whether a country or region has a comparative advantage in a certain product.

The calculation formula is as follows.

$$RCA_{cp} = \frac{M_{cp} / \sum_{p} M_{cp}}{\sum_{c} M_{cp} / \sum_{c,p} M_{cp}} \text{ [7]}$$

Where Mcp denotes c country's exp rts in product p, the ratio between the share of a country's

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exports of a certain commodity in its total exports and the share of the world's exports of that commodity in the total world exports.

The author used python language to calculate the explicit comparative advantage index of 3355 industries in all 251 countries, and some of the results are shown in the following table.

TABLE 1. PARTIAL RCA EXAMPLE TABLE (ORIGINAL)

location_id	*product_id*	*RCA*	*location_id*	*product_id*	*RCA*
0	650	0.079842897	39	650	0.85712146
4	650	0.247937375	41	650	0.20274894
5	650	13.81198558	42	650	0.399787122
7	650	7.766221716	43	650	0.001309386
8	650	2.207024743	49	650	0.614734269
13	650	0.041091319	52	650	0.127586939
14	650	2.707440413	54	650	0.062711597
15	650	0.243755409	58	650	0.054637577
18	650	0.460952414	59	650	0.275577513
21	650	0.339635364	61	650	0.309854989
23	650	1.158281287	64	650	0.366532791
24	650	0.088353625	65	650	0.027936099
28	650	6.024208658	67	650	0.099749568
30	650	2.945155527	68	650	0.01939989
31	650	0.157846692	71	650	0.058748438
32	650	0.05685801	72	650	0.540491109
33	650	0.008753337	74	650	0.014158023
34	650	0.045272373	77	650	1.014468181

In order to visualize the distribution of the RCA of the dominant comparative advantage for each country-specific industry, a scatter plot of the dominant comparative advantage against the country number is made, as follows

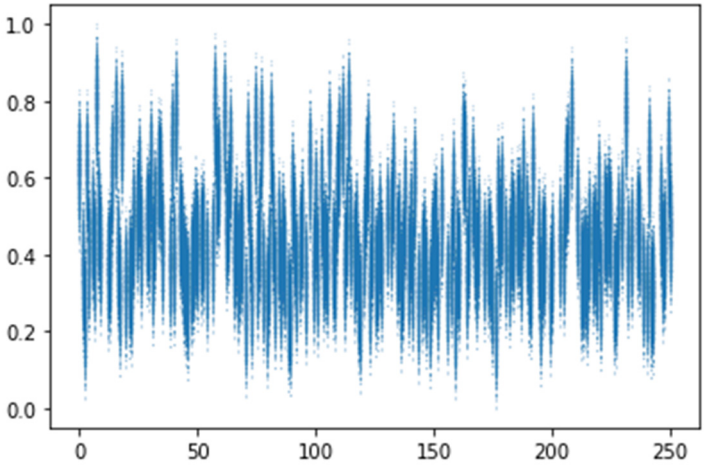

Figure 1. Scatterplot of RCA distribution(original)

It can be seen that the distribution of explicit comparative advantages is more balanced across countries, but further detailed research and analysis of specific data is still needed.

In the world

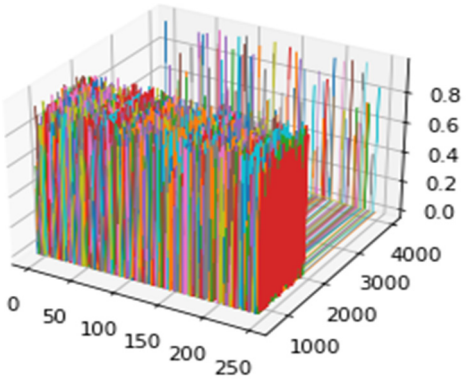

Figure 2. World-wide RCA distribution map(original)

The image of the kernel density function for the dominant comparative advantage is shown in the figure.

