Instruments of Choice for Environmental Protection

by

Tracy R. Lewis*
Department of Economics
University of Florida

Preliminary Draft
Comments Welcome

*I wish to thank Jim Hosek and Mike Riordan for their help and encouragement in this project. I have benefited from the advice of Roger Noll, Mike Riordan and Rob Stavins, regarding suitable topics for this review. Michael Blake, Margaret Byrne, Bill Encinosa, Monica Nabors, and Janis Olmstead have provided valuable research assistance. Financial assistance from the National Science Foundation, and the Public Utility Research Center at the University of Florida is greatly acknowledged.

Abstract

This paper reviews recent developments in economic and political theories of environmental regulation. I analyze different approaches for protecting the environment when stakeholders are privately informed about the costs and benefits of pollution reduction. I find that the presence of asymmetric information calls for some important departures from the textbook prescriptions of marketable permits and emission taxes for controlling pollution. Further, as a positive matter, recent developments in the Political Theory of Agency suggest that decentralized incentive regulations are unlikely to be the instruments of choice for politicians overseeing environmental regulation. I conclude this review with some suggestions for future research in this area.

I. Introduction

Economists continue to be dismayed at and frustrated with policy makers who persist in employing control and command rather than incentive policy to solve environmental problems. Perhaps this is because the solution to pollution problems seems so obvious, and so treatable using the simple pricing principles which underlie most transactions in our market economy. The classical argument for correcting environmental problems, found in most economics text books on the environment proceeds like this.[1] The cause of excessive pollution and environmental degradation is a market failure whereby property rights for environmental commodities are ill defined and individuals do not bear the full social costs of their decisions. Three simple approaches exist to overcome market failure and the attendant inefficiencies it produces: (i) Assign property rights to individuals and allow them to be traded in competitive permit markets, (ii) tax pollution to reflect social marginal cost, or (iii) assign liability for damages, and let parties bargain to mutual benefit to eliminate excessive pollution.

Numerous authors have argued vigorously in favor of adopting either the market or charges approach to solving pollution problems.[2] Yet in practice environmental policy continues to be dominated by policies of control and command. The reluctance of policy makers to employ economic incentives for reducing emissions has been rationalized in several ways. First there is a belief among many environmental economists that policy makers simply need to be educated as to the virtues of incentive based policies before such policies

[1] For example see Baumol and Oates (1991), and Tietenberg (1992).

[2] Approach (iii), the Coasian bargaining solution, is generally perceived to be ineffective and impractical as explained in Farrell (1987).

will be adopted on a large scale.[3] A related school of thought maintains that many regulators come from a legal or engineering/science background which influences their policy choice towards process oriented, detailed environmental controls and standards.[4] In addition, some regulators have an anti market mentality that it is immoral to distribute and sell rights to pollute the environment. A third view, derived from the Public Choice school of thought maintains that much environmental policy is a rational response of regulators to special interests who attempt to tilt environmental policy in their favor. And while the use of economic incentives may maximize total surplus, it may not be the preferred policy of special interests.

In this survey, I establish a framework based on recent developments in economic and political theories of regulation and agency to evaluate different prescriptions for dealing with environmental problems. I argue that the market failure associated with environmental externalities can not be completely overcome with the simple application of permit markets and charges. One reason for this is that any move away from the current regulatory regime towards an incentive based system will benefit some parties and harm others.[5] Political realities require that the harmed parties be compensated to some degree to insure their approval of and participation in the new process. However, the actual costs incurred by the

---

[3] For example see early studies by Ruff (1970), and more recent work by Hahn and Stavins (1991) and Stavins (1989, 1992) to educate policy makers as to the virtues of incentive based environmental regulation. The Project 88 program in Environmental and Natural Resources is perhaps the most comprehensive and ambitious attempt to convince environmental policy makers as to virtues of market based approaches.

[4] See Kelman (1983) for an elaboration of this view.

[5] For instance if marketable emission permits are established, producers in environmentally sensitive regions may be displaced, while firms in environmentally robust areas may prosper. See Hahn and Noll (1983)

harmed parties as well as the benefits derived by others is often private knowledge.[6] The existence of this private information may hamper attempts to redistribute income from parties who benefit to those who are harmed to such an extent that decentralized price incentives may not be sufficient, much less implementable. I review this argument in section II of the survey.

In section III, I survey recent developments in the incentives regulation literature to suggest strategies for dealing with environmental regulation when the affected parties are privately informed about the costs and benefits that they incur. In most instances, the pure forms of marketable permits or emission charges are insufficient regulatory instruments for dealing with asymmetrically informed agents. Yet, frequently, straightforward alterations in these incentive devices is all that is needed to make them more effective regulatory instruments. The analysis in section III is normative, and it borrows from recent developments in the economic theory of agency.

In contrast to this, section IV provides a positive analysis of political factors determining environmental policy based on a political science theory of agency. I argue that decentralized incentive based regulation is unlikely to be implemented in practice. Environmental policy, like other forms of regulation is administered through delegation. Congress and the executive branch delegate authority for carrying out environmental policy to agencies such as the EPA, who are presumably better informed about the costs and benefits of pursuing different regulatory options. However, political overseers seek to control the outcome of the regulatory process by carefully crafting the rules and procedures which

---

[6] The cost of reducing output, or installing abatement equipment, or switching to cleaner inputs is likely to be known better by the producer than by the pollution control agency. Similarly, the beneficiaries of pollution reduction are likely to know more about the magnitude of their benefits than policy makers.

regulatory agencies must adhere to. The outcome of decentralized incentive based environmental controls is too uncertain, and too difficult for politicians to control to be a favored instrument of policy in most circumstances.

In section V, I summarize my main findings, identify some key unresolved issues, and suggest some directions for future research in environmental regulation.

The reader will already have noticed that this is not a general survey.[7] Rather, this survey adopts the narrow but important perspective, of analyzing how the distribution of information affects the feasibility and optimality of different environmental policies. Even within this narrow area, my treatment of subjects is not comprehensive. For instance, I only briefly touch on issues of monitoring and compliance in my discussion. Further I have only managed to list some but not all of the important contributions to the particular literature on environmental regulation that I review here. Nonetheless, I hope that this selective look at the environmental regulation literature will provide the reader with useful insights about the feasibility and desirability of implementing decentralized incentive policies for environmental protection.

II. Decentralized Control with Private Informed Agents

In this section, I analyze how decentralized policies of (i) trading pollution rights, (ii) pricing emissions, or (iii) Coasian bargaining work when users of the environment are privately informed. With each of these policies one attempts to internalize environmental costs by making the user of environmental resources the residual claimant of all the social costs and benefits of his activity. While this gives users the correct incentives for making

---

[7] The reader is referred to the excellent recent survey by Cropper and Oates (1992) for a comprehensive review of developments in environmental economics.

production and emission reduction decisions it may cause distributional and political constraints to be violated thus preventing the implementation of these policies.

