Journal of Cleaner Production 177 (2018) 169–177

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Investigating the role of high-tech industry in reducing China's CO_2 emissions: A regional perspective

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ARTICLE INFO

Article history:
Received 16 September 2017
Received in revised form
8 November 2017
Accepted 20 December 2017
Available online 28 December 2017

Keywords:
The high–tech industry
CO_2 emissions
STIRPAT model

ABSTRACT

China currently is the largest emitter of carbon dioxide (CO_2) in the world. Moreover, total energy consumption and CO_2 emissions in China will continue to increase due to the rapid advance of industrialization and urbanization. Therefore, vigorously developing the high–tech industry becomes an inevitable choice to reduce CO_2 emissions at the moment or in the future. However, most of the existing literature analyzes the impact of the high–tech industry on emission mitigation from an aggregate perspective. Few studies have focused on regional differences in China. Based on 1999–2015 panel data of China's 30 provinces, this study uses the STIRPAT model to explore the influence of the high–tech industry on CO_2 emission reduction in China from a regional perspective. The results show that the high–tech industry is beneficial to reduce CO_2 emissions. Moreover, the impact intensity of the high–tech industry in the eastern region is higher than those in the central and western regions due to significant differences in R&D funding, R&D personnel investments and high–tech purchase expenditure. The study's findings not only contribute to the existing literature, but also worthy of adequate attention from China's policy makers.

1. Introduction

Since the industrial revolution, coal, oil, natural gas, and other fossil fuels have obtained rapid development. It has become the dominant energy sources for social progress and economic development. However, fossil energy consumption–based economic development has led to an important detrimental issue of industrial production which emits large amounts of carbon dioxide (CO_2) and affects people's lives (Gong et al., 2017). The concentration of CO_2 in the atmosphere continues to rise, breaking the original carbon balance. This will affect energy security, ecological security, water security, food security and environmental security, and even threaten human survival (Chen et al., 2017). From 2011, China has become the world's largest emitter of carbon dioxide. According to the latest China Statistical Yearbook, China's CO_2 emissions have exceeded 10 billion tons, reaching 11.61 billion tons in 2015. Thus, China has become the focus of global attention and faces growing pressure to reduce CO_2 emissions.

As a responsible large country, China has adopted responsible attitude not only towards the current generation, but also to the future generations. In Copenhagen, UN climate change conference (2009), China announced its carbon reduction targets that by 2020, CO_2 emissions per unit of GDP will be reduced by 40–45% compared to 2005 level. In order to mitigate CO_2 emissions, the government has taken series of measures such as adjusting the economic structure, optimizing the energy structure, and stopping operations of energy–intensive small oil refineries and small iron and steel plants (Den Elzen et al., 2016). The government is actively adjusting the economic structure, since industrial structure is very important in reducing energy consumption and CO_2 emissions. In the process of economic restructuring, the high–tech industry

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https://doi.org/10.1016/j.jclepro.2017.12.174
0959-6526/

plays an increasingly important role (Zhang and Chun, 2016).[1] Recognizing the enormous potential of the high–tech industry in energy saving and CO_2 reduction, the government has positioned the high–tech industry as one of the strategic emerging industries, and actively developed it (Zhang et al., 2016a). According to China Statistical Yearbook, fixed–asset investment in the high–tech industry increased from 16.14 billion yuan in 1996 to 1995.07 billion yuan in 2015. During the same period, the contribution of the high–tech industry to gross domestic product (GDP) rose from 6.86% to 20.42%.

Given increasing energy consumption and CO_2 emissions, many scholars have explored the role of China's high–tech industry (Yang et al., 2016; Liu et al., 2016). However, there are still two deficiencies in existing research. First, most researches are based on input–output method, system optimization techniques or descriptive statistical analysis, but few studies are based on econometric models. Second, China includes many provinces; and human capital accumulation, the level of economic development and technical level in each province are distinctly different (Xu and Lin, 2016). However, existing studies mostly focuses on national level without taking regional differences into account, leading to low practicality (Wei et al., 2016).

This paper is different from existing studies in the following two points: first, we use econometric *STIRPAT* model to investigate the heterogeneous effects of the high –tech industry on regional CO_2 emissions. Second, we divide China's 30 provinces into the eastern, central and western regions, and implement a regional study on the role of the high–tech industry in mitigating CO_2 emissions.

The rest of this article includes the following sections. Section 2 reviews existing studies on CO_2 emissions. Section 3 constructs the econometric model and explains data sources. Section 4 presents the estimation results. Section 5 discusses the regression results. The conclusions and policy suggestions are placed in Section 6.

