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Decoupling Relationship between Economic Growth and Carbon Emissions in China and OECD Countries

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Abstract: This paper compares the development course of economic growth and carbon emissions between China and OECD countries, and analyzes their decoupling relationship. The results show that China has become the world's largest carbon emitter and the second largest economy, and its carbon emission intensity is significantly higher. Most of China's provinces are in weak decoupling state, while most OECD countries have achieved strong decoupling. Hence, China's decoupling process lags behind OECD countries.

Keywords: Economic growth, Carbon emissions, Decoupling relationship

INTRODUCTION

Energy is an important input element of human economic activities. While promoting economic growth, it also produces a large number of carbon emissions, resulting in a general rise in global temperature. Under this backdrop, China has proposed the goal of "carbon peak by 2030 and carbon neutral by 2060", demonstrating China's determination to pursue low-carbon development [Tapio, 2005]. However, in order to achieve the carbon target and maintain sustainable economic growth, it is necessary to clarify the decoupling relationship between economic growth and carbon emissions.

THE DEVELOPMENT OF ECONOMIC GROWTH AND CARBON EMISSIONS

GDP, energy consumption, carbon emissions and population data of China and 17 OECD countries from 1965 to 2019 are selected, GDP (2010 constant price USD) and population data are obtained from world bank statistics database, energy consumption and carbon emissions are derived from the BP World Energy Statistical Yearbook (2020).

Comparative analysis of GDP

The comparison of GDP is shown in Figure 1. It can be seen that China's GDP achieved rapid growth, surpassing Japan for the first time in 2009 and become the world's second largest economy [Dong, et. al., 2016]. Before the reform and opening up, China's economy grew slowly with an average annual GDP growth rate of around 3% [Wang, *et. al.*, 2019]. And then, China's economy took off and maintained sustained and rapid growth with rapid economic expansion. From 1978 to 2012, China's GDP grew at an average annual rate of around 10%, known as the "miracle of the world". From 2012 to 2019, the growth rate slowed slightly, averaging around 7%.

Comparative analysis of carbon emissions

The comparison of carbon emissions is shown in Figure 2. It can be seen that in 1995, China's total carbon emissions were only 488.53 million tons, with a slow growth before 2000 and a rapid growth after 2000, which increased to 9825.8 million tons in 2019. In 2004, it overtook the United States to become the world's largest carbon emitter. China's carbon emissions growth curve is similar to GDP growth curve, they both showed rapid growth after 2000. China's carbon emissions and economic growth are closely linked. how to coordinate the relationship between economic growth and carbon emissions, is the key to solving the current dilemma of climate change.

Comparative analysis of carbon emission intensity

The comparison of carbon emission intensity is shown in Figure 3, China's carbon emissions intensity is significantly higher than 17 other OECD countries, it is related to China's low energy efficiency and coal-based energy consumption structure. In 1995, China's carbon emission intensity was 3.64 kg /USD, which was in an increasing trend before 1978. After peaking in 1978, it gradually decreased to 0.8516 kg/USD in 2019. This is the result of industrial structure optimization, energy structure optimization and clean energy utilization technologies development.

