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Impacts of spatial and temporal patterns and economic development on carbon emissions in Chinese cities

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Abstract. With the economic and social development and the improvement of people's living standards, the urban carbon emission increases. Studying the influence of industrial structure and spatial patterns on carbon emission under the economic development of different cities can help to find the main factors affecting carbon emission, formulate policies to solve the problem according to local conditions, and provide an important scientific basis for the transformation of economic growth mode and the construction of low-carbon cities. This paper draws conclusions by analyzing the trend curves of urban carbon emissions and economic factors over the years. Different regions of the city's economic development potential differences are obvious, and the potential for greater spatial concentration of cities; city's economic development potential in the spatial and temporal distribution of key cities and major urban agglomerations as the basis for the point - line - surface in order to promote. economically developed cities, the total carbon emissions, carbon emissions growth rate of a declining trend; economically underdeveloped areas, the total carbon emissions, carbon emissions growth rate of a year-on-year trend; the degree of carbon emissions and the degree of prosperity of the secondary industry is closely linked. China's urban carbon emissions have a significant positive spatial correlation between 2006 and 2016, the "cold spot" area of urban carbon emissions is relatively stable, mainly distributed in the eastern and southern economic zones, while the "hot spot" area is mainly distributed in the northwest, northeast and the middle reaches of the Yellow River economic zone.

Keyword: China, Carbon Emissions, Economic Development, Spatial Patterns Of Prefecture-Level Cities**.**

1. Introduction

The issue of global warming has become an important political and the development of a low-carbon economy has become the consensus of all countries in the world. With the dramatic changes in production and lifestyles, the impact on the climate has become very obvious, and finding a sustainable path for low-carbon urban development has become a global concern, especially in China [1]. On the one hand, the rapid urbanization development pattern has brought many problems; on the other hand, the rising energy consumption of urban residents has become an important source of carbon emissions. On the other hand, the rising energy consumption of urban residents has become an important source of carbon emissions [2]. Under the pressure of world public opinion for China to

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implement carbon emission reduction and the obstruction of China's own sustainable development, cities urgently need to find effective ways to save energy and reduce emissions. It is of great theoretical and practical significance to develop differentiated low-carbon emission reduction initiatives.

2. Literature Review

Under the national pattern, the coordination relationship between the level of urbanization and the level of economic development, as well as the driving effect of urbanization per unit of GDP, varies considerably in different regions [3]. The use of natural gas (including gas) and liquefied petroleum gas (LPG) accounted for more than 75% of the national total, making them the key areas for energy consumption and pollutant control. It is a key area for energy consumption and pollutant control [4]. Most of the eastern cities of China's rapid economic development is based on high energy consumption. The decoupling value of urban economic development and energy consumption in the central region of China has increased slowly [4]. The intensity of urban economic ties in the northwest region shows a significant spatial imbalance in distribution, with a monotonically decreasing trend from east to west [5]. Urbanization and total population and international trade are the main factors influencing industrial carbon emissions [6]. It has been pointed out that there is a bi-directional causal relationship between energy consumption and economic growth, and energy consumption and carbon emissions [7]. Therefore, reducing carbon emissions will definitely limit social and economic development. What we can do is to find a balance between urban economic development and carbon emission reduction, and find a sustainable green economic path.

The current research on the relationship between the urban economy and carbon emissions in China mainly focuses on the intrinsic connection between the economic development of cities and their geographical distribution, as well as exploring the factors influencing carbon emissions in individual regions and key cities, and mainly adopts GDP data when analyzing economic data. The research object is not comprehensive enough and lacks research on the trend of China's urban economy and the center of gravity of carbon emissions in recent years from the perspective of spatial patterns, and the economic data are not detailed enough. Therefore, this project will expand the research object to all prefecture-level cities in China, and analyze the differences and similarities between the center of gravity of economic development and the center of gravity of carbon emission in recent years from a macro perspective; clarify the law of industrial structure change under the economic development of different cities in the past years at the individual level, and explore whether it is consistent with the law of change of the center of gravity of urban carbon emission, and then provide a basis for rational planning of urban development routes, how to adjust industrial structure, and how to adjust the carbon emission. On the basis of the obtained pattern, it can provide solution policies for rational planning of urban development routes, how to adjust industrial structure and energy consumption level, and efficiently realize the goal of carbon neutrality and carbon peak.