Imagine there are a group of domestic firms who supply an export product which sells at a fixed world price. Firms, which are indexed by θ, differ according to how profitable they are.[8] θ is uniformly distributed over $[\underline{\theta}, \bar{\theta}]$. Let $\pi(\theta)$ represent the profits of firm type θ. Assume that π is increasing in θ and that there exist a minimum type firm $\check{\theta} \in (\underline{\theta}, \bar{\theta})$ which generates zero profits. The regulator knows the distribution of firm types in the economy, but does not know the profitability of any particular firm.

Figure 1 illustrates a situation where each firm emits pollutants which impose an external cost on domestic consumers of $w > 0$. The domestic value of firm θ's production is captured entirely in profits, $\pi(\theta)$. The net social surplus generated by production is $\pi(\theta) - w$. The optimal size for the industry occurs at a critical type $\hat{\theta}$ where $\pi(\hat{\theta}) - w = 0$ and net surplus is exhausted.

In a free entry equilibrium, absent regulation, all firms with $\pi(\theta) > 0$ will produce. There will be excessive entry and more pollution than is socially optimal. How can this be rectified? One simple method would be to pay the firms a subsidy not to produce. Setting the subsidy equal to w would cause firms to internalize the environmental costs they create in their production decision. In this case only firms with profits greater than or equal to w will enter the industry thus resulting in an efficient allocation.

But notice there may be a financing problem with this scheme. Assume that fiscal constraints require that the subsidy program be self financing. Therefore citizens are taxed an amount equal to the saved environmental cost to finance the subsidies paid to producers.

---

[8] Access to different quality inputs explains differences in profits among competing firms.

All firms who do not to enter, even firms who cannot produce profitably, will be entitled to the subsidy. This is because it will not be possible for the regulator to determine which firms would have produced in the absence of the subsidy. Thus, the total subsidy paid out will be $wF(\hat{\theta})$ (areas A+B in Figure 1). Citizens will receive benefits equal to $w(F(\hat{\theta})-F(\tilde{\theta}))$ (area B in Figure 1), the value of the foregone environmental costs. The value of the subsidies paid out will exceed the consumer benefits generated, by the amount $wF(\tilde{\theta})$ (area A). Consequently, it will be impossible to implement this program unless the government constraint is relaxed.

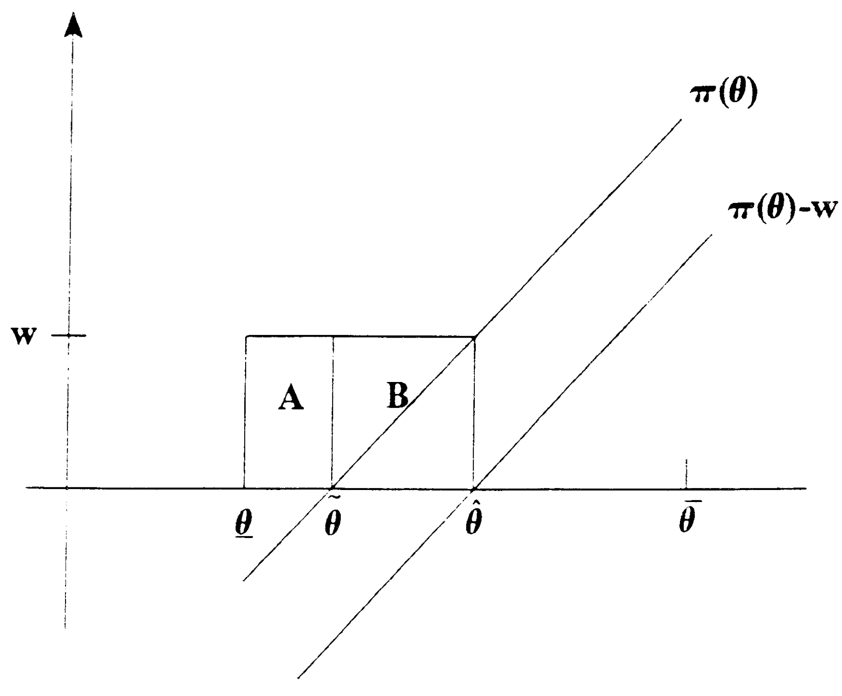

Figure 1

Notice, however, that some degree of improvement may be possible. In Figure 2, a smaller subsidy, $\hat{w}$, is offered which induces fewer than the optimal number of firms to stay out. However, this subsidy balances the budget as the benefits from reduced pollution which are collected as taxes (area C+B in Figure 2) equal the amount paid out to the firms (area A+B).[9]

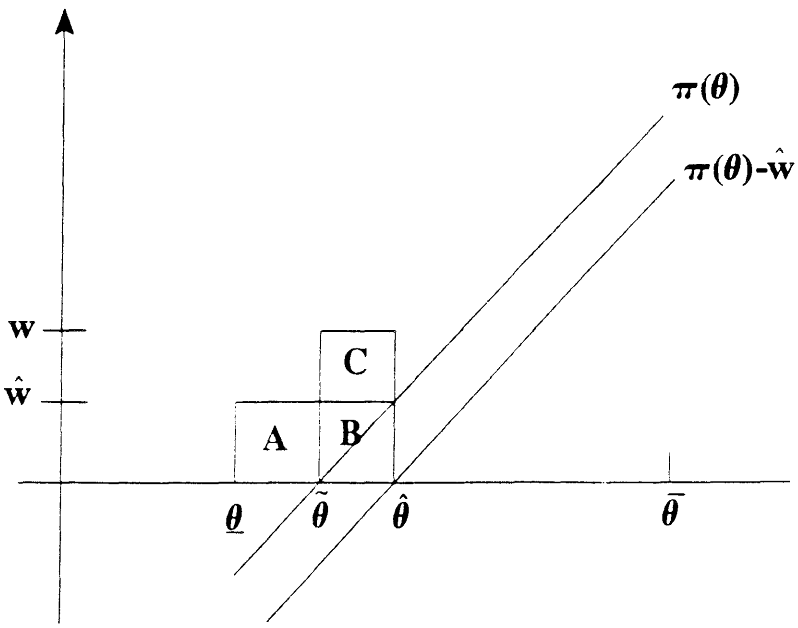

Figure 2

It is important to realize that the inability to achieve efficiency in the presence of private information is not peculiar to the subsidy scheme I have proposed. Suppose a free entry equilibrium initially exists and consider a marketable permit policy in which the government attempts to limit production to the socially efficient number of firms.[10] It distributes the efficient number of production licenses to consumers and producers some how

[9] Notice that it may not be possible to achieve any improvement if $F(\tilde{\theta}) > wf(\tilde{\theta})$. The reason is that at least $F(\tilde{\theta})$ firms are entitled to a subsidy for staying out. But there is a savings of only $wf(\tilde{\theta})$ for each type firm who is induced to stay out. This suggests that the cost of pollution, w, must be sufficiently large for exit subsidies to be self financing. A similar point is made in Klibanoff and Morduch (1994).

