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When and How does Emission Permit Allocation Method Affect the Cost-effectiveness of ETS?

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ABSTRACT

Carbon market is established to achieve CO_2 emission reduction targets cost efficiently. However, the pilot carbon markets in China emerged market downturn to certain degree with big variation of carbon price and low liquidity in trading market. The existence of transaction cost and market power affect the cost-effectiveness of the carbon market. Do different carbon emission permit allocation methods cause different efficiency losses? This paper explores whether the choice of emission permit allocation method affects the cost effectiveness of ETS when transaction cost and market power exist in carbon market, considering China pilot ETSs settings. By Stackelberg model, we find that transaction cost leads to the efficiency loss of ETS and the efficiency loss from benchmarking and grandfathering are less than auctioning. Market power causes the efficiency loss of ETS, the efficiency loss is proportional to the gap between the market power firm's carbon emissions and its free emission permits. If both transaction cost and market power exist in carbon market, market power further exacerbates the efficiency loss caused by transaction cost. The further efficiency loss caused by grandfathering and benchmarking are less than auctioning.

Keywords: cost-effectiveness, carbon emission permit allocation, transaction cost, market power

1. INTRODUCTION

Emissions trading system (ETS) has become an important policy instrument in the post-Kyoto period of climate change (González-Eguino, 2011). Many countries/regions have gradually launched their ETS since 2005, such as the European Union (EU) (comprising 31 countries), New Zealand, Australia, Korea and China (seven provinces and cities). China's National Development and Reform Commission has explicitly stated national carbon market is to be established in 2017.

Most of the current carbon markets proved to be successful in helping the corresponding countries and regions reduce CO_2 in an efficient way (Hahn and Stavins, 2011). However, there exist some problems in some of these carbon markets. For example, the carbon price in the first period of EU ETS experienced high fluctuation. And the pilot carbon markets in China emerged market downturn to certain degree with big variation of carbon price (1-122.97 Yuan/ton) and low liquidity in trading market (Only about 2% of the allowances were traded).

Many studies have been devoted to study the possible reasons for high fluctuation and variation of carbon price in carbon markets. The main reasons include over-allocation and market power in carbon market. The over-allocation helps explain why the carbon price decreased to near-zero in the end of the first period of EU ETS. The market power could be the reason why the carbon was not zero at the beginning of the EU ETS. Grubb et al. (2005) compared the allocated allowances with historical emissions, projections and national Kyoto targets in the first phase of EU ETS, and found that most Phase 1 allocations were excessive. Ellerman and Buchner (2008) used the installation-level data for verified emissions and compared them with allowance allocations. The data analysis revealed that the allocated allowances were 3% higher than CO_2 emissions. Anderson and Maria (2011) applied a dynamic panel data model to estimate the business-as-usual emissions for member states in Phase 1 of EU ETS. By comparing this baseline to allocated and verified emissions, they showed that both over-allocation and abatement occurred.

The presence of market power in the carbon market can deviate the carbon price from the cost efficient equilibrium price (Hahn, 1984; Westskog, 1996). If the firm with market power is a likely allowance seller, it has an incentive to act as a monopolist and hold back allowances from the market to drive up allowances prices (Malik, 2002), and if it is a likely allowance buyer, it has an incentive to act as a monopsonist and buy fewer allowances to keep the price lower (Hahn 1984). Under these circumstances, both the market carbon price and trading quantity are affected by market power. Since the market power depends critically on the initial allocation, it is possible that the allocation method affects the carbon price and allowance trading quantity. Hintermann (2011) examined the effect of free allocation on price manipulation with market power in both product and permit market from theory and practice point of view. Hintermann (2017) showed that some firms' excess allowance holdings were consistent with strategic price manipulation even if the dominant firm perceives market power in the permit market alone.

