International Permit Trading: Efficiency and Transfers

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Allowing emissions permits to be traded internationally can improve economic efficiency but it can also lead to large international transfers of wealth. Unfortunately, these features go hand in hand: the conditions under which international trading is most important for efficiency are also the ones that lead to the largest transfers. Since large international transfers will reduce the political viability of a proposed policy, and even the *potential* for large transfers is likely to have a chilling effect, it is important to investigate whether the efficiency gains from trading are large enough to be worth the political and administrative problems trading would create. One way to approach this is to calculate how large the gains from trade are relative to the transfers involved. In this appendix we present a simple economic model that can be used to explore that question.

Suppose that a group of countries would like to lower its greenhouse gas emissions by Q^* tons, and that the marginal cost of abatement for country i depends on the amount of abatement, q_i it does: $mc_i(q_i)$. Pareto efficiency requires that the allocation of abatement across countries be such that marginal costs are equal between all pairs of countries, i and j:

(1) $$mc_i(q_i^*) = mc_j(q_j^*)$$

where q_i^* and q_j^* are the efficient quantities of abatement in the two countries. In addition, total abatement must add up to Q^*:

(2) $$\sum_i q_i^* = Q^*$$

For convenience, let the marginal cost under the efficient allocation of abatement be denoted by A:

(3) $$A = mc_i(q_i^*) = mc_j(q_j^*)$$

Now suppose that the marginal cost of eliminating a ton of emissions for country i when abatement is q_i can be written as follows:

(4) $$mc_i = A\left(\frac{q_i}{q_i^*}\right)^{\eta_i}$$

where η_i is an elasticity reflecting the rate at which marginal costs increase as abatement departs from its efficient level. When abatement is allocated efficiently, q_i is equal to q_i^* and mc_i will equal A. A one percent increase in q_i above q_i^* will raise marginal costs by approximately η_i percent.

Integrating (4) gives the total cost to country i of abating q_i units:

(5) $$tc_i = \frac{A}{1+\eta_i}\left(\frac{q_i}{q_i^*}\right)^{\eta_i} q_i$$

At the efficient allocation of abatement across countries, $q_i = q_i^*$ and (5) can be rewritten:

(6) $$tc_i^* = \frac{Aq_i^*}{1+\eta_i}$$

When the cost elasticity η_i is very small, marginal abatement costs are nearly constant at A and tc_i is close to Aq_i^*. When η_i is larger, the total cost of q_i^* declines (holding the marginal cost of q_i^* constant at A) because inframarginal units are cheaper to abate. Put another way, a larger η_i means a steeper marginal cost curve, and hence a sharper reduction in marginal costs when q_i is below q_i^*. When η_i is 1.0, for example, tc_i drops to half of Aq_i^*.

Now suppose that non-tradable emissions permits are handed out and that country i's allotment requires it to do an amount of abatement that differs from the efficient pattern by a percentage ε_i:

(7) $$q_i = q_i^*(1+\varepsilon_i)$$

The sum of the ε_i's across countries will be equal to zero.[1] ε_i will be positive when country i has been given relatively few permits and therefore must abate more than its efficient amount; it will be negative in the opposite case. Because q_i differs from q_i^*, marginal costs will no longer be equal across countries. Inserting (7) into (4):

(8) $$mc_i = A(1+\varepsilon_i)^{\eta_i}$$

Total abatement costs in each country will differ from their efficient values as well, as can be seen by inserting (7) into (5), collecting terms, and then using (6) to write the actual costs in terms of the efficient value:

(9) $$tc_i^N = tc_i^*(1+\varepsilon_i)^{1+\eta_i}$$

In contrast, if the permits were internationally tradable in a competitive market, the equilibrium price of a one-ton permit would be A and country i would buy $\varepsilon_i q_i^*$ permits from abroad (or sell permits, when ε_i is negative) at a total expenditure given by:

(10) $$tc_i^P = \varepsilon_i q_i^* A$$

Using (6) allows this to be rewritten in terms of efficient total costs:

(11) $$tc_i^P = \varepsilon_i tc_i^* (1+\eta_i)$$

This would allow it to move its level of abatement to q_i^*, and its total cost – including both abatement and permit purchases or sales – would become:

(12) $$tc_i^T = tc_i^* + tc_i^P$$

Inserting (11):

(13) $$tc_i^T = tc_i^* (1+\varepsilon_i + \varepsilon_i \eta_i)$$

Now define g_i be the cost advantage of trading:

(14) $$g_i = tc_i^N - tc_i^T = tc_i^* ((1+\varepsilon_i)^{1+\eta_i} - 1 - \varepsilon_i - \varepsilon_i \eta_i)$$

When ε_i is zero, g_i is equal to zero: if abatement is allocated efficiently across countries, there will be no need for trading and costs will be the same whether or not trading is allowed. Moving ε_i away from zero in either direction raises g_i, which can be seen differentiating (14) with respect to ε_i:

(15) $$\frac{dg_i}{d\varepsilon_i} = tc_i^* (1+\eta_i)((1+\varepsilon_i)^{\eta_i} - 1)$$

[1] This means that the overall amount of abatement will be correct, just not its allocation across countries.

The derivative will have the same sign as ε_i, so moving ε_i away from zero in either direction raises the cost advantage of trading.[2] All countries, in other words, will be at least as well off under trading: those with $\varepsilon_i = 0$ will be no worse off and all others will be strictly better off.

What we have shown so far is a result that is very familiar to most economists: allowing emissions permits to be traded can reduce overall abatement costs and will be weakly preferred by all agents to a non-tradable system. That statement, however, is purely qualitative and gives no indication about whether the gains are small or large. Moreover, it ignores any administrative or political costs that trading might create. As a result, it is not useful for real-world policy decisions: a trading policy that produced small gains from trade at the cost of large administrative or political problems would be inefficient and counterproductive overall.