[10] Notice the government has sufficient information on the distribution of firm types to determine this number.

and allows agents to buy and sell licenses to determine who produces.[11] Presumably, under competitive conditions firms with the highest profits will bid the most for the licenses and end up producing. Notice that firms types $\theta < \hat{\theta}$ will ultimately be excluded from the market. But political realities require that these types be allocated permits initially which they can sell as compensation for their losses to insure their cooperation and participation in the market. But since the firms are privately informed about their type there is no practical way for identifying which firms should receive the permits.

Similar implementation problems arise in the Coasian Bargaining solution, even with small numbers.[12] To see this imagine that a single consumer and a single producer gather to bargain over the reduction of pollution as envisioned by Coase. As is well known, if the requirements for the Coase Theorem are satisfied (the existence of rational well-informed agents, who can bargain costlessly), then it follows as a tautology that the efficient outcome will be reached. However, suppose the producer is privately informed about his profits from production, as given by $\pi(\theta)$ and that the consumer only knows the distribution for θ. Suppose that the firm is vested with the right to produce and that the consumer offers a bribe of w to the firm to cease production. This arrangement causes the firm to fully internalize the cost imposed on consumers, and would therefore be efficient. But notice that consumers will not implement this form of bribery, as the expected cost savings, $w(F(\hat{\theta})-F(\bar{\theta}))$, is less than the expected bribe $wF(\hat{\theta})$.[13]

---

[11] This example is similar to the revenue neutral auction proposed by Hahn and Noll (1982).

[12] There is a large literature which analyzes allocations reached under Coasian Bargaining. Some of the more insightful papers in this literature that deal with asymmetrically informed agents include Cooter (1982) and Farrell (1987).

[13] All firm types $\theta < \hat{\theta}$ will accept the bribe, but the bribe will only alter the production decisions of firm types $\theta \in (\bar{\theta},\hat{\theta})$. If the consumer can present a take it or

Suppose instead that consumers have the right to an unpolluted environment. They can prevent firms from producing, and therefore must be compensated for allowing firms to enter. In that case an efficient solution in which the firm must bribe the consumer to produce by paying w is feasible and efficient. Only firms with profits exceeding w will pay the bribe and enter.[14] Thus one sees the importance of the initial assignment of property rights and the form of bargaining allowed under the Coasian solution. Note however that it generally will not be possible to achieve efficient solutions for any distribution of property rights when both producers and consumers are privately informed.[15]

In theory, reliance on the common law tort system would appear to be an attractive supplement or replacement for Coasian bargaining. By assigning liability to polluters to provide compensation for those individuals who are harmed by the pollution, a mechanism for internalizing the damages from pollution is thus provided. However, as Menell (1991) explains the usefulness of the tort system to solve environmental problems is limited because it is extremely difficult to prove liability in any particular case. This is because the harm resulting from pollutants, which may be manifested in the form of a disease or reduced health, may be attributable to a number of different factors besides the pollution. While

---

leave it offer to the firm he will choose a bribe, $w' < w$ such that the marginal benefit from inducing a type θ' to exit which is, $w'f(\theta')$, equals the marginal cost of the bribe, $F(\theta')$. Of course other outcomes are possible depending on the type of bargaining which occurs between the consumer and the firm.

[14] This also arises in market based regulation. Suppose that the firms have no standing in the industry. They must agree to compensate consumers for any external costs that they impose on consumers. In this instance if producers must pay a constant fee of w then the first best solution can be reached in which the optimal number of firms enter the industry, and the consumers are exactly compensated for the increase in external pollution costs which they bear. This result illustrates the important point that the initial distribution of rights may be crucial in determining the feasibility of reaching first best agreements.

[15] See Myerson and Satterthwaite (1983) and Makowski and Mezzetti (1993).

statistical evidence may establish a link between pollution and the harm it causes on average, this evidence is not admissible for establishing liability for harm in particular cases.[16] Thus the court's insistence in evaluating each case on its merits undercuts their ability to provide polluters with the right incentives to exercise care.

The foregoing examples illustrate the importance of distributional and political constraints in determining which departures from the status quo policy are feasible.[17] It also illustrates the advantages and disadvantages of regulating privately informed agents by decentralized incentive procedures. The advantage is that the regulator can delegate production and emission control decisions to better informed agents. The disadvantage is that it is more difficult to identify and compensate agents who are harmed by departures from the status quo. This limits the set of feasible policies which the regulator can implement. In section III, I review methods that have been suggested for implementing environmental policy when agents are privately informed.

III. Regulating Privately Informed Polluters

How does one control emissions when polluters are privately informed about the costs of achieving specified standards? The insight of early analysis of this question by Kwerel (1977), Dasgupta, Hammond and Maskin (1979) and Spulber (1988) is that each polluter

[16] Aside from this the court system is poorly designed to evaluate scientific evidence. Peter Huber (1987) argues that courts have been inundated with pseudo science testimony which has increased the amount of litigation and has introduced more variance in the damages awarded. Menell (1991) argues that the toxic system tort have produced highly variable rewards, have distorted incentives and have increased transactions costs significantly. It may be better to rely on agency control of pollution where scientific expertise can be brought to bear in a more consistently and thoughtfully manner.

[17] See papers by Dewatripont and Roland (1992) and Lewis et al. (1989) for further analysis of what regulatory reforms are feasible when agents are privately informed and possess political power.

should be a residual claimant of all the costs and benefits associated with his actions. This endows polluters with the correct incentives to reduce emissions.[18] However one must satisfy distributional and political constraints to implement new policies. Privately informed polluters can command information rents by claiming they are harmed by the imposition of a new policy and need to be compensated for their loss. These claims are impossible to verify, but they must be respected to insure the implementation of more efficient environmental policies. Occasionally, these information rents may exceed the extra surplus generated by a more efficient policy. In that instance, it will not be possible to implement the policy. Examples of such implementation problems were provided in the pervious section.

The incentive regulation literature, (as exemplified by Laffont and Tirole (1993) and the references cited therein) suggest ways to reduce information rents. A review of this work reveals that mechanisms for reducing rents typically require some sacrifice in the productive efficiency of pollution control policy. Further, the degree of intervention by regulators rises as a result of the need to limit information rents of privately informed polluters. In this section, we examine how these two factors are manifested in different instances of environmental control.