Meantime, previous studies have also explored the impact of transaction costs on the amounts of trading allowance or liquidity in carbon markets. Constantatos et al. (2014) showed that fixed transaction costs prevent firms participating in the trading market, while variable transaction costs affect firms' output choice, when the emission allowances are allocated by grandfathering. Jaraitė-Kažukauskė and Kažukauskas (2015) empirically investigated the impact of transaction costs on firm trading behavior in the first phase of the EU ETS. The result showed that the smaller firms with less trading experience were less likely to participate in the ETS and tended to choose to trade permits indirectly via third parties.

As the world's largest emitter of CO_2, China intended to peak CO_2 emissions around 2030. National carbon market is constructed to help achieve this goal in a cost-efficient way. However, pilot carbon markets in China emerged market downturn, which raised some attention to some regulation policy to promote carbon market operate smoothly and functionally. Since the existence of transaction cost and market power affect the cost-effectiveness of the carbon market. Do different carbon emission permit allocation methods cause different efficiency losses? In this paper, we try to explain the ETS efficiency loss from the perspective of emission permit allocation method considering market power and transaction cost. Meanwhile, to reduce the ETS efficiency loss, we provide some suggestions for choosing efficient allocation method for different firms.

2. CO_2 EMISSION PERMIT ALLOCATION METHODS

2.1 Grandfathering

Theoretically speaking, CO_2 emission permit allocation methods may be classified broadly into an indicator approach, an optimization approach, a game theoretic approach, and a hybrid approach. In the existing ETSs, grandfathering, benchmarking, and auctioning are used widely (Wang and Zhou, 2017).

Grandfathering means that the allocation of CO_2 emission permits is based on firms' historical CO_2 emissions . It is a free allocation method, and firms with higher CO_2 emissions in past periods will receive more CO_2 emission permits in later periods. As grandfathering has the advantages of simplicity and maintaining the competitiveness of international firms and the potential for reducing CO_2 emission leakage (Schmidt and Heitzig, 2014; Hintermann, 2016), it is the most widely used permit allocation method in the early stage of ETSs, including the first period of the EU ETS and most China pilot ETSs (Zhang et al., 2017). Though grandfathering ensures the wide acceptability of firms covered in ETSs, CO_2-efficient firms regard this as an unfair permit allocation method, based on the reasoning that firms with higher historical CO_2 emissions caused more damage in the past and, thus, have a larger responsibility to reduce CO_2 emissions in the future.

Suppose that $\bar{e}_i$ is the amount of free allocation of CO_2 emission permits for firm i, f is the CO_2 emission permit allocation coefficient, and e_i^0 is the amount of historical CO_2 emissions of firm i in the base year(s). The CO_2 emission permit allocation coefficient and the base year(s) are set by policy makers. The initial CO_2 emission permits of firm i under grandfathering are equal to the product of the CO_2 emission permit allocation coefficient and the amount of historical CO_2 emissions in the base year(s), i.e.,

$$\bar{e}_i = f e_i^0$$

2.2 Benchmarking

Benchmarking, also called output-based allocation, is defined as the free allocation of CO_2 emission permits in proportion to the reference CO_2 intensity (CO_2 emissions per unit of product) and the amount of output. Generally, one reference CO_2 intensity is set for one kind of product by the government based either on the recent average or on advanced production technology. Under benchmarking, the CO_2-intensive firms are likely to receive fewer CO_2 emission permits compared with the amount that they are required to surrender, in which case they may need to either reduce CO_2 emissions by more or buy more CO_2 emission permits. Conversely, CO_2-efficient firms tend to get more CO_2 emission permits and, thus, either reduce CO_2 emissions by less or have more surplus CO_2 emission permits to sell. Thus, compared to grandfathering, benchmarking rewards CO_2-efficient firms and punishes CO_2-intensive firms, which directly encourages firms to improve their CO_2 efficiency. Acknowledging the merits of benchmarking, policy makers gradually replaced grandfathering by benchmarking, e.g., in the second and third phases of the EU ETS and the ongoing China national ETS. In practice, a limitation of benchmarking lies in its greater complexity compared to grandfathering, as the setting of benchmarks often requires more data, and the diversity of the products often increases the complexity.

