Research on Industrial Structure Optimization of Chongqing Under Low-Carbon Economy

Chunmei Liu(✉) and Wen Bao

School of Management, Chengdu University of Information Engineering, Chengdu, China
a772824711@qq.com, bbaowen@cuit.edu.cn

Abstract. Low-carbon economy has become the only way for sustainable development in China, Low-carbon economy promotes and realizes the optimization of industrial structure has become a hot research. This paper selects eight indicators in Chongqing from 2011 to 2020: energy intensity, the province's forest coverage rate, comprehensive utilization rate of industrial solid waste, total energy consumption, industrial structure upgrading index, total output value of the three major industries, R&D Internal expenditure of funds, total retail sales of consumer goods. Based on the perspective of low-carbon economy, the gray correlation model is used to study the correlation between seven evaluation items and the industrial structure upgrading index, and provide analysis reference based on the correlation. The study found that in the past 10 years, the highest correlation between the industrial structure upgrading index and the comprehensive utilization rate of industrial solid waste was 0.917. Based on this, several suggestions were put forward for the optimization of Chongqing's industrial structure.

Keywords: Chongqing · industrial structure · low carbon economy · grey relational model

1 Introduction

Dugu Changhui (2020) pointed out the global warming seriously affects human survival and sustainable development [1]. Liu Xiaoyan (2019) proposed the carbon dioxide emitted into the atmosphere by human production activities is the main cause of the greenhouse effect. Emissions are particularly prominent [2]. Sun Yajing (2020) mentioned in the research on the development of low-carbon economy in Jilin Province from the perspective of industrial structure adjustment, the report of the 19th National Congress of the Communist Party of China emphasized the importance of establishing and improving the economic system of green, low-carbon and circular development. Low-carbon economy has become a must for my country's sustainable development. The way [3]. With the increase of population, shortage of land resources and changes in the natural environment, resource and environmental issues directly involve the question of whether economic development can be sustained for a long time. Low-carbon economy and industrial structure optimization have gradually become the focus of academic circles. The current social production activities show that the carbon dioxide emission level of our country's power industry ranks first in the world, the raw coal consumed by power generation plants accounts for about 70% of China's annual output, and the second highest demand is water. The energy consumption of bulk materials such as steel in the mud

A. Luqman et al. (Eds.): PMIS 2022, AHCS 6, pp. 187–197, 2023.
https://doi.org/10.2991/978-94-6463-016-9_23

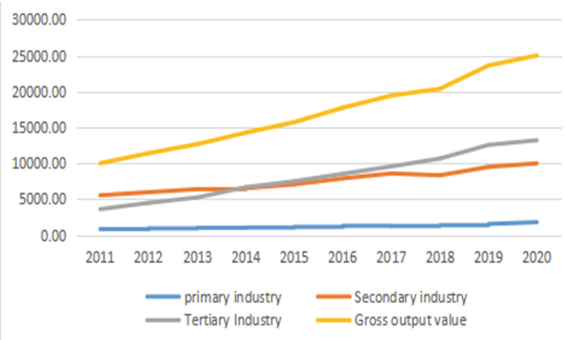

Fig. 1. Chongqing Industrial Structure Trend Chart (Photo credit: Original)

industry, and the energy consumption in the product manufacturing process account for the third largest amount of carbon dioxide emissions. In 2010, China implemented low-carbon pilot policies in 5 provinces and 8 cities, aiming to decouple economic growth from the use of fossil fuels by shifting to economy based on energy efficiency and renewable energy. While the pilot cities have made progress in developing low-carbon plans, some obstacles remain. A study in the journal Nature suggests that for every trillion tons of carbon dioxide produced, the loss of GDP could be close to 0.5%. Our country still plays the role of the world's industry, has not yet completed industrialization, and has a long way to go to reduce emissions. The low-carbon economy is guided by sustainable development, emphasizes the gradual reduction of carbon emissions in economic activities, and continuously optimizes the industrial structure in a comprehensive manner to promote high-quality economic development. Wang Yi (2010) pointed out that the path of low-carbon economy follows the trend of "low-carbonization" in the world, and plays an important role in my country's economic development, adjustment and optimization of industrial structure, energy conservation and emission reduction, and the implementation of the concept of sustainable development [4]. Low-carbon economic development is an important part of green development. As a national key industrial base, Chongqing is an important economic support point and a new level of economic growth. Based on the national strategic policy, Chongqing will promote the optimization and development of Chongqing's industrial structure. The national new pattern with green industry as the core and the realization of sustainable industrial development under the new economic normal will gradually become the mainstream to support the future world economy. This paper takes Chongqing as the research object, and it is of great significance to further study the optimization of industrial structure in Chongqing based on the development of low-carbon economy.