A. Observable Emissions[19]

For simplicity, we begin by analyzing the simplest case, where the regulator can monitor emissions, and then proceed to complicate the analysis in stages with more realistic assumptions. Suppose there is a regulated public utility who produces electricity and

[18] This is the insight of Clarke (1971) and of Groves' (1973) mechanism for provision of public goods. It carries over to other instances in which agents are privately informed about either the costs or benefits of some action.

[19] See Laffont (1993) for an analysis which is similar to the model presented here.

pollutants as a byproduct.[20] For now imagine that there is a single regulatory agency overseeing both the pricing of electricity and the protection of the environment. Later we consider how these activities might be separately regulated.

For simplicity, I assume that consumers are identical. They value electricity service q, and emissions, e, according to the utility function U(q,e). U is increasing in q and decreasing in e.

The utility's cost of producing electric service, q, while limiting emissions to a level, e, is denoted by the function $C(q,e,x,\beta)$. Costs are increasing in q and decreasing in e. The variable x represents specific inputs, including emission control equipment, that the utility employs. β is a random variable affecting the costs of service and pollution abatement. For example, β may measure the ease with which the utility substitutes fuels or installs scrubbers to reduce emissions. Costs are decreasing in β. The regulator is unable to observe C or β, though he can monitor q, e, and x. We assume that β is distributed by the cumulate distribution function $F(\beta)$ with density $f(\beta) > 0$ for $\beta \in \{\underline{\beta}, \bar{\beta}]$ and the regulator knows the distribution of β. Under decentralized regulation, the utility would choose x to minimize costs. However, we shall show how it is helpful for the regulator to control x to limit the utility's information rent.

The regulator oversees the utility by offering a menu of contracts $\{T(\beta),q(\beta),e(\beta),x(\beta),\}$ for $\beta \in [\underline{\beta}, \bar{\beta}]$. The contract specifies a transfer to the utility, T; an output level, q; a required level of emissions, e; and specified inputs to be provided, x; all of which are conditioned on the utility's report of its production parameter, β. Myerson (1979) and others

[20] The example of a electric utility is particularly pertinent Utilities are a major source of air pollution in the United States. In addition, regulators have a clear mandate to control both the prices the utility charges and the pollution it emits.

have demonstrated that it is without loss of generality that one design an "incentive compatible" menu to induce the utility to truthfully report β.

The regulator must transfer enough to insure that the utility breaks even. Notice that firms with higher β's command greater profits because of their private information about β. The reason is that a β type firm can always accept the contract intended for the β -Δ firm and earn the same transfer payment, $T(\beta-\Delta)$, but incur a smaller cost. The difference in costs given by

$$R = C(q(\beta-\Delta),e(\beta-\Delta),\beta-\Delta,x(\beta)-\Delta)) - C(q(\beta-\Delta),e(\beta-\Delta),\beta,x(\beta-\Delta))$$

is a rent which β earns because he is privately informed about his type.[21] If one divides both sides of the equation above by Δ and allows Δ go to zero, one sees that the rate at which information rents increase with β is given by

$$R'(\beta) = -C_\beta(q(\beta),e(\beta),\beta,x(\beta)) > 0$$[22]

Often the regulator will want to reduce these information rents. This arises when there is a need to make regulation self financing, as I assumed in my previous examples. It

[21] Notice that this rent calculation provides a method for quantifying the transactions costs associated with implementing certain environmental policies. Discussions of transaction costs associated with environmental regulation like that appearing in Stavins (1994) could be made more rigorous and compelling if the transactions costs are explicitly derived.

[22] I adopt the conventional notation that derivatives are denoted by variables with primes, and subscripted variable denote partial derivatives.

also occurs when the regulator desires to minimize transfers because of the premium associated with raising public funds.[23]

As a useful benchmark, consider the full information case where the regulator can observe costs and knows the firm's type, β. Assume the regulator wishes to maximize the sum of producer and consumer surplus from electricity service net of the environmental costs associated with the service. In that instance, the regulator would instruct the firm to produce where marginal cost equals price and to reduce emissions to the level where the marginal cost and benefits of emission reduction are equated.[24] Also the utility would choose inputs, x, to minimize its costs. The regulator would set transfers to just compensate the utility for its costs of production and emission reduction.

Now suppose the regulator can not observe the utility's type, β, or its costs. In this instance, the regulator selects an incentive compatible menu of contracts $\{T(\beta),q(\beta),e(\beta),x(\beta),\}$ to maximize total surplus. In addition, the regulator must insure that utility profits are non negative. One can show (see the appendix) that this exercise is equivalent to solving the following regulator's problem [RP]

$$[RP] \qquad \max_{\{q(\beta),e(\beta),x(\beta)\}} \int [U(q(\beta),e(\beta)) - \lambda C(q(\beta),e(\beta),x(\beta),\beta] - (\lambda-1)\frac{1-F(\beta)}{f(\beta)}(-C_\beta)\, dF(\beta)$$

for all $\beta \in [\underline{\beta}, \bar{\beta}]$

---

[23] Raising public funds through taxation involves a dead weight efficiency loss. Consequently, it costs more than a dollar to transfer a dollar of public funds to the utility. Every dollar saved in utility transfers can be used to reduce the distortionary impacts of taxation generated elsewhere in the economy. See Bovenberg and Goulder (1993) and the references cited therein.

[24] To be strictly correct, this formulation requires that the marginal costs of production and emission reduction are appropriately weighted to reflect the cost of meeting the budget constraint or paying the utility with public funds.

The first square bracketed expression in [RP] is the surplus from electricity consumption and production net of environmental costs. Notice that costs are weighted by $\lambda > 1$ which reflects the costs of meeting a financing constraint. Alternatively, one may interpret λ to be the distortionary costs of raising public funds to pay the utility. The second expression is type β's contribution to expected information rents. It is interpreted as follows. More efficient firms may imitate less efficient types and earn rents at the rate $-C_\beta$. The rent accrued by a β type firm also accrues to the $1-F(\beta)$ higher types, as they can always imitate a β type firm. This expression is normalized by $f(\beta)$ the probability that a β type is actually encountered .

