Correlated Uncertainty and Policy Instrument Choice

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Main Points

- Cost uncertainty can have significant effects, depending upon the relative slopes of the marginal benefit damage and marginal cost functions.
- In the real world, we rarely encounter situations in which there is exclusively either benefit uncertainty or cost uncertainty.
- What can be said about optimal policy instruments under these conditions?

- In his very general approach, Weitzman assumed that the random error characterizing uncertainty was sufficiently small to justify quadratic approximations of generalized total cost and total benefit functions

$$\Delta_{\mathrm{pq}} \approx \frac{\sigma_C^2 B''}{2C''^2} + \frac{\sigma_C^2}{2C''},$$

- Δ_{pq} is the net welfare advantage of the price inst. relative to the quantity
- B'' is the slope of the MB function and C'' the slope of the MC
- σ_c^2 is the variance of costs

- Adar and Griffin simply assumed linearity in the marginal benefit and marginal cost functions

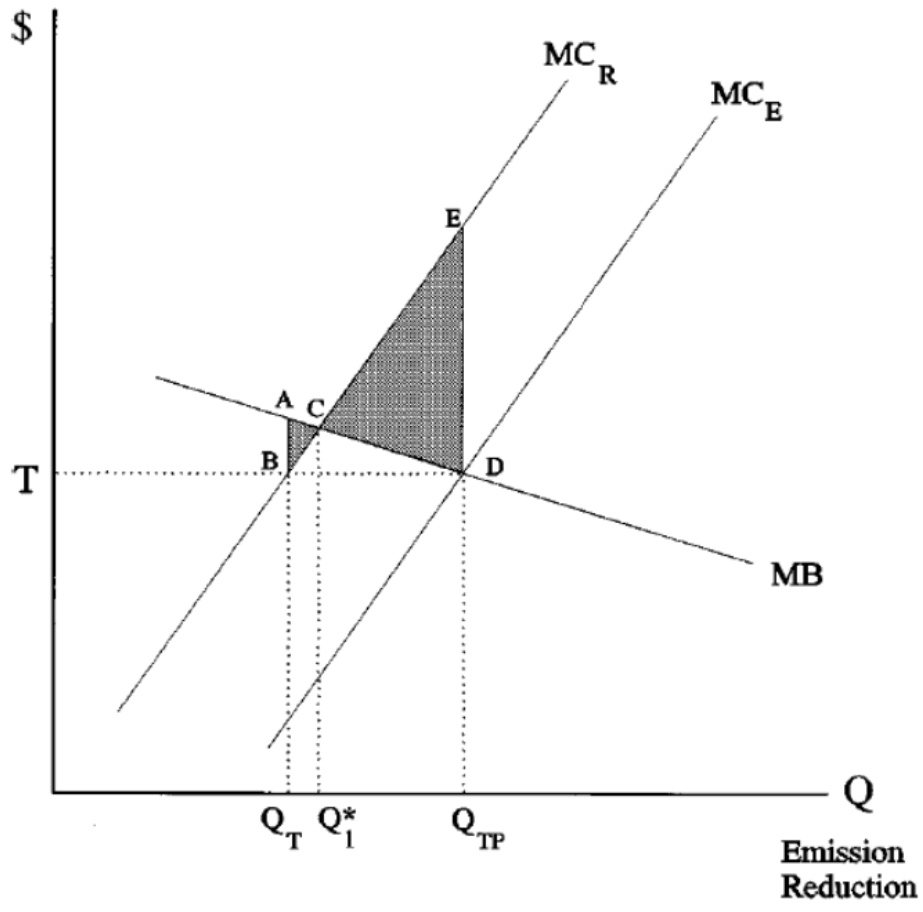


FIG. 1. Cost uncertainty and the choice of policy instrument.