2 Chongqing's Industrial Structure and the Status Quo of Carbon Economy Development

From the perspective of regional GDP, by the end of 2021, Chongqing has achieved a regional GDP of 2,789.402 billion yuan, of which the added value of the primary industry is 192.203 billion yuan, the added value of the secondary industry is 1,118.494 billion yuan, and the added value of the tertiary industry is 1,478.705 billion yuan. From 2011 to

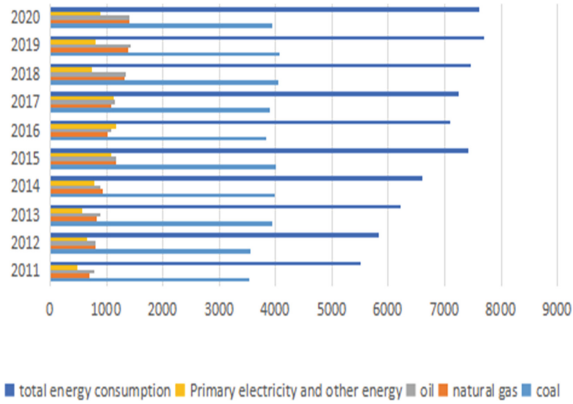

Fig. 2. Chongqing energy consumption map (Photo credit: Original)

Table 1. Industrial Structure Advanced Metrics (S Value) Value

	2011	2012	2013	2014	2015
primary industry	844.52	940.01	1016.74	1061.03	1150.15
Secondary industry	5543.04	5975.18	6397.92	6529.06	7071.82
Tertiary Industry	3623.81	4494.41	5249.65	6672.51	7497.75
Gross output value	10011.37	11409.60	12664.31	14262.60	15719.72
S	0.02	0.92	0.92	0.93	0.93
	2016	2017	2018	2019	2020
primary industry	1303.24	1276.09	1378.27	1551.42	1803.33
Secondary industry	7898.92	8584.61	8328.79	9496.84	9992.21
Tertiary Industry	8538.43	9564.03	10656.13	12557.51	13207.25
Gross output value	17740.59	19424.73	20363.19	23605.77	25002.79
S	0.93	0.93	0.93	0.93	0.93

(Photo credit: Original)

2020, the primary industry in Chongqing maintained a normal development. As shown in Fig. 1, the development trend was stable, the secondary industry generally showed a downward trend, and the tertiary industry showed an upward trend. Taking 2014 as the time node, the output value of the secondary industry and the tertiary industry have intersected since 2014. Before 2014, the output value of the secondary industry accounted for the largest proportion of the total output value of the national economy. The largest proportion of the output value. With the improvement of economic level, Chongqing's industrial structure model has changed from the "two-one-three" development model to the "three-two-one" development model. From the perspective of industrial structure modernization, the ratio of the sum of the secondary and tertiary industries to GDP is shown in Table 1. The ratio has remained above 0.9 in the past 10 years, from 0.92 in 2011 to 2020. The annual fluctuation of 0.93 is not large, so it can be seen that

Chongqing's industrial structure continues to move towards modernization. Chongqing has many industrial parks, and the secondary industry has long maintained its status as a pillar economy. During the 12th Five-Year Plan, Chongqing has included "low-carbon economy" into the 12th Five-Year Plan, vigorously developing new industries such as low-carbon energy conservation and environmental protection. A low-carbon economy is to reduce the proportion of coal in energy consumption and reduce the country's carbon emissions. Chongqing's industry has a long history of development, and industry has been in a dominant position for a long time, which has created great benefits for the development of Chongqing's national economy. From the perspective of energy consumption, as shown in Fig. 2, the overall energy consumption has shown a steady upward trend, and the coal consumption has maintained a long-term dominant position. The total energy consumption has increased from 55.1625 million tons of standard coal in 2011 to 72.6188 million tons of standard coal in 2020, and the problem of environmental pollution is also particularly prominent.

3 An Empirical Study on the Optimization of Industrial Structure in Chongqing

3.1 Indicator Selection

This paper mainly adopts the grey correlation model to analyze the correlation between Chongqing's industrial structure and low-carbon economy. It selects the energy intensity (the ratio of gross production value to total energy consumption) in Chongqing from 2011 to 2020, the province's forest Coverage rate, comprehensive utilization rate of industrial solid waste, total energy consumption (total consumption of coal, oil, natural gas, primary electricity and other energy sources), industrial structure upgrading index (the ratio of the sum of the output value of the secondary and tertiary industries to the total industrial output value), The total output value of the three major industries, the internal expenditure of R&D funds, and the total retail sales of social consumer goods.