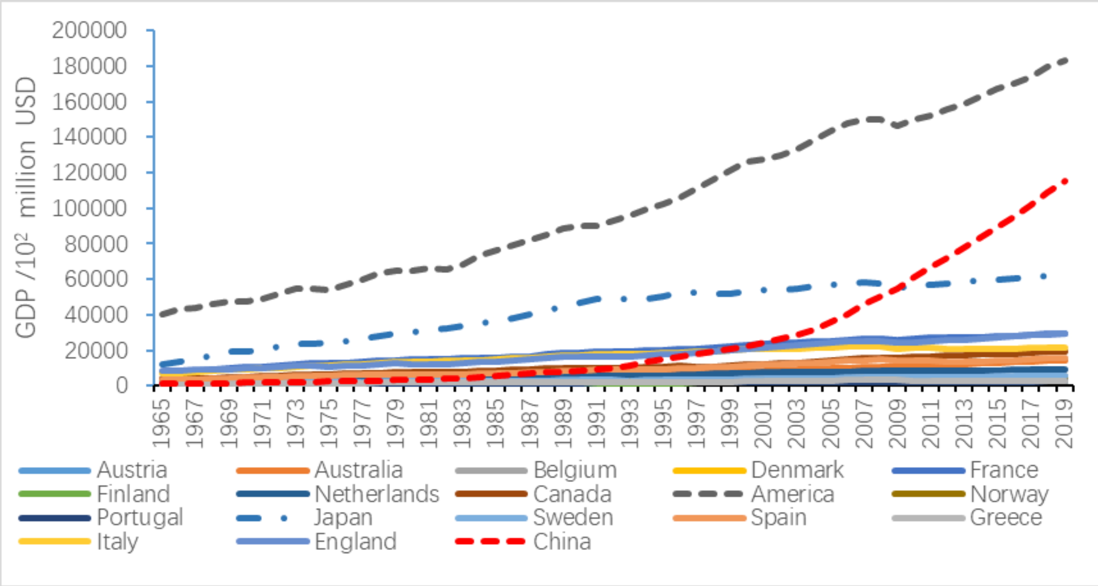

Figure 1 Comparison of GDP

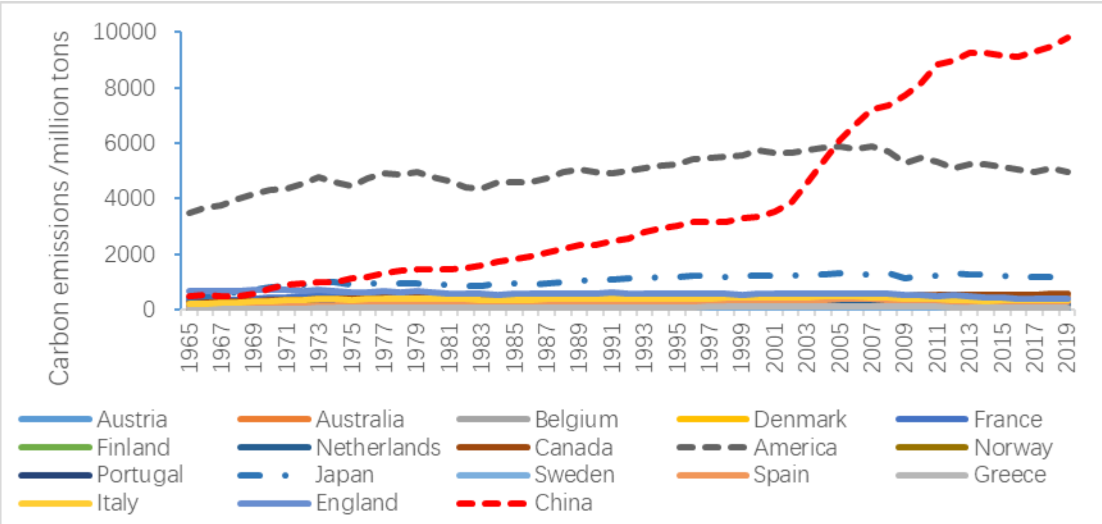

Figure 2 Comparison of carbon emissions

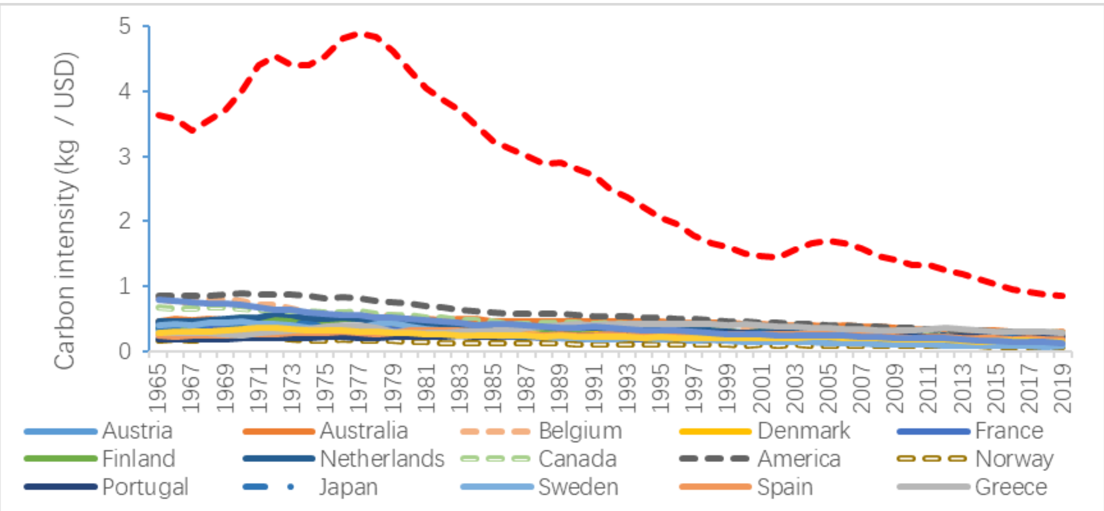

Figure 3 Comparison of carbon emission intensity

Comparative analysis of carbon emission intensity

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DECOUPLING ANALYSIS OF ECONOMIC GROWTH AND CARBON EMISSIONS

In 2002, the organization of Economic Cooperation and Development (OECD) proposed the decoupling theory, which is used to describe the relationship between the state of environmental pressure and the change of economic driving force. The decoupling factor D_f can be expressed as:

$$D_f = 1 - \frac{(EP/DF)_t}{(EP/DF)_0} \qquad (1)$$

Where , EP represents environmental pressure, and DF is Driving Factors.

However, OECD decoupling indicators are very sensitive to the selection of base periods, and the selection of different base periods will lead to great differences in calculation results . When studying the relationship between European transport industry and carbon emissions from 1970 to 2001, Tapio (2005) constructed the decoupling elasticity coefficient , which can be expressed as:

