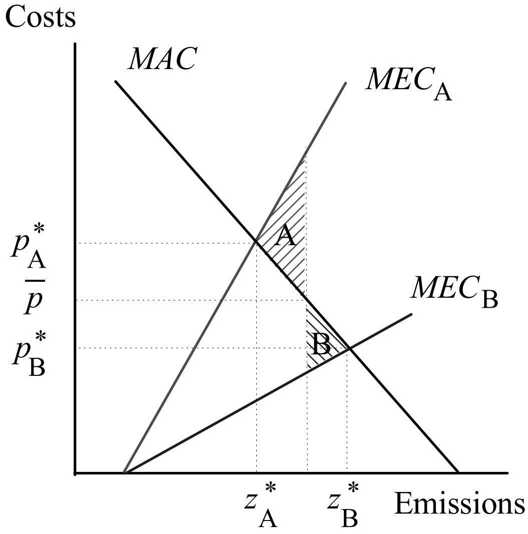
ECN 371: Exercise set 4 - suggested answers

(a) Specific problems with the suggestions made by Quick & Dirty

With the government's concerns regarding competitiveness of the industry, the immediate reaction may be that Quick & Dirty's suggestions are sound. However, there are several problems with their suggestions:

(i) The marginal economic costs in the two rivers are likely to vary considerably (indicated by MEC_A and MEC_B). Assuming that the abatement cost curves are the same (indicated by the joint *MAC* curve in the figure), the optimal emission level in the two rivers differ (z_A^* and z_B^* respectively). This results in two different optimal prices in the two rivers, p_A^* and p_B^* respectively. Having a joint trading area results in a joint price ($\bar{p}$, the "law of one price" in integrated markets) in the emission permit market somewhere between p_A^* and p_B^*, resulting in the welfare loss equaling the area A in river A from excessive emissions, and B in river B from too little emissions.



(ii) Given (i) it follows that one may want to restrict trades to take place only within the two receptor areas (rivers), i.e., what is termed a "trading bubble" within the literature. In each of the rivers there are only three firms, which is a very small number of potential traders to be certain that price taking behavior on behalf of the firms would result (the problem of "thin markets"). In short, the conditions for a well working tradable permit markets are not met.

An additional reason for concern in this case is that the product market these firms produce for also appears to be somewhat limited as six firms have a major market share. This implies that the product price is strongly related to the actions of these six firms, i.e. $p_y = p(y_i)$, where y_i denotes the produced quantity of firm *i*. Consequently, gaining control of the permit market may also be a way of influencing the product market.

To see that this is a relevant issue, assume for simplicity and without loss of generality, that increased commodity production (y_i) leads to increased emissions (z_i) for firm *i*, i.e., there is a relationship of the form $z_i = z_i(y_i)$ where

$$\frac{\partial z_i}{\partial y_i} > 0$$

for a given technology. The above implies that $z_i(y_i)$ is a monotonous function in y_i, so that the inverse function exists, i.e., it is possible to write $y_i = y_i(z_i)$ where

$$\frac{\partial y_i}{\partial z_i} > 0$$

This enables us to rewrite firm *i*'s profit function in terms of emissions being the only choice variable for a given technology, i.e.,

$$\begin{aligned}\pi &= p_y(y_i)y_i + p_z(z_i, Z_{Ni})z_i + C_i(y_i, z_i) \\ &= p_y(y_i(z_i))y_i(z_i) + p_z(z_i, Z)z_i - C_i(y_i(z_i), z_i) \\ &= p_y(y_i(z_i))y_i(z_i) + p_z(z_i, Z)z_i - C_{z,i}(z_i)\end{aligned}$$

Differentiating this with respect to z_i gives the following first order condition for profit maximization:

$$\frac{\partial \pi_i}{\partial z_i} = \frac{\partial p_y}{\partial z_i} y_i(z_i) + p_y \frac{\partial y_i(z_i)}{\partial z_i} + \frac{\partial p_z(z_i, Z)}{\partial z_i} z_i + p_z - \frac{\partial C_{z,i}(z_i)}{\partial z_i} = 0$$

By inspection of the above equation it is easy to see that there is a relationship between product prices, $p_y(z_i)$, and permit prices, $p_z(z_i,Z)$, that both depend on firm *i*'s emission level, and the total emission level, *Z*. With the six firms controlling a large share of the market for *y*, price taking behavior in either market is unlikely. This is most evident for the permit market, where the aggregate emission level, $Z = \sum_{i=1}^{6} z_i$ is fixed (at the permit level), and any firm's decision clearly influence the decisions of the others.

To conclude, Quick & Dirty's suggestion is not very well thought out.

(b) Suggested policy changes compared to Quick & Dirty's proposal

No easy solution exists here (it is always "tricky" to regulate situations where there is market power involved, or there is a low number of polluters). Some solutions that at least are better than those proposed by Quick & Dirty:

- A **tax on emissions** is a possibility. As emissions occur in separate receptors, and cannot be shifted, it is possible with differentiated tax rates between the receptors. There are two problems related to the use of a tax: (i) competitiveness, and (ii) price fluctuations in the market (that may call for adjusting the tax rate). To see this, consider the following first order condition (FOC) for the tax problem with few firms:

  $$\frac{\partial \pi_i}{\partial z_i} = \frac{\partial p_y}{\partial z_i} y_i(z_i) + p_y \frac{\partial y_i(z_i)}{\partial z_i} - t z_i - \frac{\partial C_{z,i}(z_i)}{\partial z_i} = 0$$

  where a price increase (decrease) must be offset by a partial tax increase (decrease) for the FOC to hold. Note that a differentiated tax between the receptors would shift some production from the high to the low damage receptor (as desired).

- A **command-and-control** approach (like non-tradable permits) where the environmental standard is set, but where firms are free to choose technological approaches to reduce emissions. Maximum freedom for firms' choices for abatement is always desirable, as firms then will choose the least costly abatement solution given the emission/environmental standard (this also follows from the core proposition from operations research on the objective value of less versus more constrained problems). There are two weaknesses of this approach: (i) the regulator receives little (if any) price signal on the development of firms' abatement costs over time, and (ii) with so few polluters, the total emission load, and hence the optimality of the single firm's actions, depends on the actions of the other firms. A command-and-control scheme is generally unable to solve this interaction problem.

– A **teams** approach, i.e., firms emitting to separate receptors are held jointly responsible for the emission level to the receptor (to be demonstrated in a later lecture). An important aspect of teams is that each team members must have a credible escape (exit) strategy to discipline other team members to comply (see Romstad (2003) in the course compendium) for further details.