Analysis of the Evolution Law of China's Economic Growth and Carbon Emissions

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Abstract. Global CO2 emissions are on the rise, thus governments are increasingly concerned about carbon emissions. As the trend of China's carbon emissions is also changing, previous studies have looked for factors affecting carbon emissions, including energy and economy, etc. This paper uses the Environmental Kuznets Curve (EKC) theory to have a descriptive statistical analysis of carbon emissions and related economic indicators in mainland China. In the period that follows, China's energy demand potential is huge, but it also faces a severe CO_2 emission reduction challenge. Improving energy efficiency and optimizing energy mix are effective solutions to China's carbon emission problem. China still has a long way to go in industrializing its economy and strengthening the structural transformation of the service sector, characterized by rapid development and huge energy demand. This study will help us to understand the evolution of carbon emissions in China and provide guidance for future carbon emission management and mitigation. Further research and actions to improve energy efficiency, adjust industrial structure and promote clean energy development are important for reducing China's carbon emissions.

Keywords: Carbon Emissions, GDP, Environment Kuznet Curve (EKC), Clean Energy.

1. Introduction

1.1. Research Background

Today, carbon dioxide emissions continue to rise to levels not seen in the past 20 million years, extreme weather events are more frequent and severe, ecosystems are damaged, sea levels are rising, and as warming intensifies, harm is increasing. Therefore, it is imperative to reduce carbon dioxide emissions and limit global temperature rise.

Faced with the challenge of rising temperatures in the Earth's atmosphere and increasing climate instability, the international community is working to mitigate the effects of global warming. Both developed and developing countries are striving to build a low-carbon economy by setting clearly targeted policies and taking effective measures to reduce the growth of greenhouse gas emissions.

1.2. Research Significance

The problem of climate change boils down to economics. Economic growth cannot be achieved without energy use, and the continued burning of fossil fuels is the main driver of increasing carbon dioxide emissions. Over the past two decades, China has experienced impressive economic growth, but it has also been accompanied by significant environmental consequences, including greenhouse gas emissions. China's energy structure is dominated by coal, which accounts for more than 80% of fossil fuel consumption. China's economy is also dominated by heavy industry, which has strong dependence on fossil energy, low energy utilization efficiency, carbon locking effect in many infrastructure facilities, and low energy efficiency in China's manufacturing industry further aggravates the level of carbon dioxide emissions. According to the International Energy Agency, China's share of global carbon emissions will reach 33 percent by 2035. The commitment to achieving carbon neutrality while maintaining economic and social development is a huge challenge for China.

In addition, the drivers that influence energy-related CO2 emissions are diverse and their importance varies widely across regions. Different economic development stages, development models and energy utilization models have different endogenous effects on carbon emissions and intensity. In this research, China is selected as the research object to explore China's carbon emissions,

investigate the main possible factors and their influencing mechanisms, and provide new information for other regions to develop and adjust more effective strategies to control the growth of energy-related CO2 emissions.

2. Literature Review

2.1. Energy Consumption, Economic Growth and Carbon Emissions

In the process of industrial and economic development, the use of energy has a certain externality, according to relevant data, in the global energy consumption, only less than 1/5 is not the consumption of fossil energy (ZHAO X R,2016) [1]. In recent decades, growing concerns about environmental issues have prompted countries to adopt policy measures. Many studies have analyzed the energy-growth-carbon emissions relationship in China.

To better understand the logical chain between energy utilization and the promotion of economic development, the literature typically uses three assumptions to The logical transmission chain between energy use and GDP. The first hypothesis, known as the "conservation hypothesis," is that GDP growth leads to an increase in energy use. Kraft (1978), one of the pioneers in this field, used Granger causality to support this hypothesis [2]. Based on panel data composed of real data from 30 provinces, autonomous regions and municipalities in China, Bin Xu (2019) found that the impact of more advanced energy development on emissions and economic growth varies significantly across time and space[3]. The second hypothesis is the "growth hypothesis", which is supported by Sari (2013) et al. [4]. Bowden and Payne (2009) adopted a multivariate framework to conducting further research and found that GDP and energy growth have a snowballing mutual promotion relationship [5]. The third view, the feedback hypothesis, makes a deep analysis of the factors influencing each other in GDP and energy growth. Stern (1993) supports this hypothesis by using the autoregression vector method combined with control variables [6]. The fourth view is the neutral hypothesis, as Ward (2016) compared the data predicted by the model with the past data. He said that GDP and the increase in energy use have a fixed relationship, and the replacement of clean energy by non-clean energy may even mean an increase in energy consumption in general [7]. Kourtzidis(2018) used the asymmetric threshold coordination method. He used Granger causality test to support the neutral hypothesis of the sector taking the United States as an example [8].