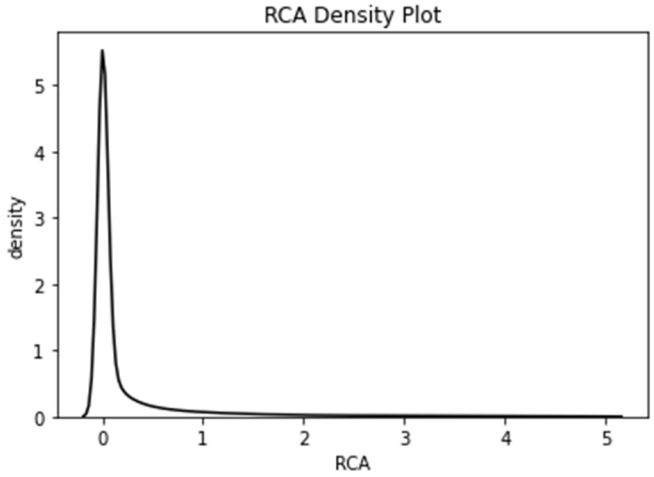

Figure 3. RCA kernel density function image(original)

(Note: Due to the wide range of RCA in different industries in different countries, [0,5] is taken as the range for the graph, and most of the values are located in this range)

As can be seen from the graph, it shows a left-skewed trend, i.e. most of the values are below 0.5, indicating that the indicator is small overall, reflecting the characteristic of "rich less poor more".

2.1.1.2 GDP

The GDP data for all 251 countries were obtained from the PWT 9.1 | Penn World Table | Groningen Growth and Development Centre | University of Groningen (rug.nl) website and standardized to serve as the basis for subsequent analysis. The data were standardized and used as a basis for subsequent analysis.

The image of the kernel density function of the worldwide GNP in 1995 is shown in the figure.

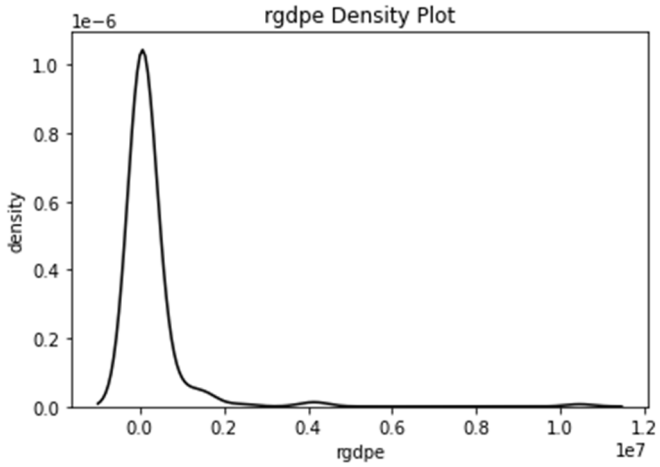

Figure 4. GDP kernel density function image(original)

In general, the GDP largely shows: the majority of countries with lower GNP and only a very small number of countries with higher GNP, showing the seriousness of the polarization between rich and poor in the world today.

2.1.1.3 Industry complexity

$$\widetilde{M}_{cc'} \equiv \sum_{p} \frac{M_{cp} M_{c'p}}{k_c(0) k_p(0)} = \frac{1}{k_c(0)} \sum_{p} \frac{M_{cp} M_{c'p}}{k_p(0)} \quad [6]$$

The industrial complexity is obtained b calculating the second largest eigenvector of the above

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Mcc matrix under the condition of calculating the dominant comparative advantage. The product complexity index is used to portray and examine in detail the pattern of division of labor and its changes in a country's industry, and to lay the foundation for the subsequent research related to industrial structural transformation.

The image of the kernel density function of the product complexity index at the world level is shown in

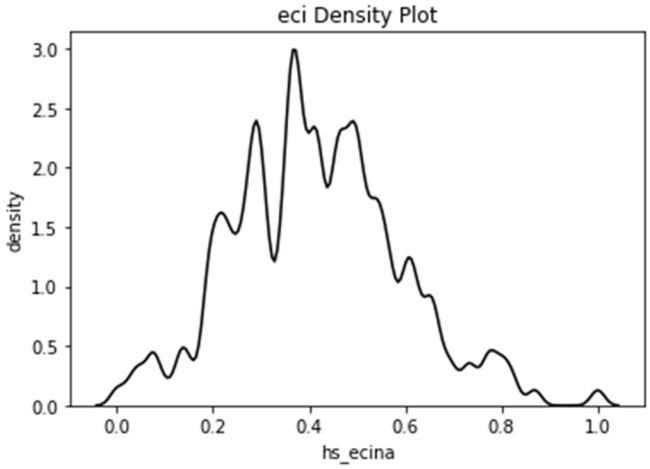

Figure 5. Mcc kernel density function image(original)

As can be seen from the figure, the product complexity index shows a relatively balanced state, i.e., most of the values lie between 0.2-0.6, with approximate symmetry between left and right, in an inverted U-shape, so the product complexity index of each country can be considered to roughly and approximately obey a normal distribution.

