Energy Economics 63 (2017) 332–347

Contents lists available at ScienceDirect

Energy Economics

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

Can an emission trading scheme promote the withdrawal of outdated capacity in energy-intensive sectors? A case study on China's iron and steel industry

Lei Zhu [a], Xiao-Bing Zhang [b,*], Yuan Li [c], Xu Wang [d,e], Jianxin Guo [c]

[a] School of Economics and Management, Beihang University, Beijing 100191, China
[b] School of Economics, Renmin University of China, Beijing 100872, China
[c] Center for Energy and Environmental Policy Research, Institute of Policy and Management, Chinese Academy of Sciences, Beijing 100190, China
[d] School of Management, China University of Mining and Technology, Xuzhou 221116, China
[e] SINOPEC Economics and Development Research Institute, Beijing, 100029, China

ARTICLE INFO

Article history:
Received 23 May 2016
Received in revised form 2 February 2017
Accepted 8 February 2017
Available online 20 February 2017

JEL classification:
C63
Q48
Q52
Q59

Keywords:
Emission trading scheme
Iron and steel sector
Energy saving
Competitiveness
Output-based allocation

ABSTRACT

Outdated capacity and substantial potential for energy conservation are the two main features of energy-intensive sectors in developing countries. Such countries also seek to implement market-based options to further control domestic carbon emissions as well as to promote the withdrawal of outdated capacity and upgrade production level. This paper presents a quantitative assessment of the emission trading scheme (ETS) for China's iron and steel industry. The diverse array of normal and outdated capacities was modeled in a two-country, three-good partial equilibrium model. Simulation results show that the abatement potential can be underestimated if the energy-saving effects that result from emission abatement are not considered. In the scenario analysis, we demonstrated that the free allocation of allowances can cause a competitiveness distortion among domestic normal and outdated capacities. Given the government's intention to promote outdated capacity withdrawal and production-level upgrading, an output-based allocation approach is strongly suggested for China's iron and steel sector.

1. Introduction

Aside from the energy sector itself, energy-intensive sectors (iron and steel, cement, chemical, and nonferrous metals) are arguably the sectors most sensitive to CO_2 emission abatement actions. In developing countries, there are two related features that exist in energy-intensive sectors: 1) diverse levels of technology among firms within the sector, with some outdated capacity, and 2) on average, higher energy consumption per unit of output than international advanced level (Wang, 2011). A typical example is China's iron and steel sector. As the world's largest steel producer, China's crude steel production accounts for 44% of the total global production in 2010, and the sector consumes 17% of the total domestic energy consumption, which leads to large amounts of greenhouse gas emissions. Meanwhile, there are more than 500 iron and steel enterprises in China, and the technological efficiency varies greatly among them. The limited capital budgets and short-sighted investment behavior have made most small and medium enterprises adopt out-of-date technologies in their production.[1] Compared with advanced production technologies, these outdated technologies consume more energy when producing equal units of output, and they produce more CO_2 emissions and air pollution. In 2010, the share of outdated capacity accounted for more than 25% of total domestic production capacity in the iron and steel sector (Jiang, 2013).

Accelerating the withdrawal of outdated capacity in the iron and steel sector is one of the synergistic effects that the Chinese government wishes to generate through the implementation of an emission trading scheme (ETS). Given the weakened effects of command and control

* Corresponding author.
E-mail addresses: lions85509050@gmail.com (L. Zhu), xbzhmail@gmail.com (X.-B. Zhang).

[1] According to Lv and Li (2010), the definition of outdated capacity is mainly based on two considerations 1) the technological level of production capacity, i.e., production equipment that is below the industry average level and 2) the consequences of production, such as greater pollution and emissions generated by the production process, or higher consumption of water and energy resources than the industry average level. It should be mentioned here that the evaluation of outdated capacity will change over time due to technological progress in the industry.

http://dx.doi.org/10.1016/j.eneco.2017.02.004
0140-9883/

measures to address the above-mentioned issues weakened in the 12th Five Year Plan (from 2011 to 2015) after the first-stage implementation in the 11th Five Year Plan (11th FYP, from 2006 to 2010),[2] the government proposed the application of market-based instruments (e.g., ETS) to further control domestic carbon emissions and energy consumption in energy-intensive sectors as well as to promote withdrawal of outdated capacity and upgrading of production (MIIT, 2011; State Council, 2012). Currently, seven CO_2 pilot regions for emission trading have been established, and a national CO_2 emission trading scheme (ETS) has also been prepared.[3]

An ETS would result in a change in the relative competitiveness[4] among firms with normal and outdated capacities. Referring to Demailly and Quirion (2008), two of the most intuitive indexes for measuring competitiveness changes are loss in production and loss in profits.[5] The outdated capacity can be withdrawn if its output and profit are reduced with a proper ETS design; otherwise, a competitiveness distortion will appear among normal and outdated capacities. Such distortion is possible because the efficiency of the ETS would be affected under the imperfect competition in the output market. Therefore, it is of great significance to investigate the questions such as whether an ETS can promote outdated capacity withdrawal and how different allocation approaches can affect the relative competitiveness among firms with normal and outdated capacities in China's iron and steel sector.

With the establishment of a two-country, three-good partial equilibrium model, this paper proposes an analytical framework for studying the impact of CO_2 emission trading on China's iron and steel sector, where we establish a market structure with both output competition (between two goods in the domestic market) and price competition (between domestic and foreign goods). In addition to its application to the ETS for China's iron and steel industry as we have illustrated in this study, the model can also be adopted to analyze the impacts of ETS on other energy intensive sectors with large production level diversity, especially for the sectors in developing countries.

