Environmental Regulation and Technological Innovation

David M. Hart (dhart@gmu.edu)
Schar School of Policy and Government
George Mason University

NSF SciSIP PI Conference
January 8, 2018
Catalytic Converters vs. Zero Emission Vehicles

Source: https://schoolworkhelper.net/catalytic-converter-parts-function/

Source: https://www.hemmings.com/blog/2013/06/27/cars-of-futures-past-gm-ev1/
Work in Progress, Feedback Welcome

• NSF SciSIP research report
  – Synthesize and clarify what is known
  – Provide recommendations for policy and practice
  – Suggest areas for additional research
Scope

• Type of regulation:
  – Environmental
    • With an emerging focus on automobile emissions
  – Possibly generalizable to health and safety
  – Probably not to economic regulation or taxation

• Geographical/jurisdictional
  – United States
  – Probably generalizable to states and localities
  – Perhaps not to international locations
Why Should We Care?

• Not because we like new technology
  – Purpose: reduce externalities
  – Innovation: means not end
• But because innovation may reduce cost and increase efficacy of compliance
• And because innovation may open up new market opportunities
Poorly-Framed Question, Inconclusive Results

• The “Porter Hypothesis”: regulation may stimulate innovation to such an extent that regulated firms are better off than they were before being regulated

• Cohen and Tubb (2017) meta-analysis:
  – “We find considerable heterogeneity in both the sign and significance level of the over 2,000 estimated “effect sizes” found in these studies.”
A Better… But More Difficult Question

• “Under what conditions does environmental regulation induce technologically innovative responses by regulated firms that achieve regulatory goals more efficiently or effectively than alternative responses?”
Firm Responses to Regulation (Not Mutually Exclusive)

1. Resist
2. Comply by reducing (or ceasing) regulated activities in regulated jurisdiction
3. Comply by applying existing technology
4. Comply by innovating in order to reduce the cost or increase the efficacy of compliance
Four Kinds of Conditions that Shape Firm Responses

1. Technological opportunity
2. Industrial competition
3. Political environment
4. Regulatory design
1. Technological Opportunity

• Condition 1-1: “Expensive”
  – Expected cost of compliance is high

• Condition 1-2: “Target-rich”
  – Innovation pathways that might become cost-effective are perceived to be available by some regulated firms
Example: Not “Target Rich” California’s 1990 ZEV Mandate

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>Date Introduced in ZEV</th>
<th>Vehicle Sales 2001–2005</th>
<th>Example Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero-emission vehicle</td>
<td>1990</td>
<td>4,400(^a)</td>
<td>Toyota RAV4 electric vehicle</td>
</tr>
<tr>
<td>Partial-zero-emission vehicle (PZEV): Vehicle that meets the most stringent tailpipe standards, meets the zero-evaporative-emission standard, and has a 150,000-mile emission warranty</td>
<td>1998</td>
<td>430,000</td>
<td>Some models of Ford Focus, Toyota Camry</td>
</tr>
<tr>
<td>Advanced technology partial-zero-emission vehicle (AT-PZEV): Vehicle that meets the PZEV requirements and incorporates such advanced technology as energy storage or electric motors</td>
<td>2001</td>
<td>70,000</td>
<td>Toyota Prius, Honda Civic Hybrid, Honda Civic GX (CNG)</td>
</tr>
<tr>
<td>Fuel cell vehicle (FCV)</td>
<td>2003</td>
<td>None to date, although some demonstration vehicles are in use</td>
<td></td>
</tr>
</tbody>
</table>

Source: Vehicle sales figures were obtained through personal communication with K. Eley, Air Pollution Specialist, ZEV Implementation Section, California Air Resources Board, 2006.
\(^a\)These are BEVs that were either sold or placed into use between 1996 and 2003.

Source: Bedsworth and Taylor 2007
2. Industrial Competition

- **Condition 2-1: “No exit”**
  - Jurisdictions where firms might plausibly locate regulated activity do not vary significantly in stringency

- **Condition 2-2: “Slack”**
  - Firms have resources available to invest in innovation

- **Condition 2-3: “No cushion to sleep on”**
  - Competition exists in the regulated industry, or there is a real threat of entry
Example: “No Cushion”: The Catalytic Converter

<table>
<thead>
<tr>
<th>Table 1. Chronological development of the automotive catalytic converter (Source: Haagen-Smit, 1970; Twigg, 1999; Mondt, 2000; Acres and Harrison, 2004; Interviews with Gary Acres, 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1950s</strong></td>
</tr>
<tr>
<td>Work by Dr Haagen-Smit at the California Institute of Technology proved that automotive exhaust emissions were a major source of photochemical smog in Los Angeles</td>
</tr>
</tbody>
</table>
| JM carried out research with Ricardo and Corning | JM approached car companies such as Ford, Chrysler, and GM | JPM was competing with Engelhard, and Degussa, etc. | The first cars fitted with oxidation catalysts reach the showroom in the US | Unleaded gasoline was widely available | }
3. Political Environment

- **Condition 3-1: “No appeal”**
  - Regulated firms do not expect to be successful contesting regulation in non-regulatory venues

- **Condition 3-2: “Strong state”**
  - Enforcement is perceived to be legitimate and credible

- **Condition 3-3: “Package deal”**
  - Regulation is one element of a broader policy package to build industrial innovation capacity
Example: “Package Deal”
EPA Flue Gas Desulphurization R&D

• Close coordination with User and A&E communities; TVA and Bechtel partners
• R&D was conducted in parallel with the passing of tough SO2 NSPS (based on BACT) regulations, driven by the 1970 CAA
• Primary R&D was via three large (3x10 Mw(e)) parallel pilot plants evaluating competing scrubbers; smaller in-house pilot plant provided rapid low cost technology fixes to guide large pilots. Both lime and limestone reagents tested
• Economics were seriously considered, goal was to minimize capital and operating costs with reliable operation

Source: Frank Princiotta
4. Regulatory Design

• Condition 4-1: “No straitjacket”
  – Regulatory standards are based on performance

• Condition 4-2: “Frank and open”
  – Regulated industry and regulator engage in a robust information exchange

• Condition 4-3: “No dummies”
  – Regulatory staff and decision-makers have a sophisticated understanding of industry

• Condition 4-4: “Ratchet”
  – Regulated industry and regulators share expectations of regulatory stringency over time
Example: “Frank and Open”
CAFÉ Standards under Obama

“The “letters of commitment” signed by the stakeholders, although not legally binding, resemble legal documents. They envision a detailed step-by-step process of implementation, which requires reciprocal demonstrations of good faith by regulators and industry: the auto companies would stay the lawsuits upon issuance...All of this was done...voluntarily....the parties entered an agreement that is best described as a “trust, but verify” regime.” (Freeman 2011, p. 369)
Recommendations for the Research Community

- Do more research (especially on the US)
- Ask different questions
- Take the long view
- Assume strategic behavior
- Incorporate context (political, competitive, technological)
- Focus on regulatory design features, rather than binary command and control vs. market-based instruments
What I Might Say to Policy-Makers

• Don’t neglect innovation as a mechanism for reducing compliance costs
• But it’s not a sure thing, and it takes time to discover if it will work
• Achieve stringency over the long term by building credibility over the intermediate term
• Trust, but verify, what “industry” says
  – “Industry” probably isn’t monolithic
  – Verification requires sophisticated regulators
• Embed regulation in broader innovation policy package (R&D funding, procurement, trade, etc.)