The origin of Environmental Kuznets curve (EKC) analysis was found by Grossman and Krueger's (1992). They study on a series of related provisions on the concentration of substances that may have a negative impact on the atmospheric environment [9]. They argue that economic expansion does not necessarily lead to greater environmental harm, and that increased trade may be beneficial to the environmental sector, which can offset the impact of economic growth on pollution. Their research shows that sulfur dioxide and dark matter concentrations increase with per capita income, but decrease at higher levels. Although many studies have attempted to test the EKC hypothesis, the current literature has not established a universal EKC curve due to the influence of data, indicator selection, analytical methods, and other independent variables.

2.2. Driving Factors of Carbon Emission

There are many factors affecting CO_2 emission, However, scholars from various countries have different opinions on the factors affecting CO_2 emissions. Lin and Liu (2015) propose that Rising income levels are the main reason for the increase in CO2 emissions. However, they further note that the importance of this factor is diminishing Due to the reduction of losses in energy utilization and the adjustment of more green and environmental protection of industrial layout [10].

2.3. Research Content

This research makes a descriptive analysis of China's carbon emission: Through statistical analysis, data on China's carbon emissions are described. By examining factors such as industrial upgrading

and energy structure transformation, writer will explore the changing trend, and conduct in-depth research, including sectoral demand structure and energy supply.

3. Evolution Law of Carbon Emission and Economic Growth in China

3.1. Analysis of data on China's carbon emissions

In order to cope with the ecological deterioration caused by global warming, carbon dioxide emissions must be reduced. Globally, total carbon dioxide emissions have continued to increase in recent decades, almost tripling. At the same time, China's carbon emissions have been rising as it has developed in recent decades, as shown in Fig.1, and the energy-related CO2 emissions have grown significantly due to expanding energy demand and a higher carbon-content energy mix. However, it needs to be clear that the growth trend of China's total carbon emissions is still accelerating, and the task of achieving the peak carbon emissions by 2030 is very difficult. As can be seen from Fig.2, although China's per capita carbon emissions continue to rise, they have slowed down in recent years, including the carbon emission intensity in Fig.3, which also shows that China's carbon use efficiency is actually increasing, and a series of emission reduction policies and industrial transformation plans adopted by China have also played a certain role. However, overall, China's total greenhouse gas emissions are still in the growth stage, and there is no turning point. (The data in the following pictures are from the relevant indicators on the official website of the World Bank.)

