Renewable and Sustainable Energy Reviews 53 (2016) 1348–1355

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Emissions reduction in China's chemical industry – Based on LMDI

Boqiang Lin [a,*], Houyin Long [b]

[a] Collaborative Innovation Center for Energy Economics and Energy Policy, China Institute for Studies in Energy Policy, Xiamen University, Fujian, 361005, PR China
[b] State Grid Zhejiang Economic Research Institute, Zhejiang, 102209, PR China

ARTICLE INFO

Article history:
Received 3 November 2014
Received in revised form
25 May 2015
Accepted 18 September 2015
Available online 10 November 2015

Keywords:
LMDI
GHG emissions
Provincial panel data

ABSTRACT

China's chemical industry is the second largest industrial source of carbon emissions. This article employs the LMDI to explore the driving factors of carbon emissions changes in China's chemical industry utilizing time series data and provincial panel data. We find that output per worker, industrial economic scale, energy intensity and energy structure were the main factors that influenced carbon emissions changes in the chemical industry. Based on the time series, energy intensity and energy structure are conducive for decrease in carbon emissions, while output per worker and industrial economic scale were the aggravating drivers for carbon emissions increase. We further analyze the driving factors of carbon emissions in every province. Finally, we suggest some policy implications such as applying low-carbon equipment, improving energy structure, promoting energy efficiency, etc for reducing carbon emissions.

Contents

1. Introduction

Currently, carbon emissions have become an increasing subject of study. The index decomposition analysis (IDA) has been one of the most popular methods for studying energy and environmental issues [1]. It is composed of the Laspeyres index method and the Divisia index method. Because the Laspeyres index method has an excessive residual, it has seldom been used to study environmental issues since 1995. The divisia index method consists of

Abbreviations: LMDI, Logarithmic Mean Divisia Index; USA, United States of America; Mt, million tons; GHG, greenhouse gas; Mtce, million ton coal equivalent; GDP, gross domestic product; IDA, index decomposition analysis; AMDI, arithmetic mean divisia index; CI, carbon intensity effect; ES, energy structure effect; EI, energy intensity effect; OW, output per worker factor; IS, industry scale effect; IPCC, Intergovernmental Panel on Climate Change; IPAT model, Impact=Population*Affluence*Technology.

* Corresponding author.
E-mail addresses: bqlin@xmu.edu.cn, bqlin2004@vip.sina.com (B. Lin).

http://dx.doi.org/10.1016/j.rser.2015.09.045
1364-0321/

AMDI and LMDI [2]. LMDI was studied by Sun et al. [3] and Ang [4,5] after the world oil crisis in 1990s. LMDI substitutes a logarithmic average formula for the previous simple arithmetic average weight method. Its advantage is that it never produces a residual and allows data to take zero and negative value [6]. In 2005, Ang [7] summarized various index decomposition analysis methods and revealed that the LMDI method was the best. Therefore, this article employs LMDI to study the change in carbon emissions in the chemical industry.

Importantly, we provide an introduction for China's chemical industry. The issue of climate change and global warming has become a serious challenge for nations. Among the factors causing damage to the environment, carbon dioxide is estimated to contribute about 58.8% of emissions (World Bank 2007). Further in 2010, China, followed by USA, has been the largest carbon emitter in the world. These emissions were estimated at 8332.5 Mt and accounted for 25.1% of the world's total emissions(Gregg et al. [8]). With economic development, carbon emissions in China will further increase [35]. Presently, it has become increasingly important to limit and reduce GHG emissions in china.

China's energy structure has been coal-dominated for a long time and coal consumption accounts for approximately 70% of its primary energy source. Moreover, it is extremely difficult to change this situation in the short time. To effectively control carbon emissions in China, the government target to increase the proportion of non-fossil fuels in primary energy consumption by 15% in 2020 and reduce carbon intensity by 40–45% compared to 2005 levels, in medium-term and long-term national and social development planning. On December 1st, 2011, the Chinese government further clarified its goals to reduce the national energy intensity by 16% from 2010 level and reduce national total carbon dioxide emissions per unit GDP by 17% during the “12th Five-Year” period. At the same time, the government will accelerate the construction of the statistical accounting system of GHG emissions and carbon emissions trading market.