2. Literature review

The previous studies on the impact of the high–tech industry have been conducted with different perspectives and with different methods.

As for the research perspective, firstly, many scholars have conducted multi-country analysis. Using a standard structure approach, Kong et al. (2016) found that the high–tech industry could significantly improve energy–saving technology of the pulp and paper industry in 25 emerging countries, thus helping to reduce energy consumption and CO_2 emissions. Sgobbi et al. (2016) employed the JRC-EU-TIMES model to assess the impact of technological progress on the utilization of marine energy high–tech industry in European countries. The results indicated that improvements in marine energy technology could obviously expand marine energy supply, and abated CO_2 emissions. Similarly, Wiebe (2016) studied the application of high–tech in European countries' power industry using input–output method, and found that the high–tech industry could improve energy efficiency of the power industry. This would significantly reduce the coal consumption and CO_2 emissions from the power industry. Furthermore, Lee et al. (2017) analyzed the impact of environmental protection high–tech industry on CO_2 emissions reduction in Asian countries. The results showed that low-carbon, green vehicle and energy-saving technologies played an increasingly important role in mitigating CO_2 emissions. McDowall et al. (2018) explored the contribution of new energy high-tech industry to fossil energy consumption control and CO_2 emission reduction for European countries. Applying an environmentally-extended input-output model, they found that the development of the photovoltaic industry reduced the total CO_2 emissions by 7%.

Secondly, some scholars have implemented in–depth study on a single country. Using a statistical–mathematical method, Velazquez-Martinez et al. (2016) found that the high–tech industry significantly improved fuel efficiency and reduced CO_2 emissions in the transportation sector. Similarly, Haddadian et al. (2016) and Shokrzadeh and Bibeau (2016) used optimization method and found that the electric vehicle high–tech industry of the USA and Canada created a negative impact on the transport sector's CO_2 emissions, ensuring environmental sustainability. Based on the research of the thermal power industry, Bratanova et al. (2016) found that renewable and new energy high–tech industries had a negative effect on emissions mitigation in Russia because it could significantly improve energy efficiency of this industry. Applying a life cycle assessment model, Morrison and Golden (2017) concluded that the bioenergy high–tech industry helped to abate coal consumption and CO_2 emissions from coal-fired power plants in the United States. Similarly, Weber and Cabras (2017) employed the Delphi Method to investigate the impact of renewable energy high-tech industries on CO_2 emission reduction in Germany. Empirical results indicated that the rapid development of renewable energy industry would significantly reduce the demand for high-polluting coal, helping the reduction in CO_2 emissions from the power stations. Therefore, they suggested that the government should expand the R&D of new energy technology and high-tech talent training.

With respect to the research methods, there are basically three methods. The first method is input–output method. Using this method, Nishiguchi and Tabata (2016) explored the contribution of biomass high–tech industry to reduction in energy consumption. The results showed it could reduce 8.58 million tons of coal consumption annually. Huang et al. (2016) utilized an extended input–output model to investigate the efficiency of pure electric technology in transport sector's fuel consumption. The results manifested that the energy efficiency of the railway sector was much higher than that in the highway sector. The second method is system optimization approach. Using a multi–stage system optimization method, Cutz et al. (2016) investigated the role of renewable energy technologies at different stages of industrial production in the USA and found that it could save 4–8 million tons of fuelwood. Similarly, Dimitrova and Maréchal (2016) applied a multi–objective optimization method to estimate the contribution of hybrid electric high–tech industry to fuel savings of the transport sector and environmental improvement. The empirical results indicated that the application of hybrid electric technology could significantly reduce the fossil fuel consumption in the transport sector (e.g., cargo, passenger and water transports) and their CO_2 emissions. Also, Ko et al. (2017) assessed the potential of biofuels high–tech industry in conserving fossil fuel consumption in Southeast Asian countries with the same method. The results showed that this industry could take full advantage of local rich biomass resources to produce biomass energy, thereby reducing the traditional fossil energy consumption and the resulting CO_2 emissions. The third method is statistical and econometric methods. Using descriptive statistical analysis, Nakomcic-Smaragdakis et al. (2016) reviewed the potential of producing

[1] According to "The Market Outlook and Investment Strategy Analysis Report of China's High-tech Industrial Park (2014–2018)" published by Beijing Institute of Industry, the High-tech industry includes the high-end electronic information industry, new materials industry, new medicine and bio-industry, new digital equipment industry, semiconductor lighting industry, high-speed trains and new energy automotive industry, new energy industry, shipbuilding and marine industries, comprehensive utilization of resources and environmental protection industries, and high-tech service industry.