$$D_f = \frac{\Delta EP/EP}{\Delta DF/DF} \qquad (2)$$

The Tapio decoupling elasticity coefficient can avoid the defect that OECD decoupling index. This section analyzes the decoupling relationship between economic growth and carbon emissions in China and OECD countries. The Tapio decoupling elasticity is calculated by the formula

$$t_{C-G} = \frac{\Delta C/C}{\Delta GDP/GDP} \qquad (3)$$

t_{C-G} is the decoupling elasticity index of carbon emission and economic development, C is the total amount of carbon dioxide emission, △C is the change of environmental pressure index , △GDP is the change of GDP .

The Tapio decoupling elasticity consists of six levels, as shown in Figure 4.

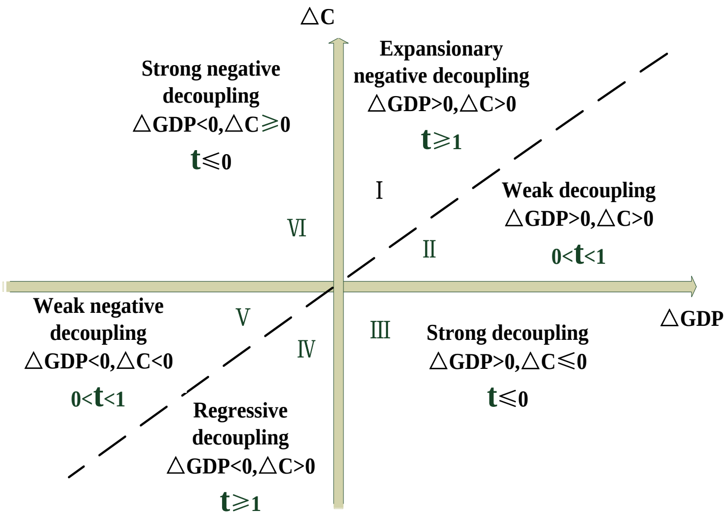

Figure 4 Decoupling analysis model of carbon emissions and economic growth

Decoupling analysis of economic growth and carbon emissions in China

GDP and carbon emission data of 30 provinces, autonomous regions and municipalities in China (data of Xizang is missing) from 1995 to 2017 are selected to calculate the decoupling coefficient in two stages 1995- 2006 and 2007 - 2017. The results are shown in Table 1.

