The environmental mechanism of urbanization impacts on carbon emissions peak and carbon neutrality

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Abstract. In recent years, with China's urbanization rapid development, carbon emissions have increased sharply and ecological and environmental problems have been prominent. This paper studies the dual effects of urbanization on carbon emissions and carbon neutrality, analyzes the heterogeneity of different time periods and spatial locations, and summarizes the impact mechanism of urbanization on peak carbon dioxide emissions and carbon neutrality.

Keywords: urbanization; peak carbon dioxide emissions; carbon neutral

1. Introduction

With the rapid economic development, the urbanization process characterized by urban expansion and population growth has become an inevitable development trend in many developing countries [1]. As the largest developing country, China’s urbanization has developed rapidly since Economic Reform and open up. From 1978 to 2019, China’s urbanization rate increased from 17.9% to 60.6%, and the average annual growth rate far exceeded the level of the same period in the world. But at the same time, the advancement of China’s urbanization is expanding the scale of urban development, increasing the number of urban populations, and expanding the scale of urban industries. At the same time, carbon emissions have also increased sharply, and ecological environmental problems have become prominent. In 2019, China's carbon emissions accounted for 27% of the world's total emissions, far surpassing the United States, which ranks second. Whether the impact of urbanization on carbon emissions and carbon neutrality is positive or negative may vary in different countries or regions and at different stages of development [2]. Studying the mechanism of urbanization’s impact on peak carbon dioxide emissions and carbon neutrality is of great significance to the development of urbanization and the construction of low-carbon cities.

Urbanization is an important symbol of human economic and social development. It reflects the change process of the social production structure from the primary industry to the secondary and tertiary industries. It is in line with industrialization and has a profound impact on the ecological environment. [3]. The expansion of urban land and the increase of non-agricultural population accompanied by urbanization means the growth and accumulation of industrial labor. Social resources are concentrated in cities and towns. The expansion of industrial scale and the improvement of industrial quality have promoted the improvement of production efficiency and the increase of industrial output value. The
accumulation of capital in cities brings abundant employment opportunities, attracts more agricultural population to transfer to cities, and promotes the development of urbanization [4]. The proportion of urban population is a common indicator that reflects the development of urbanization and measures the level of urbanization in a region. With the continuous enrichment of the connotation of urbanization, scholars have carried out research on the connotation and evaluation system of urbanization from different dimensions such as land, population, space, and society [5].

2. The impact mechanism of urbanization on peak carbon dioxide emissions and carbon neutrality

The impact of urbanization on carbon emissions and carbon neutrality has a dual effect. The basic principles are analyzed as follows.

The process of urbanization is accompanied by the migration of population, especially labor and human capital, from rural to urban areas, which triggers the spatial agglomeration of population and factors in urban areas, and exacerbates the differences in the distribution of people of different age levels and education levels between urban and rural areas. At the same time, urbanization promotes the transformation of land resources from agricultural land to urban and industrial land, which not only increases the number of small and medium-sized cities and industrial parks, but also makes existing cities and parks larger and spatial structures more complex. The above process has a dual effect on regional carbon dioxide emissions and carbon neutrality. On the one hand, changes in the urban and rural population structure and the spatial structure of the country have led to changes in regional economic characteristics such as production, consumption, and infrastructure, which in turn increases energy consumption and drives carbon dioxide emissions. Moreover, the process of urbanization has brought about an increase in the number of cities and towns and an expansion of the scale of cities and towns, encroaching on a large amount of soil, green vegetation and waters, reducing the carbon absorption capacity of the ecosystem, and having a negative impact on carbon sinks. First, changes in production characteristics. The non-agriculturalization of population and land directly provides elemental support for industrial development, which in turn drives the increase in the scale of regional output and the proportion of the secondary industry in the national economy, leading to the expansion of the scale of energy consumption. Second, changes in consumption characteristics. The increase in production capacity means that the scale of residents' material consumption will expand, which will lead to the needs of construction and repair of large-scale infrastructure, municipal facilities and residential buildings. This not only increases energy consumption, but also increases the consumption of high-carbon building materials such as cement and glass. Third, changes in traffic characteristics. The expansion of the scale of cities and urban agglomerations and the complexity of the spatial structure have also increased the demand for commuting within and between cities, and increased the energy consumption of mobile sources such as transportation.

On the other hand, the accumulation of production factors brought about by urbanization can greatly increase the pace of technological innovation and technological diffusion, improve energy consumption intensity and structure, and promote carbon dioxide emissions reduction. First, energy enhancement and improvement. Technological progress can improve energy efficiency, accelerate the transformation of traditional industries into high-tech industries, and reduce the dependence of industrial production on energy consumption. Second, the energy structure is optimized. The innovation and popularization of new energy technologies have reduced energy supply costs and helped promote the transition to clean energy and low-carbon energy. In addition, the improvement of government governance capacity and the increase of public environmental awareness accompanying the urbanization process also contribute to the advancement of energy conservation and emission reduction. At the same time, scientific innovation empowers the research and development of carbon neutral technologies. For example, CCUS (Carbon Capture, Utilization and Storage), which is currently a key technology to cope with global climate change, uses carbon dioxide as a resource, which has significant economic, social and ecological benefits, and promotes carbon neutrality realization.
3. Analysis of heterogeneity

