Public bad: two firms in a market for a "pollutant"

Definition – Two firms have different marginal costs to reduce a public bad, such as pollution. Societal damages necessitate reduction. Regulators use firms' marginal abatement costs to determine optimal distribution of abatement.

Source: Gruber, J. (2016) *Public Finance & Public Policy*

Intuition – We can balance the existence of a public bad, like pollution, with the costs of reducing it. The balance point is just where the damage of the next unit of pollution is less than it costs for firms to reduce it. Any two firms likely have different costs of reducing pollution. Suppose one is old and the other is new. It costs the new firm less to reduce a unit of pollution than the old, it makes sense that they should be the one to reduce that unit. As it costs more to reduce the first unit than the last, costs rise the more they reduce, so ideally they will share the burden of reducing, in proportion to how much it costs them per unit.

Mathematical / Technical

- **Marginal Damages (MD):** the value of damage resulting from each additional unit of a public bad, such as pollution.
- **Marginal Abatement Cost (*MAC*):** The cost for a polluter in order to reduce each unit of pollution.
- To find the optimal price and quantity of abatement, the *MAC* for firm L (*low* costs) and *MAC* for firm H (*high* costs) must be aggregated horizontally to produce the aggregate *MAC*.

$$MAC_A(Z) = MAC_L(Z_L) + MAC_H(Z_H) \text{ where } Z = Z_L + Z_H$$

- With MAC_A, the optimal price, P^*, and quantity of abatement, Z^*, is where **Marginal Abatement Cost** is equal to the **Marginal Damages.**

$$MD(Z^*) = MAC_A(Z^*) = P^*$$

Solve for Z_L^*, Z_H^* using $MAC_L(Z_L^*) = P^*,\ MAC_H(Z_H^*) = P^*$

- Where the P^* intersects each firm's *MAC* are the optimal quantities of pollution reduced by each firm.
- Another approach is dividing Z^* among the two firms in proportion to their *MAC* s:

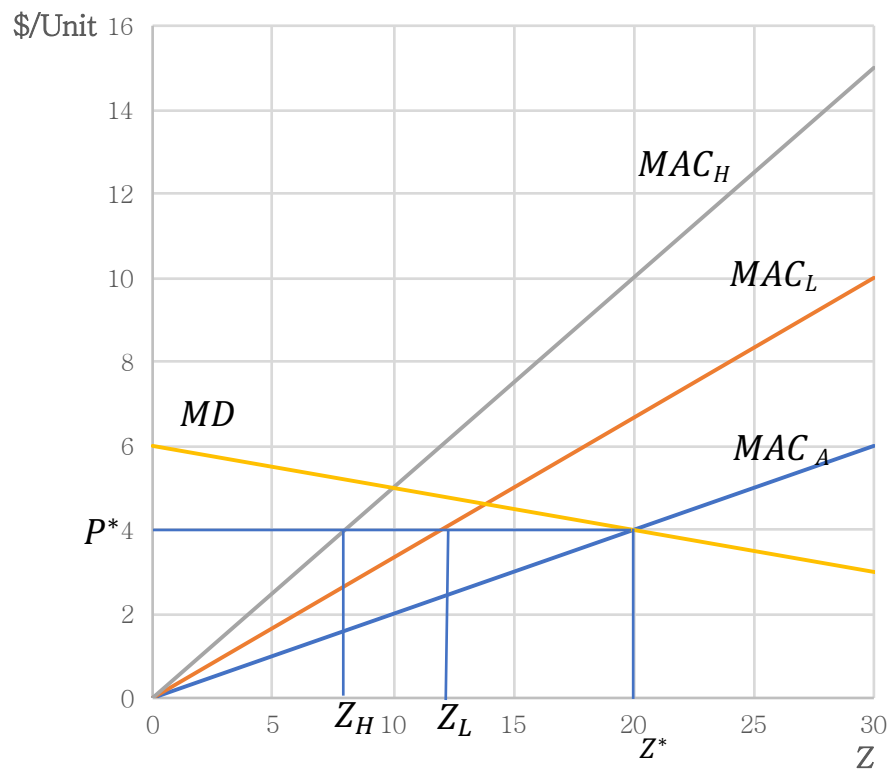
If $MAC_L = 2$ & $MAC_H = 4$, then $Z_L^* = Z^*/3$ & $Z_L^* = 2 \cdot Z^*/3$

