Journal of Cleaner Production 207 (2019) 225–235

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Cost effectiveness analysis for emission trading mechanisms: A provincial simulation of upcoming five-year plans in China

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ARTICLE INFO

Article history:
Received 27 March 2018
Received in revised form
15 August 2018
Accepted 24 September 2018
Available online 3 October 2018

Keywords:
Directional distance function
Emissions trading
Initial rights allocation
Marginal abatement cost
Polluter pays principle
Total abatement cost

ABSTRACT

This study simulates the total abatement cost (TAC) of CO_2 emissions reduction for province, municipality, and autonomous district with different levels of gross domestic product (GDP) under the egalitarian allocation, sovereignty allocation, ability to pay, and polluter pays principles of an emissions trading policy to achieve five-year plans of 2020, 2025, and 2030 in China. The TACs are estimated by directional distance function, and savings of TAC are compared with and without the implementation of an emission trading policy nationwide. The TAC savings results for the group with low GDP per capita is consistent with that for the whole nation. Sacrificing economic development for provinces with high GDP and medium GDP is required to reach consensus for implementation of the trading policy. From province's standpoint, the sovereignty initial right allocation principle provides incentive for high-GDP-per-capita provinces to join the emissions trading mechanism for its consistency with the nation. Under such a circumstance, a subsidy policy is necessary along with the emissions trading mechanism to give less developed provinces incentives to join the emissions trading array.

1. Introduction

According to the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), the average temperature in the northern hemisphere between 1983 and 2012 reached its hottest over the past 1400 years (IPCC, 2014). The concentration of the greenhouse gases of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) is now higher by 40%, 150%, and 20% respectively than before the industrialization era (IPCC, 2014). Extreme events are occurring much more frequently than previous years. Reduction of greenhouse gases is one of the effective ways to slow or reverse this phenomenon (National Center for Climate Change Strategy and International Cooperation, 2015).

Records show that total CO_2 emissions reached 36.1 billion tonnes (1000 kg) in 2013. Of this, China emitted about 10 billion tonnes from all kinds of energy consumption, which accounts for about 28% of total global emissions. The emissions in China have consistently grown since economic reforms and the opening up of its economy to the world in 1978, which have brought the gross domestic product (GDP) in 2012 to 51.9 billion Chinese Yuan (CNY).[1] This amount is about 22.5 times that in 1978, and the annual increase was 9.6% in 2012 (Wang, 2014). Furthermore, this has resulted in emissions per capita higher than the world average (Friedlingstein et al., 2014). China has thus become the nation with the highest emissions, and one of the top priority spots for global emissions reduction. The impact of large amounts of greenhouse gases on public health and safety has also become one of the major missions for different administration levels in China.

In 2013, China set up seven regional emissions trading trial spots, with two provinces and five municipalities,[2] i.e. Hubei, Guangdong, Beijing, Tianjin, Shanghai, Chongqing, and Shenzhen. For these trial spots, more than 2000 firms joined this trial emissions trading, with about 13.75 million tonnes of CO_2 trading. This trading market currently ranks next to the European Emissions Trading Scheme (EU-ETS) as the second largest emissions trading market in the world (Li et al., 2014; Qi and Cheng, 2015). The seven

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[1] The average exchange rate of US$ to CNY in 2012 was about 6.2725.
[2] Province is used henceforth to denote province, municipality, and autonomous district for succinctness.

https://doi.org/10.1016/j.jclepro.2018.09.210
0959-6526/

emission trading trial spots in China, however, do not reflect the large amount of potential CO_2 emissions reduction for the whole nation.

As a result, to achieve the higher emission reduction commitment set up in each five-year plan, the National Development and Reform Commission of China intends to employ an emissions trading mechanism nationwide. Currently, there is no unique and single emission trading market in the world. China, as one of the largest CO_2 emissions nations in the world, could potentially become an important emission trading partner for the rest of the nations. Thus, construction of a top-down emissions trading scheme within China is not only an important mission to meet its emissions reduction obligation but also a way to prepare for its linkage to the rest of the world.

There is, however, great controversy regarding equity of initial rights allocation for setting rules of emission trading mechanisms. Each trading unit has different views on the equity of allocation of initial emission rights. Thus, determination of a consensus equity principle is critical for this mechanism. One of the greatest concerns nationwide is the savings of the total abatement cost (TAC) with and without joining an emissions trading market when such a policy is set into action. The framework proposed by Liou and Wu (2015) in simulating global emissions trading among nations is employed here to simulate the CO_2 emissions reduction cost for provinces with different levels of GDP in China.