Let e_k^b be the benchmark, i.e., reference CO_2 intensity, which is set to be same either for one kind of product *k* or in one product market. Meanwhile, e_k^b is generally different either for diverse products or in different product markets. q_i is the amount of output produced by firm i. The initial CO_2 emission permits of firm i allocated by benchmarking are equal to the benchmark multiplied by the amount of output, i.e.,

$$\bar{e}_i = e_k^b q_i$$

2.3 Auctioning

Auctioning requires that firms covered in ETS should buy CO_2 emission permits in auctions organized by governments rather than receive them freely. This CO_2 emission permit allocation method complies well with the Polluter Pays Principle. Economists suggest that the CO_2 cost burden is the largest driver stimulating firms to take action to reduce CO_2 emissions. Nevertheless, firms are reluctant to accept auctioning because of the economic burden. In this circumstance, many scholars argue that auctioning with revenue recycling is the preferable CO_2 emission permit allocation method. However, the design of a revenue recycling scheme could be complicated and may lead to other fairness issues. In the existing ETSs, more and more regulators are attempting to use auctioning to allocate a portion of the CO_2 emission permits, e.g., the third phase of EU ETS and the Guangdong ETS in China pilot ETSs.

When auctioning is used, all the CO_2 emission permits need to be bought from the carbon market, and, thus, the initial CO_2 emission permits of firm i are null, i.e.,

$$\bar{e}_i = 0$$

3. MODEL

3.1 Competitive carbon market without transaction cost

In this section, we present a simple model to show firm's compliance cost under grandfathering, benchmarking and auctioning. Firms are assumed to trade CO_2 emission permits in a competitive carbon market without transaction costs. All CO_2 emission permits are auctioned and traded at a single carbon price P_c. The initial CO_2 emissions of firm i is e_i and firm i reduces its CO_2 emissions by r_i. The total abatement cost of firm i is $C(r_i)$ and the marginal abatement cost of firm i is $MAC(r_i)$. Under free allocation, firm i receives initial CO_2 emission permits $\bar{e}_i$. Under auctioning, the initial CO_2 emission permits of firm i are null.

Under the ETS, the compliance cost of the firm *i* consists of two parts, including abatement cost and CO_2 emission permits purchasing cost. If firm i fulfils the compliance requirement, the compliance cost of firm i is

$$CC_i = C(r_i) + P_c(e_i - r_i - \bar{e}_i)$$

The achievement of cost-efficiency of ETS requires that all firms' marginal abatement costs and the CO2 price are equal. The marginal efficiency loss in the carbon market can be described as the gap between the marginal abatement cost of the dominant firm and fringe firms (Westskog, 1996; Eshel, 2005; Hagem and Westskog, 2009). We use gap to represent the ETS efficiency loss.

$$Gap = |MAC_i - P_c|$$

Under grandfathering, firm i optimal emission reduction and ETS efficiency loss are,

$$MAC(r_i) = P_c$$
$$Gap = 0$$

Under benchmarking, firm i optimal emission reduction and ETS efficiency loss are,

$$MAC(r_i) = P_c$$
$$Gap = 0$$

Under auctioning, firm i optimal emission reduction and ETS efficiency loss are,

$$MAC(r_i) = P_c$$

$$Gap = 0$$

3.2 *Carbon market with transaction cost and market power*

In this section, firms are assumed to trade CO_2 emission permits in a carbon market with transaction costs and market power.

Considering transaction cost settings in China pilot ETSs, both buyer and seller need pay the transaction cost (including variable transaction costs and fixed transaction costs, i.e. $c_t P_c |\Delta e_i| + c_m$).

Firm 1 has market power. All the CO_2 emission permits traded in the carbon market are assumed to have a single CO_2 price, P_c, which is determined by firm 1. Other firms are price takers.

