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Pricing the permission of pollution: Optimal control-based simulation of payments for the initial emission allowance in China

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ABSTRACT

China has modified its pollution control policy system with such price tools as the pollution charge (PC) policy and the payment for initial emission allowance (PIEA) policy. The aim of PC policy is to compensate for the environment damage caused by pollutants, while PIEA is in charge of the initial emission allowance (IEA) within the emission trading system (ETS). However, since the implementation of PIEA, it has been criticized as redundant because of the similar pricing scheme with the PC. In addition, the existing PIEA pricing approaches have ignored interactions with other policies, such as PC and total emission control (TEC) policies. In this research, we established an optimal control-based model with chemical oxygen demand (COD) and ammoniacal nitrogen (NH_3-N), two independent pollutants variables, to simulate the water pollutants' PIEA price. Simulation results indicated that emission quantity and optimal social benefit in the PC–PIEA combination scenario was equal to the situation in the PIEA scenario. Under this design, PC compensated for the emission damage, and PIEA paid for the scarcity rent, while PIEA does not duplicate the PC policy. In addition, the PIEA policy has a complex effect on pollutant emission. Because PIEA policy increases the enterprises' discharging cost, most regions' COD emissions are less than the baseline, excepting Beijing, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, and Guangdong, in which emission quantities are greater than the baseline. The NH_3-N emission shows an opposite trend. The simulation result is that excluding Inner Mongolia, Hubei, Hunan, Tibet, Gansu, Qinghai, Ningxia, and Xinjiang, the NH_3-N emissions in the rest of regions are increased. TEC policy has a significant effect on pollutant emissions and the PIEA price. The COD emission quantity with TEC is lower than that without the TEC policy, therefore, the TEC policy will be effective for pollutant emission control. The pollutant beyond the restricted target will be charged a payment for IEA at a higher price than without the TEC policy.

1. Introduction

The natural environment not only provides human beings with a habitat for survival but is also involved in manufacturing processes as a factor of production. In addition to providing natural resources, the environment receives pollution produced by manufacturing processes. It is well-known that environmental capacity to receive pollutant emissions is a type of natural resource. Environmental capacity resources are limited, while the demand for it is growing; therefore, people need to measure the cost and benefits to use resources efficiently. The cost of using environmental capacity resources is primarily caused by its external damage, but the government employs a methodology to internalize externalities to make the beneficiaries undertake the real environmental costs. When calculating the benefits of environmental resources, the scarcity rents are often overlooked. The Chinese government implemented the payment for initial emission allowance (PIEA) policy to capture scarcity rents for environmental capacity resources.

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The PIEA policy arises from the actual demand of the emission trading policy. In the initial stage of emission trading, the manager allocated the allowance to enterprises by some rules for free. Free allocation causes a lot of problems. Unpaid emission allowances are for existing enterprises, and new entrants are required to purchase allowances from the emissions trading market. Compared to the new entrants that have to pay for the allowance, the enterprises that receive the allowance for free are basically receiving a subsidy (Bovenberg et al., 2005). In addition, with free allowances, the enterprises lack incentives and pressure to reduce emissions (Goulder et al., 2010). Unpaid allowances make enterprises using environmental capacity resources inefficient, and the enterprises tend to use more allowances than they need. Furthermore, allocating allowances for free promotes manager power rent-seeking, that is, enterprises will attempt to obtain special approval for allowances (Gu, 2007).

To avoid the free allowance as a subsidy for enterprises, to improve the efficiency of resource allocation and to avoid rent-seeking behavior in allocating, the Chinese government launched the PIEA policy in 2008. The policy stipulates that for chemical oxygen demand (COD), ammoniacal nitrogen (NH_3-N), sulfur dioxide (SO_2) and nitrogen oxide (NO_X) four pollutants, enterprises should pay for the emission allowance that they obtained (General Office of the State Council, 2014).

The practical significance of the PIEA policy is to meet the needs for an initial allowance allocation in the first stage of the emissions trading market, since managers gradually realized that if the demands for allowances are adequate, unrestricted rights to use them will lead to an overextension of resources, and the scarcity rents of resources are wasted. Therefore, additional policies are needed to ensure the sustainable use of resources. Since charging appropriate scarcity rents for depleted resources can keep resource consumption at a sustainable level (Hartwick, 1977), the PIEA policy has been implemented.