- When the uncertainty is exclusively with marginal benefits, both instruments achieve the same realized level of control and hence exhibit the same social loss

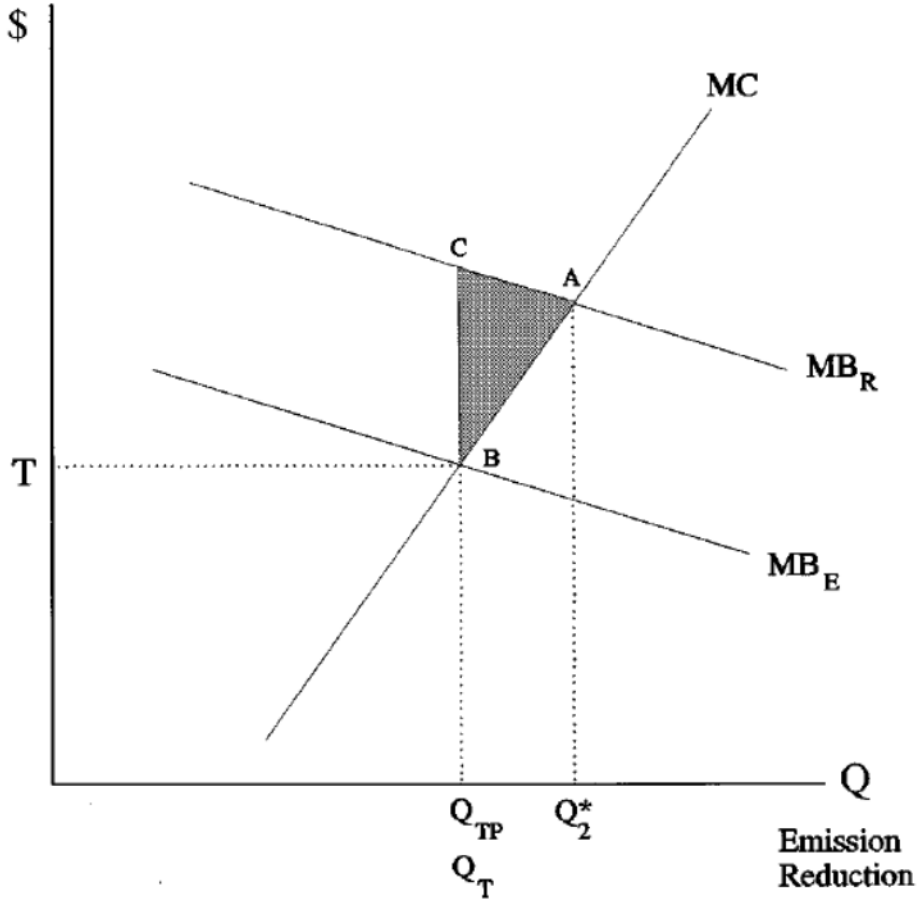
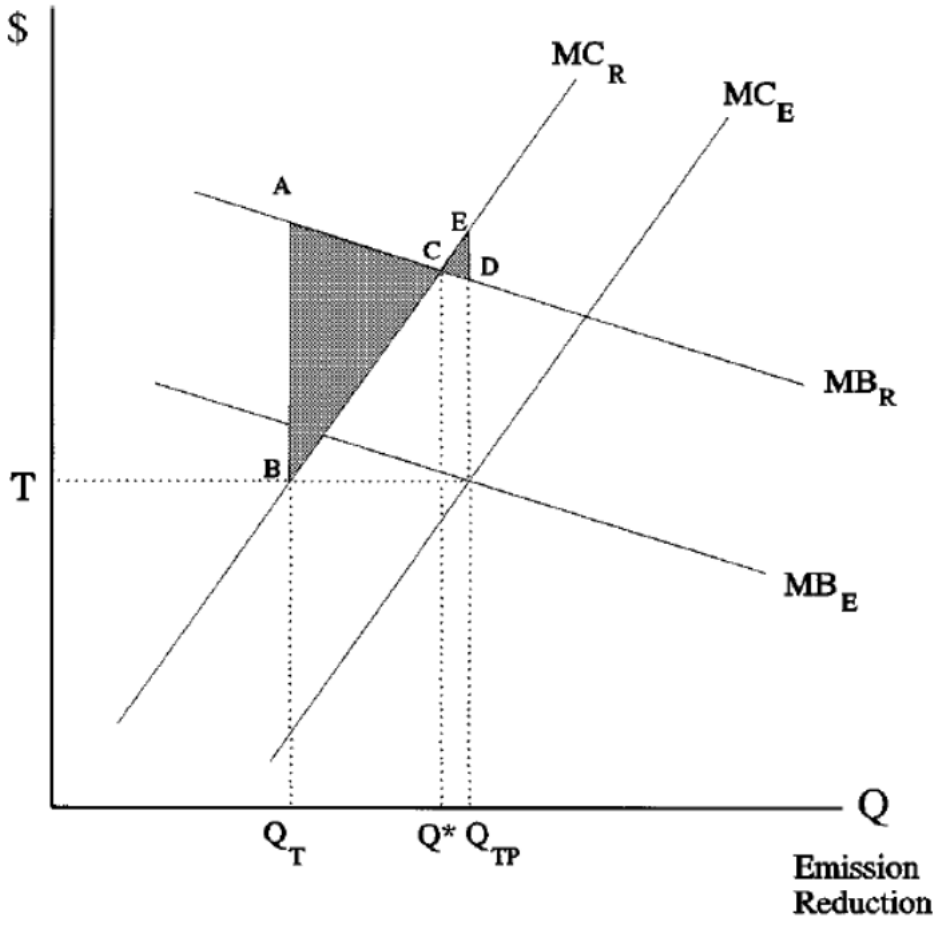