2.1.1.4 Industrial production efficiency

Industrial production efficiency mainly measures the production efficiency of a country's industry. Its calculation formula is.

$$eff^{c} = \frac{GDP_c}{L_c}$$

where Lc denotes the number of labor force in a country. Based on the above calculation of GDP and other indicators, we calculated the labor productivity data from 1995-2018 for all 251 countries using relevant data, while normalizing 0-1, and made the labor productivity change curves for all 251 countries, as shown in the following figure (red curve is China).

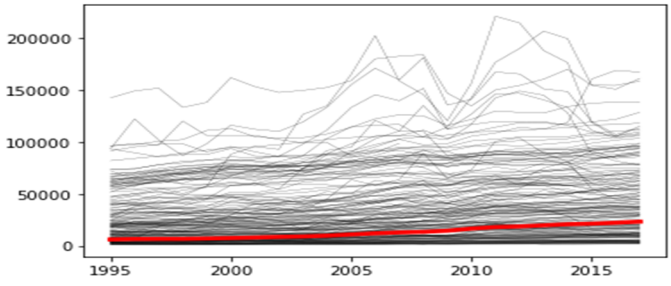

Figure 6. Labor productivity trends in the world by country, 1995-2018(original)

As can be seen from the figure, China's labor productivity has been steadily rising, from 698.6 in 1995 to 791.7 in 2018, but it is at the lower middle level relative to the world, which is in line with the reality that China's industries are relatively low-end at this stage, its technology is relatively backward, and its GDP per capita is very low.

The image of the kernel density function of labor productivity at the world level is shown in the figure.

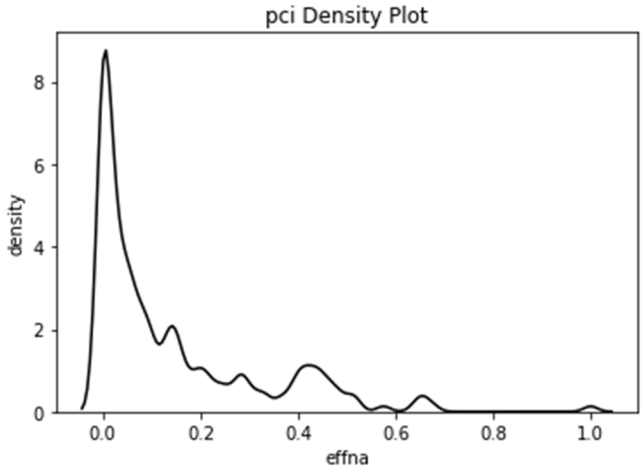

Figure 7. eff kernel density function image(original)

As can be seen from the figure, the distribution of labor productivity generally shows a left-skewed trend, i.e., most of the values are below 0.5, and most of them are between 0 and 0.2, indicating that the indicator is small on the whole, reflecting the characteristic of extreme differentiation of "less rich, more poor".

2.1.1.5 Patent growth rate

Patent growth rate measures the speed of a country's industrial bending, shows the upgrading of the industry, and is an important indicator of the change of a country's industrial structure.

The indicator is denoted by p_c^i and processed with the formula:

$$P_c^i(nomalize) = \frac{P_c^i - \max(P_c^i)}{\max(P_c^i) - \min(P_c^i)}$$

The image of the kernel density function of the worldwide patent growth rate is shown in the figure.

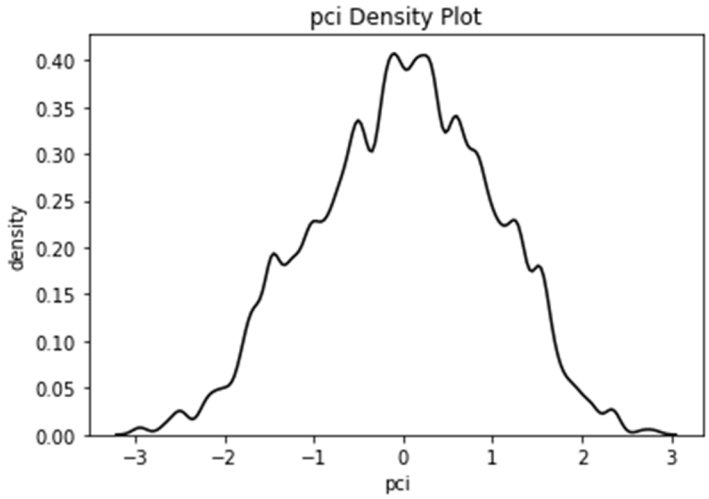

Figure 8. p_c^i Kernel density function image(original)

