The Acid Rain Program: Background, Impacts, and Lessons for Climate Change Policy

Jacob Bradt
Section 8
ECON 1661 / API-135: Spring 2022

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Announcements

- Office hours today from 3:00-5:00pm EDT
- Problem set #3 due next Wednesday, March 30 at 12:00pm EDT
- Midterm grades and solutions posted

Outline

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Correlated air pollutants

- GHG emissions from many sources are associated with a number of co-pollutants:
  - Burning of fossil fuels generates other pollutants in addition to GHGs
  - E.g., burning of coal → GHGs + SO_2, NO_x, and PM
- This has major implications for the economic analysis of climate policy
  - → E.g., "Clean Power Plan" rule: 94% of domestic and 59% of global annual benefits in 2030
- Natural question: should we think about climate policy and air quality regulation separately?

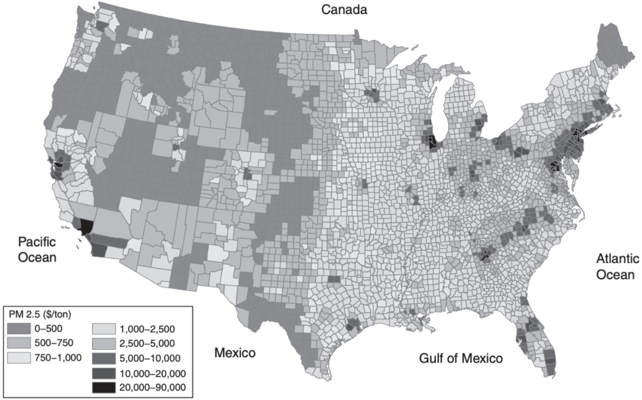
Review: cost-effectiveness vs. efficiency

- Cost-effectiveness: conditional on the level of abatement, is the allocation of abatement across firms cost-minimizing?
  → Necessary condition: $MC_1 = MC_2 = \cdots = MC_n$

- Efficiency: is the level of abatement net benefit maximizing?
  → Necessary conditions: $MC_i = MB_i$ (marginal cost of abatement equals the marginal benefit of abatement across all sources)
    - Standard case so far: $MB_i = MB$ for all firms i
      - Efficiency implies that MC will be equalized across all sources and we can think of MB=MC as determining the optimal level of control

- But what if MB_i is not constant or known across firms?
    - Example where MB_i constant: CO_2 emissions
    - Example where MB_i not constant: local air pollutants (e.g., SO_2, NO_x, PM)

Benefit heterogeneity: $PM_{2.5}$ emissions[1]



- Benefits of $PM_{2.5}$ reductions (avoided marginal damages) concentrated in northeast, southern California, Chicago
- Drivers of benefit heterogeneity:
  - Population exposure differences
  - Nonlinearities in dose-response function

[1] Muller, N. Z. and R. Mendelsohn. 2009. "Efficient Pollution Regulation: Getting the Prices Right." *American Economic Review*, 99(5):1714-39.

Implications for climate policy and air quality regulations

- Should we jointly regulate GHG emissions and local air pollutants?

- Marginal benefit of CO_2 abatement known and constant: Social Cost of Carbon
  - $\rightarrow$ Efficient policy design feasible in theory: set policy such that $MC_i = SCC$ for all firms i

- Joint regulation $\rightarrow$ MB_i no longer constant (and "easily" known) across firms
  - Potential argument for separate regulation: we can design a fast train to the *right* station, at least with climate policy
  - Tinbergen (1952, 1956): efficient policymaking requires separate policy instruments to correct for separate market failures
  - Muller (2012)[2]: economic cost of setting the wrong aggregate emission reduction target when jointly regulating GHG emissions and co-pollutants can be large!

- Need to be careful about interactions between policies, though — more on this in the next few weeks!

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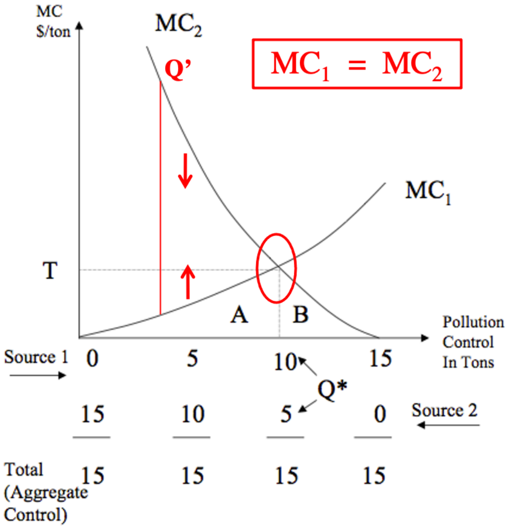
[2] Muller, N.Z. 2012. "The design of optimal climate policy with air pollution co-benefits." *Resource and Energy Economics*, 34(4): 696-722.

