Tradable Emissions Permits in the Presence of Trade Distortions

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【Abstract】

This paper investigates how trade liberalization affects domestic emissions trading scheme in a political economy framework. Developing a model in which the amounts of emissions cap are endogenously determined, we show that a pro-industry government issues too large amount of emissions cap to benefit an industry group, while a pro-environment government issues too small amount of emissions cap to benefit an environmental group. Then, we examine how a country's decision to liberalize trade can affect the equilibrium price of emissions cap chosen by the corruptible government. In particular, we show that trade liberalization will increase the too low price of permits chosen by the pro-industry government, while it will decrease the too high price of permits chosen by the pro-environment government.

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1. Introduction

Tradable emissions permits are a system for achieving target emissions volumes in a cost-effective manner, in which the total amount of an emissions cap is distributed, for free or at a cost, to sources of pollutant emissions such as firms, that each trade emissions caps on the market according to their own permits. While, in the field of environmental economics, emissions taxes and tradable emissions permits have been regarded as equivalent policy instruments in terms of efficiency, they could have different impacts on efficiency in the presence of corruptible policymakers that are influenced by political economic incentives.

The purpose of this paper is to examine how trade liberalization affects a domestic emissions trading scheme in a political economy framework. First, we characterize the amount of emissions cap chosen by governments influenced by political economic incentives and compare how they differ from their socially optimal levels. We show that a government that cares about industry profit chooses too large amount of emissions cap, while a government that cares about environmental group's welfare chooses too small amount of emissions cap. Second, we examine how a country's decision to liberalize trade affects the equilibrium price of the emissions cap and hence its amount chosen by the politically-motivated governments. We show that trade liberalization that leads to a decrease in the price of the exportable good will raise the too low price of permits caused by their too large amount chosen by the pro-industry government, while it will lower

the too high price of permits caused by their too small amount chosen by the pro-environment government.

Montgomery (1972) is the first work that conducted research using theoretical frameworks for tradable emissions permits. Sterner and Isaksson (2006) adopt a political economy model to analyze emissions trading, and demonstrate the political superiority of the grandfathering system. Lai (2007, 2008) examines emissions trading based on the political economy model developed by Grossman and Helpman (1994), and shows that the grandfathering system is chosen in order to control the issuance of emissions permits that exceed efficient levels. Harstad and Eskeland (2010) focus on imperfect information in the emissions trading system, and show that the government, facing uncertainty in firm's cost of abatement, distributes more permits to high-cost firms that purchase too large amount of permits, which results in too high price of permits.

This paper is organized as follows. The next section sets up a political economy model of emissions trading that will be used in the following analysis. Section 3 examines the determination of total amount of emissions cap. Section 4 examines the effect of trade liberalization on the equilibrium price of emissions permits. The final section concludes the paper.

2. Model

This section sets up a political economy model in which the environmental policy is endogenously determined. Consider a small open economy that has three industries: a non-polluting numeraire good z and two polluting goods (an import-competing and an exportable good) x_m and x_e. The economy also has a representative citizen whom we call an environmentalist.

The production side of the economy is described by a specific factors model of a small open economy that is frequently used in the theory of

international trade. The non-polluting numeraire good z is produced by labor with constant returns to scale technology; unit input-output coefficient is assumed. On the other hand, each polluting good x_i $(i = m, e)$ is produced by labor l_i and an inelastically supplied specific factor with constant returns to scale technology $x_i = f_i(l_i)$, where $f_i' > 0$ and $f_i'' < 0$.[1] Each unit production of good x_i generates one unit of emission that negatively affects the environmentalist's welfare. For each unit of emissions, firms have to purchase emissions permits at a price τ. If the permit initially allocated to firm i is e_i, the amount of emissions permits purchased by firm i becomes $x_i - e_i$.[2] Firm i's optimization problem is given by

$$\max_{l_i} \; p_i f_i(l_i) - w l_i - \tau(x_i - e_i) \text{ s.t. } x_i = f_i(l_i).$$

Assuming that all goods are produced in the equilibrium, the equilibrium wage rate becomes equal to one, and hence the first-order condition for this optimization problem gives the amount of labor l_i and the supply of good x_i as $l_i(p_i - \tau)$ and $x_i(p_i - \tau)$. We assume that $x_i'' = 0$.[3] Comparative statics give the following.