3.2 The Establishment of Grey Relational Model

The grey relational analysis method is mainly based on the similarity or different degree of development trend among various factors, namely "grey relational degree". Grey system theory puts forward a new category of grey relational analysis for various sub-systems, and quantifies the development trend of the system, which is very suitable for dynamic process system analysis. The specific analysis process includes:

3.2.1 Determine the Comparison Object (Evaluation Object) and the Reference Sequence (Evaluation Standard)

The data sequence that reflects the behavior of the system is called the reference sequence. A data sequence composed of factors that affect system behavior is called a comparison sequence. Suppose there are m evaluation objects, n evaluation indicators, and the reference number column is $x_o = \{x_o(k)|k = 1, 2,\ldots, n\}$, the comparison sequence is $x_i = \{x_i(k)|k = 1, 2,\ldots, n\}$, i = 1, 2, m.

3.2.2 Determine the Weight Corresponding to Each Index Value

The weight $w = [w_1,\ldots, wn]$ corresponding to each index can be determined by the AHP method, where w_k, $k = 1, 2,\ldots,n$ are the weights corresponding to the kth evaluation index.

3.2.3 Calculate the Grey Correlation Coefficient

$$\varepsilon_i\ (k) = \frac{\min\limits_{s}\min\limits_{t}\left|x_o(t) - x_{s(t)+p}\ \max\limits_{s}\ \max\limits_{t}|x_o(t)-x_s(t)|\right|}{\left|x_o(t) - x_{s(t)+p}\ \max\limits_{s}\ \max\limits_{t}|x_o(t)-x_s(t)|\right|}$$

3.2.4 Calculate the Grey Weighted Correlation Degree

$$r_i \sum_{k=1}^{n} w_k \varepsilon_{i(k)}$$

3.2.5 Evaluation Analysis

The evaluation objects are classified according to the grey-weighted correlation degree, and the correlation order of the evaluation objects is established. The higher the correlation degree, the better the evaluation result.

3.3 Grey Relational Analysis Results Research Results

3.3.1 Grey Correlation Coefficient

Taking the industrial structure upgrading index as the "reference value", the total energy consumption, energy intensity, the city's forest coverage rate, the comprehensive utilization rate of industrial solid waste, the total output value of the three major industries, the internal expenditure of R&D funds, and the total retail sales of social consumer goods are used as the evaluation items. Combined with the data of Chongqing from 2011 to 2020, the grey correlation degree analysis is carried out to study the correlation degree between the seven evaluation items and the industrial structure upgrading index. When using the grey correlation degree analysis, the initial value is selected for dimensionless processing, The resolution coefficient takes p to choose 0.5, and based on the correlation degree to provide analysis reference, calculate the value of gray correlation coefficient and correlation degree to do evaluation analysis. It can be seen from Table 2 that from 2011 to 2020, except for the correlation coefficients of the comprehensive utilization rate of solid waste in 2017 and 2020, which were 0.850 and 0.761, respectively. In other years, the maximum correlation degree between the industrial structure upgrading index and the comprehensive utilization rate of industrial solid waste was above 0.9, and the correlation coefficient reached the maximum value of 0.999 in 2013. In 2016, the industrial structure upgrading index had the largest correlation with the city's forest coverage rate, and the correlation coefficient was 1. The specific correlation coefficient is shown in Fig. 3. Taking 2017 as the limit, before 2017, the correlation coefficients of the seven evaluation items showed an overall increasing trend. After 2017, in addition to the comprehensive utilization of industrial solid waste, the correlation coefficients of several other evaluation items showed a fluctuating downward trend as a whole.