As can be seen from the figure, the patent growth rate shows a relatively balanced trend, i.e. most of the values lie around 0, indicating that the indicator is relatively balanced on the whole, and the patent growth rate of each country can be considered to roughly follow a normal distribution approximately.

2.2 Analysis of industrial structure classification indicators

Statistical analysis of the above indicators was performed to analyze the mean, variance, standard deviation, maximum and minimum, 25% and 75% quartiles, and median of each indicator, which are statistical indicators, and the results are as follows (all nearly standardized).

TABLE 2. STATISTICAL ANALYSIS TABLE OF EACH PARAMETER

	unnamed: 0	***location-id***	***year***	***product-id***	***hs-eci***	***pci***	***hs-ecina***	***pcina***	***effna***	***standard***
count	273023.0	273023.0	273023.0	273023.0	272963.0	272818.0	272963.0	272818.0	273023.0	272770.0
mean	136511.0	122.3	1995.0	1280.7	-0.0138	-0.0013	0.4168	0.5136	0.1406	1.0712
std	78815.0	71.1	0.0	394.9	0.9869	0.9986	0.1731	0.1729	0.1748	0.3433
min	0.0	0.0	1995.0	650.0	-2.3894	-2.9666	0.0	0.0	0.0	0.0
25%	68255.5	63.0	1995.0	961.0	-0.7184	-0.6883	0.2932	0.3946	0.0088	0.8304
50%	136511.0	120.0	1995.0	1273.0	-0.0522	0.034	0.4101	0.5197	0.0650	1.0324
75%	204766.5	183.0	1995.0	1585.0	0.6243	0.7164	0.5288	0.6379	0.2091	1.2752
max	273022.0	250.0	1995.0	4004.0	3.3091	2.8068	1.0	1.0	1.0	2.3841

As can be seen from the table, the mean value of dominant comparative advantage is 1.5217, the maximum value is 36773.24996, and the minimum value is 0; the mean value of product complexity index ECI is -0.01387, the maximum value is 3.309178, and the minimum value is -2.389496; the mean value of patent growth rate is -0.001323, the maximum value is 2.807, and the minimum value is - 2.966689; productivity (standardized) mean value of 0.140696, maximum value of 1 and minimum value of 0.

3 INDUSTRY STRUCTURE DIVISION

3.1 Principle and way of industrial structure division

In this paper, we design the relevant industry classification index as ILI, which represents the degree of industry leadership of a certain industry in a country, considering five parameters in a comprehensive manner, with the following formula:

$$ILI = (RCA_c^i)^2 \times (\max(rank_c(GDP)) - rank_c(GDP)) + eff_c^i \times e^{p_c^i} \times e^{\frac{P_c^i}{\sum_1^n P_c^i}}$$

The product complexity RCA_C^i index of the ith industry of country c. The squared term is chosen to emphasize the influence of the product complexity index on the industrial structure of a country and to ensure the consistency of the polynomial power; $rank_c(GDP)$ the ranking of the gross national product of country c in the world (the ranking has been standardized from 0 to 1 to avoid the excessive influence on the final result caused by the different magnitudes) $e^{p_c^i}$ The growth rate of a country's patent is not very obvious, but the growth rate of patent has an important influence on industrial development, so this form is chosen to represent the growth rate of patent; eff_c^i $e^{\frac{P_c^i}{\sum_1^n P_c^i}}$ the growth rate of a country's patent stock is reflected in the world ratio, considering the important influence of a country's original technological leadership on the industrial structure. Finally, the value of industrial leadership ILI is used to comprehensively classify the five major industrial types of a country.

3.2 Calculation method of industry leadership (ILI) :

By using python software, the industry leadership indicators of 3355 industries in all 251 countries of the above formula were calculated, and the analysis focused on the industry classification in 1995 and 2018, and the industry leadership indicators of some national industries are shown in the following table.