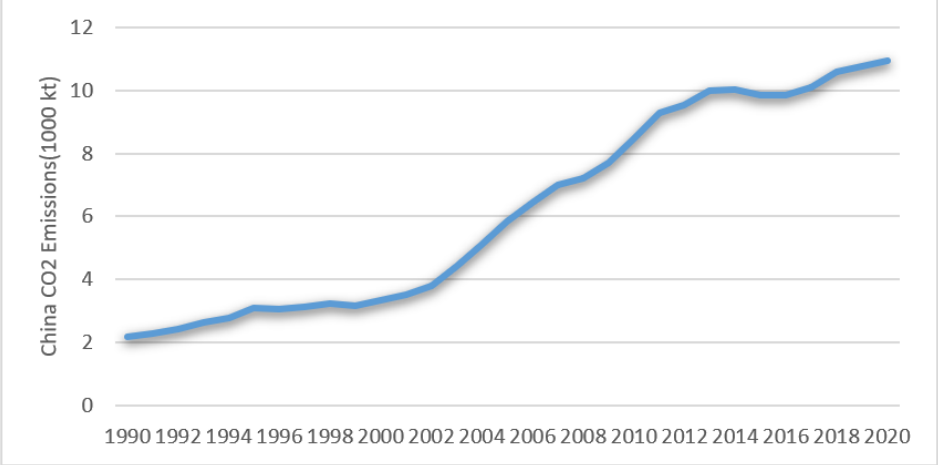

Figure 1. China CO2 Emissions

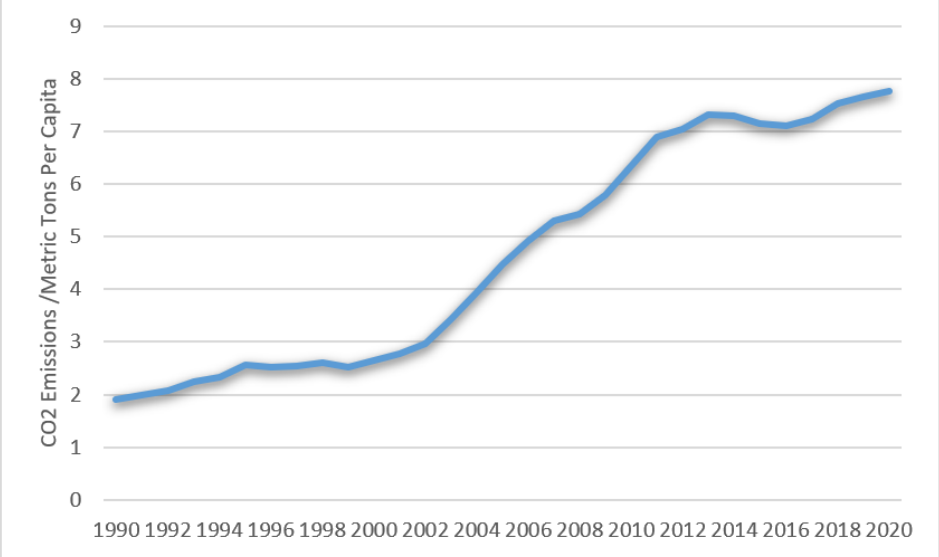

Figure 2. CO2 Emissions (Metric Tons Per Capita) – China

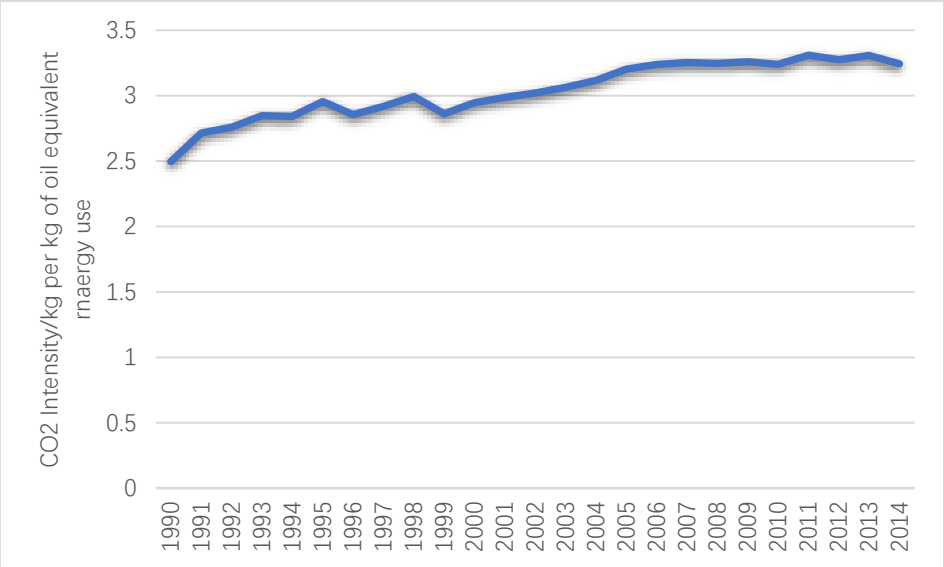

Figure 3. CO2 Intensity – China

3.2. Sectoral Structure Analysis of China's Carbon Emission Demand

China's carbon sector structure is changing. The share of the transportation sector continues to increase, while the share of industrial manufacturing and public services is declining.