The initial emission allowance price as results of this study could be in support of the policy implementation. In addition, the price is not only for the initial emission allowance but also actually shows the scarcity rents for environmental capacity resources, meaning that the price calculation method in this study could be implemented in resource value accounting.

2. Literature review

In the PIEA policy, the allowance price is the key factor; thus, how to price allowances is a concern of researchers. Many researchers studied methods for pricing initial emission allowances. The market price method is conveniently used in pricing allowance. Several researchers employed an auction to pricing emission allowance, such as the CO_2 emission allowance within the EU emissions trading system (EU ETS) (Watanabe and Robinson, 2005), carbon monoxide (CO), volatile organic compounds (VOC), sulfur dioxide (SO_2) (Karl, 1992), and nitrogen oxides (NO_X) (Napolitano et al., 2007) in the United States Clean Air Act (CAA) (McCarthy et al., 2013) and COD, NH_3-N, SO_2 and NO_X in the China PIEA policy (Xiao et al., 2001). The auction method has advantages for pricing allowance. Compared to the free allocation method, the auction method will generate income, thereby reducing the government's dependence on ordinary taxes (Andrew Muller et al., 2002; Parry, 1997). Auction revenue also leads to a revenue-recycling effect that reduces tax distortions (Goulder et al., 1999; Muller et al., 2002; Parry, 1997). In the carbon emissions trading market, the allocation of initial allowance has significant impacts on price and allocation efficiency, and auctions tend to reduce price and marginal cost differences, while free allocation tends to amplify the differences (Burtraw et al., 2001). The auctions will encourage companies to implement effective technical innovations (Milliman and Prince, 1989; Popp, 2003). However, the auction method has several drawbacks. As a market-based mechanism, an auction is considered to be able to allocate resources efficiency and generate income, but when the auction is applied to negative externality products, the effect on consumer welfare and social welfare is uncertain (Li, 2015). In addition, in the EPA's emissions trading market, auction settings may cause both buyers and sellers to underestimate the allowance value, leading to lower efficiency in the emission trading market (Cason, 1993), and when the seller can set the bid price, it will distort the market efficiency (Dijkstra and Haan, 2001). Thus, researchers seek pricing methods other than auctions.

PIEA is charging for the environmental capacity to collect scarcity rent, which means “missing money” (Fullertona and Metcalf, 2001; Zöttl, 2011); therefore, several researchers adopted a pricing approach for natural resources. In the US SO_2 emission trading, the shadow price of the SO_2 emission reduction is estimated using the output distance function, which is considered to be the allowance price (Coggins and Swinton, 1996; Fare et al., 2007). Several researchers believe that the initial emission allowance price is related to the cost of using the environmental capacity resources. The environmental self-purification capacity is regarded as environmental capacity resource, and its price is equivalent to its marginal opportunity cost (Zhang, 1996). The cost recovery method was used to assess the price of environmental capacity and took the price as the reference for the initial emission allowance price (Bi et al., 2007). Similarly, it is believed that the price paid for the initial emission allowance is based on the value of the environmental capacity resources; therefore, pollution control costs could be used as a reference for pricing (Ye et al., 2011).

Other researchers believe that the price of the initial emissions allowance from the costs and benefits of using environmental capacity should be considered, especially the damage caused by the pollution emitted to the environment. The costs and benefits were took as a consideration for the initial emissions allowance price model (Huang and Wu, 2004). An initial allowance pricing strategy was established based on the value of water environmental capacity, and the pricing strategy considered the economic value and ecological value of water environmental capacity, as well as the differences between regions and industries (Yu et al., 2012).

In the abovementioned studies, only the manager participates in pricing. However, when manager and enterprises are involved in the pricing process, the pricing process becomes a game process. From the perspective of a dynamic game, the evolution of the strategy of the manager and enterprises in the formulation of the allowance price were analyzed, which provides a reference for the government to formulate a fair and effective pricing model of the initial allowance (Xia et al., 2010). The cooperative game theory was employed to construct the Nash-Bargaining pricing model for the initial allowance of the Tai lake industry based on multi-stakeholder cooperation (Liu et al., 2012).

Researchers discussed varied kinds of pricing approaches, several methods have been applied in practice, and others remained at the theoretical stage. Observing these approaches from an independent perspective, each approach has different considerations. However, when the Chinese environmental policy framework is taken into account, certain approaches ignore the interaction with existing policies (del Río González, 2007).

Prior to the PIEA policy, China embarked on policies related to environmental capacity resources such as the pollution charge (PC)