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An analysis of the driving forces of energy-related carbon dioxide emissions in China's industrial sector

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ABSTRACT

Both energy consumption and the growth of carbon dioxide (CO_2) emissions in China are attributed to the industrial sector. Energy conservation and CO_2 emissions reduction in China's industrial sector is decisive for achieving a low-carbon transition. We analyze the change of energy-related CO_2 emissions in China's industrial sector from 1991 to 2010 based on the Logarithmic Mean Divisia Index (LMDI) method. Results indicate that industrial activity is the major factor that contributes to the increase of industrial CO_2 emissions while energy intensity is the major contributor to the decrease of CO_2 emissions. Industry size shows a varying trend interchanging intervals of growth along the study period. Moreover, both energy mix and carbon intensity of energy use have negative effects on the increase of CO_2 emissions. The cointegration method is adopted to further explore determinants of CO_2 emissions in China's industrial sector. Results show that there exists a long-run relationship between industrial CO_2 emissions and affecting factors such as CO_2 emissions per unit of energy consumption, industrial value added, labor productivity and fossil fuel consumption. China's industrial CO_2 emissions are mainly attributed to the coal-dominated energy structure. Policy suggestions are thus provided to reduce industrial CO_2 emissions in China.

Contents

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1. Introduction

1.1. Research background

The massive fossil fuel consumption promoted by the rapid process of urbanization and industrialization has led to the serious problem of CO_2 emissions in China. For example, Chinese economy has kept an average annual growth rate of about 10% since the year 1978. The average annual growth rates of the primary energy consumption and electricity consumption were 6% and 9.2% [1], respectively. Notably, the growth rate of fossil-fuel CO_2 emissions was consistent with the growth rate of the primary energy consumption [2]. Carbon dioxide emissions in China were highly associated with the industrial structure, energy structure and energy efficiency. Apparently, China's economy was dominated by the industrial sector. The average proportion of industrial value added (IVA) in the gross domestic product (GDP) was 40.2% during 1978–2012. Meanwhile, both China's energy structure and electricity structure were dominated by coal, the shares of which were about 70% and 80%, respectively. Although energy intensity in China decreased from 362.60 tons of coal equivalent (tce) per hundred thousand USDs to 94.37 tce per hundred thousand USDs during 1978–2012 (at constant prices in 2000) [3], the efficiency of energy use in China was still relatively low compared to those in other developed economies.

In November 2009, the Chinese government proposed that carbon dioxide emission per unit of GDP (carbon intensity) would be decreased by 40% to 45% in 2020 compared to the year 2005 [4]. In 2010, both energy intensity target and carbon intensity target were included in the12th Five-Year Plan (2011–2015) for National Economic and Social Development, which regulated that in 2015, energy consumption per unit of GDP (energy intensity) would be decreased by 16% and the carbon dioxide emissions per unit of GDP would be decreased by 17% compared to the year 2010. Needless to say, the industrial sector plays an important role in China's energy conservation and emissions reduction. According to the regulation of industrial energy conservation during the 12th Five-Year Plan period (2011–2015), energy consumption per unit of value added in industrial enterprises above designated size (enterprises with the annual sales revenue over 806 thousand USDs) would be decreased by 21% in 2015 compared to the year 2010, and the expected amount of energy conservation would be 670 million tons of coal equivalent (Mtce) during 2011–2015. In addition, the Chinese government also proposed targets of energy consumption per unit of value added in energy-intensive industrial sub-sectors such as iron and steel industry (ISI), nonferrous metals industry (NMI), petroleum processing and coking industry (PPCI), chemical industry (CI), building materials industry (BMI), etc.

Industrialization is currently the major character of economic growth and energy consumption growth in China. During 1985 to 2011, energy consumption in the industrial sector accounted for about 70.3% of the national energy consumption. The proportion has shown an increasing trend over the last few years. On the contrary, the share of industrial value added (IVA) in GDP revealed a decreasing trend. In the year 2011, value added of the industrial sector was 2918.03 billion USDs, accounting for 39.8% of the national GDP; however, industrial energy consumption amounted to 2464.4 Mtce, accounting for 70.8% of China's total energy consumption, and industrial electricity consumption reached 3470.7 billion kW h, accounting for 73.8% of China's total electricity consumption [1]. It can be seen that the industrial sector in China is prominently energy-intensive. Energy conservation and emissions reduction in the industrial sector is the key to China's emissions reduction and the achievement of low-carbon transition.

1.2. Overview of China's industrial sector

China's economic growth is dominated by the industrial sector at the industrialization stage. The importance of industrial sector derives from the fact that the sectoral employment accounts for 30% of China's total employment, and that industrial value added accounts for nearly 40% of GDP, etc. China's industrial sector has developed rapidly over the past three decades, which was mainly driven by the accelerating speed of industrialization and urbanization. The industrial value added (IVA) increased from 92.28 billion USDs in 1985 to 1531.80 billion USDs in 2010 (at constant prices in 1990) [5].

The importance of industrial sector also highlighted by its role in providing raw materials for meeting the massive infrastructure needs during urbanization process. As one of the most energy-intensive sub-sectors of industry, iron and steel industry of China (ISI) produced 683.9 million tons of crude steel in 2011 (about 6.4 times as much as that of Japan, and 7.9 times as much as that of the United States), which ranked first in the world and accounted for 45.1% of the world's total production. Take the cement industry for another example. Cement production of China was 2058 million tons in 2011 (increased by 10.6% compared to the year 2010), and ranked first in the world, which was about 9.3 times as much as that of India, 31 times that of the United States and 37 times that of Japan.

Similar to the rapid growth in value added and output, energy consumption of China's industrial sector also increased significantly, which grew from 714.13 Mtce (million tons of coal equivalent) in 1991 to 2320.2 Mtce in 2011 [1]. Industrial final energy use, a common indicator for tracking industrial energy consumption, grew from 505.29 Mtce to 1478.12 Mtce in China during 1991–2011, of which the average annual growth rate was 5.9%. The average annual growth rate of CO_2 emissions from industrial final energy use was 5.4%. Specifically, CO_2 emissions from industrial final energy use increased from 1185.40 Mt to 3134.92 Mt during the same period, which is equivalent for an increase of 164.5%. Industrial processes including cement and limestone manufacture also contribute to CO_2 emissions of China's industrial sector. Due to the massive infrastructure construction, China's cement production increased rapidly from 248.32 Mt in 1991 to 1881.91 Mt in 2010, and the corresponding CO_2 emissions from cement production grew from 130.86 Mt to 991.76 Mt as a result (see Fig. 1).

From the perspective of carbon dioxide emissions from industrial final energy use, CO_2 emissions was driven up by 5.4% when industrial final energy consumption increased by 4.9%. However, a decrease in industrial final energy use occurred during the "stagnancy" period of 1998–2001 and consequently there was a subsequent reduction in the corresponding CO_2 emissions. The phenomenon was mainly because of the ownership restructuring in Chinese state industry. Numerous small-and medium-sized state-owned enterprises were converted into shareholding companies with mixed public and private ownership, which were sold, leased, merged or just allowed to go bankrupt. The growth of