Environmental Regulation and Technological Innovation: Uncertainty and Strategy

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How can …

regulation and other policy …

more effectively promote …

socially beneficial technological change …

in production processes or products …

to reduce environmental burdens?

- An Old Question: Technology-Forcing Regulation
  - How much is possible, at what cost, how do you do it?
- Old … But understood? Enduring myths and fallacies…
  - False dichotomy: "Innovation and markets, not regulation"
  - Belief in fixed set of options, assess ex ante – choose good technologies, reject bad ones
  - Treat advances as homogeneous: fail to distinguish near vs. long term, incremental vs. radical, innovation vs. diffusion
  - "Force" technology without considering incentives of private actors – who do most innovation, often have most knowledge
  - Policy Double-Bind: Force technology, but prove you're not demanding the impossible
  - Think these are gone? See the "technology breakthrough" fights

A new look at the question …

- Focus: Uncertainty and Strategic Behavior …
  - About technological capabilities and costs
  - At all policy stages: statutes, (treaties), regulation, implementation, adaptation
- Basic approach, presumptions:
  - Proponents of regulation (usually) must meet burden of showing feasibility (can be explicit/codified under statute, or informal need to build support … only occasionally completely suspended.)
  - Technological capabilities, costs are uncertain
  - Landscape of perceived possibilities varies over cases, time
  - Tech knowledge is asymmetrically held: Firms (often) know more (not always – but usu when targeting major products, producton processes – cncentrated industries w/ lots of capital, sci/tech caaability …Obviously regulating widely distributed small-scale enterprises (dry cleaners, gas stations) poses different problems.
- So expect interesting strategic behavior:
  - Proposals/threats and resistance over performance and regulations…
  - Supported by contending claims re feasibility, cost, obstacles
  - Disclosure vs concealment
  - Attempts to gain/hold/erode knowledge and authority

How to study this? Five case histories

In which dissent over tech capability was prominent:

- Motor vehicle air pollution (US, 1950s – 2000s)
- Dioxin effluent from pulp mills (US, 1980s – 1990s)
- Ozone-depleting chemicals (Int'l, 1970s – 1990s)
- Methyl Bromide (US and int'l, 1990s – present)
- Vinyl chloride workplace exposures (US, 1950s – 1970s)

(All environment, not energy – some close parallels, some less – perceived connection between targeted envt burden and valued services is less tight …)

Project goals: with these cases …

- Write the history: With this lens … reconstruct histories with detailed attentoin to policy plus tech and sci knoledge, debate … what did a competent catalytic chemst know in 1970?
- describe strategic behavior re tech uncertainty
  - Bargaining over policy and performance
  - Contending claims about feasibility and cost
  - Maneuvering re technological information and authority
  - Interactions of strategies, association with outcomes (policy, performance)

- Inductive inference: look for regularities, hints about causation and influence – bootstrap toward general hypotheses ..AND also look for instances of clever solutions to widely recurring problems …potentially generalizable.

- Generalize and formalize – toward game-theoretic models … Would be fun, on back burner.

- Insights for Policy : How to make a regulatory system that is …
  - Bolder at promoting innovations (by incumbents, new entrants, other 3rd-parties)
  - Cost-effective
  - Effective at motivating knowledge acquisition (R&D), disclosure, and deployment
  - Robust to uncertainty, adaptive – Respond to both over- and under-shoot

Regulatory strategy must consider firm incentives comprehensively

- Exist many opp'ys for regulatory systems to create/modify incentives of relevatn private actors, and to seek and exploit situations of partial complementarity of interests between private actors and public purposes of regulaton.

- To do this, need to distinguish firms on multiple dimensions
  - To target incentives
  - To exploit divergent interests – for support, info disclosure

- Incumbents vs. 3rd-party Innovators:
  - Incumbents: wary about disclosing capabilities
  - Entrants: No such tension, may over-claim
  - Get them to argue ("Ride each other's horses")
- Producers vs. Users – of material, technology, product of concern …
- Leaders vs. Followers
- Diverse expectations re policy outcomes
  - Positive feedbacks, abrupt transitions
  - Entrants: When confident enough to invest? To lobby? (CA Prop 23)

- Pursuing major tech transition?
  - Industry structure and incentives change as you go
  - Regulation alone may not be enough: Strategic coupling with R&D support
  - Multiple prospects? Need staged, adaptive processes, consideration of eventual shakeout.

