Journal of Cleaner Production 207 (2019) 857–865

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Challenges for China's carbon emissions peaking in 2030: A decomposition and decoupling analysis

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A R T I C L E I N F O

Article history:
Received 29 April 2018
Received in revised form
2 October 2018
Accepted 5 October 2018
Available online 8 October 2018

Keywords:
CO_2 emissions
Carbon emissions peaking
Decomposition and decoupling analysis
China

A B S T R A C T

Investigation of China's Carbon dioxide (CO_2) emissions peaking has become a popular topic. Under the mandatory push of the national policy, exploring the challenges of achieving carbon emission peaking deserves enough attention. In this study, a hybrid method combing logarithmic mean divisia index (LMDI) and decoupling index approach, called LMDI-D, is proposed to model the challenges faced by China to achieve its CO_2 emissions peaking in 2030. This problem is examined from the perspective of historical trend and future prediction. The results indicate the following: (1) The effects of economic growth are far much larger than the other inhibiting effects of energy intensity and carbon emissions coefficient on the increase of China's CO_2 emissions; (2) Increment of total CO_2 emission in China shows a steady downward trend under the together influence of different factors, which is good news for the "2030 target"; (3) The decoupling relationship between China's CO_2 emissions and economic growth will be stronger during 2015–2030, which is the necessary condition for China to reach its "2030 target". Overall, the goal for China's to peak its CO_2 emissions in 2030 is a challenging task. Finally, several suggestions were put forward to achieve total CO_2 emissions reduction in China.

1. Introduction

Since 2009, China has already overtaken the United States as the biggest CO_2 emitter in the world (IEA, 2009). It is an urgent problem for China to realize the reduction of its total CO_2 emissions (Liu, 2015). During the APEC meeting 2014 in Beijing, the "U.S.-China Joint Statement on Climate Change" was issued and signed by the United States and China. Chinese government pledged to peak its CO_2 emissions around 2030 and will make the "best efforts" to peak early (Mi et al., 2017b). The plan has profound impacts on China's economic development and society. Under the mandatory push of the national policy, it is generally believed that the peak of China's CO_2 emissions can be achieved. However, challenges of achieving this goal did not receive enough attention.

In the past decades, Chinese government has implemented kinds of strategies and policies to curb CO_2 emissions. In Copenhagen Climate Conference, Chinese government announced that they will reduce their CO_2 emissions intensity by 40–45% in 2020 than that in 2005 (Wang et al., 2011; Qin et al., 2017). The China's average annual growth rate of GDP is assumed to be 6.5%, which is proposed in its 13th "five-year plan". It can be inferred that the average annual growth rate of total CO_2 emissions in China is around 2.4% under the scenario of per unit GDP CO_2 emissions being decreased by 45%, and about 3.3% if with 40% decrease during 2010–2020. That means, even if China has completed the CO_2 intensity reduction targets previously set, its total CO_2 emission will still have a relatively greater growth. From the point of view of emissions sources, China has stepped up energy usage efficiency and renewable energy development since its 12th "five-year plan"; however, the total amount of energy consumption in China maintains the stable fast growth, while the proportion of its coal consumption is still as high as more than 60%. More seriously, the CO_2 emissions patterns in China have changed significantly in recent years, and the proportion of CO_2 emissions caused by consumption is growing rapidly (Mi et al., 2017a). Thus, China faces big challenges to achieve its "2030 target" under China's current situation of CO_2 emission, which should be paid enough attention by Chinese government and policy makers. At present, there have been some

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https://doi.org/10.1016/j.jclepro.2018.10.043
0959-6526/

researches on whether China can reach its CO_2 emission peak in 2030 (Mi et al., 2017b; Yang and Teng, 2017; Asuka, 2016; den Elzen et al., 2016). Compared with the previous research, this study highlights the challenges for China to peak its CO_2 emissions in 2030 through qualitative and quantitative analysis.

There have been many studies on the related issues of China's CO_2 emissions currently, such as factors impacting carbon emission (Lin et al., 2009; Li et al., 2011, 2012; Xu et al., 2014; Mi et al., 2015; Karmellos et al., 2016), import and export trade (Guan et al., 2009; Mi et al., 2018; Weber et al., 2008; Shao et al., 2011; Wu et al., 2016), carbon footprints (Zhang and Qi, 2011; Tian et al., 2013; Chang et al., 2008; Brizga et al., 2017), and other related issues (Yu et al., 2014; Wang et al., 2013a; Wei et al., 2014; Zhen et al., 2017; Mi et al., 2017c). It's to be found that carbon emissions derived from capital formation are greater than from consumption in China (Zhang and Chen, 2010). Through a structural decomposition analysis, Tian et al. (2013) quantified the contribution of socioeconomic factors and technological to Beijing's CO_2 growth during 1995 and 2007. After accounting China's CO_2 emissions in historical years according to the IPCC method, Sun et al. (2010) found that the electrical, manufacturing, agriculture and thermal industries are the first four emitters, accounting for over 80% of footprint of China's total CO_2 emissions. Using the "long-range energy alternative planning system" (LEAP) model, Cai et al. (2007) analysed kinds of development paths for power industry to reduce its CO_2 emissions in China under three scenarios. Wu et al. (2006) did a logarithmic mean Divisia index (LMDI) simulation to discuss CO_2 emissions in China from 1980 to 2002, finding that the changes of CO_2 emissions in China are mainly derived by economic amount, fuel structure and energy intensity on the energy-demand side before 1996, while industry structure and efficiency changes on the energy supply side only had a minor impact. Based on an input–output structural decomposition analysis, Liu et al. (2010) analysed China's energy that embodied in its production goods from 1992 to 2005, then, proposed five major factors impacting the changes of embodied energy in exports. Lu et al. (2010) used the 2002 IO table and set up a CGE model, to analyse the impact of the increasing investment in the China's energy sectors on China's economy and carbon emissions. To identify the key influencing factors for China's provincial carbon emission, Geng et al. (2013) studied carbon emission growth of Liaoning province in China in the period of 1997 and 2007, through the application of the structural decomposition model. In general, the researches on China's CO_2 emissions have been studied from different perspectives by far. However, for the largest carbon emitter in the world, whose CO_2 emissions inevitably continue to growth with its economy growth, few analyses have focused on the issue of peaking of China's CO_2 emissions, including peaking time and possibility. After 2030 target proposed by Chinese government, this question becomes more urgent.