Outline

Review: cap-and-trade logic

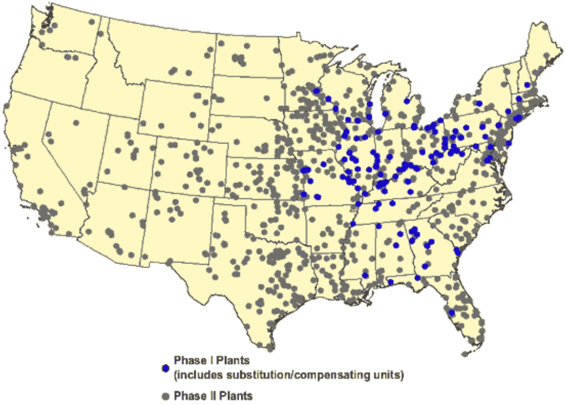


- Simple two-source model (but generalizes to N firms!)
  - Importantly, firms have different MC
- Incentives to trade:
  - Firm 1 will sell permits (control more) at price $> MC_1$
  - Firm 2 will buy permits (control less) at price $< MC_2$
- Key intuition: under C&T, firms will trade such that permit price = marginal cost of abatement

U.S. Acid Rain Program

- As early as Dales (1968), economists have discussed the tradable permit approach and its potential to achieve cost-effectiveness
- Up until the Acid Rain Program, however, market-based approaches had attracted hostility from non-economists and were rarely employed in practice
- The Acid Rain Program, or Title IV of the CAAA 1990, is an important, real world experiment in market-based environment policy

CAAA 1990: Title IV



- Phase I (1995-1999): covered the 263 most SO_2 emissions-intensive sources
- Phase II (2000-): covers virtually all fossil fuel boilers in U.S.
- Tradeable permit program
  - Cap not set to maximize net benefits
  - Permit allocation: not auctioned

Economic costs of ARP: Chan et al. (2018)[3]

- Quantify cost savings from ARP by comparing compliance costs for 761 coal-fired generators under ARP with those from a counterfactual uniform performance standard

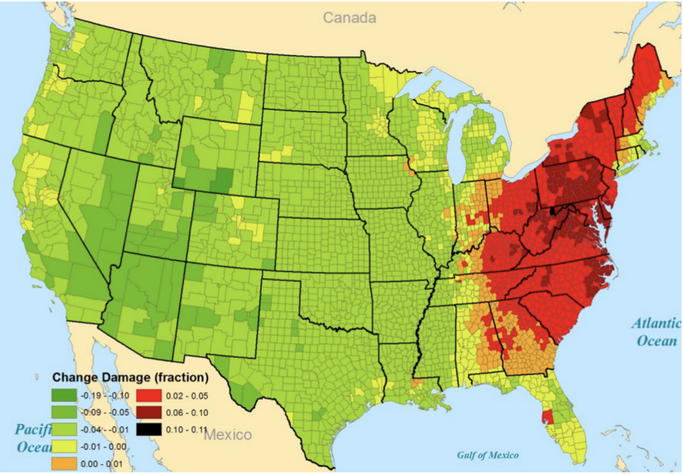
- Estimate compliance costs in 2002 are $200M lower under ARP than analogous counterfactual uniform standard

- Health damages in 2002 are $170M lower under the ARP

- ARP appears to be cost-effective given the target

[3] Chan, H.R., B.A. Chupp, M.L. Cropper and N.Z. Muller. 2018. "The impact of trading on the costs and benefits of the Acid Rain Program." *Journal of Environmental Economics and Management*, 88: 180-209.

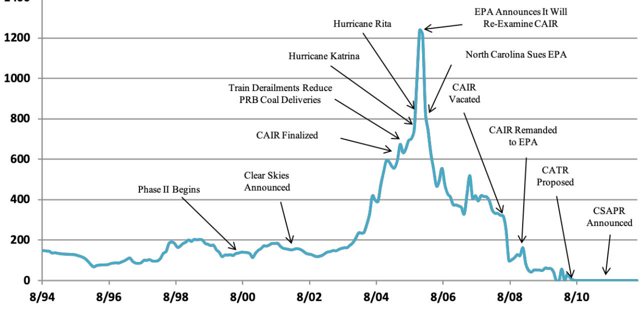
Effect of trading: Chan et al. (2018)[4]



- Also compare health damages associated with ARP with a no-trade scenario
- Damages under the ARP are \$2.1B higher than under the no-trade scenario
- Driven by transfer of allowance from low MC units in western US to high MC units in the eastern US
- Fast trains, wrong station?