- Whomever faces the lowest *MAC* for the next unit of pollution to be produced should reduce their pollution by this unit and sell their permit for a higher price than the cost from reduction.
- Because firm L faces lower marginal abatement costs than firm H, firm L reduces more units of pollution.
- Thus, having firm H and firm L both reduce half of the units would be inefficient.

Two solutions to reach the optimal Z^*, efficiently:

- First note, pollution Q is $Q_0 - Z$, with Q_0 being the original level of unabated pollution.
  1. Set a **tax** per unit of *pollution*: $tax(Q) = P^*$; or
  2. Create permits with a **cap** $= Q_0 - Z^*$ and allow firms to **trade** permits as long as $Z_L + Z_H = Z^*$. With optimal permits, firms will trade until *MAC* for the next unit is the same for all firms.
- Both approaches produce the **same outcome**: The cap-and-trade \$/Permit = optimal tax.

Graphical – Two firms with different MACs



Z, the horizontal axis, is the quantity of emissions abated. Firm H faces marginal abatement cost $MAC_H = Z/2$. Firm L faces marginal abatement cost $MAC_L = Z/3$. Marginal damages to society are described by the equation $MD = 6 - Z/10$. The P^* is \$4 per permit, and Z^* is 20 units of pollution abated. $Z_L = 12$, $Z_H = 8$, which add to 20.

Real-world aspects – British Columbia utilizes a carbon tax to incentivize companies to reduce the amount of carbon released, at \$40 per tCO_2e.[a] California uses a cap-and-trade system, issuing permits to limit the amount of greenhouse gases released. California distributes these allowances by a combination of free allocation and quarterly auctions. Cap-and-trade is critiqued by some as being inequitable. Opponents argue that this strategy can create pollution "hot spots" disproportionately disadvantaging low-income communities. However, this is not an intrinsic property of the system.[a] Also, critics argue that forcing firms to internalize these costs they previously externalized on society raises costs of production, which raises consumer prices. Low-income or disadvantaged groups are disproportionately affected by raising consumer prices, as the price of consumer goods makes up a larger portion of their expenditures (similar to a regressive tax).

Sources: [a]https://tinyurl.com/y6qmws4j [b]https://tinyurl.com/y759ldvt [c]https://tinyurl.com/y7hsgbgu

Practice questions

1. If marginal damages are given by $MD = 3$, and the MACs for firms E and F are given by $MAC_E = 0.75Z$ and $MAC_F = 0.6Z$, what is the optimal total number of units of pollution to be reduced if these are the only two firms in the market? Which firm optimally reduces more? Describe intuitively.
2. Marginal damages due to pollution are $MD = 10 - Z$. Firm G has $MAC_G = 2 \cdot Z/3$; firm H has $MAC_H = 8 \cdot Z/5$. Explain using math why it is not optimal for either firm to reduce pollution past a certain quantity. Find their respective individual "limit" quantities. Should firm H reduce the entire amount pollution desired because its *MAC* function is always lower at any given quantity, or not? Explain using math and/or words.
3. Explain using an example why one should aggregate marginal abatement cost functions horizontally (adding quantities) to find the optimal total number of pollution units reduced. Describe qualitatively how a third firm entering this market, emitting the same public bad, would shift the optimum point for the whole market.

Numerical solutions: **1.** 9 units. Firm F reduces more. **2.** $Z_G = 4.8$, $Z_H = 2$.