TABLE 3. ILI PERFORMANCE IN SELECTED COUNTRIES

product_id	*location_code*	*standard*
1662	ARE	2.384126957

1418	ARE	2.361696252
1662	CYM	2.325632521
1811	ARE	2.308486787
929	ARE	2.308262078
1542	ARE	2.306536365
1697	ARE	2.305576505
1662	USA	2.304931546
1418	CYM	2.303201519
1104	ARE	2.302163389
1818	ARE	2.301792397
959	ARE	2.291503722
1662	CHE	2.288297506
1662	JPN	2.287572897
1418	USA	2.282519711
1046	ARE	2.279915965
1662	DEU	2.27930393
1717	ARE	2.266525604
1092	ARE	2.266134065
1418	CHE	2.265802591

According to the calculation of the above classification index ILI, the results of the classification of some of China's 1,247 industries in 1995 are shown in the following table.

TABLE 4. RESULTS OF ILI AND INDUSTRY CLASSIFICATION OF SELECTED INDUSTRIES IN CHINA IN 1995

product_id	*location_code*	*standard*	*Industry Classification*
1662	CHN	1.530575296	2
1418	CHN	1.50814783	2
1811	CHN	1.454935784	2
929	CHN	1.454718368	2
1542	CHN	1.45298518	2
1697	CHN	1.452025803	2
1104	CHN	1.448610859	2
948	CHN	1.134851704	3
1792	CHN	1.13447659	3
1737	CHN	1.133994103	3
1097	CHN	1.133848722	3
992	CHN	1.133604617	3
930	CHN	1.133433859	3
878	CHN	0.890611518	4
884	CHN	0.890543203	4
1377	CHN	0.890328826	4

931	CHN	0.889759077	4
1161	CHN	0.889627123	4
1176	CHN	0.889499318	4

Among them, 1 represents the leading industry, 2 represents the bending overtaking industry, 3 represents the catching up industry, and 4 represents the switching array industry.

4 ANALYSIS

4.1 Visualization analysis:

First, the distribution of industry leadership indicators of 3355 industries in all 251 countries is analyzed, and a three-dimensional image is made with the country number and industry number as xy coordinates and industry leadership indicators as z coordinate values.

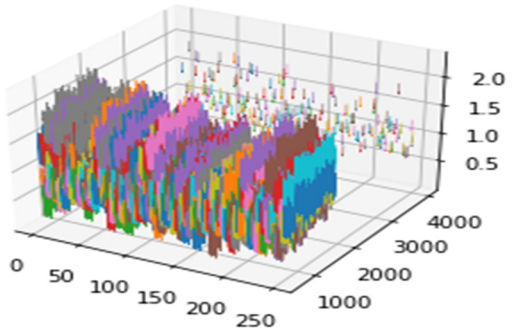

Figure 9. Distribution of ILI by Industry by Country

From the figure, it can be found that the distribution of industry leadership indicators of each country varies greatly across years and industries, but there are still some countries with high similarity of industry leadership indicators among them, indicating the existence of many countries with similar industrial structures.

The kernel density function image of the overall probability distribution density for the industry leadership indicators of 3355 industries in all 251 countries was further analyzed as shown in Fig.

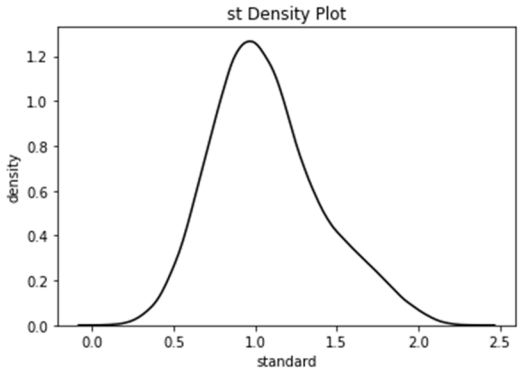

Figure 10. ILI kernel density function image

It can be observed that the industry leadership indicators of all countries clearly show the characteristics of an approximate normal distribution, and most of the industry leaderships are distributed between 0.5 and 2.0. The mean value of industrial leadership is 1.07124, the variance is 0.3433, the median is 1.032491, the maximum value is 2.384127, and the minimum value is 0.000053. The overall distribution is relatively uniform.

The following is a scatter analysis of the industrial classification of 3,355 industries in all 251 countries.