In the past 30 years, coal has increasingly been the main energy source in the chemical industry. This situation is quite difficult to reverse in a few years. The main reason is that no other resource is cheaper and abundant than coal. The increase in energy demand to sustain economic growth is a key factor that leads to the rise in carbon emissions. Furthermore, it is necessary that the amount of GHG from every industry and the variables affecting the GHG emissions are determined. Consequently, it has become increasingly important to estimate GHG emissions of the six high emission-intensive sectors, one of which is the chemical industry. Carbon emissions reduction in the chemical industry is particularly important but relatively difficult because the industry needs to grow rapidly to sustain China's economic development. Stimulated by the increase in demand from domestic and foreign markets, carbon emissions of the chemical industry are expected to continually increase in the next few years. In this article, we analyze the driving factors affecting the changes in carbon dioxide emissions according to the total energy consumption of the chemical industry.

China's chemical industry accounted for 10% of the total energy consumption of all industries in 2010, with an energy consumption estimated to be 34.7 Mtce (million tons coal equivalent). The total energy consumption of the chemical industry grew at an annual average growth rate of 4.68% during the period 1980–2010. Similarly, corresponding total carbon dioxide emissions increased at an annual average growth rate of 3.37%. In the light of the dilemma between the decrease in emissions and the increase in economic development, it is significant to explore the driving factors that influence the GHG emissions of the chemical industry. Therefore, it is necessary to analyze the following questions: what are the key driving factors that influence the increase in GHG

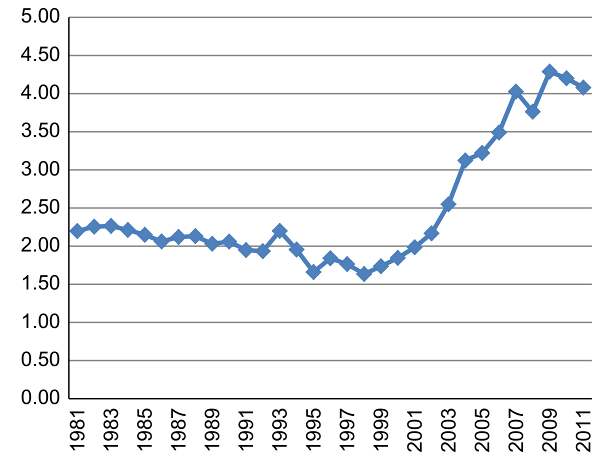

Fig. 1. Proportion of the total added value of GDP.
Data sources: China statistical yearbooks and China chemical industry statistical yearbooks.

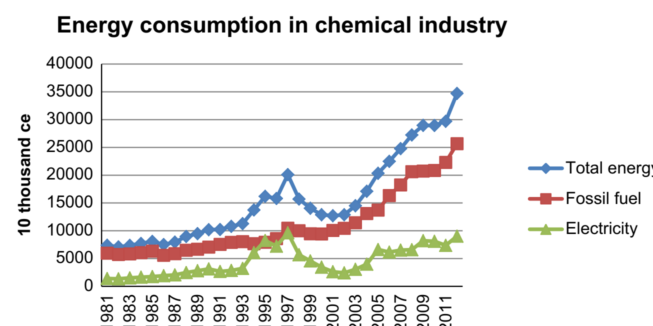

Fig. 2. The total energy consumption in chemical industry.
Data Sources: China statistical yearbooks and China energy statistical yearbooks.

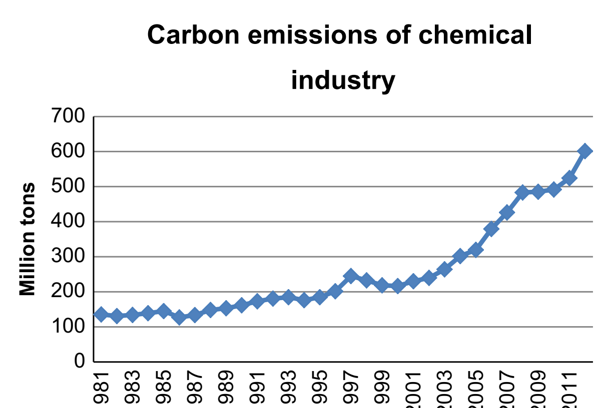

Fig. 3. Carbon dioxide emissions of chemical industry.
Data Sources: Emissions data calculated by authors (energy data from China statistical yearbooks and China energy statistical yearbooks and energy emission coefficient from IPCC).

emissions of the chemical industry? What is the size of the effect of each factor?

With China's economic growth, the chemical industry has experienced rapid growth. The total industrial output value of China produced chemicals are the largest in the world. The proportion of the added value of the chemical industry in GDP