3. Changing law of the center of gravity of urban economy and carbon emissions in spatial pattern

3.1. Migration pattern of the center of gravity of urban GDP hot and cold spots

As can be seen from Figure 1, in 2006, the best economic development of China's cities was Shanghai, Guangdong, and Beijing; better economic development of cities mainly coastal distribution in the eastern region such as Shandong, Zhejiang, etc., the inland Chongqing and Sichuan economy is more developed. Ten years later, the overall economic development of China's cities has risen dramatically, with more coastal cities joining the ranks of the better economy, and the center of gravity of economic development has developed from the east like the central development trend, with Beijing, Shanghai, and Guangdong still being the leading areas of economic development, and Chongqing has also developed into one of the most economically developed cities.

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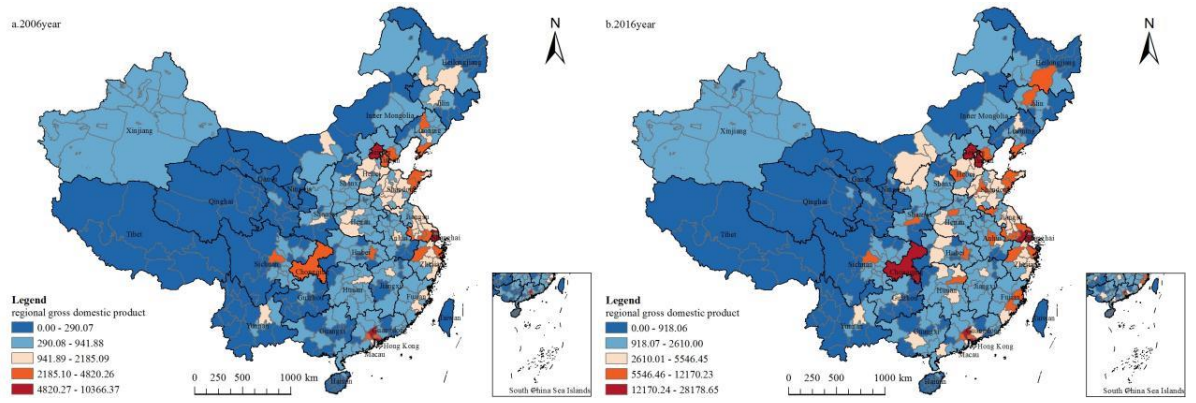

Figure 1. A comparison of the distribution trend of regional GDP in 2006 and 2016.

It can be seen that there are obvious differences in the economic development potential of cities in different regions, and the cities with greater potential are more spatially clustered; the spatial and temporal distribution of urban economic development potential is based on key cities and major city clusters, which are promoted according to the order of point - line - surface.

3.2. Migration patterns of urban carbon emission centers of gravity

As can be seen from Figure 2, in 2006, the most serious carbon emission area in Chinese cities was Shanghai, and CO2 emission areas were concentrated in the eastern coastal regions of Beijing, Hebei, and Shandong, and inland Chongqing and Chengdu in Sichuan Province, which are two highly industrialized regions; while ten years later, carbon emissions in Chinese cities generally increased, with the serious carbon emission areas spreading from the east to the north, and Beijing and Chongqing, together with Shanghai, became the most serious emission areas. Beijing and Chongqing, along with Shanghai, are the worst emitters.