3.1. Time phase analysis
The relative intensity of the dual effects of urbanization on carbon emissions and carbon neutrality is not static, but fluctuates from one to the other at different stages, successively occupying a dominant position in the process of urbanization. In the middle and early stages of urbanization, the contradiction between the citizens' need for higher material living standards and limited urban resources has become prominent, and the agglomeration of production factors such as capital and labor has accelerated. At this stage, the income base of residents is small, the growth rate is fast, and the population of young and middle-aged people is relatively large. The industry develops rapidly and the demand for infrastructure is strong. The society as a whole tends to invest more resources to maintain production and consumption, so the effect of increasing emissions occupies a major position, and it is more inclined to invade green vegetation and waters to expand towns. In the later stages of urbanization, the main development contradiction has gradually changed into a contradiction between the citizens' need for a more sustainable development model and the limited technical level and utilization level, and the concentration of production factors has slowed down. At this stage, the economic growth rate began to decline, and the aging population trend appeared. The government tended to create a sustainable production and living model by improving the governance level and the comprehensive utilization efficiency of resources, reducing infrastructure activities and optimizing the industrial structure, thus reducing emissions occupies a major position. The impact of urbanization on carbon neutrality is also dominated by positive scientific boosting effects.

On the whole, multiple effects jointly shape the dynamic relationship between urbanization and carbon emissions and carbon neutrality. However, China is still in the middle and early stages of urbanization in which urbanization promotes the increase of carbon emissions. On the one hand, urbanization is still advancing rapidly; on the other hand, the gap between urban and rural areas is still significant. As China’s urbanization is still in the rapid progress stage, and the quality of development needs to be improved. At this stage, the increase in the rate of urbanization means an increase in carbon emissions and a negative impact on carbon sinks.

3.2. Spatial heterogeneity analysis
From the perspective of spatial dimensions, there are differences in the strength and weakness of different effects in different regions and the mechanism of action. First, due to the significant spatial differences between China’s urbanization and economic development levels, the phase characteristics of the impact of urbanization on carbon emissions and carbon neutrality have formed regional heterogeneity in the spatial dimension, that is urbanization development. The emission reduction effects and the positive effects of carbon neutrality brought about by technological development are more significant in regions with higher levels. On the contrary, the effects of increasing emissions and negative effects on carbon sinks dominate. Secondly, because our country's industrial structure and income structure are all related to the local natural endowments and comparative advantages, the factors of production in various regions promote energy demand growth to different degrees. Third, different regions have different ways to meet energy demand. The cost of using fossil energy in resource-intensive areas is lower. Therefore, the increase in carbon emissions caused by rising per capita consumption is more obvious, the comparative advantage of clean energy is weaker, and the optimization of energy structure is also more difficult. In addition, differences in natural endowments and urban spatial design will affect the mechanism of urbanization on carbon emissions and carbon neutrality.

The impact of urbanization on carbon emissions and carbon neutrality is also related to the urbanization development model. From the perspective of spatial structure, cities have two development directions: compact and intensive and scale-expanding. The former not only contributes to the rational allocation of elements and promotes the effective use of agglomeration effects and the advantages of the sharing economy, but also provides environmentally friendly services in the industry, which is more conducive to energy conservation and emission reduction. Technological transformation is also more
Conducive to innovation and R&D, providing intellectual support for the realization of carbon neutrality. Relatively speaking, the scale-expanding urbanization breadth promotion model is more low-density and decentralized. On the one hand, it is not conducive to the utilization of the advantages of the agglomeration economy and the sharing economy. On the other hand, under the GDP-oriented official performance evaluation mechanism, in order to stimulate economic growth in the short term, government departments usually increase the city’s economic growth to expand the scale of infrastructure construction and real estate development. It has led to rapid and low-density expansion of urban sprawl, which has led to changes in original land use types, reduced vegetation areas, traffic congestion, and increased emissions problems.

4. Summary
The impact of urbanization on carbon emissions and carbon neutrality has a dual effect, and differs in different time stages and spatial locations. On the one hand, the process of urbanization has led to changes in the urban and rural population structure and the spatial structure of the land, changing production characteristics, consumption characteristics, and transportation characteristics, thereby increasing energy consumption and increasing carbon dioxide emissions. Moreover, the expansion of cities and towns encroached on a large amount of soil, green vegetation and waters, which has a negative impact on carbon neutrality. On the other hand, the accumulation of production factors brought about by urbanization can promote technological innovation and development, thereby improving energy consumption intensity and structure, and promoting the research and development of advanced technologies for carbon dioxide emission reduction and carbon neutralization.

At present, China’s urbanization is still in the rapid progress stage, there are large differences between regions, and the overall quality of development needs to be improved. There are still many challenges in realizing a low-carbon economy and a low-carbon society. How to deal with the relationship between the present and the future, take a long-term view of the symbiosis of urbanization and the sustainable development of ecological civilization, and realize the effective, efficient and long-term synergy of energy conservation and emission reduction, ecological environmental protection and urbanization development, is of great significance.

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