FIG. 2. Benefit uncertainty and the choice of policy instrument.

- Despite the fact that the same expected and realized functions as before are pictured, we now find that the optimal instrument is no longer the Pigouvian tax, but the tradeable permit system instead



- How should we think about these results in more general and more rigorous terms?
- Weitzman noted that if benefit uncertainty and cost uncertainty are simultaneously present and B and C are not independently distributed, the correct form becomes:

$$\Delta_{pq} \approx \frac{\sigma_C^2 B''}{2C''^2} + \frac{\sigma_C^2}{2C''} - \frac{\sigma_{BC}^2}{C''},$$

- where $\sigma_{BC}^2 = E\{B - E[B]\} \times E\{C - E[C]\}$, the covariance of benefits and costs

$$\Delta_{pq} \approx \frac{\sigma_C^2}{C''}\left[\frac{B''}{2C''} + \frac{1}{2} - \frac{\rho_{BC}\sigma_B}{\sigma_C}\right]$$

- where ρ_{BC} is the correlation (coefficient) between benefits and costs
- σ_B is the standard deviation of benefits and the standard deviation of σ_C costs
- When there is statistical dependence between benefits and costs, benefit uncertainty does matter in our choice of the optimal instrument
- It is always the case that a positive correlation tends to favor the quantity instrument

- is it reasonable to suggest that benefit uncertainty is significant in the environmental arena, particularly relative to cost uncertainty?
- is it reasonable to assume that in many cases, the marginal benefits and marginal costs of environmental protection are indeed correlated?
- is there any reason to believe that these factors are likely to be sufficiently important to overwhelm a "conventional analysis" of efficient instrument choice, based on the simpler relative-slopes rule?
- Examples: Weather (sunny day)
  - marginal cost of ambient concentration reduction would increase
  - marginal benefits of ambient-reduction would also increase
- Negative correlation?

- In the presence of simultaneous uncertainty in both marginal benefits and marginal costs and some statistical dependence between them, benefit uncertainty can make a difference for identifying the efficient policy instrument.
- A positive correlation tends to favor the quantity instrument
- A negative correlation favors the price instrument