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# Environmental regulation with technology adoption, learning and strategic behavior

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## Abstract

We analyze a model of environmental regulation with learning about environmental damages and endogenous choice of emissions abatement technology by a polluting firm. We compare environmental policy under discretion, in which policy is updated upon learning new information, versus under rules, in which policy is not updated. When investment in abatement technology is made prior to the resolution of uncertainty, neither discretion nor rules with either taxes or standards achieve an efficient solution except in special cases. When there is little uncertainty, rules are superior to discretion because discretionary policy gives the firm an incentive to distort investment in order to influence future regulation. However, when uncertainty is large, discretion is superior to rules because it allows regulation to incorporate new information. Taxes are superior to standards under discretion regardless of the relative slopes of marginal costs and marginal damages for the case of quadratic abatement costs and damages.

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## 1. Introduction

Environmental policy issues often have important temporal dimensions as well as significant uncertainty. Environmental regulations are periodically adjusted based on updated understanding or new circumstances. Over time, new scientific findings generate additional information that may cause a change in our understanding of how much damage is likely to be caused by emissions of various pollutants. For example, EPA revised its standard for particulate matter (PM<sub>2.5</sub>) after new scientific evidence linked PM<sub>2.5</sub> to serious health problems.<sup>1</sup> Similarly, investment in research and development or investment in new plant and equipment may change how costly it is to abate emissions. Once ARCO showed the feasibility of producing “reformulated gasoline with fewer smog-forming and toxic ingredients” in the early 1980s, EPA and the California Air Resources Board “required all oil companies to develop and sell even cleaner gasoline.”<sup>2</sup>

Because environmental regulations may be adjusted through time to reflect updated understanding or new circumstances, there may be scope for strategic behavior. On the one hand, a regulator should anticipate how regulations affect not only current emissions levels, but also the effect on investment in R&D or new plant and equipment by regulated firms. In the long-run, the dynamic effects of policy on incentives to innovate may be of greater importance than the static effects of policy on emissions. On the other hand, regulated firms should anticipate how their investment in R&D or new plant and equipment affects not only costs given current regulations, but also how investment might influence future regulation. In other words, a firm may have an incentive to alter investment in a strategic fashion in order to induce favorable shifts in future environmental policy. Such strategic investment can occur when regulated firms are large in the sense of producing a significant share of emissions (e.g., large automobile companies, electric power generators, or oil companies). Such firms regularly lobby governments to influence environmental policy. These firms also have incentives to influence future regulations through their choice of investment strategies. DuPont’s successful R&D efforts to find substitutes for chlorofluorocarbons (CFCs) was a major factor in changing the Montreal Protocol from calling for a 50% reduction of CFC production by 1999 to a complete production ban. DuPont profited by shifting demand from CFCs to substitutes where Dupont held patents [16].

In this paper, we analyze an environmental regulation game of symmetric but imperfect information between a regulator and a single regulated firm in which there is learning about environmental damages and investment in abatement technology. One question we investigate is whether it is better for a regulator to commit to an emissions policy prior to learning about the environmental damage function and investment decisions by the firm (rules), or whether it is better to adjust policy after learning about the environmental damage function and investment decisions by the firm (discretion). In a game where investment occurs prior to learning about the damage function, the first best solution cannot in general be achieved under either rules or discretion. Rules are not first best because regulation may not reflect actual benefits or costs of abatement after investment and uncertainty about damages is resolved. As in Kydland and

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<sup>1</sup>Cited from [http://www.epa.gov/ttn/oarpg/t1/fact\\_sheets/pmfdsp\\_fs.pdf](http://www.epa.gov/ttn/oarpg/t1/fact_sheets/pmfdsp_fs.pdf), “August 2003 Draft Staff Paper for Particulate Matter.”

<sup>2</sup>Cited from <http://www.aqmd.gov/monthly/aprilcov.html>, “The Southland’s War on Smog: Fifty Years of Progress Toward Clean Air.”

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