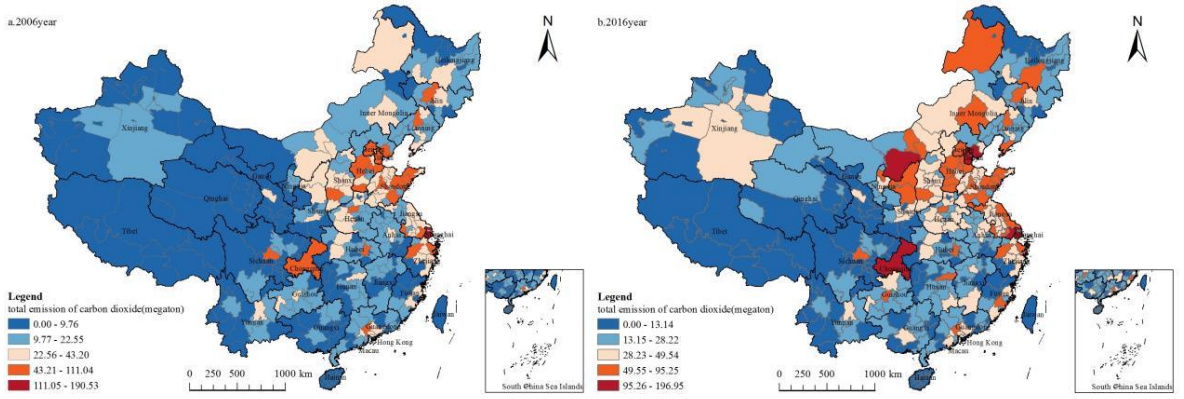

Figure 2. A comparison of the distribution trend of carbon emission in 2006 and 2016.

It can be seen that China's urban carbon emissions have a significant positive spatial correlation between 2006-2016 the center of gravity of urban carbon emissions change is more stable, showing a trend of migration from the eastern coastal economic zone to the northeastern part of the region, while the Northwest and the middle reaches of the Yellow River economic zone emission value is more stable, generally lower.

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4. Changing Laws of the Economy and Carbon Emissions of Chinese Cities from 2006 to 2016

4.1. Changing Law of Carbon Emission in Prefecture-level Cities in China

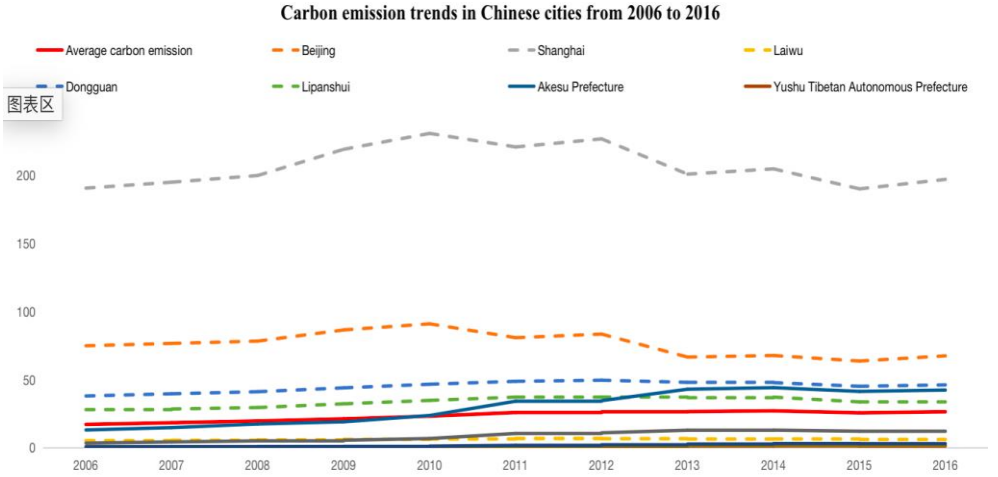

Figure 3. Carbon emission trends in Chinese cities from 2006 to 2016.

As can be seen from Figure 3, during the decade from 2006 to 2016, the total carbon emissions of Chinese cities were gradually rising, with the average carbon emissions of cities increasing from 17.093 megatons to 26.372 megatons, an increase of nearly 1.5 times. The cities with the highest degree of growth were Aksu, Yushu Tibetan Autonomous Prefecture, Hotan, Tumushuk, and Wujiaqu; the cities with the lowest growth were Beijing, Shanghai, Laiwu, Dongguan, and Liupanshui. Beijing and Shanghai have reduced their emissions, but the value of their emissions is still much higher than the average carbon emissions of the cities, Wujiaqu and Hotan areas have increased their carbon emissions, but they are still much lower than the carbon emissions of the cities.