Under grandfathering, firm i optimal emission reduction and ETS efficiency loss are,

$$if\ \ \Delta e_i > 0,\ MAC_i = (1 + c_t)P_c$$

$$if\ \ \Delta e_i < 0,\ MAC_i = (1 - c_t)P_c$$

$$if\ \ \Delta e_1 > 0,$$

$$MAC_1 = (P_c + P_c^{'}\Delta e_1)(1 + c_t)$$

$$if\ \ \Delta e_1 < 0,$$

$$MAC_1 = (P_c + P_c^{'}\Delta e_1)(1 - c_t)$$

$$if\ \ \Delta e_1 > 0, \Delta e_i < 0,$$

$$Gap = |c_t P_c + (1 + c_t)P_c^{'}\Delta e_1|$$

$$if\ \ \Delta e_1 < 0, \Delta e_i > 0,$$

$$Gap = |c_t P_c - (1 - c_t)P_c^{'}\Delta e_1|$$

Under benchmarking, firm i optimal emission reduction and ETS efficiency loss are,

$$if\ \ \Delta e_i > 0,\ MAC_i = (1 + c_t)P_c$$

$$if\ \ \Delta e_i < 0,\ MAC_i = (1 - c_t)P_c$$

$$if\ \ \Delta e_1 > 0,$$

$$MAC_1 = (P_c + P_c^{'}\Delta e_1)(1 + c_t)$$

$$if\ \ \Delta e_1 < 0,$$

$$MAC_1 = (P_c + P_c^{'}\Delta e_1)(1 - c_t)$$

$$if\ \ \Delta e_1 > 0, \Delta e_i < 0,$$

$$Gap = |c_t P_c + (1 + c_t)P_c^{'}\Delta e_1|$$

$$if\ \ \Delta e_1 < 0, \Delta e_i > 0,$$

$$Gap = |c_t P_c - (1 - c_t)P_c^{'}\Delta e_1|$$

Under auctioning, firm i optimal emission reduction and ETS efficiency loss are,

$$MAC_i = (1 + c_t)P_c$$

$$MAC_1 = (P_c + P_c^{'}E_1)(1 + c_t)$$

$$Gap = |c_t P_c + (1 + c_t)P_c^{'}E_1|$$

4. DISCUSSIONS AND CONCLUSIONS

By Stackelberg model, we find that transaction cost leads to the efficiency loss of ETS and the efficiency loss from benchmarking and grandfathering are less than auctioning.

Market power causes the efficiency loss of ETS, the efficiency loss is proportional to the gap between the market power firm's carbon emissions and its free emission permits.

If both transaction cost and market power exist in carbon market, market power further exacerbates the efficiency loss caused by transaction cost (Fig.1). The further efficiency loss caused by grandfathering and benchmarking are less than auctioning.

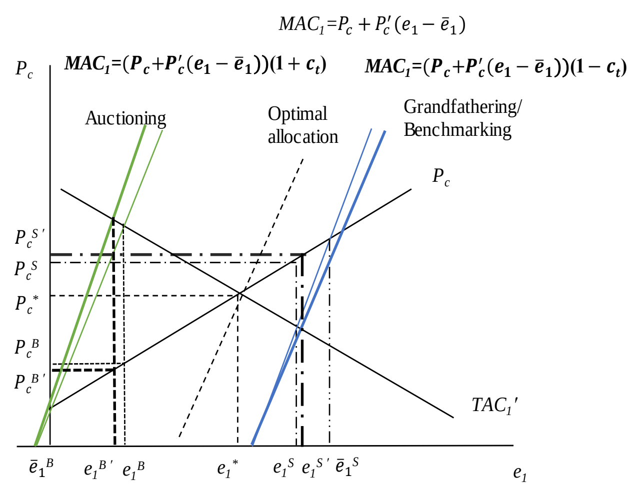

Fig.1 ETS efficiency loss due to market power and transaction costs under different allocation methods

In order to reduce the efficiency losses from transaction cost and market power, we suggest that policy makers apply grandfathering or benchmarking to allocate emission permits to market power firms and cancel transaction-based fee in carbon market.

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