The ratio of value added in China's manufacturing and construction sectors to GDP and that in the residential, commercial and public services sectors is rising. This reflects the proportion of manufacturing will decline, and the service sector will gain a more influential position in the future, resulting in a significant structural emission reduction effect. At the same time, demand-side induced carbon emissions will also increase, because the reduction of people's poverty and the process of moving towards a well-off life will lead to increased demand for all kinds of appliances, air conditioners and cars. In the process, it can be expected that China's power and heat sector will continue to be a major source of carbon emissions for a considerable period of time. As can be clearly seen from Fig.4, the trend of carbon emissions in the power and heat sector is still very steep.

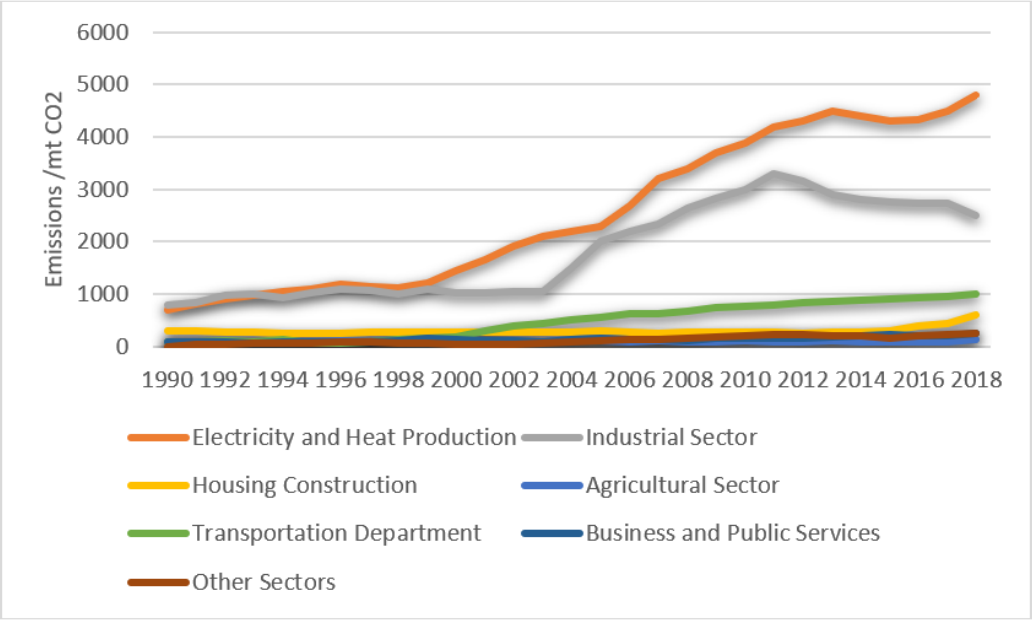

Figure 4. China's Carbon Emissions by Sector

The transportation industry is developing rapidly in China, and Driven by the trend of China's primary and secondary industries gradually shifting to high-tech industries and services and the effective promotion of e-commerce, its scale continues to expand. The transport and services sectors

will also have a strong carbon growth effect. China's carbon emissions from the transport sector have been growing rapidly since 2002, and since then economic growth and industrialization have been greatly stimulated. Between 2000 and 2018, the length of roads increased from 1,679,800 km to 5,012,500 km, rose 5.9 percent/year on average. While China's demand for automotive products has increased significantly since 2002.

In the future, the transportation industry will experience a large-scale expansion. Assuming that the number of cars per 1,000 people in China reaches 400 in the future, there is still about 230 room for growth. In the process, without effective policy intervention, the expansion of China's transport sector will poses a greater challenge to the cause of environmental protection. Therefore, how to make revolutionary efforts to promote environmental protection in the transportation sector is crucial to China's economy.

3.3. Analysis of Energy, Power and Economy in China

Energy plays a key role in a country's process of increasing productivity levels, and energy use and production reflect a country's comprehensive strength. In the future, countries will face major challenges in achieving sustainable energy development, and mitigating climate change.

