ECON4910 Environmental Economics
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Problem set 4

Ex. 1. Prices vs. Quanitities Weitzman (1974)

In this exercise we will explore the different regulatory instruments under certainty and uncertainty. The regulator has to choose a rule of pollution regulation and stick to it. He has two alternatives, one rule is to name a price for pollution reduction and the other rule is to name the quota (quantity) of pollution reduction. The timing is as follows: First the regulator sets the value (of price or quota) and then economic agents undertake pollution reduction. Suppose the society has benefit $B(q)$ and cost $C(q)$ of q units of pollution reduction (abatement), satisfying $B'(q) > 0$, $B''(q) < 0$, $C'(q) > 0$, and $C''(q) > 0$, however, the functional forms are unknown.

1. Draw an approximation of these two functions and the social planner's target. What is the optimal amount of pollution reduction q^* that maximizes social welfare?

2. Estimate operational social benefit and cost functions by second order Taylor approximation at the origin.

3. Suppose $MB(q) = \beta - bq$ and $MC(q) = a + cq$, then what are the values of β, b, a, and c in terms of the parameters of your approximation in (2)?

   Assume the planner has full certainty and knows the values β, b, a and c.

4. To implement q^* using a quantity instrument, what should the quota be? Calculate the total welfare.

5. To implement q^* using a price instrument, what should the price of q be? Calculate the total welfare.

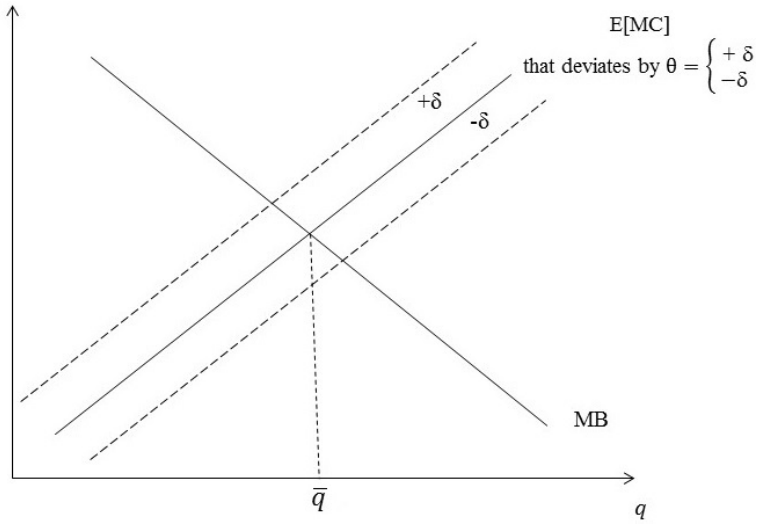

Figure 1: Uncertainty with expected marginal cost curve

6. Compare the total welfare in 4 and 5. Which instrument is better in terms of maximizing the social welfare?

   Assume now that the planner has imperfect knowledge, he is uncertain about the value of a, i.e. the social marginal cost of pollution reduction. More specifically, suppose the planner knows that $a = \gamma + \theta$ in which γ is known but θ is a random variable taking two values i.e. $+\delta$ and $-\delta$ with equal probability, see Figure 1.

7. Calculate the optimal amount of pollution reduction q^{**}, for any *given* value of θ. Do you think this optimal value is directly implementable with *price* or *quantity* instruments, or will we miss the target?

   The quota instrument under uncertainty

8. Suppose the regulator sets a quota of $\bar{q}$ where $\mathbb{E}[MC] = MB$. Calculate one of the deadweight losses (The case is symmetric and the two losses are equal):

$$DWL_q = \frac{\big(B'(\bar{q}) - C'(\bar{q})\big)\big(\bar{q} - q^{**}\big)}{2} \tag{1}$$

9. Calculate the expected deadweight loss, $\mathbb{E}[DWL_q]$. In what sense is the deadweight loss a welfare measure?

10. Minimize the expected deadweight loss and calculate the best quantity instrument $\hat{q}$ to impose ex-ante:

$$\hat{q} = \arg\min_{\bar{q}} \left\{ \mathbb{E}[DWL_q] \right\} \tag{2}$$

The price instrument under uncertainty

11. Now, suppose the regulator sets the price p per unit of q *before* the value of θ is realized. Firms maximize profits *after* the value of θ is realized. Calculate the optimal price p^{**}, and the profit maximizing quantity response $q(\bar{p}, \theta)$.

12. Calculate the deadwheight loss:

$$DWL_p = \frac{\big(B'(q(\bar{p})) - C'(q(\bar{p}))\big)\big(q(\bar{p}) - q(p^{**})\big)}{2} \tag{3}$$

13. Calculate the expected deadweight loss, $\mathbb{E}[DWL_p]$

14. Calculate the price that minimizes the *expected* deadweight loss:

$$\hat{p} = \arg\min_{\bar{p}} \left\{ \mathbb{E}[DWL_p] \right\} \tag{4}$$

Compare the two instruments

15. Calculate the *expected difference* in deadweight loss between the best-regulated *ex ante* quantity $\hat{q}$ and the best regulated *ex ante* price $\hat{p}$:

$$\mathbb{E}\left[DWL_q(\hat{q})\right] - \mathbb{E}\left[DWL_p(\hat{p})\right] \tag{5}$$

16. How does the choice of instrument depend on the slopes of the two instruments? When does the social planner prefer one instrument over the other?

References

Weitzman, M. L. (1974). Prices vs. Quantities. *The Review of Economic Studies*, 41(4):477–491.