4.2. Changing Law of the Share of Secondary Industry in GDP of Prefectural-level Cities in China

Urban economic development is closely linked to the three major industries, and the secondary industry includes mining, manufacturing, electricity, water and gas supply industry and construction industry, etc., which is the main support system for economic development, and the study of the pattern of change of the proportion of the secondary industry in the gross domestic product of each city from 2006 to 2016 can be derived from the change of the urban economic development in the past ten years.

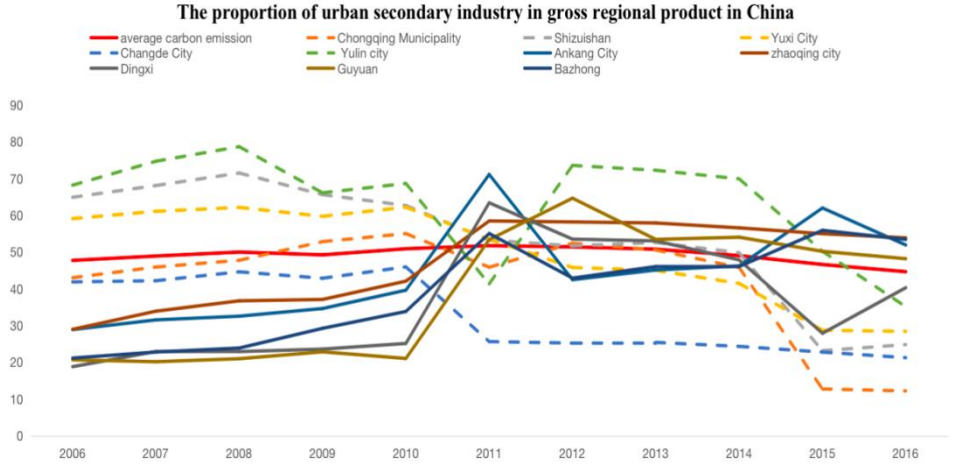

Figure 4. The proportion of urban secondary industry in gross regional product in China.

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As can be seen from Figure 4, the proportion of secondary industry to GDP in Chinese cities is on a decreasing trend, from 47.715% to 44.633%, a decrease of 3%; the proportion of secondary industry to GDP in some cities is decreasing, with Shizuishan City decreasing to the greatest extent, down by 40.09%, Chongqing, Yuxi and Yulin decreasing by 30%, and Changde City decreasing by 20%; while the proportion of secondary industry to GDP in some cities is increasing, with Ankang, Zhaoqing, Dingxi and Guyuan following. The proportion of the secondary industry in GDP is on the rise, with Bazhong City rising the most, by 32%, followed by Ankang City, Zhaoqing City, Dingxi City, and Guyuan City, by about 20%.

4.3. Changing Laws of the Industrial Structure of the Secondary Industry in Cities under Economic Changes

Take the number of employees in secondary industry-related industries in two cities with more obvious changes in the ratio of secondary industry to GDP, Bazhong City, and Chongqing Municipality, as an example, to explore the changes in the structure of the secondary industry within the cities under the economic changes.