$$\frac{\partial x_i}{\partial p_i} = x_i' = -\frac{f_i'^2}{(p_i - \tau) f_i''} > 0, \;\; \frac{\partial x_i}{\partial \tau} = -x_i' = \frac{f_i'^2}{(p_i - \tau) f_i''} < 0. \qquad (1)$$

The reward to the specific factor in industry i becomes dependent on e_i as well as p_i and τ, and hence can be written as

$$\pi_i(p_i, \tau, e_i) = (p_i - \tau) f_i(l_i(p_i - \tau)) - l_i(p_i - \tau) + \tau e_i. \qquad (2)$$

The application of Hotelling's lemma gives the relationship $\partial \pi_i / \partial p_i = x_i$ and $\partial \pi_i / \partial \tau = -x_i + e_i$.

[1] To save on notation, the specific factor is omitted from the production function.

[2] If the amount of emissions by firm i is less than the amount initially allocated, then firm i can sell emissions permits in the market for the price τ.

[3] That is, we assume linear supply function.

An environmentalist suffers environmental damage from emissions by polluting firms. We denote total amount of emissions as $\sum_i x_i$ and the environmental damage as $D\left(\sum_i x_i\right)$, where $D' > 0$ and $D'' > 0$. The environmentalist's utility is represented by $u_g = c_z + \sum_i u_i(c_i) - D(\sum_i x_i)$, where c_z and c_i denote the consumption of goods z and x_i, respectively. The subutility function $u(\cdot)$ is assumed to be increasing and strictly concave. The environmentalist's utility maximization problem gives the indirect utility as

$$v_g = y + \sigma(p) - D\left(\sum_i x_i\right), \tag{3}$$

where y is the environmentalist's income and $\sigma(p) = \sum_i u_i(c_i(p_i)) - \sum_i p_i c_i(p_i)$ represents the consumer surplus as a function of p_e and p_m.

The market for emissions permits can be described as follows. First, total supply of emissions permits is represented by E. The fraction of those permits distributed free of charge (under the grandfathering system) is given by α ($\in [0,1]$), and the fraction of those obtained by firm i is denoted by β_i ($\in [0,1], \sum_i \beta_i = 1$); firm i thus obtains $\beta_i \alpha E$ emissions permits.[4] The amount of emissions permits distributed via auction system can be expressed as $(1-\alpha)E$. Revenue from the auction $R = \tau(1-\alpha)E$ is assumed to be uniformly distributed to the environmentalist.

Total demand for the emissions permits is the sum of each firm's amount of emissions $\sum_i x_i$. Equilibrium condition for the market can be written as

$$\sum_i x_i(p_i - \tau) = E. \tag{4}$$

Totally differentiate (4) and use (1) to obtain

$$\frac{d\tau}{dE} = -\frac{1}{\sum_i x_i'} < 0. \tag{5}$$

[4] We assume β_i as being fixed as it is determined in accordance with firm i's past amount of emissions.

That is, an increase in total supply of the emissions permits (or the amount of emissions cap) decreases the price of permits.

3. Total amount of emissions cap in a political equilibrium

There are two types of groups in the economy: firms and the environmentalist. A firm in industry i (firm i) forms the industry lobby i. The benefit for firm i from forming the lobby, gross of political contributions, is represented by

$$\Pi_i = \pi_i(p_i, \tau, e_i). \tag{6}$$

On the other hand, the environmentalist forms the environmental lobby. The benefit for the environmentalist from forming the lobby, gross of political contributions, can be expressed as

$$V_g = v_g = l + \tau(1-\alpha)E + \sigma(p) - D(E), \tag{7}$$

where we use the equilibrium condition for the emissions permit market $E = \sum_i x_i$ to derive the second equality.[5]

The game in this model is a Grossman and Helpman (1994) type common agency model among the government and lobby groups. The timing of the decisions is as follows. In period 1, firms and the environmentalist form lobbies and make political contributions $(C_i,\ C_g)$ to the government, where C_i $(i = 1, \ldots, N)$ denotes political contributions by industry lobby i and C_g represents those by environmental lobby. Based on the political contributions, the government in period 2 determines the total amount of emissions cap E.

[5] Note also that the environmentalist's income consists of the revenue from auction R as well as labor income l.