One way to move beyond a purely qualitative result is to compare the gains from trade to the value of the international permit transactions necessary to bring them about, since the latter is likely to be closely correlated with the political costs of the policy. Let ϕ_i be the ratio between the two:

$$\phi_i = \frac{g_i}{tc_i^P} = \frac{(1+\varepsilon_i)^{1+\eta_i} - 1 - \varepsilon_i - \varepsilon_i \eta_i}{\varepsilon_i (1+\eta_i)} \qquad (16)$$

Simplifying this slightly gives:

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[2] This equation holds when ε_i is greater than –1; if ε_i were less than –1 (a country were given more than 100 percent of the emissions rights it needed), trading would still be superior but the derivation would be slightly different because total costs in the no-trading case would be zero.

(17) $$\phi_i = \frac{(1+\varepsilon_i)^{1+\eta_i} - 1}{\varepsilon_i(1+\eta_i)} - 1$$

When ϕ_i is large, trading is likely to be a sound, practical policy: the gains from trade are large compared to the transfers it would cause. On the other hand, when ϕ_i is small, it may be that the gains from trade will be overwhelmed by the political costs.

From (17) it is clear that as either ε_i or η_i approaches zero, ϕ_i approaches zero as well. The intuition behind this is straightforward and can be seen from Figure 1, which illustrates the relationship between η, marginal costs, ε and tc^P. Suppose a country is initially allocated fewer than the efficient number of permits and would have to abate $q^*(1+\varepsilon)$ tons. If the elasticity of marginal abatement costs, η, were small, it would face a cost curve like MC_1. By buying permits at a total cost shown by area tc^P in the diagram, the country would lower abatement costs enough to produce a net gain equal to area G_1. The net gain is positive but small compared to tc^P because the marginal cost curve is fairly flat. The ratio is larger when the marginal cost curve is steeper: a larger η would lead to a cost curve like MC_2 and a gain of G_2.

The analysis can be taken one step further by evaluating (17) for a range of values of η_i and ε_i. The results are shown in Table 1. If the cost elasticity, η_i, is very high and the permits are allocated very inefficiently (ε_i is large), the efficiency gain will be relatively large compared to the transfer. For example, when $\eta_i = 4$ and $\varepsilon_i = 0.30$, ϕ_i will be about 81 percent. However, if either or both of these parameters are small, the gains from trade will be small compared to the transfer. All of the cells above the gray region, in particular, have gains from trade that are less than 10 percent of the permit transactions. Put another way, in this region the value of permit sales will be more than 10 times the efficiency gains they create.

Figure 1: Efficiency Gains and Transfers For Different Values of η

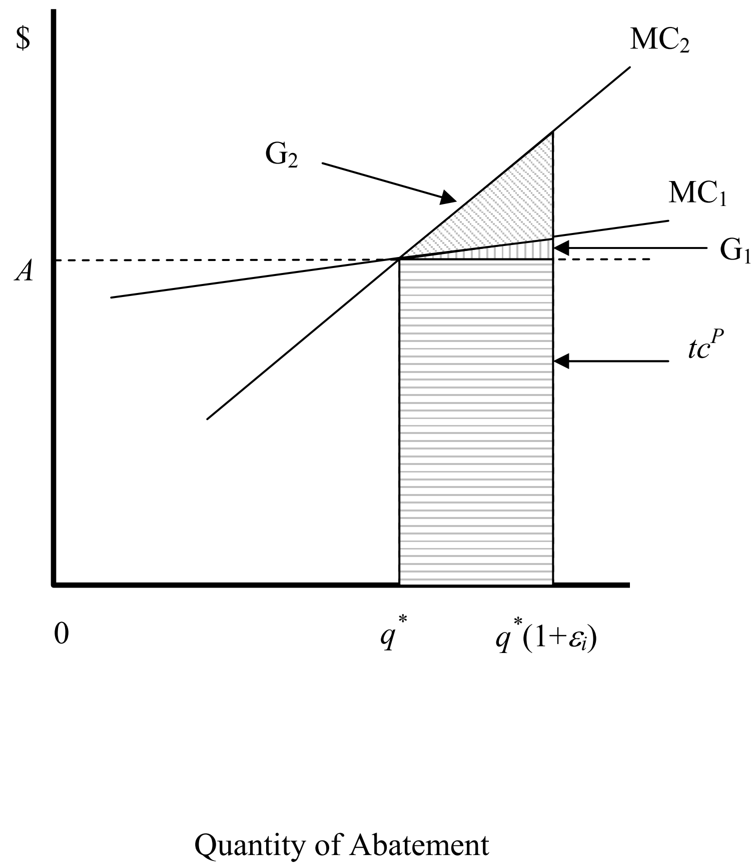

Table 1: Ratio ϕ for Alternative Values of η and ε

		Excess Abatement, ε					
		0.05	0.10	0.15	0.20	0.25	0.30
MC elasticity, η	0.25	0.62%	1.22%	1.81%	2.38%	2.95%	3.50%
	0.50	1.24%	2.46%	3.66%	4.84%	6.01%	7.16%
	0.75	1.87%	3.72%	5.56%	7.38%	9.19%	10.99%
	1.00	2.50%	5.00%	7.50%	10.00%	12.50%	15.00%
	1.50	3.78%	7.62%	11.53%	15.49%	19.51%	23.59%
	2.00	5.08%	10.33%	15.75%	21.33%	27.08%	33.00%
	3.00	7.75%	16.03%	24.83%	34.20%	44.14%	54.68%
	4.00	10.51%	22.10%	34.85%	48.83%	64.14%	80.86%