Table 2. Indicator correlation coefficient

Correlation coefficient results							
	energy intensity	Forest coverage rate in the whole province (%)	Comprehensive utilization rate of industrial solid waste (%)	Total energy consumption (10,000 tons of standard coal)	Internal expenditure of R&D funds (10,000 yuan)	The total output value of the three major industries (100	Total retail sales of social consumer goods (ten thousand yuan)
2011	0.514408209	0.708221588	0.78913054	0.6293246	0.367399	0.4407796	0.408377488
2012	0.607513052	0.836196698	0.915650404	0.6933781	0.420743	0.4978432	0.463262143
2012	0.667961602	0.836196698	0.999155122	0.792375	0.455887	0.5632808	0.540599939
2014	0.806776973	0.861823996	0.972490997	0.891146	0.513001	0.6612834	0.636664717
2015	0.761045728	0.972872965	0.981738771	0.8150815	0.687861	0.8056616	0.817235481
2016	0.843521085	1	0.998016992	0.9220454	0.884965	0.8986802	0.861040203
2017	0.709747634	0.948049894	0.850633556	0.8661612	0.550845	0.7012823	0.640742734
2018	0.709747634	0.847262152	0.92331694	0.8018023	0.466255	0.6248071	0.520924798
2019	0.585865035	0.765844747	0.979444497	0.7378686	0.319088	0.4538134	0.43955606
2020	0.518048163	0.678864384	0.761361146	0.7546398	0.337021	0.4059485	0.428324362

(Photo credit: Original)

3.3.2 Grey Relational Degree

According to the weighted operation processing of the above correlation coefficient results, the correlation degree is finally determined by the formula, and then the correlation degree of the seven evaluation objects is scored and sorted. As shown in Table 3: the comprehensive utilization rate of industrial solid waste is the highest, with a correlation of 0.917; followed by the province's forest coverage with a correlation of 0.846; the total energy consumption correlation of 0.79, the energy intensity correlation of 0.672, and the three major industries The correlation degree of total output value is 0.605, the correlation degree of total retail sales of social consumer goods is 0.576, and the correlation degree of internal expenditure of R&D funds is 0.506.From the correlation value, it can be seen that the comprehensive utilization rate of industrial solid waste has made a great contribution to the optimization of the industrial structure in the past 10 years, but the high energy consumption still has a certain impact on the optimization and upgrading of the industrial structure. A large amount of CO2 is not conducive to the development of the industrial structure in the direction of low carbonization. From the above data, it can be seen that the internal expenditure of R&D funds has little impact on the upgrading of the industrial structure, and the correlation is 0.506. The ranking is last. It can be seen that the expenditure of scientific research funds has little impact on the optimization of the industrial structure. Chongqing's technological progress needs to continue to improve the optimization of the industrial structure. Making good use of technology is the role of the primary productive force.

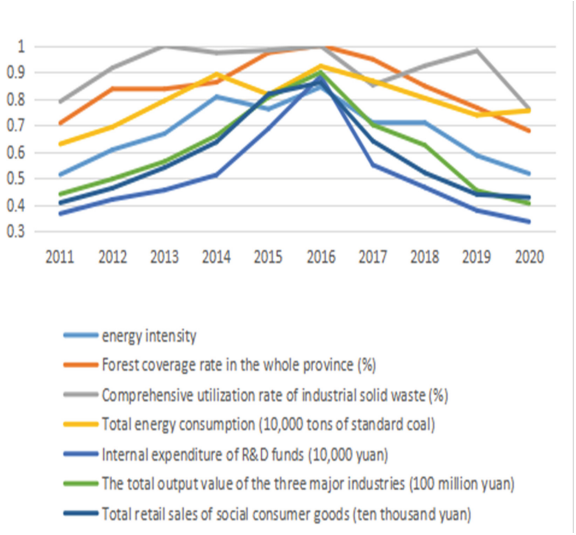

Fig. 3. Correlation coefficient diagram (Photo credit: Original)

Table 3. Index correlation ranking result chart

Correlation results		
Evaluation item	Correlation degree	rank
Comprehensive utilization rate of industrial solid waste (%)	0.917	1
Forest coverage rate in the whole province (%)	0.846	2
Total energy consumption (10,000 tons of standard coal)	0.79	3
energy intensity	0.672	4
The total output value of the three major industries (100 million yuan)	0.605	5
Total retail sales of social consumer goods (ten thousand yuan)	0.576	6
Internal expenditure of R&D funds (10,000 yuan)	0.506	7

(Photo credit: Original)

4 Countermeasures and Suggestions

According to the above empirical analysis, Chongqing's industrial structure is closely related to the development of low-carbon economy. A low-carbon economy is more concerned with reducing environmental impact than promoting some kind of solution to reducing emissions. That is, a low-carbon economy is more of a goal than a means or strategy to achieve it. A low carbon industry is a core business for inclusive growth with a strategic infrastructure that can provide local, competitive and resilient energy with significant local economic benefits, as well as reduced energy demand through efficiency

and reduced waste through a circular economy.The International Energy Agency estimates that by 2030, total carbon dioxide emissions will need to fall by about 45% from 2010 levels. Importantly, progress over the next decade will play a key role in ensuring net-zero greenhouse gas emissions by 2050.