Incentives include Rewards and Threats

- Rewards (mainly to leaders):
  - Market benefits through regulation – powerful motivator
    - Explicit rewards (prizes, etc.)?
    - Shape standards to leaders' capabilities
    - Explore analogy and relationship to patent: CFC essential-use exemptions
  - In addiion to explicit rewards, may opportunities to modulate costs/burdnes of reuglation.
  - E.g., More flexibility to adapt and sequence policy:
    - Time-limited permits, exemptions
    - Grandfathering with limits (Over-learned from failure of NSPS)

- Threats: (surprising frequency and explanatory potency)
  - Diffuse (pre-enactment) vs. codified
  - Diffuse: sometimes better motivators than enacted requirements
  - Codified: must be strong enough to motivate, but also credible
  - More credibility with weaker consequences: irritating, infuriating, not lethal

Benefits of Heterogeneity

- Firm Heterogeneity
  - Can provide feasibility demonstration, disclosure
  - Unless every leader gets framed as “special case” (Dioxin, methyl bromide)
- Regulatory Heterogeneity
  - Leading jurisdictions can motivate advances, demonstrate feasibility
  - The California advantage: (not just statutory)
    - Market scale – big enough for learning, scale economies, small enough to limit business risks
    - Political conditions – strong regulations harder to block
    - Institutions: Demonstrated possibility of over-reach and (gradual) retreat

Technology assessment processes

- Ex ante assessment of technologies w/ benefits, costs
  - Routinely attempted
  - Attempt to rationalize policy/political process
- Normal experience: Not helpful
  - Vague and academic, or echo industry pessimism
  - Long-term benefit: disseminate technological capabilities, issues, arguments
- Ozone TEAP striking exception: Problem-solving, disclosure, evangelism
  - Details crucial for success: mandate, participation, leadership – But also …
  - Initial effectiveness depended on prior policy action – Reversed normal view of rational policy-making
  - Continuing effectiveness:
    - Same mechanism (re further anticipated regulations – positive feedback)
    - Plus conferral of private benefits – superior info, market opportunities and power
    - Plus true conversion, sincere pursuit of public service
- Disturbing lessons of this success: Something to offend everyone?
  - Cart before the horse – In defense of arbitrary and capricious regulation
  - Private payoffs from aiding regulatory process – In defense of regulatory capture

More Policy Design – misc points

- First action on a new issue: May need "bold stroke"
  - Significant initial action absent assessment of costs or even proof of feasibility
  - Strong regularity across cases
  - But how big a step? How do you decide? Some vague pre-assessment that still draws on extant expert knowledge as available? How protect such a process from incompetence or capture, defend it from political attacks?
- Breadth and Flexibility of Policies: Tension between cost-min and strong incentives
  - Cost-min → MBMs with broad base, max flexibility – incrementalism, diffusion
  - Saliency, Targeted incentives on big gains (if you know where) → narrow, less flexibility
- Time Horizon of Policies:
  - Near-term enhances saliency and (maybe) credibility
  - But narrows search space, focuses on incremental gains, risks lock-in
  - Better design of inter-temporal obligations –borrowing with progressive increase in scrutiny, default protection?
- Demand more? Must be able to retreat in case of over-reach and failure
  - Need *ex post* processes that can distinguish unsuccessful good-faith effort from foot-dragging, obstruction
  - Another look at science (and technology) courts?
  - Even if ex post judgments are perfect – system must consider adjustment costs – Compensation?
- P vs. Q policies: Credibility of regulatory threats is additional reason to favor P

Questions, Comments

Case Summaries

Emissions from Automobiles

- 1950-1970:
  - Collusion to suppress innovation, control innovation
  - Technical dominance: Success despite sophisticated opponents, clever policy devices
- 1970 – 1990:
  - 1970 CAA: Bold political stroke (cut 90%), with no change in capabilities or knowledge
  - Over-reach? Several years resistance, delay (including 1977 CAAA)
  - Statutory penalty for failure would close industry – not credible
  - Good progress by ~ 1980: interim standards, sustained policy threats
- 1990 – 2010:
  - Broad technical advance:
    - Delimits feasibility arguments
    - Capabilities of industry, regulators now roughly equal
  - Improved regulatory design
    - Fleet average (cars and trucks), rather than every vehicle
    - Joint regulation of fuel and vehicles for cost-effectiveness
  - Multi-jurisdiction competition: California demo effect blocks extreme infeasibility claims
  - Nuanced and credible threats:
    - Policy design puts (credible) price on violations
    - Interaction between new-vehicle standards and on-road, I&M,
    - Threat of recall motivates continued advance in new-car performance
    - Adoption of California program by other states – especially with original ZEV mandate!