The model can be solved by backward induction as in Grossman and Helpman (1994). The objective function of the government can be expressed as

$$G = \sum_i C_i + C_g + aW, \tag{8}$$

where W denotes aggregate social welfare

$$W = \sum_i \Pi_i + V_g, \tag{9}$$

and a represents the extent to which the government cares about aggregate social welfare relative to the political contributions. As in Grossman and Helpman (1994), it is assumed that the contribution schedule chosen by any organized lobby reflects its true preferences. That is, the organized lobby always chooses a truthful contribution schedule. We focus on the equilibrium in which the organized lobbies always make positive contributions. Thus, under any truthful Nash equilibria (Nash equilibria in which the organized lobbies choose truthful contribution schedules), we have

$$\frac{\partial C_i}{\partial E} = \frac{\partial \Pi_i}{\partial E}, \ \frac{\partial C_g}{\partial E} = \frac{\partial V_g}{\partial E}. \tag{10}$$

The equilibrium amount of emissions cap can be characterized using those relationships.

3.1 Emissions cap in the presence of both lobbies

Suppose that both groups are organized in period 2. Then, the government chooses the total amount of emissions cap E so as to maximize its objective function:

$$\max_E G = \sum_i C_i + C_g + aW.$$

The optimality condition for this problem is

$$\frac{\partial G}{\partial E} = \sum_i \frac{\partial C_i}{\partial E} + \frac{\partial C_g}{\partial E} + a\frac{\partial W}{\partial E} = 0. \tag{11}$$

Using (10), this can be written as

$$\sum_i \frac{\partial \Pi_i}{\partial E} + \frac{\partial V_g}{\partial E} + a\frac{\partial W}{\partial E} = 0. \tag{12}$$

The first term on the left-hand side of (12) represents the sum of the effects of E on each firm's profit. Differentiating (6) with respect to E, this term can be written as

$$\frac{\partial \Pi_i}{\partial E} = \tau\beta_i\alpha + e_i\frac{d\tau}{dE} - x_i\frac{d\tau}{dE}. \tag{13}$$

The first two terms on the right-hand side of (13) express the effect of E on the value of initial amount of emissions permits τe_i by firm i. The sign of the first term is positive while the sign of the second term is negative from (5). Lai (2007) interprets that if the demand for the emissions permits becomes inelastic, then it is likely that the second term dominates the first term, i.e., the sum of the first two terms becomes negative. The third term represents the effect of E on the firm's cost of emissions via the price of permits. An increase in total amount of emissions cap decreases the price of permits, which increases the firm's profit. Thus, the sign of this term will be positive.

Next, the second term on the left-hand side of (12) represents the effect of E on the environmentalist's welfare. Differentiating (7) with respect to E, this term can be written as

$$\frac{\partial V_g}{\partial E} = (1-\alpha)\left(\tau + E\frac{d\tau}{dE}\right) - D'(E). \tag{14}$$

The first term on the right-hand side of (14) represents the effect of E on the value of transferred income from the government $\tau(1-\alpha)E$. Again, if the demand for the emissions permits is inelastic, then an increase in total amount of emissions cap causes a significant decrease in the price of permits and, therefore, causes a decrease in the value of transferred income. This exerts a negative effect on the environmentalist's welfare. The second

term represents negative effect that an increase in E has on environmental damage.

Finally, the third term on the left-hand side of (12) represents the effect of E on the aggregate social welfare. Using (13) and (14), this term can be represented as

$$\frac{\partial W}{\partial E} = \tau - D'(E). \tag{15}$$

The above equation reveals that a government which aims to maximize the aggregate social welfare chooses E such that $\tau = D'(E)$. That is, the government chooses the total amount of emissions cap E^* so that the marginal damage and the marginal benefit from emissions become equal.

Substituting (13)-(15) into (12) gives the optimal conditions regarding the total amount of emissions cap chosen by the government

$$(1+a)\left[\tau - D'(E)\right] = 0. \tag{16}$$

That is, the government chooses the total amount of emissions cap such that $\tau = D'(E)$. Thus, if both groups are organized, then a government will choose socially optimal level of emissions cap E^*.