The first order conditions for maximization of [RP] include:

(1) $$-U_e = -\lambda C_e - (\lambda-1)(-C_{\beta e})[1-F(\beta)]/f(\beta)$$

(2) $$U_q = \lambda C_q + (\lambda-1)(-C_{\beta q})[1-F(\beta)]/f(\beta)$$

(3) $$\lambda C_x = -(\lambda-1)(-C_{\beta x})[1-F(\beta)]/f(\beta)$$

First consider the regulator's choice of emissions level, e. The regulator induces the firm to set emissions such that the marginal benefit from emission reduction ($-U_e$) equals the *modified* marginal costs of emission reduction. Marginal costs are modified to account for the effect of emission reduction on information rents as captured by the second term on the rhs of (1). To see the implications of this suppose $-C_{\beta e} < 0$ so that the marginal cost of reducing emissions, $-C_e$, is smaller for more efficient firms. Then according to (1) the regulator induces the firm to reduce emissions by an inefficiently small amount since $-U_e \geq -\lambda C_e$ (with > for β

$< \bar{\beta}$). This distortion causes a reduction in information rents, as the cost advantage in reducing emissions enjoyed by the more efficient firms is diminished.

The regulator may similarly distort the utility's output choice to limit information rents. Suppose that $C_{\beta q} < 0$, so that marginal production costs are decreasing with higher β types or more efficient firms. Equation (2) indicates that to limit information rents it will be necessary to induce the utility to reduce production below its surplus maximizing level to reduce the rate of rent accrual, $-C_{\beta}$.

Notice that under decentralized regulation, the utility would be allowed to choose the cost minimizing set of inputs to minimize the costs of meeting a specific emissions standard. But according to (3) the regulator will want to control the firm's choice of inputs, and possibly to distort it from the cost minimizing level. For instance if $-C_{\beta x} < 0$ so that rents decrease with higher input use, then the regulator will induce the utility to employ an excessive amount of inputs in order to limit information rents.

Some interesting conclusions emerge from this analysis. First one finds in the absence of financing constraints, (where $\lambda = 1$) that the usual efficiency conditions obtain. However, when financing is constrained, certain sacrifices in productive efficiency are required to reduce information rents. Traditional efficiency conditions are replaced by a modified rule that requires that the marginal benefits from some activity be equated to marginal cost that are modified to account for the marginal impact of the activity on information rents.

Second, containing information rents requires greater regulatory intervention in specifying the mix of inputs to be employed by the utility. For instance, it is not possible to use uniform emission taxes to achieve the desired outcome characterized in eqs (1)-(3). In theory, though, it may be possible to employ decentralized means to support this information constrained solution by a set of transfers, input and output prices and emission taxes.

According to this procedure, the utility first selects a vector of transfers, price and taxes from a specified menu. Next, the utility determines its profit maximizing levels of inputs and outputs and emissions given its personalized prices and taxes. Under certain conditions, this procedure can induce the utility to chose the second best allocation characterized in (1)-(3). Unfortunately, though, stringent monotonicity and curvature conditions are required for the implementation of this scheme.[25] And, even if the procedure is implementable, it requires that the regulator design a different set of prices and taxes for each conceivable type of utility, $\beta \in [\underline{\beta}, \bar{\beta}]$.

Third, notice that to reduce information rents that the regulator will specify the mix of inputs employed by the utility to limit emissions. Consequently, there is little latitude afforded the firm to choose a strategy for controlling pollution.[26]

Finally, reducing output and abatement are ways to limit information rents. This suggest that the goals of supplying low cost service and maintaining environmental quality may be in conflict. For instance, if the regulator wishes to increase output and reduce the price of service to the utility's customers, it will need to induce less abatement from the utility in order to limit the utility's information rents.[27]

---

[25] Laffont and Tirole (1986) and Laffont (1993) suggest that appropriately chosen taxes and subsidies can be used to implement information constrained allocations when agents are privately informed. See Rogerson (1987) for a discussion of conditions necessary for the implementation of decentralized allocations when agents are privately informed.

[26] See Oates et al. (1989) for a discussion of the benefits from direct controls.

[27] See Laffont (1994) for a discussion of the regulatory tradeoffs between cost minimization and safety care.

B. Unobservable Emissions

In many instances, it may be impossible or too costly for the regulator to effectively monitor the firm's emission.[28] Yet one may control emissions by controlling output. To analyze this possibility, I assume that e(q) represents maximum emissions resulting from production q. In the absence of direct emission controls the firm emits e(q) to minimize its cost of production. The cost for a firm, $C(q,\beta)$ depends only on the level of production, q , and on its type β.[29]

Now production is the single instrument which the regulator controls to influence both the level of output and the level of emissions simultaneously.[30] Proceeding as before, one can show that the level of production that solves the regulator's problem for this case satisfies the condition

$$(4) \qquad U_q - \lambda C_q - U_e\, e'(q) = (\lambda-1)(-C_{\beta q})[1-F(\beta)]/f(\beta)$$

The left hand side of (4) represents the net marginal surplus from production, including the marginal cost of emissions. Generally, it will be desirable to curtail production so that price exceeds the marginal cost of production in order to account for the environmental costs associated with greater output. The right hand side of (4) measures the marginal impact on

---

[28] Monitoring emissions is a major expense of most environmental regulatory programs. At best, the regulator can only perform spot checks, and periodic inspections to verify that emission control equipment is properly installed and that the firm is following approved procedures in disposing of environmental wastes. Furthermore, if pollution comes from many sources (as discussed in sections 5 and 6 of Laffont (1993)) or from mobile sources, monitoring individual emissions may be impractical.

[29] Here I ignore inputs, x, by assuming they are technologically fixed.

[30] Lewis and Sappington (1992a) analyze an analogous situation where a regulator chooses the price of electricity as a single instrument to influence both the level of output, and the amount of conservation services offered by the utility.

information rents from an increase in production. If $-C_{\beta q} > 0$, then increases in production increase information rents. Thus, to reduce rents it will be desirable to further reduce output. Thus (4) indicates that it will be desirable to curtail production both to reduce environmental damage and to limit information rents.

C. Monitoring Outputs Vs. Inputs Which Produce Pollution

The previous analyses emphasize the usefulness of regulating output and emission levels to minimize information rents. But monitoring is costly and regulators may only be able to monitor the amount of emissions or the amount of output the firm produces, but not both. Which quantity should they monitor? Lewis and Sappington (1993)[31] analyze a situation where the firm can only reduce emissions by cutting output. Firms differ in their capacity to limit emissions by reducing output. Firms wish to overstate the reduction in output necessary to achieve a given level of emission to receive more favorable treatment from the regulator. Lewis and Sappington find that it is preferable to monitor output rather than emissions when the marginal loss in output from reducing emissions is decreasing in the level of production. By regulating output the ability of the firm to overstate the cost (in terms of foregone production) of reducing emissions can be limited more effectively. This is surprising since it may seem preferable to control pollution directly, rather than by controlling output.

D. Stochastic Emissions

In this section, I amend the previous model by assuming that the utility's emission's may be monitored but that the level of emissions and the costs of abatement are stochastic.