[4] Chan, H.R., B.A. Chupp, M.L. Cropper and N.Z. Muller. 2018. "The impact of trading on the costs and benefits of the Acid Rain Program." *Journal of Environmental Economics and Management*, 88: 180-209.

SO_2 allowance prices



- Substantial price volatility in SO_2 allowance market
- Driven by changes in policy, natural disasters, business cycle, litigation, etc.
- Volatility affects firm decision-making (e.g., investment decisions)

How can we design a tradeable permit system to reduce volatility?

Outline

Hybrid policy instruments

- Definition: a hybrid or "safety-valve" policy instrument refers to a combined cap-and-trade and tax system
- Price ceiling: government can announce in advance that it is willing to sell (an unlimited number of) additional allowances at a specific price (the "trigger" price)
- Price floor: government can announce it will buy allowances at a specific price or set a minimum allowance price at auctions
- Combination of a price ceiling and price floor creates a "price collar" $\Longrightarrow$ limits the volatility of permit prices
    - As the difference between the price ceiling and price floor goes to zero, the cap-and-trade system becomes a tax

Hybrid policy example problem (1/5)

The EPA wants to reduce emissions of CO_2, which is currently unregulated. Economists estimate that the marginal costs and benefits of pollution control are as follows:

$$MC = 3 + Q \qquad\qquad MB = 9 - 0.5Q$$

where Q is the quantity of CO_2 emissions reductions. Calculate the efficient level of emissions reductions, Q^*, and the marginal cost of emissions reductions at this level, P^*.

- Equating MC and MB and simplifying gives:

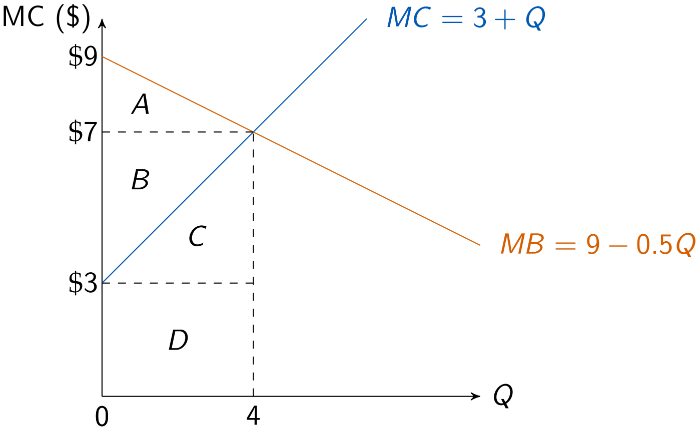
$$3 + Q^* = 9 - 0.5Q^* \implies \boldsymbol{Q^* = 4}$$

- The cost of emissions reductions, P^* at $Q^* = 4$ can be found by plugging Q^* into MC:

$$P^* = MC(4) = 3 + (4) \implies \boldsymbol{P^* = \$7}$$

Hybrid policy example problem (2/5)

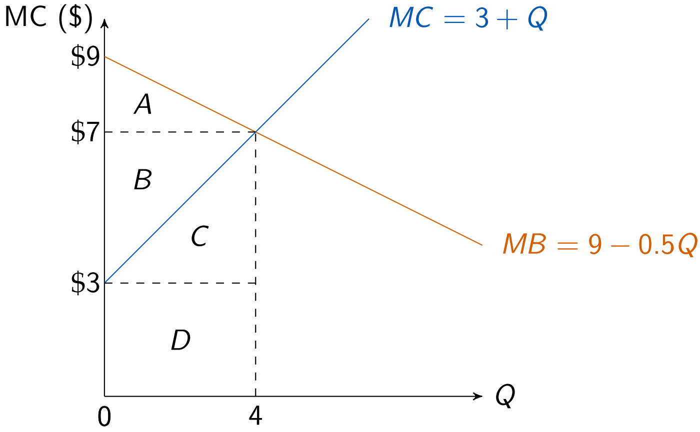
What are the net benefits of setting the efficient policy?