Firstly, based on the development of low-carbon economy, secondly, we will deepen the five development concepts and continue to adhere to the innovation-driven concept. Innovation-driven development is the direct driving force for the optimization of Chongqing's industrial structure. From the above analysis, it can be seen that the comprehensive utilization of industrial solid waste has the greatest role in promoting the optimization and upgrading of the industrial structure. Continue to strengthen the comprehensive utilization of solid waste, continue to make innovations and breakthroughs in various industries, promote the free flow of various elements, optimize the allocation of resources, and promote the industry develop towards high quality. In the empirical analysis of the relationship between economic growth, industrial structure and carbon emissions in Gansu Province, Zhao Fang (2013) proposed that the government should further support enterprises to pursue low-carbon development and technological upgrading through the guidance and improvement of policies, and introduce technical and innovative talents to jointly promote the progress of emission reduction technology [5]. At the same time, efforts are made to build eco-industrial parks, strengthen the economic links between industries and industrial chains, and promote the integrated development of industries. To develop an eco-friendly, innovation-driven economy and a low-carbon economy, strengthen support for green industrialization, and promote sustainable economic growth. Under the development of low-carbon economy, the optimization of primary, secondary and tertiary industrial structure is as follows:

4.1 Optimize the Internal Structure of the Primary Industry and Focus on Making Breakthroughs in Forestry

The primary industry will further develop a green and ecological industrial structure, focusing on making breakthroughs in forestry. The biggest function of forests is to absorb and fix carbon dioxide. Forest coverage also plays a significant role in the optimization and upgrading of industrial structures. Protect and make good use of forest resources, vigorously develop green industries, and strengthen pollution control. The government should provide more preferential subsidy policies for forestry development, expand the sources of funds for forestry development, continue to implement the project of returning farmland to forest, and increase the forest coverage rate. However, forests have many other functions, including job creation and income generation through the forestry, agricultural and mining sectors. Local governments can step up their efforts to improve existing forest management, greening/reforestation to increase forest cover and ecological value, and develop forest biomass. For grasslands and agricultural land, local governments can focus on improving energy efficiency, recycling agricultural waste, expanding existing practices and planning, developing ecotourism, and introducing more low-carbon technologies into primary industries.

4.2 Explore the Low-Carbon Industry Cluster Model of the Secondary Industry and Create a High-Quality Industry

According to Chongqing's automobile manufacturing, new material industry, high-end equipment manufacturing industry, etc., through "chain building, supplementary chain, and strong chain", give full play to the advantages of core cities, transition the traditional enterprise model to a low-carbon economic model, and make use of modern low-carbon and low-carbon economic models. Technology realizes the optimization and upgrading of traditional industries. Build high-quality secondary industries, transform from energy-intensive industries to technology-intensive industries, improve infrastructure in the industrial sector, and reduce greenhouse gases by replacing carbon-intensive fossil fuels with renewable energy (solar, wind, hydro, etc.) Emissions, carbon capture and storage capabilities can also be used to expand existing processes, retrofit equipment, and use industrial waste gas to fuel additional energy needs. Industries such as coal and coal-fired power generation will face the risk of shrinking markets, as well as pressure from capacity declines and business transformation. At the same time, through technological upgrading, the energy utilization efficiency of steel, non-ferrous metals, chemical, construction, building materials and other industries will be improved. Optimize the energy consumption structure, vigorously develop and utilize clean energy, research and develop new energy to replace traditional petrochemical energy, create a high-quality industrial development model, and promote the efficient use of resources. Ecological organizations and industrial facilities also need to work together to identify and implement greenhouse gas reduction projects, creating stronger partnerships between facilities and existing energy efficiency service providers.

4.3 Based on the Tertiary Industry, Build a Modern Industrial System with Core Competitiveness

Information and communication high-tech industries play a very important role in reducing greenhouse gas pollution, especially in developed countries. Many industries in Chongqing can use modern information and communication technology to enter the global high-efficiency and low-carbon market, and break through people's existing energy-intensive work habits and lifestyles. Focusing on establishing and improving the level of the modern tertiary industry system, vigorously develop the modern service industry and strategic emerging industries, gradually establish a modern manufacturing system with core competitiveness, and actively expand the field of cooperation with foreign countries. Optimize the allocation, rational flow of important production factors such as talents and information in various places, so as to improve the capacity level of the tertiary industry. Low-carbon technology is an important key to the development of low-carbon economy, and it is an important means to alleviate climate warming, energy crisis and sustainable development. From the perspective of technological innovation, the R&D competition around new low-carbon technology industries has advanced at full speed, using low-carbon technology to establish its own brand system, identifying new green and low-carbon industries, formulating various low-carbon technologies including emission reduction standards, and reach various green rules including carbon trading to form core competitive products. As a strategically important area in Chongqing, green

technology has become an important driving force for low-carbon economic development and competition, providing a solid foundation and competitive advantage for future technology transfer and green industry upgrades.