From the view of points of research methods on related issues of CO_2 emissions, the index decomposition analysis (IDA) has been widely used in recent years due to its easily understandable and application. There are mainly two approaches for IDA, namely the Laspeyres and Divisia index, where LMDI is one famous format of Divisia index approach. Currently, LMDI method is one of the most popular decomposition methods on the study of CO_2 emission changes (Lee and Oh, 2006; Liu et al., 2007; Akbostancı et al., 2011; Zhang et al., 2011; Lin and Long, 2016), as meeting all constraints such as being consistent in aggregation and satisfy the factor-reversal test (Zhang and Da, 2015). Diakoulaki et al. (2006) analysed Greece's CO_2 emissions during 1990 and 2002 using a LMDI decomposition model. The results showed the explanation of the observed increase in Greece's CO_2 emissions and identify its policy priorities on CO_2 reduction for Greece to comply with the Kyoto target. Based on LMDI decomposition method, Jeong and Kim (2013) paid attention to the CO_2 emissions changes in Korean industrial manufacturing sector in the period of 1991 and 2009 from the perspective of multiplicative and additive. They found that the intensity effect and structure effect have a significant positive impact on Korea's CO_2 reduction, and that of the structure effect is bigger than the intensity effect. Using LMDI, Oh et al. (2010) studied the specific trends of South Korea's CO_2 emissions and key factors influencing its emissions patterns over a 15-year period. They suggested that South Korea government should make climate change policies focusing on these specific influential factors of increasing different sector's CO_2 emissions. Wang et al. (2013b) researched the decoupling effect between GDP growth and CO_2 emissions and in Jiangsu province of China during 1995–2009 with a combination model of LMDI method and decoupling index. In addition to LMDI, decoupling analysis is a common method currently used. In these years, decoupling analysis focusing on carbon emissions and economic growth has had a growing number of studies (Zhang, 2000; Diakoulaki and Mandaraka, 2007; De Freitas and Kaneko, 2011; Wang et al., 2017). Utilizing the decoupling theory, Tapio (2005) analysed the decoupling relationships of the EU15 countries between traffic volumes, GDP, and CO_2 emissions during 1970 and 2001, and proposed eight logical possibilities of decoupling. In the research work of Liu et al. (2015), the key factors for the changing of energy-related CO_2 emissions of manufacturing industry were explored, as well as its decoupling relationship with economic growth.

Under the background of China's carbon emissions peak target in 2030, this study tries to points out the big challenges for achieving this target for China's government. Using a combination method of LMDI decomposition and decoupling approach (LMDI-D), this study presents the driving factors affecting total carbon emissions in China in the first step, and then analyses the possibility of peaking target using the prediction results of decoupling index between the economy scale in China and its CO_2 emissions during 2015 and 2030.

In this paper, the proposed combined LMDI-D model is targeted and easy to understand for both scholars and policy makers. Essentially, total CO_2 peaks for China in 2030 is a macro and complicated issue which should be discussed at a general level of society and economy. The hybrid method focuses on the key indicators of CO_2 emission in China. Additionally, we compare the trends of these indicators with historical trends. The contributions of this paper can be summarized two aspects: (1) There are some studies on China's CO_2 emissions and China's emission peaks. However, challenges on CO_2 emission peaking faced by Chinese society did not get enough attention from the view point of the law of economic development. (2) We proposed a novel LMDI and decoupling analysis to investigate China's carbon emission peaking from the perspective of the historical trend and future prediction. Although LMDI method is a common and useful decomposition method for studying CO_2 emission issues, in this paper we defined the emission features in the past and the future in order to find the clues of China's challenges. These analyses facilitate China's governments to formulate realistic and scientific CO_2 emission reduction policies under the current development pattern.

The rest of this paper is organized as follows. In Section 2, the research methodologies and data resources are presented. Section 3 discusses the empirical results. Section 4 concludes and puts forward some policy implications.