[31] The Lewis and Sappington (1992b) work draws on previous analysis by Maskin and Riley (1985) who study whether it is preferable to monitor inputs versus output in controlling information rents.

For instance, abatement costs may vary as pollution control devices break down unexpectedly and this may also cause the waste emitted by the utility to randomly fluctuate.

Baron (1985a) models this case by assuming that emissions are distributed by the function $G(e \mid q,x,\beta)$ with density $g(e \mid q,x,\beta) > 0$ for $e \in [\underline{e}, \bar{e}]$. The variable x is the level of abatement dictated by the regulator. The firm is privately informed about its productivity parameter, β, which affects both the cost of abatement as well as the level of emissions. The function G has the properties that emissions are stochastically decreasing with greater abatement, $G_x > 0$, and stochastically increasing with output, $G_q < 0$. Further, $G_\beta > 0$ so that emissions are stochastically decreasing as the utility becomes more efficient. We also assume that the distribution of emissions satisfies the monotone likelihood ratio property that g_x/g is decreasing in e.[32]

Suppose the regulator imposes a uniform emission tax, $\tau > 0$ on the utility in order to control pollution. The imposition of the tax decreases the utility's expected profits by $-\tau\int eg(e \mid q,x,\beta)de$. Differentiating this expression with respect to β shows the impact of the tax on the rate of rents accruing to more efficient firms,

(5) $$d/d\beta\{-\tau \int eg(e \mid q,x,\beta)de = -\tau \int eg_\beta(e \mid q,x,\beta)de$$

$$= \tau \int eG_\beta(e \mid q,x,\beta)de > 0$$

One obtains the second expression in (5) by integrating by parts and the inequality follows from the assumption $G_\beta > 0$. Equation (5) demonstrates that more efficient firms earn greater

[32] Intuitively, the monotone likelihood ratio property implies that an increase in abatement reduces the relative likelihood of observing high emission levels.

rents from the imposition of a tax, because they are able to avoid emissions more readily than less efficient firms. Baron concludes that it is preferable to set the uniform tax to zero to minimize information rents. In that case, one controls emissions directly by specifying the level of abatement or by limiting production as in the previous model.

Suppose taxes are allowed to vary with the level of emissions. In this case the change in profit from the imposition of a non negative emission tax, $\tau(e)$ (bounded above by $\bar{\tau} > 0$) becomes $-\int \tau(e)\, eg(e\,|\,q,x,\beta)de$ and the accrual of rents to more efficient firms is given by

(6) $$d/d\beta\{\int -\tau(e)\, eg(e\,|\,q,x,\beta)de = \int -\tau(e)\, eg_\beta(e\,|\,q,x,\beta)de$$

Notice from (6) that rents are minimized by setting $\tau(e) = \bar{\tau}$ whenever $g_\beta < 0$ and zero otherwise. The assumption that g satisfies the monotone likelihood property implies there exits an emissions level $e^*(\beta,q.x)$ such that g_β (<,=,>) 0 when e (<,=,>) $e^*(\theta,q.a)$. Thus the minimization of rents calls for taxing the firm at the <u>maximal</u> rate whenever emissions fall below some critical level, and to render a <u>zero</u> tax when emissions are higher. The intuition for this paradoxical result is that one can monitor emissions to verify the accuracy of the firm's abatement efficiency. If the firm claims that abatement costs are high, then emissions which are correlated with abatement costs through β, should also be high. Consequently, if emissions are unexpectedly low, this suggests that the firm may have lied about its abatement costs to obtain greater compensation from the regulator. In this instance, the regulator fines the firm to deter it from misrepresenting abatement costs.

One should interpret these results about emission taxes with some care. The analysis I presented above assumes that the regulator controls waste discharges directly by specifying the abatement equipment employed by the utility and by reducing the level of output q. In instances where these options do not exist, emission taxes may be a preferred option for controlling pollution.

Swierzbinski (1994) extends Baron's (1985a) analysis by assuming that it is costly for the regulator to monitor the firm's emissions. He finds that the regulator only monitors with some frequency to reduce costs. Further, the firm is rewarded whenever monitoring reveals that it is complying with abatement standards. In effect, the regulator offers the firm a rebate for complying. Swierzbinski finds that costly monitoring reinforces the tendency to reduce abatement to limit information rents (discussed in section 3A). This is because the expenses of monitoring and offering a reward for compliance add to the cost of inducing the firm to limit emissions.

E. Common Agency

Frequently a utility or a commercial or industrial firm will be regulated by several agencies. For instance, the state Public Utilities Commission (PUC) may regulate the price of service for the utility, whereas the state Environmental Protection Office (EPO) may regulate pollution. Further it is not uncommon for both federal and state regulators to oversee the same set of firms. When the agencies cooperate in setting policy they can achieve the second best (cooperative) regulation which we have characterized above. However, agencies are typically unable or unwilling to work together in pursuing their separate regulatory goals. In this instance, the agencies may compete with each other through the policies that they separately impose on the firm.

Baron (1985b) models the interactions between the firm and the two regulatory agencies as a Stackelberg game. In this game, the EPO moves first by establishing an emissions policy, followed by the PUC which sets a pricing policy for the firm. By moving first, the EPO may act strategically. The EPO realizes that the firm's cost of abatement parameter, β, will be revealed by the pricing arrangement adopted by the firm and the PUC. Consequently the EPO makes its policy contingent on this price regulation allowing it to "free ride" on the information extracted by the PUC contract. This allows the EPO to impose a higher abatement level since it need not limit information rents. On the other hand the PUC bears the entire burden of limiting the firm's information rents. As a consequence, the non cooperative regulation results in an emissions standard that is higher and an output level that is lower than the cooperative second best levels.

Different results occur when both agencies move simultaneously as analyzed by Encinosa (1994). In this case, the abatement and the output levels are higher than their cooperative second best levels, although both remain lower than their first best levels. The intuition for this finding is as follows. Each regulator wishes to limit the utility's information rent. Recall that rents accrue to the utility at the rate of $-C_\beta > 0$ and that $-C_{\beta q} > 0$ and $-C_{\beta e} < 0$. This implies that the EPO wants to increase emissions to lower rents, and that the CPU wants to reduce output to lower rents. But if q and e are cost substitutes, $C_{qe} < 0$, as seems reasonable,[33] the rent reduction strategies undertaken by the independent regulators will conflict with each other. If the EPO reduces abatement standards, then the PUC will increase output q since marginal production costs decline. Similarly, if the PUC decreases output, the EPO will reduce emissions since the cost of abatement falls. As a result, the regulators extract less rent from the firm when acting independently than when they cooperate.

[33] Assuming $-C_{qe} > 0$ is equivalent to assuming that the marginal cost of production increases with the amount of emission reduction which occurs.

