When Does Cap-and-Trade Increase Regulated Firms' Profits?

And what does it mean for promoting clean technologies?

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Policy Framework

- With cap-and-trade the government limits total emissions by distributing a fixed amount of exchangeable allowances to pollute.
- Methods of distributing allowances include, historic behavior (grandfathering), recent production/input (updating), and auction.
- Currently the U.S. has two major programs (Acid Rain and NBP) and EU has one (ETS)
  - These programs grandfather allowances

GHG Cap-and-Trade

- Much attention is being paid to the distributional effects of greenhouse gases (GHG) regulations.
- Studies find that the profits of regulated industries will increase if GHG permits are grandfathered.
  - Bovenberg and Goulder, 2001
    - 4.3% to coal producers, $25/ton carbon
  - Burtraw et al. 2002
    - Electricity industry better off under auction, $25/tonC
    - Incumbent coal generators are not.

Turning to auctions…

- Recognizing value of allowances and influence on profits, regulators turning to auctions
  - Burtraw and Evans, 2008
- EU ETS proposal for post-2012
  - Full auctioning in the electricity sector in 2012
  - Full auctioning for other sectors by 2020
- Lieberman-Warner (Senate bill)
  - Increasing % of allowances auctioned over time
- RGGI proposal in NE U.S.
  - 6 of 10 states auctioning 100% of allowances

Non-GHG Cap-and-Trade

- Recent studies of cap-and-trade programs for conventional pollutants indicate that regulated firms better off with grandfathering (or similar), but that ratio is higher:
  - Bovenberg, Goulder and Gurney, 2005
    - General equilibrium, sulfur and carbon
  - Burtraw and Palmer, 2004
    - Partial equilibrium, sulfur, nitrogen and mercury
    - Need to compare to earlier work on carbon to see result

What explains the difference?

- Hypothesis: Availability of abatement opportunities
  - Technologies with lower uncontrolled emission rate
  - Low cost “end-of-pipe” control technologies
  - Emission rate of marginal producer
- We can show impact of “end-of-pipe” technologies with a simple analytical model
  – Also shows how profits may increase with cap
- Recognizing this, we plan to explore effect of reducing cost of abatement technologies and of less-emitting generation technologies

Simple Model of Polluter Welfare

$$\max \ \pi \equiv Pq - C(q) - f(zq - e)$$

$$s.t. \quad A \geq e$$

q: Total production/consumption of final good in market

e: Total controlled emissions

z: Emissions intensity (i.e., uncontrolled emissions per unit of q)

A: Total allowable emissions (i.e., the cap)

a: Total abatement $\Rightarrow a = qz - e$

$C(q)$: Total cost of producing q: $C'(q) > 0$, $C''(q) \geq 0$

$f(qz - e)$: Cost of "end-of-pipe" abatement: $f'(qz-e) > 0$, $f''(qz-e) \geq 0$

Profit Change from Decreasing Cap

- What happens to profits as the cap decreases (i.e., if we impose a cap)?
- Total profits:

$$\Pi \equiv P(q)q - C(q) - f(zq - e) - \lambda(1-s)A$$

Where:

$P(q)$: marginal-willingness to pay: $P'(q) \leq 0$

s: share of allowances provided gratis to producers

λ: Shadow value on cap (i.e. allowance price)

$\lambda(1-s)A$: value of allowances auctioned by gov't

Profit Δ from Allocation Decrease, Con't.

$$0 \gtrless -\frac{d\Pi}{dA} \equiv \underbrace{-\left[P'(q)q\right]\frac{dq}{dA}}_{(+)} \underbrace{-s\lambda\frac{de}{dA}}_{(-)} \underbrace{+A(1-s)\frac{d\lambda}{dA}}_{(-)}$$

- Left term: Inframarginal effect on revenue from constraining production (*dq/dA>0*)
  - ↑ with ↑ in slope of end-of-pipe marginal cost
- Middle term: Reduction in value of allowances provided gratis as cap falls (*de/dA=1*).
- Right term: Increased payment to gov't as allowance price rises ($d\lambda/dA<0$).
  - ↑ with ↑ in slope of end-of-pipe marginal cost

"Cooperative Oligopoly"

- Firms participating in a cap-and-trade program with grandfathering can realize increased profits as:
  - Cap acts as an output constraint
  - Firms restrict output w/o fear of competitor's response
  - Firms face an inelastic demand curve relative to supply (production cost).

Elasticity of abatement

- However, if marginal "end of pipe" elasticity is high:
  - Link between emissions and output is low
  - Ability to restrict output lower
  - Increase in output price lower
- When would "end of pipe" elasticity be high?
  - Low cost of end-of-pipe technology
  - Entry costs low for low-emitting technologies (technologies with a lower *z*)
  - Also, incentive to innovate is low

An Important Aside

- Bovenberg, Goulder and Gurney (2005) analyze effect of “end of pipe” cost on compensation ratio
  - *But* they scale the marginal cost curve; they do not change “end of pipe” marginal cost elasticity.
  - The do find that level of marginal abatement cost does not have much affect on compensation ratio.
  - Analytic model does not suggest this, but it is empirical question.
  - Suggests we need to be careful in analysis: are we changing marginal cost levels, or elasticity of curve?

Planned contribution…

- Could analyze effect of elasticity of marginal end of pipe cost and see affect on profitability, but want to go even further…
- Earlier studies of effect on profits of GHG policies have not explored **how R&D policy and subsidies to low emitting technologies and abatement controls** influence the profits of incumbent sources.
- Will use a detailed partial equilibrium model of the U.S. electricity sector for analysis.