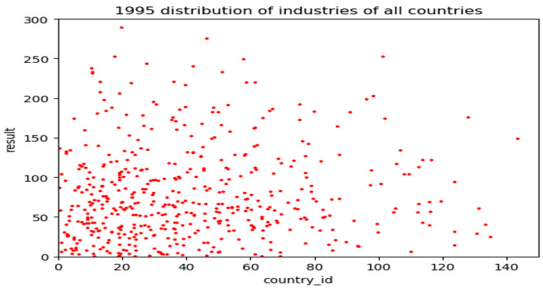

Figure 11. Scatter diagram of the distribution of the conversion type industry by country

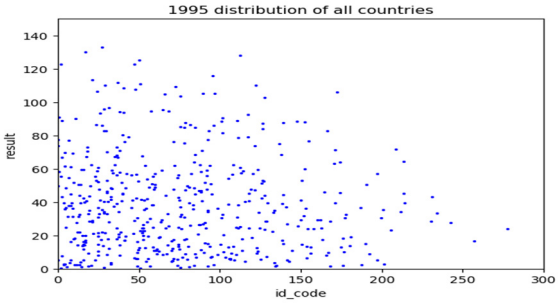

Figure 12. Scatterplot of the distribution of the industry of bending overtaking by countries

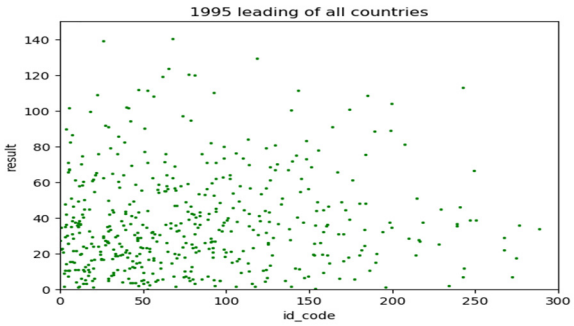

Figure 13. Scatterplot of catching-up industries by country

As can be seen from the three graphs, the classification results in a progressively sparse distribution from the bottom left to the top right, which is due to the basic fact that some countries have more leading industries, while others are mostly transitional and catching-up industries, and the industrial structure of different countries varies widely.

4.2 Analysis of the industry type share division

Distribution of the four types of industries in the world: by analyzing the results of the industry division in 1995 and 2018, the following pie chart was made for industry share analysis.