F. Influence of Special Interests on Regulation

The foregoing analyses assume that the regulator acts independently and benevolently to serve the best interests of society. This abstracts from the possibility that the regulator may be captured by special interest groups representing industry, consumers, or perhaps environmentalists. For instance, firms may bribe agency personnel to ease emission constraints. Alternatively, environmentalists may persuade elected regulatory commissioners to support tougher environmental standards by contributing to reelection campaigns.

The idea of regulatory capture was introduced by Stigler (1971), Peltzman (1975), and Buchanan and Tullock (1975). Building on this foundation Laffont and Tirole (1993) and Tirole(1992) have modified the theory of optimal incentive regulation to allow for coercive behavior by special interests. In the Laffont and Tirole analysis, the regulator can be bribed or coerced to make policy that favors a particular group. The body overseeing the regulator (e.g. Congress) establishes the type and degree of decision making authority which the regulator may exercise in setting regulatory policy. Congress would like to give the regulator discretion in setting policy to take advantage of her superior knowledge of the industry. However, giving the regulator authority to influence policy encourages special interests to try to capture the agency.

Several interesting results emerge from this analysis. First, it is often (but not always) optimal for the overseer to prevent collusion between the regulator and the firm (or other special interests) from occurring. Although it may not arise in equilibrium, the possibility of collusion does affects the form of permissible regulation. Even though bribery is not widely observed, the possibility of it occurring does affect regulation.

Second, to combat collusion the degree of authority delegated to the agency and the incentives for the firm to reduce pollution are restricted. This may be one reason why regulators are sometimes forced by law to offer limited options to firms for reducing pollution. It may also explain the preference for direct controls over performance standards which afford the firm greater latitude in meeting pollution targets.

G. Auction Markets For Pollution Permits

In section I, I argued that distributional constraints may impede the implementation of tradable permit markets when firms are privately informed about the effects of permit trading on their profits. An interesting alternative to marketable permits is the auctioning of pollution permits as described in Lewis and Sappington (1994). Imagine there are N firms who emit pollution as a by product of their productive activity. $R(e_i,\theta_i)$ is the reduced form expression of firm i's profit as a function of its allowable emissions e_i. The parameter, θ_i, which is known privately by the firm reflects the firm's value of polluting. For instance one firm may benefit from polluting more because it is more difficult for it to utilize cleaner fuels. Profits are increasing in e_i and θ_i. Firms benefit by increased emissions as it either permits them to increase production or to reduce expenditures on emission control.

$\tilde{A}$ is the total number of allowable emissions which is determined somehow, perhaps by political considerations. The auction is conducted by asking each firm to reveal its θ_i, Based on the firms' reports each firm is assigned a number of permits and required to pay the government a tax (or receive a subsidy). The auction is designed to maximize the total surplus generated by the distribution of available permits subject to (i) no firm may be harmed by the implementation of the auction, and (ii) budget balancing; the subsidies paid out cannot exceed the payments which are collected. Once the permits are distributed, firms are not allowed to trade allowance thereafter. We explain the importance of this feature below.

It is instructive, as a benchmark, to describe the optimal allocation of permits when the government is informed about each firm's pollution value, θ_i. In this instance the government distributes allowances to equate the marginal value of emissions $R_e(e_i,\theta_i)$ for all firms i = 1,,,N. In the second best case, where the θ_i's are private knowledge, the government auctions permits to equate the "adjusted" marginal value of emissions, $m_e(e_i,\theta_i)$ for all firms, i = 1,,N, where $m_e(e_i,\theta_i)$ is given by

(6) $$m_e(e_i,\theta_i) = R_e(e_i,\theta_i) - \lambda \tilde{R}_{\theta e}(e_i,\theta_i)$$

$m_e(e_i,\theta_i)$ is the marginal value of emissions for firm i, modified to account for the impact of firm i's accrual of information rents on the budget constraint. This impact is given by $\lambda \tilde{R}_{\theta e}(e_i,\theta_i)$, where $\tilde{R}_{\theta e}$ measures the effect of an increase in emissions on rent accrual and λ is the budget constraint multiplier.[34]

Notice that in the absence of budgetary constraints (so $\lambda = 0$) the second best allocation coincides with the first best distribution of permits where $R_e(e_i,\theta_i)$ is equated for all firms i. In that case the preferred allocations can be implemented by a tradable permit market in which allowances are bought and sold for a common price equal to $R_e(e_i,\theta_i)$. Generally, however, budget constraints will bind, and it will not be possible to achieve the first best allocation of permits. Further, it will not be possible to use decentralized market mechanisms and uniform prices to obtain the second best allocation.[35]

---

[34] Proceeding as before, it is straightforward to show that higher θ type firms contribute to rent accrual at the rate of $\tilde{R}_\theta = R_\theta(1\text{-}F(\theta)/f(\theta)$ where $F(\theta)$ is the distribution for θ.

[35] When confronted with a uniform price, firms will purchase emission permits so that the marginal value of emission is equated for different firms. Generally, this will violate condition (6).

Policy analyst generally agree that it is not possible to determine the socially optimal emission level because one can not know the social benefits of emission reduction. Nonetheless it is useful to have information on the marginal cost of achieving different levels of environmental quality. It is interesting to note that the marginal cost of tightening the total emissions constraint is equal to $m_e(e,\theta)$ when allowances are auctioned. Intuitively, one might expect that it becomes more costly to achieve a given level of reductions when firms are privately informed. Surprisingly, one finds that marginal costs may fall in the presence of private information. For instance, suppose that $\tilde{R}_{e\theta} > 0$.[36] Then Lewis and Sappington (1994) demonstrate that the marginal cost of achieving a given level of emission reduction is smaller when firms are privately informed. The reason is that a reduction in emissions helps to reduce information rents (since the accrual of rents, R_θ, is increasing in emissions) which makes it less costly to achieve a given environmental standard. However, when $R_{e\theta} < 0$ the reduction of emissions increases information rents, which makes it more costly to achieve a given environmental standard when firms are privately informed.

Its important to note that to limit rents it is necessary to prevent firms from trading allowances once they have been distributed. The reason is that a firm with high use value for emissions may claim that it has little demand for emission allowances, to minimize its payment to the government. But if trade of permits is allowed after the initial allocation, the firm who has a high use for permits can purchase them in the market. Thus, preventing such trading makes it easier to solicit truthful information from the firms. This restriction

[36] This would arise if larger θ reflects greater demand for the firm's product. Consequently, increased output (which comes from greater emissions) is more valuable when demand is greater.

on trading may be quite costly, however, if firms' demands for certificates change over time.[37] For that reason, it may be advisable to allow trading to occur after the initial distribution of allowances, even if this increases rents, to afford greater future flexibility.