- Total benefits: $A + B + C + D$
- Total cost: $C + D$
- Net benefits: $A + B$

Hybrid policy example problem (2/5)

What are the net benefits of setting the efficient policy?



- Total benefits: $\frac{1}{2}(9-7)(4) + (7 * 4) = 32$
- Total cost: $\frac{1}{2}(7-3)(4) + (3 * 4) = 20$
- Net benefits: $32 - 20 = 12$

Hybrid policy example problem (3/5)

It turns out that the estimated marginal cost function is an average of two competing reports: a high cost estimate and a low-cost estimate:

$$MC_H = 6 + Q \qquad\qquad MC_L = Q$$

Given this uncertainty, would you recommend that the regulator use a price or a quantity instrument to regulate emissions?

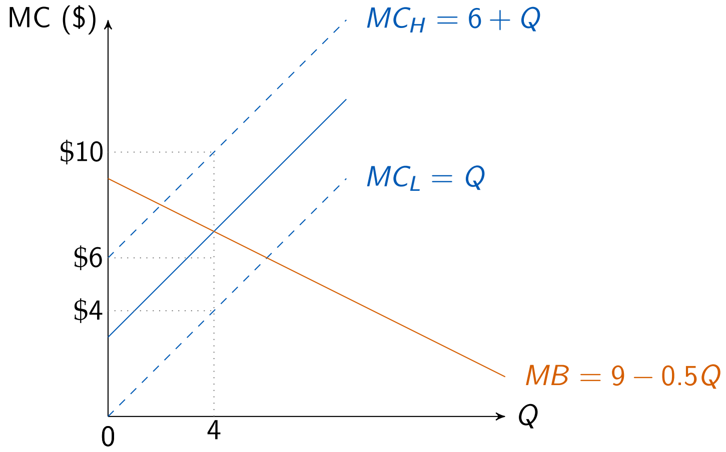
- We can use the Weitzman rule!

- We would recommend a price instrument, because the slope of the marginal cost curve is greater than the absolute value of the slope of the marginal benefits curve:

$$|slope_{MC}| = 1 > 0.5 = |slope_{MB}|$$

Hybrid policy example problem (4/5)

The regulator chooses to use a quantity instrument, mandating emissions reductions equal to the efficient level, Q^*. Calculate the expected net benefits of this policy (assume that there is a 50% chance of each cost curve, high or low).



- Gross benefits do not change: MB unchanged and regulators still set $Q^* = 4$ as the cap

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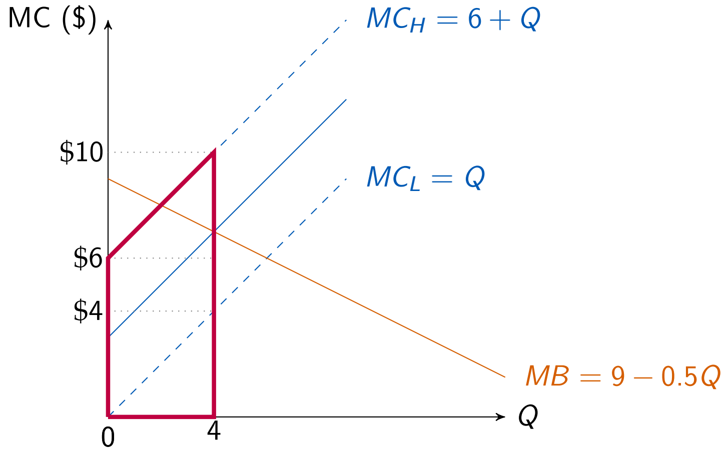
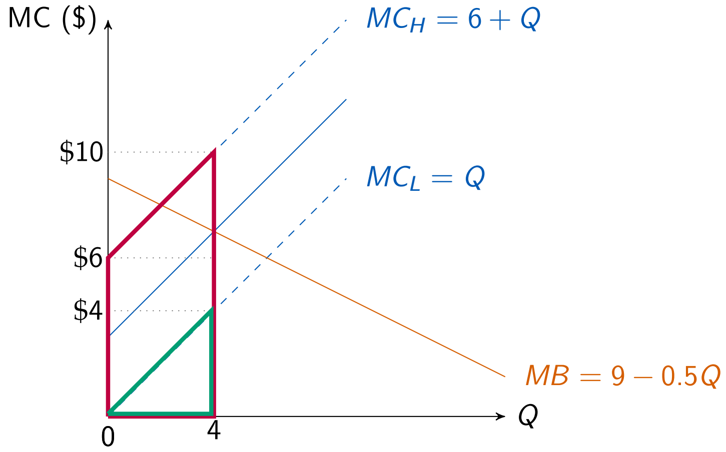