3.2 Emissions cap in the presence of industry lobby

Next, suppose that only the industry lobby is organized in period 2. Then, the government chooses the total amount of emissions cap E so as to maximize its objective function, which gives the optimality condition as

$$\frac{\partial G}{\partial E} = \sum_i \frac{\partial C_i}{\partial E} + a\frac{\partial W}{\partial E} = 0. \tag{17}$$

Using (10), this can be written as

$$\sum_i \frac{\partial \Pi_i}{\partial E} + a\frac{\partial W}{\partial E} = 0. \tag{18}$$

Substituting (13) and (15) into (18) gives the optimality conditions regarding the total amount of emissions cap chosen by the government

$$\sum_i \left[\tau\beta_i\alpha + e_i\frac{d\tau}{dE} - x_i\frac{d\tau}{dE}\right] + a\left[\tau - D'(E)\right] = 0. \tag{19}$$

From (19), the price of emissions permits in period 2 when only the industry lobby is formed can be derived as

$$\tau^b = \frac{a}{a+\alpha}D' + \frac{(1-\alpha)E}{a+\alpha}\frac{d\tau}{dE}. \tag{20}$$

From the equation above, it can be shown that $\tau^b < D'$; therefore, $E^b > E^*$.[6] That is, when only the industry lobby is formed in period 2, the government that cares about the industry lobby chooses too large amount of total emissions cap. With too large amount of total emissions cap, its price decreases, which increases industry profits.

3.3 Emissions cap in the presence of environmental lobby

Finally, suppose that only the environmental lobby is organized in period 2. Then, the government chooses the total amount of emissions cap E so as to maximize its objective function, which gives the optimality condition as

$$\frac{\partial G}{\partial E} = \frac{\partial C_g}{\partial E} + a\frac{\partial W}{\partial E}. \tag{21}$$

Using (10), this can be written as

$$\frac{\partial V_g}{\partial E} + a\frac{\partial W}{\partial E} = 0. \tag{22}$$

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[6] Note that $\tau^b < D'$ follows from $d\tau/dE < 0$, and $E^b > E^*$ follows from $D' > 0$ and $D'' > 0$.

Substituting (14) and (15) into (22) gives the optimality conditions regarding the total amount of emissions cap chosen by the government

$$(1-\alpha)\left(\tau + E\frac{d\tau}{dE}\right) - D'(E) + a\left[\tau - D'(L)\right] = 0. \tag{23}$$

From (23), the price of emissions permits in period 2 when only the environmental lobby is formed can be derived as

$$\tau^g = \frac{1+a}{(1-\alpha)+a}D' - \frac{(1-\alpha)E}{(1-\alpha)+a}\frac{d\tau}{dE}. \tag{24}$$

From the equation above, we have $\tau^g > D'$; therefore, $E^g < E^*$. That is, when only the environmental lobby is formed in period 2, the government that cares about the environmental lobby chooses too small amount of total emissions cap. With too small amount of total emissions cap, its price increases, which benefits the environmentalist.

The following result summarizes those obtained in this section. Suppose that the economy consists of industrialists and environmentalists. Suppose also that the government issues tradable emissions permits and its decision is subject to political pressure. Then, if both lobbies are formed, the government issues socially optimal amount of emissions permits. If only the industry lobby is formed, the government issues too large amount of emissions permits to benefit industrialist's profit. If only the environmental lobby is formed, the government issues too small amount of emissions permits that generates benefits to environmentalists by reducing pollution.

4. Trade liberalization and the total amount of emissions cap

The preceding section examined the determination of the total amount of emissions cap by governments that are politically influenced by lobby

groups. This section examines how a country's decision to liberalize trade, which leads to a price change, affects the political economic choice of environmental policy in the country. In particular, this section examines how a change in the price of the polluting goods affects the equilibrium price of emissions permits. For simplicity, we assume that the price of the importable good is one and let $p_e = p$. As p represents the domestic price of the exportable good, removing trade distortions by the small country will cause a reduction of p.