It can be seen that, from 1995 to 2006, the decoupling elasticity coefficient of Xinjiang is t≥1 , belongs to expansionary negative decoupling, which is located in region I in Figure 4, although GDP and carbon emissions both grow, carbon emissions increase faster than GDP. The decoupling elasticity coefficient of other provinces is 0≤ t ≤1, which belongs to weak decoupling and is located in region II, although GDP and carbon emissions grow, GDP increases faster than carbon emissions. From 2007 to 2017, the decoupling elasticity coefficient of Xinjiang and Shanxi is t≥1, which belongs to expansionary negative decoupling and is located in region I. The decoupling elasticity coefficient of Beijing and Sichuan is t≤0, belongs to strong decoupling and is located in Region III, GDP increases while carbon emissions decrease.The decoupling elasticity coefficient of other provinces is

0≤ t ≤1, which belongs to weak decoupling and is located in region II in Figure 4.

Table 1 Decoupling state of China

province	1995-2006	2007-2017	province	1995-2006	2007-2017
Beijing	II	III	Henan	II	II
Tianjin	II	II	Hubei	II	II
Hebei	II	II	Hunan	II	II
Shanxi	II	I	Guangdong	II	II
Neimenggu	II	II	Guangxi	II	II
Liaoning	II	II	Hainan	II	II
Jilin	II	II	Chongqing	II	II
Heilongjiang	II	II	Sichuan	II	III
Shanghai	II	II	Guizhou	II	II
Jiangsu	II	II	Yunnan	II	II
Zhejiang	II	II	Shanxi	II	II
Anhui	II	II	Gansu	II	II
Fujian	II	II	Qinghai	II	II
Jiangxi	II	II	Ningxia	II	II
Shandong	II	II	Xinjiang	I	I

Decoupling analysis of economic growth and carbon emissions in OECD countries

GDP and carbon emission data of 17 OECD countries from 1965 to 2019 is selected to calculate the decoupling coefficient in five stages: 1965-1974, 1975-1984, 1985-1994, 1995-2004 and 2005-2019. The results are shown in Table 2.

Table 2 Decoupling coefficients of OECD countries

country	1965-1974	1975-1984	1985-1994	1995-2004	2004-2014	2014-2019
Austria	II	III	II	II	III	II
Australia	I	II	II	II	II	II
Belgium	II	III	II	II	III	II
Denmark	II	III	II	III	III	III
France	II	III	III	II	III	III
Finland	I	II	I	II	III	III
Netherland	I	III	II	II	III	III
Canada	II	II	II	II	II	II
America	II	II	II	II	III	III
Norway	I	II	II	II	III	III
Portugal	I	II	I	II	IV	III
Japan	I	II	II	II	III	III
Sweden	II	III	III	II	III	III
Spain	I	I	II	I	III	III
Greece	I	II	I	II	IV	III
Italy	I	III	II	II	IV	III
England	III	III	III	II	III	III

As shown in Table 2, from 1965 to 2019, Britain was basically in the state of strong decoupling, with GDP increasing and carbon emissions decreasing. Austria, Belgium and Canada are basically in the state of weak decoupling, with GDP growing faster than carbon emissions. Australia has achieved the transformation from expansionary negative decoupling to weak decoupling. Denmark, France, America and Sweden achieved the transition from weak decoupling to strong decoupling; Finland, Netherlands, Norway, Portugal, Japan, Spain, Greece and Italy achieved the transition from expansionary negative decoupling, weak decoupling to strong decoupling.

CONCLUSION

The decoupling relationship between economic growth and carbon emissions is analyzed, and we found that Xinjiang and Shanxi are in expansionary negative decoupling state, Beijing and Sichuan have achieved strong decoupling, and other provinces are in weak decoupling state. Among the 17 OECD countries, all but Austria, Belgium, Canada and Australia have achieved strong decoupling. Hence, in the decoupling process, China lags behind OECD countries, and China can achieve strong decoupling by learning advanced experience of OECD.

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