5 Conclusions

In conclusion, this paper takes Chongqing's industrial structure as the research object, and objectively evaluates the optimization and upgrading of Chongqing's industrial structure from the perspective of low-carbon economy according to the actual situation. Comprehensive utilization rate of waste, total energy consumption, industrial structure upgrading index, total output value of the three major industries, internal expenditure of R&D funds, and total retail sales of social consumer goods.

From the perspective of the industrial structure upgrading index, the proportion of the sum of the secondary industry and the tertiary industry in the total GDP has remained above 0.9 in the past 10 years. Chongqing has been striving to create the best possible development for the optimization of the secondary and tertiary industries for the optimization of the industrial structure. Conditions, and continuously promote the industrial structure to continue to modernize, and maintain this trend status for a long time. The grey relational model is used to study the correlation between 7 evaluation items and the industrial structure upgrading index. From the grey relational coefficients in the above grey relational model, from 2011 to 2020, from the perspective of the relational coefficient of comprehensive utilization rate of solid waste, the industrial the correlation degree between the structural upgrading index and the comprehensive utilization rate of industrial solid waste was the largest. In 2016, the industrial structure upgrading index had the highest correlation degree with the city's forest coverage rate, and the correlation coefficient was 1. According to the weighted operation processing of the above correlation coefficient results, the correlation degree is finally determined by the formula, and then the correlation degree of the seven evaluation objects is scored and sorted, and it is found that the comprehensive utilization rate of industrial solid waste is the highest, and the correlation degree is 0.917; followed by the correlation degree of the province's forest coverage rate of 0.846; the total energy consumption correlation degree of 0.79. From the correlation coefficient and correlation value, it can be seen that the comprehensive utilization rate of industrial solid waste has made a great contribution to the optimization of the industrial structure in the past 10 years, and the forest coverage rate in 2016 has the best effect on the optimization and upgrading of the industrial structure. These factors have played an important role in promoting the optimization and upgrading of the industrial structure, reducing carbon emissions and better promoting the development of the industrial structure. Although the utilization of solid waste has achieved remarkable results, on the whole, Chongqing's industrial structure is developing, but the high energy consumption still has a certain impact on the optimization and upgrading of the industrial structure. The amount of coal in the process of industrial consumption is large, and a large amount of CO2 is generated. It is conducive to the development of the industrial structure towards low carbonization. From this, it can be seen that there are still certain problems in the optimization of Chongqing's industrial structure under the background of low carbon. Therefore, the countermeasures

of the industrial structure are put forward: optimize the internal structure of the primary industry, and focus on forestry. Breakthrough; based on the tertiary industry, build a modern industrial system with core competitiveness; explore the low-carbon industrial cluster model of the secondary industry, and create high-quality industries.

As an indispensable part of my country's economic development, low-carbon economy is an important manifestation of sustainable economic development and an important way for my country's economic transformation and upgrading. Chongqing, which is oriented by the development of heavy industry, continuously optimizes its industrial structure under a low-carbon background, which is conducive to better highlighting its own competitive advantages in the competition with other developed regions, and is also conducive to the better development of Chongqing's economy. Development creates more GDP and realizes the sustainable development of Chongqing's economy.

References

1. Dugu C (2020) Research on carbon emissions and influencing factors of agricultural land use in China: 1990–2016. Ecol Econ 19–23
2. Liu X (2019) Analysis of influencing factors of industrial energy consumption carbon emissions based on STIRPAT model. Ecol Econ 27–31
3. Sun Y, An J, Shi S (2020) Research on the development of low-carbon economy in Jilin Province from the perspective of industrial structure adjustment. Tax Econ 103–107
4. Wang Y (2010) Implementing green development and transforming the mode of economic development. J Chin Acad Sci 122–123
5. Hao F, Zhu W (2013) Empirical analysis of the relationship between economic growth, industrial structure and carbon emissions in Gansu Province. Coop Econ Technol 14–15