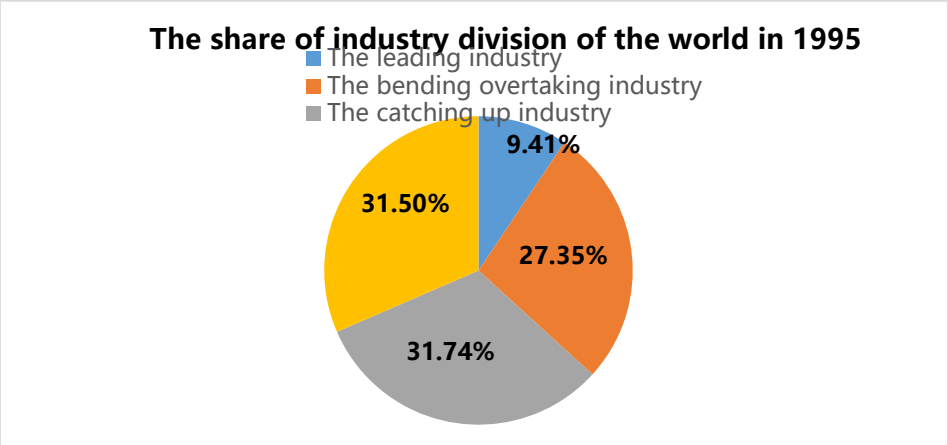

Figure 14. 1995 world industry division proportion pie chart

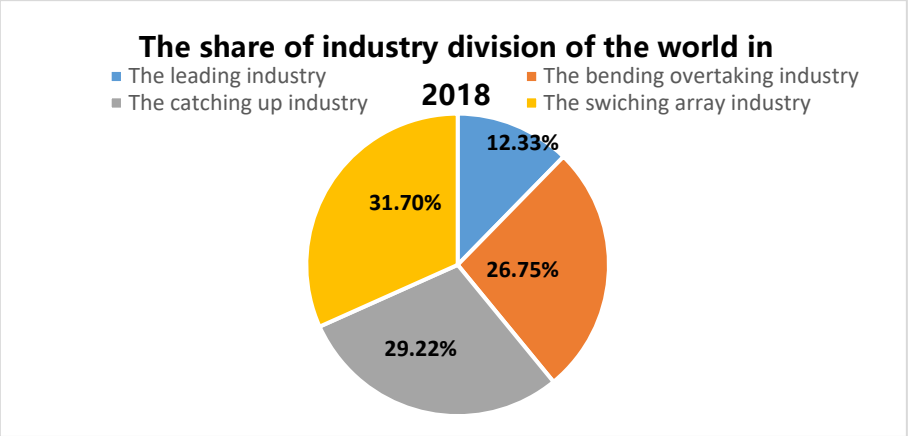

Figure 15. Pie chart of world industry division ratio in 2018

As it can be seen from the graph, the proportion of industry division in the world as a whole does not change much. This is because, in the world wide, industries are transferred from some countries to other countries, and only the internal industrial structure of some countries may change, for example, some developed countries create new leading industries and transfer their low-end manufacturing industries to other countries. The disappearance of some old industries must also be accompanied by the emergence of some new industries, which eventually leads to an insignificant change in the structure of different types of industries worldwide.

5 Comparative Analysis of the Upgrading and Transfer of Industrial Structures in China and the United States.

This paper explores the changes in the industrial structure of the two countries during twenty-three years by analyzing the five major industrial classifications of China and the United States in 1995 and 2018, and discusses the current state of the industrial structure of the two countries.

According to the classification results of this paper, the author chose to compare the industry divisions of China and the United States in 1995 and 2018, and the results are as follows.

TABLE 5. The four major industries in 1995.

1995 Industrial Classification	***China***	***United States***
Leading type	51	858
Curve overtaking models	306	214
Catch-up type	606	102
Switching Formations	284	73

TABLE 6. FOUR MAJOR INDUSTRY DIVISIONS IN 2018.

2018 Industrial Classification	***China***	***United States***
Leading type	269	794
Curve overtaking models	388	231
Catch-up type	446	169
Switching Formations	144	53

From the table, we can see that in 1995, the United States had a huge advantage in industrial structure in the world, and the number of leading industries exceeded 2/3 of the total number of industries, when the Cold War was over and the United States was in an absolutely dominant position in the world. China, on the other hand, just after the "Southern Tour Speech", the second wave of China's reform and opening up, China's economic level and industrial structure were still lagging behind, and industrial upgrading had just started, and the industrial level in the world was also in a backward state.

At 2018, the United States still maintains a considerable advantage, focusing on the development of high-tech industries within these 20 years or so, the United States has achieved a leading position in the world, while almost all ordinary manufacturing industries have been transferred to other countries with relative advantages in labor endowment. At the same time, China has experienced more than 20 years of ultra-high growth and has completed a qualitative leap in its industrial structure by virtue of the demographic dividend and many opportunities such as WTO accession. We find that China has formed a certain industrial advantage in the world, especially the leading industries and bending industries account for more than half of its total industries, which shows that China's industrial policy in the past 23 years has been effective, but China still has a lot of potential for development in high-tech industries, financial industries and high-end manufacturing industries [5].

6 CONCLUSION

In this paper, i calculate five indexes of explicit comparative advantage index, gross national product, industrial complexity, industrial productivity, and patent growth rate, and use them to calculate ILI that can divide industries. I found that the gap between rich and poor in the world is obvious, the patent growth rate of each country roughly obeys normal distribution, a small number of countries have excellent technical innovation ability, a small number of countries are still underdeveloped and have poor innovation ability. The United States has maintained industrial leadership in more than 20 years. Since the reform and opening up, China has used the demographic dividend to successfully undertake international industrial transfer, accelerated industrial development, transformed and upgraded a large number of industries, and upgraded leading industries by more than five times, but catching-up industries still occupy the bulk of the industrialization process in 2010. If we want to achieve further industrial upgrading and sustainable economic growth, we need more independent technological innovation.

Acknowledgment. Firstly, I would like to show my deepest gratitude to my teachers and professors in my university, who have provided me with valuable guidance in every Further, I

would like to thank all my friends and parents for their encouragement and support. Without all their enlightening instruction and impressive kindness, I could not have completed my thesis.

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