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Promoting carbon emissions reduction in China's chemical process industry

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ABSTRACT

The chemical process industry is the second largest carbon-emitting sector in China. Therefore, it is extremely urgent and crucial to explore how to reduce carbon emissions in the sector. This paper employs the co-integration method and scenario analysis to investigate how to reduce carbon emissions in the sector. The granger causality test is conducted and the result indicates that all the variables except lnPare granger-causes lnCE. Moreover, comparing the JJ (Johansen-Juselius) co-integration with the EG (Engle-Granger) co-integration based on the squared residual, the fitting effect and the prediction effect, we find that the EG co-integration method is better. Furthermore, we adopt the EG co-integration and scenario analysis and find that the emission reduction potential of the sector will be 63.9 Mt in 2015 and 180 Mt in 2020 under the middle scenario; and 121.4 Mt in 2015 and 327.9 Mt in 2020 under the advanced scenario. Finally, the paper provides some policy implication.

1. Introduction

China has become the second largest economy in the world. Based on *China Statistical Yearbook*, the real GDP (gross domestic product) of China grew at an average annual rate of 9.3 percent from 1980 to 2011 and 7.8 percent in the first half of 2012. To support its economic development, China has consumed large amount of fossil fuel in the past 30 years. The average annual growth rate of fossil fuel consumption was 5.5 percent. According to the IEA (International Energy Agency), China is now the world's second largest oil consumer following the United States and the largest global energy consumer. The more energy is consumed, the more CO_2 is emitted.

According to IEA statistics, China has become the world's largest CO_2 emitter after surpassing the United States in 2007. As the largest developing country, China is still in the process of industrialization and urbanization and its energy demand is rigid. It is difficult to change the country's coal-dominated energy structure which means that CO_2 emissions in China will rise further with sustained economic growth and increased energy consumption. Furthermore, carbon emissions of the industrial sectors account for 90% of the overall carbon emissions. Therefore, it is extremely urgent and important to study the carbon emissions reduction in industrial sectors. This paper mainly analyzes the carbon emissions reduction in China's chemical industry.

Broadly speaking, the chemical process industry uses chemical process to produce chemical products. There are three ways to categorize the chemical process industry. Based on statistical method, the chemical process industry is composed of chemical raw materials and chemical products industry, pharmaceutical manufacturing industry, rubber products industry, plastic products industry and chemical fiber manufacturing industry. Unfortunately, China integrated the chemical fiber manufacturing industry into the textile industry before 1986, thereby making it very difficult to separate the data of chemical fiber manufacturing industry. To make the data accurate, we dropped the chemical fiber manufacturing industry, which has little effect on our research. The total value of output in the chemical fiber manufacturing industry only accounted for 6.3% of that in chemical process industry [1].

In 1876, Vitriol Chamber plant was built in China, which marked the beginning of the chemical process industry. Since reform and opening up, the chemical process industry has rapidly developed. By the end of 2010, China has surpassed the U.S.A as a chemical giant [2].

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The chemical process industry is the second largest industrial sector and the enterprises designated size in the chemical process industry was 62,432. As can be seen in Fig. 1, the total gross output of the chemical process industry has grown rapidly since reform and opening up in 1978. Its average annual growth rate was 13.6% and after 2001, it was 31.2%.

The chemical process industry is the second largest carbon-emitting sector. As the chemical process industry develops, its carbon emissions grow substantially from 135.6 million tons to 644.8 million tons during 1980–2010, as shown in Fig. 2. The average annual growth rate was 5.3%. The total carbon emissions in China's chemical process industry are as much as the overall carbon emissions in Canada. Therefore, it is necessary to analyze the carbon emissions in the chemical process industry.

China has taken measures to reduce carbon emissions in the chemical process industry. In the past few years, advanced technology and equipments in chemical processing have been introduced in China, which contributes to reduction in CO_2 emissions. Meanwhile, the Chinese government has also announced some policies targets. Carbon emissions are required to be reduced by 17% in the 12th Five-Year Plan.

Economic models have been used to analyze carbon emission-related problems since 1970s. These models called the top-down models include the co-integration model, DEA (data envelopment analysis theory), Index decomposition, CGE (computable general equilibrium) and so on. In this paper, we briefly introduce the models.

First, traditional macro-economic methods are used to investigate energy issues. Aigner et al. [3] and Berglund et al. [4] placed Learning-by-Doing Model into energy system to analyze the effects of technological innovation on energy consumption. Moreover, Adriaan et al. [5] employed Endogenous Growth Model to study the change in technology. Furthermore, Lin et al. [6] adopted CGE to analyze the effect of removing China's fossil fuel subsidies.