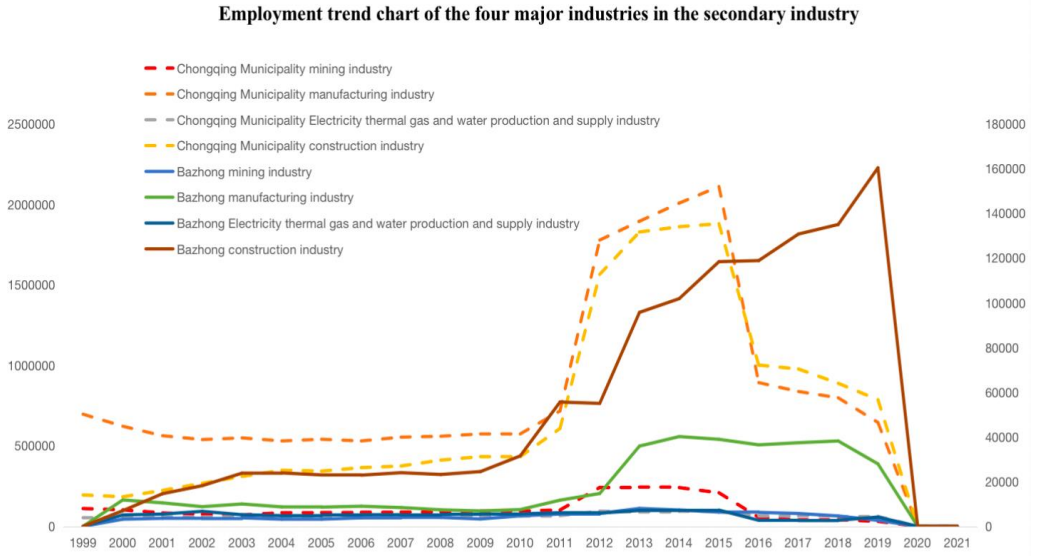

Figure 5. Employment trend chart of the four industries in the secondary industry.

As can be seen from Figure 5, between 1999 and 2019, the number of employees in the mining and construction industries under the secondary industry in Chongqing Municipality first rose steadily, rose sharply from 2011 to 2012, and after peaking in 2015, there was an extremely rapid decline, followed by a steadily declining trend; in Chongqing, the mining and electricity, water, and gas supply industries have lower employees, and the trend of change in the number of employed persons is similar to that of the mining industry; and the Bazhong City's secondary industry employment is generally much lower than that of Chongqing, but in the city, the construction industry has a steep upward trend in employment, the manufacturing industry has a slow upward trend in employment, while the mining and electricity, water and gas supply industries have a slight increase in employment, but compared to the manufacturing industry and the construction industry, the upward trend is not significant.

5. Conclusion

5.1. Linkages between urban carbon emissions and urban economic development

Through the analysis, it can be seen that Beijing, Shanghai, Chongqing, and other economically developed cities have great carbon emissions, far more than the average urban carbon emissions. Over

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the past decade, these economically developed cities have reduced their carbon emissions by lowering the production of secondary industries, and the growth rate of carbon emissions has slowed down very significantly, but the value of carbon emissions is still higher than the average value of the city, so it is necessary to continue to save energy and reduce carbon emissions, find a better way to purify the air and balance the relationship between development and carbon emissions; whereas, Bazhong city, Aksu region and other economically weaker regions are gradually improving their economies by increasing the development of secondary industries, and consequently the carbon emissions are also rising, with a higher growth rate, but the carbon emissions are higher. While Bazhong City, Aksu, and other areas with weaker economic development are gradually improving their economies by increasing the development of secondary industries, and consequently carbon emissions are on the rise, with higher growth rates, but the total amount of carbon emissions have temporarily stabilized within a more reasonable range. There is an obvious spatial relationship between the urban economy and carbon emissions. Therefore, it can be concluded that: in economically developed cities, the total amount of carbon emissions, and carbon emissions growth rate is declining year by year; in economically underdeveloped areas, the total amount of carbon emissions, and carbon emissions growth rate is low, carbon emissions growth rate is increasing year by year; the extent of its carbon emissions and the degree of prosperity of the secondary industry is closely linked. At the same time, the location and spatial structure of a city determine its economic development, which in turn affects its carbon emissions.

5.2. Impact of changes in industrial structure on carbon emissions

Through analysis, it can be seen that economically developed regions, first through the massive development of mining and construction industry to improve urban construction and promote economic development, and then slow down the related industries, and industrial development to reduce carbon emissions; while economically underdeveloped regions, also want to now through the development of the construction industry and manufacturing industry to develop the economy, but it will undoubtedly increase the city's carbon emissions.

5.3. Policy recommendations

Industrial structure transformation policy: Help economically developed cities complete the transition from industrialization to green urbanization by means of bonuses and policy support measures.

The spatial distribution of the country's development should be well controlled, consciously distribute the population and economy to the cities that are to be developed and have a better environment, to reduce the burden of population and urbanization in the key cities for development.

Control the progress of the city to be developed, should be combined with the city's spatial pattern and specific conditions, the use of green development methods, such as returning farmland to forests to promote employment, the use of clean energy, reduce energy intensity and other methods.

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