1. Suppose that there are two firms. The two firms production lead to pollution. Firm 2 invested in pollution abatement capital. Therefore, while for Firm 1 production and pollution are one-on-one, each unit Firm B produces leads to one-half of pollution. With no environmental standard, the marginal costs are as follows:

$$MC_1 = Q,$$
$$MC_2 = 10 + Q. \tag{1}$$

   Both firms are price-takers and the market price is $P = 30$. The environmental authority targets a pollution level of 30 and sells the two firms (tradable) pollution permits based on their current shares of market output. A pollution permit gives the right to emit one unit of pollution. The cost of each permit is 8.

   a- Calculate the production and pollution levels before the implementation of the cap-and-trade system.

   b- What is the reduction (in percentage) in the total emission level with the cap?

   c- Calculate the production and pollution levels of the two firms after the implementation of the cap-and-trade. How much money does each firm earn/spend on tradable permits?

2. Suppose that the environmental authority sets a target level of $\bar{E}$ tons of pollution (per week). Originally, the two firms emit a total of E_0 tons/week. For x_j $(j = 1, 2)$ the marginal abatement costs of firm 1 and firm 2 are x_1 $(MAC_1 = x_1)$ and $\frac{1}{2}x_2$ $(MAC_1 = \frac{1}{2}x_2)$, respectively.[1] Suppose that the permit price of a ton of pollution is $\hat{p}$. Lastly, each firm is grandfathered $\frac{\bar{E}}{2}$ permits.

   1. How much would each firm pollute after the permits are traded? How many permits are traded (purchased/sold) by firm 2?

   2. Let the initial level of emissions of each firm and the target level of emissions be $E_0 = 4500$ and $\bar{E} = 6000$, respectively. Calculate the equilibrium pollution levels for each form after the trade. What is the permit price? How many permits are traded by firm 1? by firm 2?

   3. Show all your results in a graph.

3. Suppose that the environmental authority sets a target level of 6000 tons of pollution (per week). Originally, the two firms emit a total of 12000 tons/week. For x_j $(j = 1, 2)$ the marginal abatement costs of firm 1 and firm 2 are $\frac{x_1}{4}$ $(MAC_1 = x_1/4)$ and $\frac{x_2}{8}$ $(MAC_1 = x_2/8)$, respectively. Suppose that the permit price of a ton of pollution is p. Lastly, each firm is grandfathered 3000 permits (each permit allows for a ton of emissions).

   a- Calculate the MACs for each firm before the trade.

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[1] Note that the level of abatement x_j is equal to $E_0 - E_j$ where E_j denotes firm j's level of emissions after the environmental authority determines $\bar{E}$.

b- Calculate the equilibrium pollution levels for each firm after the trade of permits. What is the permit price? How many permits are traded by firm 1? by firm 2?

c- How much does firm 1 gain from the trade? What is firm 2's gain?

d- Show all your results in a graph.

4. Suppose that the environmental authority begins to tax pollution following the introduction of a new legislation. Consider the following marginal abatement cost (MAC) curves.
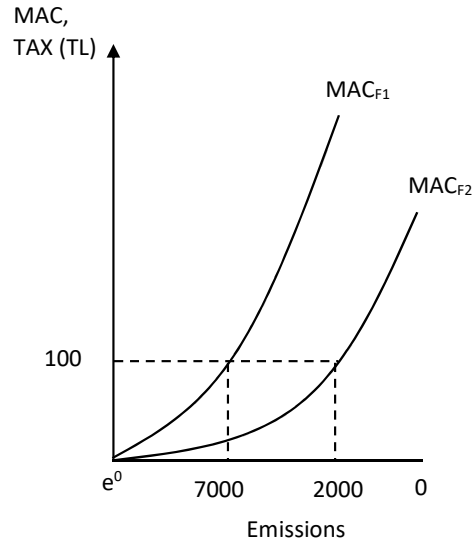
a- Why Firm 1 (F1) does not emit more than 7000 tons of SO_2 emissions? Explain.

b- Why Firm 2 (F2) does not emit less than 2000 tons of SO_2 emissions? Explain

c- What is the tax that is paid in total?

d- What is double dividend with green taxes?

5. What does Coase theorem state? What are the problems with the Coase approach?

6. What are the conditions under which a tradable permit system is more likely to work?