Second, IOA (Input-Output Analysis) approach is adopted to analyze import-export embodied emissions, including a single-regional input–output model and a multi-regional input–output model. When it comes to the single-regional input–output model, Sanchez Choliz and Duate [7] employed it to estimate the emissions of Spain in international trade. Moreover, Lin et al. [8] analyzed the embodied carbon emissions of China's international trade based on the input–output table in 2005. Using the multi-regional input–output model, Chen et al. [9] quantitatively investigated the embodied energy in international trade in China from 2002 to 2006. Weber et al. [10] further applied it to examine the emissions of the trade between USA and its seven largest trading partners (Canada, China, Mexico, Japan, Germany, the UK, and Korea) and to estimate the environmental effects of US trade structure and volume variation over 1997–2004.

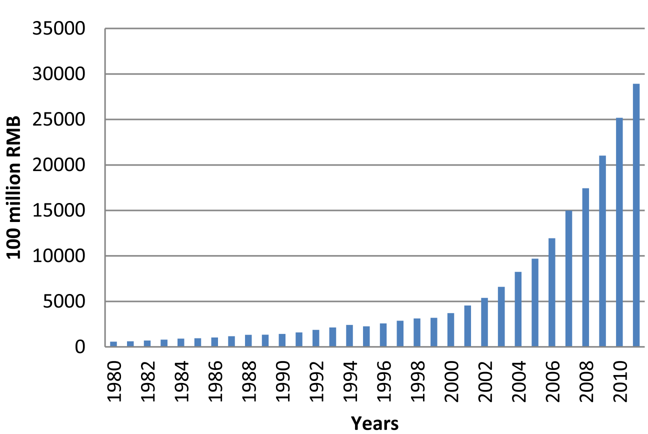

Fig. 1. The total value of output in chemical process industry (at the constant price of 1980).

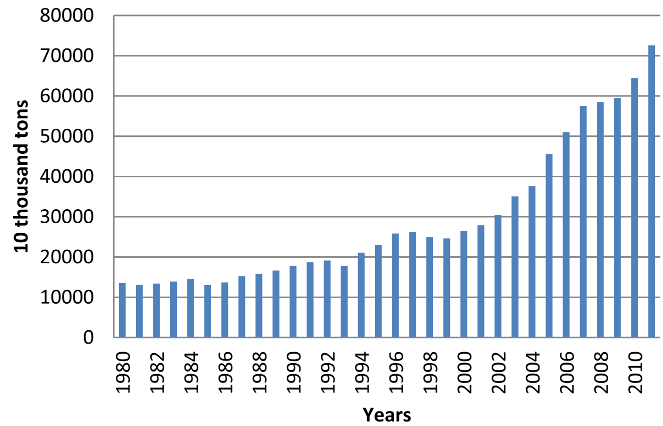

Fig. 2. Carbon emissions in chemical process industry.

Third, there are lots of approaches to evaluate energy saving potential. From an aspect of production efficiency, one method consists of DEA (data envelopment analysis theory), which was developed by Cooper et al. [11] and SFA (stochastic frontier analysis), which was introduced by Meeusen et al. [12]. Wang [13] used the DEA method to study the technology gap in China and Zou et al. [14] analyzed China's energy efficiency using the SFA model. Another method for studying energy efficiency is the LMDI (Logarithmic Mean Divisia Index), which was introduced from an aspect of partial factor efficiency by Sun et al. [15] and Ang [16–19] in 1970s. It does not produce a residual and could allow data to be zero and negative. In 2005, Ang [20] described all index decomposition analysis methods and concluded that the logarithmic mean Divisia index method is the best. Furthermore, conservation supply curve is another method used to analyze energy saving. Meier [21] firstly adopted it to analyze the potential of energy saving in California and Worrell [22–24] employed the CSC (Conservation Supply Curves) to investigate energy saving of the industrial sectors in the USA. The most popular method for examining energy conservation is the co-integration method. Applying the method, Galindo [25] predicted energy demand in Mexico, and Trkekul and Unakıtan [26] in Turkey; Kulshreshtha and Parikh [27] estimated coal demand in India; Park and Zhao [28] forecasted gasoline demand in the United States; Amarawickrama and Hunt [29] investigated electricity demand in Sri Lanka.

Considering the important role China plays in the international energy market and carbon emissions reductions, a number of researchers and analysts are increasingly interested in studying industrial energy or fossil-fuel-saving potential in China. The co-integration method has long been used to analyze energy demand and energy saving. In China, the main factor affecting electricity demand was economic growth and the relationship between them is 1:1. Xue and Wang [30] predicted petroleum demand in China. Lin et al. [31] estimated China's energy demand in the process of urbanization and industrialization.

Lin et al. (2011) [32] found that R&D, investment, labor, and structure effects, energy intensity are the determinants of energy conservation potential in China's steel industry. Using the co-integration approach, Lin, et al. [33] evaluated the electricity saving potential of China's chemical industry in 2020 and concluded that more active electricity saving policies are objectively required to reduce the electricity intensity of China's chemical industry and shrink future electricity saving potential. In terms