- Gross benefits do not change: MB unchanged and regulators still set $Q^* = 4$ as the cap
- If MC_H realized, total cost: $\frac{1}{2}(10-6)(4) + (6 * 4) = 32$

Hybrid policy example problem (4/5)

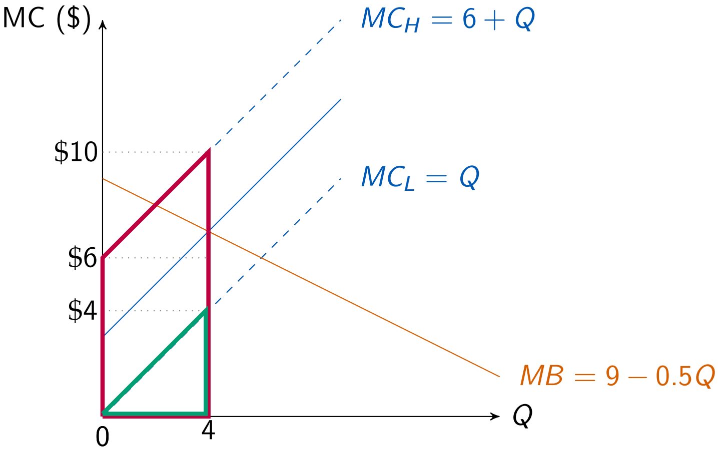
The regulator chooses to use a quantity instrument, mandating emissions reductions equal to the efficient level, Q^*. Calculate the expected net benefits of this policy (assume that there is a 50% chance of each cost curve, high or low).



- Gross benefits do not change: MB unchanged and regulators still set $Q^* = 4$ as the cap
- If MC_H realized, total cost: $\frac{1}{2}(10-6)(4) + (6 * 4) = 32$
- If MC_L realized, total cost: $\frac{1}{2}(4-0)(4) = 8$

Hybrid policy example problem (4/5)

The regulator chooses to use a quantity instrument, mandating emissions reductions equal to the efficient level, Q^*. Calculate the expected net benefits of this policy (assume that there is a 50% chance of each cost curve, high or low).



Net benefits are zero if MC_H is realized and 24 if MC_L is realized, so expected net benefits are:

$$0 * 0.5 + 24 * 0.5 = 12$$

Hybrid policy example problem (5/5)

Industry is concerned about price spikes if emission reductions turn out to be expensive. To allay their fears, the regulator writes a "safety valve" into the law: specifically, treasury agrees to sell an unlimited number of permits at $8. Calculate the expected emissions reductions and the expected net benefits with the safety valve.

- When $MC = MC_L = Q$, the market permit price at $Q = 4$ will be 4
  - Since this is below 8, there will be no demand for the treasury's additional permits and the net benefit remains the same as previously calculated: 24

- When $MC = MC_H = 6 + Q$, the market permit price at $Q = 4$ is 10
  - This is greater than the safety valve price; firms will abate until $MC = 8$, after which they buy permits from the treasury to meet the $Q = 4$ cap

- $MC = 8$ when $Q = 2$, so 2 units will be abated
  - Gross benefits when $Q = 2$ will be: $\frac{1}{2}(9 - 8)(2) + (2 * 8) = 17$
  - The cost will be: $\frac{1}{2}(8 - 6)(2) + (2 * 6) = 14$
  - So the net benefits are 3

Hybrid policy example problem (5/5)

Industry is concerned about price spikes if emission reductions turn out to be expensive. To allay their fears, the regulator writes a "safety valve" into the law: specifically, treasury agrees to sell an unlimited number of permits at \$8. Calculate the expected emissions reductions and the expected net benefits with the safety valve.

- The expected emissions reductions is just the probability-weighted sum of the emissions reductions in each case: $0.5(4) + 0.5(2) = 3$
- The expected net benefits is the probability-weighted sum of the net benefits in each case: $0.5(24) + 0.5(3) = 13.5$
- The expected net benefit is larger than 12, which was the expected net benefit without the safety valve!

Takeaways

- Reductions in correlated air pollutants are an important ancillary benefit to climate policy, but there may be reasons to regulate separately
- The Acid Rain Program is a great example of a market-based policy in action
- ARP offers a number of important takeaways; two in particular (see lecture for others):
    1. It may have been cost-effective, but welfare loss from inefficiency plausibly large
    2. Hybrid policy features that address price volatility can improve outcomes