To the best of our knowledge, no existing study explores a comprehensive understanding of possible abatement cost from a national standpoint under the five-year plans of 2020, 2025, and 2030 proposed by the National Development and Reform Commission of China, through the emission trading mechanisms. Such an investigation will prove invaluable for the rest of the world once the emission trading policy is ready for implementation. Thus, the purpose of this study is to simulate the TAC of CO_2 emissions reduction for provinces under the egalitarian allocation, sovereignty allocation, ability to pay, and polluter pays principles when CO_2 emissions reduction is to achieve different stages of the five-year plans in China.

2. Literature review

China was one of the signatory states of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. In June 2007, specific emission reduction objectives and methods of implementation were determined in *China's National Climate Change Programme*. China committed to reducing CO_2 emissions intensity[3] below 40%–45% of the 2005 level by 2020 in Copenhagen's COP15 in 2009. In order to achieve this objective, the five-year plans set up an emissions reduction plan for provinces with different levels of GDP. China has further ratified the Paris Climate Change Agreement in COP22 of 2016.[4] The commitment is to decrease emissions intensity by 60%–65% from the level of 2005 by 2030.

Emission trading mechanisms have been deemed a market-type incentive policy. The trading rules are set worldwide if trading units are nations, and set nationwide if trading partners are cities or provinces, such as the case we are concerned with here. For a successful implementation of an emission trading mechanisms, how to allocate emission initial rights is crucial (Jaffe and Stavins, 1994). Various efforts in evaluating different kinds of impact have been made in China. One study, (Wu et al., 2016a, b), conducts a zero-sum gains data envelopment analysis to evaluate the specific type of air pollutant, $PM_{2.5}$, under emission trading. This pollutant, however, is not representative of the broad scope of greenhouse gases. Another study, by Chen et al. (2018), utilizes a model similar to that in (Wu et al., 2016a; b). Although the trading permits are for carbon emissions, the trading units are at the scale of agriculture and other industrial sectors. Wei and Rose (2009) adopted various principles to allocate the initial rights for six regions in China due to lack of comprehensive data, and thus divided six regions into 31 administrative entities. These is evidence that China has paid much attention to trading policy. However, the emitted targets or trading units that these studies evaluate are either pollutant-, sector-, or area-specific, instead of greenhouse gases or carbon emissions and a nationwide focus.

Nevertheless, there are studies which conduct a much more integrated evaluation to determine the initial rights allocation with a concern for equity. A study done by Wu et al. (2016) selects five initial quota allocation criteria and uses a computable general equilibrium (CGE) model to evaluate different performance aspects in terms of economy, regional disparity, welfare, and investment for each province or region. Moreover, Wang et al. (2018) use an improved technique for order preference based on similarity to an ideal solution, with a Gini coefficient to account for the fairness of allocation outcomes. These analyses are complete to a certain degree. However, it is much more important to evaluate the change in the cost with and without the policy from the viewpoint of the nation before carrying out that policy. Since every trading unit has different thoughts about the fairness of initial rights allocation, the Gini coefficient via distribution of GDP may not be able to capture the subjective view of other elements for allocation equity. Thus, selection and comparison of different allocation equity principles is essential.

EU-ETS has been the world's largest cap-and-trade mechanism applied to the climate problem. They have accumulated a great deal of experience. Segar et al. (2018) has reviewed this experience for all types of economic performance. Among these, Hintermann et al. (2016) has further explored the formation of allowance price and the relationship between price and economic growth. Some studies, Martin et al. (2016) for instance, compare economic performance for firms in EU-ETS and those in non-EU-ETS. Calel and Dechezleprêtre (2016) compare the patent of low-carbon technologies for firms in EU-ETS and those in non-EU-ETS. All these analyses are under status quo allocation of initial rights. However, once the rule for reallocation of initial rights encounters a challenge, analyses for all the economic performance have to be reconsidered. Thus, taking account of allocation of initial emission rights is particularly important for a nation like China to commence such a policy.

As a result, this study is the first to evaluate the TAC for an emission trading mechanism while China is in preparation for implementing such a policy. Thus, from a national standpoint, the cost effectiveness of different methods for allocation of initial emission rights is one of the critical issues to control before the policy comes into effect. The estimation is not just for now but for the preparation in the future three five-year plans. An egalitarian allocation principle, sovereignty allocation principle, ability to pay principle, and polluter pays principle are the four most commonly proposed principles (Philibert and Pershing, 2001; International Energy Agency, 2001), and will be used in the evaluation of effective cost.

[3] Emission intensity is the ratio of greenhouse gas emission to gross domestic product.

[4] The first five-year plan of economic and social development began in 1953. There have been 13 five-year plans since then (China.org.cn, 2016).