Subsidies for R&D and Clean Technologies

- Lieberman-Warner had a complex scheme for allocating auction revenues.
- Some activities receiving revenues.
  - 4% of auction revenues to go to renewable energy sources
  - 1.5% low carbon technology deployment
  - 3% for CCS bonus allowances
  - Specific nuclear subsidies considered

Influence May be Large

- Some comparison:
  - In 2020, total annual value of allowances $250 billion under Lieberman-Warner:
    - 40% of allocation will be auctioned (i.e., $100 billion in targeted revenues).
    - 10% of auction revenues to go to renewable energy sources ($10 billion)
    - Source: CEB, U.S.EPA, 2008
  - (An additional) $16/MWh subsidy for renewable generation in 2020 would (absent a GHG policy):
    - Increase renewable generation from ~5% to ~13% of total generation.
    - Total cost of the subsidy ~$10 billion/year (2004$)
    - Source: Palmer, Evans and Paul, 2008

Model Laboratory

- Model developed at RFF to estimate partial equilibrium welfare changes from environmental regulations affecting electricity sector.
- Solves for equilibrium in electricity markets by customer class, time of day, season, and region.
  - Solves over 25 year time-horizon
  - Price responsive electricity demand and fuel supply
  - Marginal or average cost pricing depending on region
  - Load serviced by existing and new generators
    - New technologies include IGCC, nuclear, and renewables
  - Carbon capture and storage.
  - Can represent a variety of renewable promotion policies. Incorporates existing renewable promotion policies.

Possible Experiments in Model

- Direct subsidies to non-emitting technologies *or* pollution control technologies
  - Immediate effect on investment decisions
  - Model as percent of allowance revenues
  - PTC effects versus ITC effects
- R&D Policy
  - Model as declining cost of low emitting technologies?
    - R&D does not necessarily discriminate
  - Effect not until in future; capital stock turnover already underway by then.

Model Outputs

- Change in asset values of exiting generators
- Change in consumer surplus
- Electricity price
- Renewable/nuclear penetration
- Adoption of carbon capture and storage
- Coal price

Questions, comments, thoughts?

Thank you!

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- Ian: TBD

Supplemental Slides

Optimality Conditions

$$P - C'(q) - zf'(zq - e) = 0$$

$$f'(zq - e) - \lambda = 0$$

$$A - e = 0$$

λ: Shadow value on emissions restriction (allowance price)

Second Order Conditions

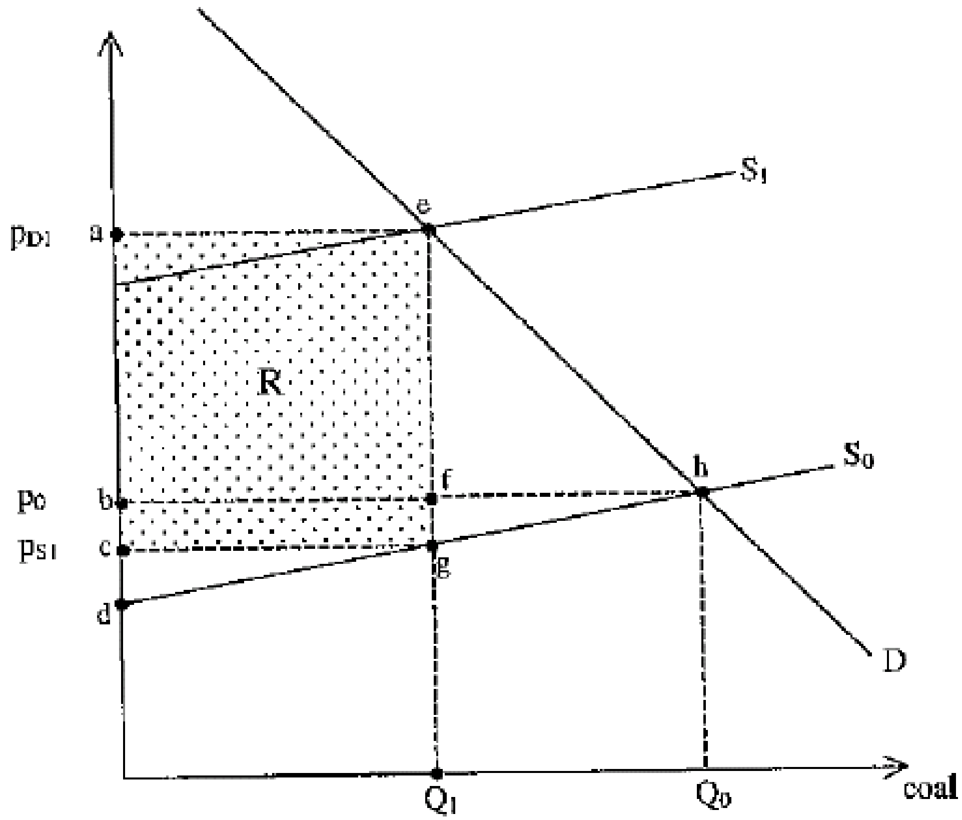
$$SOC = -P'(q) + C''(q) + z^2 f''(qz - e) \geq 0$$

$$\frac{dq}{dA} = \frac{zf''(qz-e)}{SOC} \geq 0$$

$$\frac{de}{dA} = 1$$

$$\frac{d\lambda}{dA} = \frac{[P'(q) - C''(q)] f''(qz-e)}{SOC} = \frac{zf'(qz-e) f''(qz-e)}{SOC} \leq 0$$

Profit Increase Graphically



- Source: Bovenberg and Goulder, 2001