Ozone-Depleting Chemicals (CFCs, etc.)

- 1974 – 1985: "Easy" domestic aerosol controls, international deadlock
  - CFC makers monopolized authoritative technological information
  - Activists could not make case cuts were feasible -- "Low-confidence equilibrium"
- 1986-1987: Negotiation of Montreal Protocol
  - Bold political stroke (cut 50%) with ~ no change in capability or knowledge
  - Feasibility and cost ***unknown*** (for those who had banned aerosols)
- 1987 – present:
  - Aggressive policy drove rapid innovation to reduce chemical use – mainly by users
  - Interaction with repeated tightening of regulatory targets
  - Mediated by novel technology assessment panels, organized by usage sectors:
    - Advise the parties on feasible reductions (the official job)
    - Focused, high-level technical problem-solving: how do we make the cuts we need?
    - Technology diffusion, evangelism, through private-industry networks
- How did this work?
  - Align private incentives of participating individuals, firms with policy goals – Two ways
  - Initially: Help solve urgent technical/business problems: "Horse before Cart"
  - Later: Participation confers diverse private benefits – access, information, occasional market power

Methyl Bromide

- Flip side of Montreal Protocol success: 20-year deadlock in policy and innovation ***despite easier technical problem***
  - Loose "critical-use" exemptions – up to 35% of baseline use.
  - Producers and users united and recalcitrant in opposition
  - Tech assessment– "can't-do" representation, dueling cost studies
  - Can't generalize: proven feasible elsewhere, but not here

- Why the difference? "Exception that proves the rule"
  - Recall: this is the normal situation
  - No "Cart before Horse": Normal sequence for rational policy-making allows normal patterns of obstruction
  - No private benefits: Industry structure precluded finding private benefits for incumbents.
    - Producers: much to lose, nothing to gain
    - Users: no urgency to innovate – confident they could keep MB

Dioxin effluent from pulp mills

- Shock of 1985: Dioxin in streams and fish
  - EPA-industry "semi-cooperation" to find source, reduction options
- Industry: "This far and no further" strategy
  - Rapid, pre-emptive commitment to substantial cuts, at salient breakpoint
  - With credible commitment to resist more, sunk costs growing over time
  - Advantageous framing of debate: "Elemental chlorine-free"
- Draft rule 1993, final rule 1998
  - EPA slow to regulate: contentious assessment, burned by prior leap
  - Push for somewhat more, defeated: Final rule ~ industry proposal
  - > 80% of industry in compliance before enactment
- Source of successful resistance?
  - Fast movement, demonstrated progress
  - Known options, no low-R&D industry
  - Strongest options all from foreign suppliers
  - No fights over feasibility, just cost (and environmental benefit)
  - Industry coordination despite heterogeneity: Every leader was "special case," no generalization

Vinyl Chloride workplace exposure

- Shock of 1974: Multiple worker deaths → Industry crisis
  - Extreme infeasibility claims
  - Extreme reductions (from 500 ppm to 1 – 5 ppm) demanded – and quickly achieved
  - Widely understood (probably incorrectly) as extreme case of dishonest infeasibility claims

- How were such extreme cuts achieved so fast?
  - Good luck, sure, but also …
  - Clearly feasible but hated alternative – Respirators
    - Decisive refutation to claims of infeasibility
    - The perfect threat – credible, yet disliked enough to motivate extreme efforts to reduce exposures

Extra slides

Environmental Regulation and Technology: 50 years of commentary …

"To require (auto pollution controls) before a satisfactory device is perfected and available on the market would be arbitrary, capricious, and void."

LA County Counsel, letter to Supervisor Kenneth Hahn, ~ 1954

"Washington politicians should not demand what technology cannot deliver"

US Chamber of Commerce, 2008

"If acid rain controls were cheap, there wouldn't be any disagreement on the science."

EPA Administrator William Ruckelshaus, 1983

Effects of Industry collaboration

- Can promote progress (ODS), or suppress it (autos, methyl bromide)

- Origin of differences?
  - Firm incentives, individual and collective
  - Strongly driven by firm expectations: What will we be required to do?
  - Institutional design, mechanisms for collaboration, participation – also crucial