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Economic and environmental implications of raising China's emission standard for thermal power plants: An environmentally extended CGE analysis

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ABSTRACT

Thermal power plants are considered as the main source of atmospheric pollutants in China due to their massive emissions of sulfur dioxide (SO_2) and nitric oxide (NO_X). In order to enhance the environmental protection, the Ministry of Environmental Protection of China has recently introduced a new emission standard of atmospheric pollutants for thermal power plants. However, it is still unclear to what extent the new emission standard may impact on China's environment and economy. In this study we apply an environmentally extended Computable General Equilibrium (CGE) model to assess environmental and economic impacts of the new emission standard in the short term. Our results show that imposing the new emission standard may lead to a reduction in SO_2 and NO_X emissions by 22.8% and 11.4%, respectively per year, with the absolute amounts being reduced by 5597and 1482 thousand tons. This is the result of improvement of the emission removal technologies and the sharp decline of the coal consumption. On the other hand, the new emission standard may cause about 0.2% loss of GDP in the target year. In terms of changes in prices of goods and services and final demand structure, the new emission standard can make contribution to curbing inflation, with the consumption demand reduced. In addition, the new emission standard can greatly stimulate the industrial output of other special equipment manufacturing sector. Besides, due to the decreasing price of labor and capital, the new emission standard leads to increase in economic output for industrial sectors, and the depreciation of domestic currency would drive an expansion of the export-oriented industries.

1. Introduction

China has experienced a rapid economic growth mainly indicated as gross domestic product (GDP) which has increased more than 22-fold since 1978 (Zhang et al., 2015) along with very fast-paced industrialization and urbanization. However, the significant achievements in economic development has led to increasing environmental pressure, such as air pollution, natural resource overshoot, and loss of biodiversity, having made China the largest single contributor to global SO_2 emission (Danny et al., 2013) in the world. China's economy is overwhelmingly dependent upon coal, which accounted for 67% of its total primary energy consumption in 2012 (Chang et al., 2014). Due to the fast economy development in the past three decades and the consequently soaring demand for coal to generate electricity, China has become the largest coal producer and consumer in the world (Liu and Liu, 2010). For example, the Chinese electric power industry has become the second largest in the world, with installed capacity rising from 5712 GW in 1978 to 125,768 GW in 2013 and an average annual growth rate of 9.9% (China Electricity Council, 2013). The majority of generation plants are either coal-fired – almost 69% of the total capacity in 2013 – or hydro powered – over 22% (China Electricity Council, 2013). Atmospheric emissions from electricity generation is a major contributor to many pollutions, such as acid rain and fine particle concentrations in the atmosphere, mainly caused by sulfur dioxide (SO_2) emissions, and depletion of ground-level ozone mostly from nitrogen oxides (NO_x) emissions (Dallas et al., 2005). In order to

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achieve sustainable development and promote industrial structural adjustment, the Chinese government recently implemented strict energy saving and pollution reduction policies, especially regarding high energy and pollution intensive industrial sectors (Zhang et al., 2009). In 2011, China's 12th Five year plan clearly put forward the reduction target of the major pollutants, such as sulfur dioxide emissions reduced by 8% and nitrogen oxide emissions reduced by 10% during this national plan period, respectively (State Council, 2011). To achieve the emissions reduction target, the Ministry of Environmental Protection of China has introduced a new Emission Standard of Atmospheric Pollutants for Thermal Power Plants (ESAPTPP GB13323-2011) (MEP) started from January 1, 2012. The new emission standard impacts on not only the total air pollution emissions but also the economic output by various channels such as the change of market prices of goods and services. Without a good understanding of economic impacts, the new emission standard may not be able to be implemented efficiently. So far, there are no studies about assessing the impacts of the new emission standard on the economic cost (e.g. GDP loss), economic structure change, the market prices of different consumption items, and structural change of final demand sectors.