The rest of the paper is organized as follows: Section 2 presents a literature review of previous studies; Section 3 introduces the theoretical model employed in this study; Section 4 presents the case study on China's iron and steel sector in the context of the ETS; Section 5 analyzes the sensitivity of calculation results to key parameters; and Section 6 provides conclusions.

2. Literature review

Focusing on industry competitiveness and carbon leakage, a series of studies have presented quantitative assessments of the impact of unilateral emission abatement policies (emission trading, carbon tax, border carbon adjustment, and output-based rebating and allocation) on energy-intensive sectors (Grubb and Wilde, 2004; Demailly and Quirion, 2008; Dissou, 2006; Monjon and Quirion, 2010; Fischer and Fox, 2012; Böhringer and Keller, 2011). And the choice of approaches to allowance allocation (grandfathering, auction, or output-based allocation) plays an important role in affecting the sector's competitiveness (Fischer and Fox, 2004, 2010; Peterson and Schleich, 2007; Demailly and Quirion, 2008; Takeda et al., 2014; Meunier et al., 2014). However, most of the emphasis has been placed on developed countries, especially the sectors covered by the European Union Emission Trading Scheme (EU-ETS), while less attention has been paid to developing countries.

Meanwhile, a number of quantitative studies have been conducted on energy use and CO_2 emissions in China's iron and steel industry, including the performance measure of energy efficiency and CO_2 emissions (Ma et al., 2002; Movshuk, 2004; Wei et al., 2007), assessment of energy saving and CO_2 emission reduction potential (Wang et al., 2007; Ali et al., 2013; Wen et al., 2014), energy or CO_2 emissions embodied in China's exports (Kahrl and Roland-Holst, 2008; Yan and Yang, 2010; Su and Ang, 2013; Cui et al., 2015), as well as the driving forces investigation to the changes of embodied energy/emissions with the adoption of structural decomposition analysis (SDA) (Chai et al., 2009; Dong et al., 2010; H.T. Liu et al., 2010; W. Liu et al., 2010; Su and Ang, 2012). Additionally, the impacts of carbon policies and national emission intensity reduction targets on the iron and steel sector have been investigated with the adoption of the national/regional CGE models (Zhang, 2000; Liang et al., 2007; D. Zhang et al., 2013; H. Zhang et al., 2013). Although the issues of outdated capacity and diversity of technological levels have been noted in most of the above-mentioned studies, the impact of emission reduction policies on normal and outdated capacities within the sector was not addressed because the sector was treated as a whole in these studies.

Our study adds to the existing literature in the following ways:

1) A splitting-up of production capacity within the sector. In view of the large diversity of production levels among China's iron and steel enterprises, it is not enough to view the sector as a whole. Thus, with the consideration of outdated capacity, we divide total domestic iron and steel production into two groups—production from normal capacity and production from outdated capacity—to investigate the interaction between these two products under ETS.
2) The adoption of technology-based abatement cost curves. Given that the main option for reducing CO_2 emissions in the iron and steel sector is to continuously improve energy efficiency and with the curves being consistent with energy saving technologies, the effects resulted from saved energy together with emission abatement can be investigated, while in previous studies the marginal abatement cost (MAC) curves derived from the integrated assessment models (IAM) or the computable general equilibrium models (CGE) were not able to clearly define the energy saving effects.
3) Detailed evaluation of the price pass-through effects of the iron and steel sector's up and down streams. The ETS covers multiple sectors and energy-intensive sectors' production costs are sensitive to output price change in the energy sectors. As the technology-based abatement cost curves are not able to consider the effects of energy price change due to the carbon price in one sector will obviously affect its downstream sectors, we use price pass-through rates to describe the energy cost change in the iron and steel sector's production. Furthermore, by applying the price multiplier matrix, the impact of the output price change in the iron and steel sector on other sectors has also been modeled in the welfare calculation.

3. Theoretical model

China is considered to be the domestic region, and its production is divided into two groups: production from normal capacity (N) and production from outdated capacity (B), each of which is produced by a representative firm. The rest of the world is considered to be the foreign region, which produces good F.

[2] During the 11th FYP, the two measures that the government launched in the iron and steel industry were 1) energy efficiency improvements and emission reduction, where the government set a goal for the comprehensive energy consumption per ton of steel to be reduced to 730 kgce (kg standard coal equivalent) in 2010, compared to 760 kgce in 2005. 2) Outdated capacity withdrawal, in which a total of 100 million ton of iron smelting outdated capacity and 55 million ton of steel outdated capacity are forced to withdraw from the market by the end of 2010.

[3] In 2011, the NDRC (National Development and Reform Commission) issued a document stating that the carbon emission trading scheme (ETS) will be piloted in seven regions (Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei, and Shenzhen). In 2014, the state council announced the establishment of a national unified CO_2 emission trading market in its "2014–2015 Energy Saving, Emission Reduction, and Low-carbon Development Action Plan".

[4] Industrial competitiveness usually refers to the ability to offer products and services that meet the quality standards of local and world markets at prices that are competitive and provide adequate returns on the resources employed or consumed in producing them, among the firms within the sector.

[5] According to Demailly and Quirion (2008), the changes in production and profit can affect industrial relocation, domestic employment, carbon leakage, and the stock value of domestic firms, so they are the most intuitive indexes to measure the competitiveness change.