As a widely used form of energy, electricity reflects the difference of energy supply structure. Fig.5 shows the change of energy supply structure over time. This share of coal-fired power generation in China has increased rapidly since the 1980s, reaching a five-year average of 80 percent between 2005 and 2009, before gradually declining during the 2013-2018 period and now stands at 5665.5 billion KWH, nearly 65 percent.

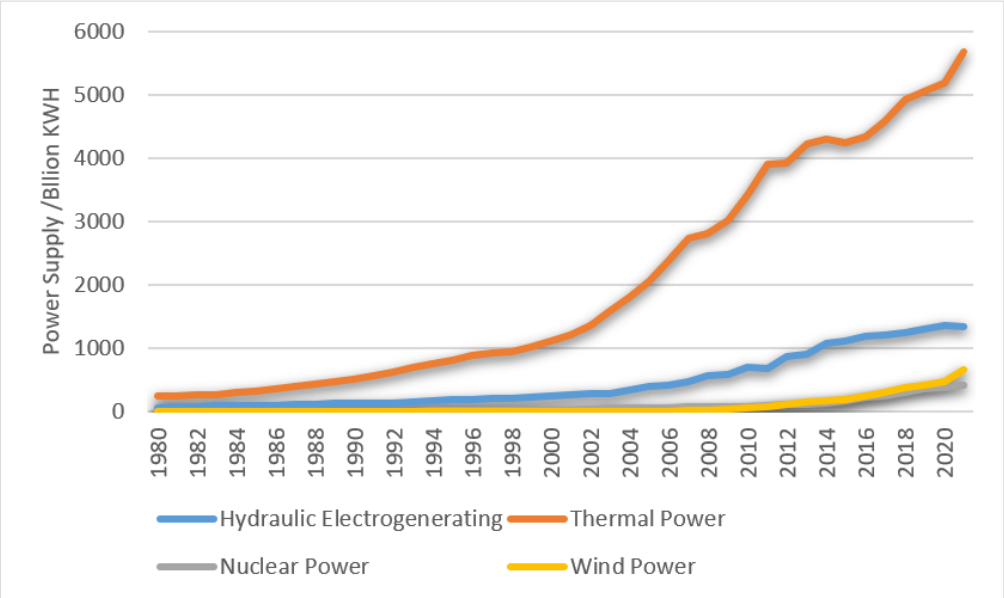

Figure 5. Power Supply Structure - China

China attaches great importance to the development of renewable energy. Although China has adopted the traditional centralized power supply model, which mainly relies on coal for power generation and transmission through the high-voltage grid, improving the energy consumption structure is an effective way to reduce dependence on fossil energy and reduce carbon dioxide emissions. China's share of oil and natural gas continues to decline, while the share of coal is relatively stable, despite a slight downward trend in recent years, but is still the main source of energy, showing the high carbonization characteristics of fossil fuels. Although non-fossil energy alternatives to fossil energy still face challenges, China is committed to promoting the development of renewable energy. Although this system of energy consumption, which relies on fossil fuels in general, will be a long process if it needs to change China insists on maintaining the downward trend and actively promotes the development of a low-carbon economy to contribute to further reducing carbon dioxide emissions.

China's electricity consumption surpassed that of the United States in 2011 to become the world's largest consumer. Since 2005, China's electricity consumption has reached 6880.1TWh and is still growing. However, from a per capita perspective, indicators related to per capita carbon emissions start from a low point, but continue to grow.

China's electricity consumption structure also has unique characteristics. Per capita consumption is influenced by a number of factors, including geographical climate, housing size, per capita income, household appliances, residential infrastructure and unit electricity prices. Although China's per capita income and per capita housing space are expected to continue to grow, based on China's relatively high population density, the population's energy consumption compared with that of developed countries in the world, there is still a huge gap to be closed. If this level is reached, the world will face a huge energy supply gap, which will pose a certain challenge for China to achieve the peak carbon emissions. At the same time, China relies heavily on coal reserves and needs to actively seek alternative energy sources, such as renewable energy, to reduce the burden of electricity consumption.