At present, there are mainly three strands of researches in studying the influence of the old and new emission standard: (1) focusing on the technology- or strategy-oriented issues concerning how to reduce pollution and save energy in thermal power industry through qualitative analyses or case studies (Sun, 2001; Shang and Zhang, 2007; Jing et al., 2009; Sun and Zhang, 2012; Fu, 2011; Qin, 2014); (2) using the emissions trading model to assess the economic analysis of air pollutants emission reduction in thermal power industry (Wang, 2005; Wang, 2013a,b), or a mathematical model to estimate the NO_x emissions of the power plant (Liu, 2008), or an integrated air quality model in the control of different standards or emission limits to study the environmental impact of the main emission sources of NO_x (Sheng, 2011; Wang, 2013a,b). (3) using the Asia-Pacific Integrated Model (AIM) model and dynamic recursive Computable General Equilibrium (CGE) model to study the impact of SO_2 control policies on the reduction of air pollutants and CO_2 (Xu and Masui, 2009), or use CGE model to analyze the impact of coal price rise on electric power price and macro economy (He et al., 2010). Most of the existing literature relating to the new emission standard mainly addresses the technical issue but lack of discussions on its economic impacts. To fill this research gap, in this study, we focus on elucidating the generation and emissions reduction mechanism of SO_2 and NO_X in the whole economic system and simulate the impacts of the new standard on emissions and China's economy during the period of the twelfth five-year plan based on an environmentally extended CGE model. In addition, this paper integrates the firm-level micro information based on a large scale enterprises survey (the 2007 pollutant census database[1]) into the conventional input–output database which allows us improving the quality and reliability of parameter calibration in the CGE model used in this study.

[1] On February 6, 2012, the National Bureau of statistics decided to carry out the first national census of pollution sources in order to strengthen the supervision and management of the environment. Census of standard time was December 31, 2007 and the standard period was 2007. The census object was the discharge of pollutants within the territory of China including the industrial pollution sources, agricultural pollution sources, living pollution sources and centralized pollution treatment facilities. The survey content included the basic situation of all kinds of pollution source, the generation and emissions of main pollutants, and pollution treatment, etc. The pollutant database this paper adopts is the 2007 input-output table department through the original classification of national economic industries, simultaneously, combined with all kinds of life source pollution census data of 2007, which comprehensively tease out the production and emission of waste gas of 135 industries using 5 energy products (coal, oil gas, petrol, coking, electricity and gas), combined with other related data.

2. The emission standard of air pollutants for thermal power plants

The Ministry of Environmental Protection of China published the old emission standard (ESAPTPP GB13323-2003) on January 1, 2004, including emissions limits on SO_2 and NO_X. The key control is to promote thermal power flue gas desulfurization. The implementation of the standard has played an important role in controlling emissions of atmospheric pollutants, protecting the environment and promoting technological advancement of the power industry. However, the total NO_X emissions have been kept increasing and the sulfuric acid rain pollution has been turned into a mixed pollution of sulfuric acid and nitric acid rain. The urban atmospheric environmental situation in China is still grim, regional air pollution problems have become more significant than ever. Additionally, the old standard of NO_X emissions in China is much lower than the standard in developed countries, thus it is no longer able to fulfill the requirements of the environmental protection and emissions control for the thermal power plants at the present time. Considering that the demand for controlling on NO_X emissions from thermal power plants is imminent, the new version of the EASPTPP GB13323-2011 was issued. In this paper, we focus on the two important polluting emissions: SO_2 and NO_X, as they are the main source of atmospheric pollutants from Thermal power plants in China. According to the new emission standard, the emission concentration of SO_2 is controlled in 100 mg/m^3 for new thermal power boilers and gas turbines (the existing thermal power boilers are still in 200 mg/m^3). For NO_X, the newly built and the existing thermal power boilers which have been approved by environmental impact assessment from January 1, 2004 to December 31, 2011 must fully implement the flue gas denitrification to limit the emission concentration of NO_X within 100 mg/m^3. For those that are approved before December 31, 2003, the concentration of NO_x should be lower than 200 mg/m^3. In this study, we will use these standards for our CGE modeling of environmental and economic impacts.

3. Model and data

CGE models have been widely used in policy impact analyses such as taxes, subsidies and so on. Depending on the research purposes, various CGE models have been presented, for example, single-region model, multi-region global or country model, comparative static model, dynamic model *etc* (Dong et al., 2015). Igos et al. (2015) undertake a practical combination of a CGE and a Partial Equilibrium (PE) model by linking the outcomes from the coupling with a hybrid input–output process to assess the environmental consequences of two energy policy scenarios in Luxembourg between 2010 and 2025. Liu and Lu (2015) applied a dynamic CGE model–CASIPM-GE model to explore the impact of a carbon tax and different tax revenue recycling schemes on China's economy (Liu and Lu, 2015). This paper adopts the static environmentally extended CGE model developed jointly by Institute of Policy and Management, Chinese Academy of Sciences and Center of Policy Studies, Victoria University for Chinese economy. The model includes 135 industrial sectors, 3 primary factors (labor, capital, land) and 6 economic agents (product, investment, household, export, government and stock). The model also considers 8 margins, including transportation cost by modes (water, air, rail, road, and pipeline), insurance, trade (wholesale, retail), and warehousing (Dixon and Rimmer, 2002).

3.1. The setting of the closure

This paper adopts short-term closure hypothesis to analyze the impact of the new emission standard on the economy in the