4.1 Trade liberalization in the presence of industry lobby

First, from (5) and (20) when only the industry lobby is formed in equilibrium, the price of emissions permits can be expressed as

$$\tau^b = \frac{a}{a+\alpha} D'(\sum_i x_i) - \frac{(1-\alpha)\sum_i x_i}{a+\alpha} \frac{1}{\sum_i x_i'}. \tag{25}$$

Totally differentiate (25) to obtain

$$\frac{d\tau^b}{dp} = \frac{\frac{a}{a+\alpha} D'' x_e' - \frac{1-\alpha}{a+\alpha} \frac{x_e'}{\sum_i x_i'}}{1 + \frac{a}{a+\alpha} D'' \sum_i x_i' - \frac{1-\alpha}{a+\alpha}}. \tag{26}$$

The above equation represents the effect of p on τ_b. This can be interpreted as follows. A decrease in p contracts the export industry. This will exert two opposing effects. On the one hand, it will shrink the demand for emissions permits, which works for lowering the price of the permits. This is reflected in the first term in the numerator on the right-hand side of (26). On the other hand, decreasing p reduces the industrialist's lobbying effort. This will decrease the supply of permits, which works for raising its price τ. This is reflected in the second term in the numerator on the right-hand side of (26). Total effect is ambiguous and depends on the relative magnitude

of those effects. However, under the assumption of linear damage function $D'' = 0$, the first effect vanishes, and hence the trade liberalization will lead to an increase in the too low price of permits that was caused by the too large amount of emissions cap.

The following proposition summarizes those obtained in this section.

Proposition 1 : Suppose that the economy consists of industrialists and environmentalists. Suppose also that the government issues tradable emissions permits and its decision is subject to political pressure and that the environmental damage function is given by a linear form. Then, in the presence of the industry lobby, the trade liberalization that leads to a decrease in the price of the exportable good will raise the too low price of permits.

4.2 Trade liberalization in the presence of environmental lobby

Next, from (5) and (24), when only the environmental lobby is formed in equilibrium, the price of emissions permits can be expressed as

$$\tau^g = \frac{1+a}{(1-\alpha)+a} D'(\sum_i x_i) + \frac{(1-\alpha)\sum_i x_i}{(1-\alpha)+a} \frac{1}{\sum_i x_i'}. \tag{27}$$

Totally differentiate (27) to obtain

$$\frac{d\tau^g}{dp} = \frac{\frac{1+a}{(1-\alpha)+a} D'' x_e' + \frac{1-\alpha}{(1-\alpha)+a} \frac{x_e'}{\sum_i x_i'}}{1 + \frac{1+a}{(1-\alpha)+a} D'' \sum_i x_i' + \frac{1-\alpha}{(1-\alpha)+a}}. \tag{28}$$

The above equation represents the effect of p on τ_g. This can be interpreted as follows. Again, a decrease in p contracts the export industry. This will exert two effects. First, it will shrink the demand for emissions permits, which works for lowering the price of the permits. This is reflected in the first term in the numerator on the right-hand side of (28). Second, decreasing p reduces the environmentalist's lobbying effort. This will increase the

supply of permits, which works for lowering its price τ. This is reflected in the second term in the numerator on the right-hand side of (28). Thus, the sign of (28) is positive, implying that the trade liberalization will lead to a decrease in the too high price of permits that was caused by the too small amount of emissions cap.

The following proposition summarizes those obtained in this section.

Proposition 2 : Suppose that the economy consists of industrialists and environmentalists. Suppose also that the government issues tradable emissions permits and its decision is subject to political pressure. Then, in the presence of the environmental lobby, the trade liberalization will, in turn, lower the too high price of permits.

5. Concluding Remarks

This paper examined how trade liberalization would affect a domestic emissions trading scheme in a political economy framework. We constructed a model in which the total amounts of emissions cap were endogenously determined, and examined how a corruptible government issued inefficient amounts of emissions cap to benefit its preferable group. We also examined how a country's decision to liberalize trade, which leads to a decrease in the price of the exportable good, could affect the equilibrium price of permits chosen by the government. The conclusions obtained from the analyses can be summarized as follows.

First, we showed that if both lobbies were formed, the government issued socially optimal amount of emissions permits. If only the industry lobby is formed, the government issues too large amount of emissions permits to reduce its price, which benefits industry group. If only the environmental lobby is formed, the government issues too small amount of emissions permits to reduce pollution emissions, which benefits an environmental group.

Second, we showed that trade liberalization, leading to a decrease in the price of the exportable good, would raise the too low price of permits that was caused by the too large amount of emissions cap in the presence of industry lobby, while it would lower the too high price of permits that was caused by the too small amount of emissions cap in the presence of environmental lobby.

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