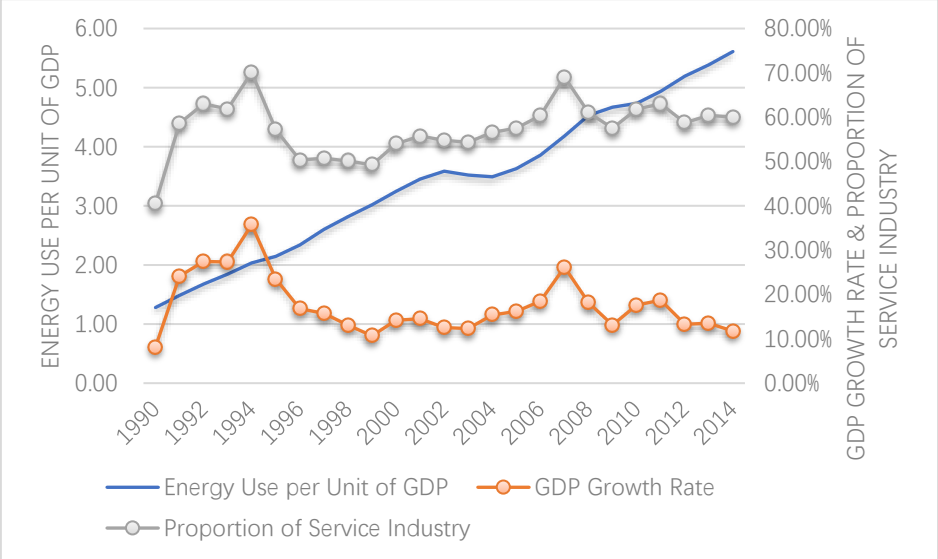

Figure 6. Energy Use per Unit of GDP

The proportion of coal power in China remained stable, while this output decreased due to the economic structural transformation, the increase in the proportion of the service industry, and the economic growth faster than the increase in carbon emissions.

4. Conclusion

Through this research, from the perspective of industrial upgrading and energy structure transformation, this research makes a comprehensive discussion on the changing trend. Writer consider both carbon efficiency and carbon emissions, and highlight the link between differences in emissions efficiency and economic value. Here are our key findings:

Taking China as the research object, both the per capita GDP level and the carbon emission level are showing an increasing trend rather than a possible peak. At present, no turning point has been observed.

China's energy mix has long relied heavily on high-carbon energy sources, especially coal. In the meanwhile, China's per capita energy demand is relatively low, which means that China's energy demand potential is huge in the future, but it also faces severe CO_2 emission reduction challenges.

To achieve peak carbon and control carbon emissions, China needs to adopt two main models: improving energy efficiency and optimizing the energy mix.

In China's, the proportion of coal has remained high for a long time, while the proportion of oil and natural gas is relatively small. With the progress of technology, the role of fossil fuels in China's

energy consumption will gradually be replaced by clean and renewable energy sources, even if it is not a short-term process.

Although developed countries have certain advantages in the exploration and green energy, their sources are still struggling to dominate China's energy consumption, such as less than 10% in Japan and 13% to 14% in the United States. Therefore, increasing the proportion of non-carbon energy in China remains a challenge.

In response to China's CO2 emissions problem, it is important to adjust the industrial structure to reduce excessive reliance on fossil energy, especially coal consumption. Replacing traditional high-emission energy sources with renewable energy sources is key to achieving this goal. The drivers of carbon emissions vary across countries, so energy consumption and mitigation strategies need to be adjusted accordingly. In order to achieve an effective reduction in carbon emissions, China also needs to consider the future adjustment of energy consumption structure, reduce reliance on coal for industrial and domestic consumption.

However, although many influencing factors have been considered in this research, there are some limitations. The availability of data limits the full consideration of factors such as industrial structure and policy coherence. In addition, this research focuses only on energy-related CO2 emissions and does not consider other sources of emissions from industrial processes. Further research should expand the range of CO2 emissions and explore the relationships between the various factors. Only through comprehensive analysis and a systematic approach can the problem of carbon emissions be better understood and addressed.

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