The issue of how to design marketable permit markets which run for several periods is also important. Laffont and Tirole (1993b, 1993c, 1994) argue that the government's plan for allocating permits over time will affect firms' incentives for investing in abatement technology to bypass the market and avoid future costs of purchasing permits. Private incentives to innovate may be excessive if the government limits permits to raise revenues in future periods. If financing constraints are important, it may be desirable for the government to price discriminate among firms according to their tendency to bypass the market in future periods. This is accomplished by allowing firms to buy different options to purchase emission permits at reduced prices in the future.

IV. Positive Theories of Regulatory Instrument Choice

In previous sections I examined normative properties and problems with employing decentralized incentives when agents are privately informed about the costs and benefits of regulation. In contrast, the emphasis of this section is on positive issues. Are decentralized controls like emission charges and tradable permit programs likely to be the instruments of choice among special interest groups and the politicians that oversee the regulators?

When competitive markets are successfully organized we know from theoretical predictions, experimental results and practical experience that the "invisible hand" magically obtains efficient (total surplus maximizing) allocations of goods and services with a minimum

[37] Changes in technology, or consumer demand, may cause individual firms' demand for emission allowances to vary over time.

of assistance from outside forces. Indeed the beauty of the invisible hand is that the myriad of decisions about where to locate business, what production processes to employ, and which emission control devices to use to achieve pollution standards at least cost can be made automatically without input from special interests or political overseers. Unfortunately, though, the fact that market processes remove control from politicians and regulators and limit the ability of special interests to intervene implies that these groups will prefer more direct forms of control to decentralized incentives.

A. Public Choice Theories of Instrument Choice

To develop this idea further first let us review some of the literature on the choice of instruments in environmental protection. Most public choice analysts conclude that the purpose and effect of environmental policy is to serve narrow political and economic objectives, not environmental objectives. Efficient proposal are adopted when they do not unduly interfere with the primary concerns of key interest groups. Efficient solutions to environmental problems are tolerated only when they are also a political necessity.[38]

This does not bode well for establishing market based controls. To move from a control and command system to marketable permits, for example, one must overcome several obstacles. First there are ideological problems to contend with. If citizens view property rights to pollute as a public good, then allocating these rights to private citizens will be troublesome. Second, the administrative costs of changing to marketable based systems may be high. This includes expenses of allocating initial permits, monitoring emissions, developing

[38] For example, Yandle (1983) explains that this was the case in developing offsets for air pollution control in California.

trading rules, and informing market participants. A relatively small group of participants are likely to bear the brunt of these expenses and may not be compensated for these costs.[39]

Third, moving to marketable permits will produce winners and losers. Losers will demand compensation, and winners will be difficult to identify. Ironically in some cases, those who stand to benefit most from marketable permits may oppose their implementation. This is because the value of initial allocations is made explicit when market prices for permits are established. Recipients of generous initial allocations (e.g. farmers entitled to historical water rights) fear that when the market value of their allocation becomes known, that their entitlements will be reduced.

If decentralized controls are not likely to be implemented what form of regulation is most likely to prevail? Several theories have been developed to answer this question. One school of thought due to Buchanan and Tullock (1975) focuses on the influence of existing firms within an industry to affect environmental control. They argue that existing firms will lobby against emission taxes and in favor of emission quotas (distributed to existing firms) and strict new source pollution standards. With their preferred policy, existing firms avoid the cost of the emissions tax. Owners of capital and labor inputs also earn more absent the tax according to Dewees (1983) In addition existing firms may deter new entrants with new source standards.[40] Maloney and McCormick (1982) argue more generally that input and output restrictions associated with environmental policy create rents for existing firms.

Regional concerns also influence congressmen's preferences for the type and stringency of environmental controls. Pashigian (1982) argues that recently there has been a move from

---

[39] See Crandall (1983).

[40] See Coelho (1976), Dewees (1983), and Yohe (1976) for further development of this theory.

local and state to federal legislation. This is an attempt to attenuate tensions between different parts of the country resulting from the relocation of business caused by environmental regulation. A shift to greater reliance on federal regulation is viewed by some as detrimental. This is because local regulation tends to be more efficient to prevent local firms from moving to other regions.

Some observers maintain that the form of regulation is chosen to conceal a hidden agenda of special interests. For instance Smith (1986) argues that environmentalists prefer litigious regulatory processes to publicize their movement. And advocates of more stringent environmental controls prefer technological standards to emission fees to hide the true costs of pollution control.

Of course the preferences of regulators for different types of environmental control will also be an important determinant of policy. Regulators will be reluctant to endorse market based controls. This is because favored social programs (like life line for the elderly, or subsidized energy services for the poor) require support through cross subsidization of different customers. Such cross subsidization is likely to be eliminated under market based regulation. This is reflected by the recent concern of state regulators over increasing competition in the electricity sector which threatens to drive out utility sponsored conservation (demand side management) programs.

Government policy makers may also find that decentralized market based controls are not appropriate when other goals in addition to environmental protection are pertinent. For instance Barthold (1994) explains that the idea of using pollution taxes to correct environmental externalities may get lost when issues of deficit reduction, foreign competition, job loss, and domestic competition policy arise. Several authors including Barthold (1994) and Hahn (1989a) have remarked that pollution taxes have been utilized primarily to collect revenues rather than correct externalities. Studies by Barrett (1994a) show that limiting pollution with emission fees is generally a second best policy to follow when domestic firms are concerned about foreign competition. Besanko (1987) demonstrates the possibility that direct controls may function better than taxes to reduce emissions when the polluting industry is imperfectly competitive. In each of these cases the policy maker is concerned with attaining other goals in addition to protecting the environment.

B. Political Science Theories of Regulatory Organization

Noll (1983) argues that it is the structure of political control and not the preferences of interest groups which determines regulatory policy . Interest groups vie for the favors of political overseers, who ultimately shape regulations. Thus to understand why environmental regulation has evolved in a particular way, one must understand how politicians control the regulatory process. Systems of political control vary from country to country. This explains the variety of different regulatory approaches that one observes throughout the world. In the United States political control exists in a hierarchical agency setting. Congress and the executive branch oversee the workings of regulatory bureaucracies, who in turn administer policy directly to the affected parties. We have discussed the interaction between regulators and stakeholders in section III. Much of that discussion imputes benevolent behavior to the regulators which may conflict with what we observe in reality. Nonetheless, the methods we described for limiting the information rents of privately informed regulated firms remains valid whatever the preferences of the regulator happen to be. In this section we focus on the second tier of agency control in which political operatives oversee the bureaucracies.

Two questions arise in considering how politicians oversee the regulatory process. The first question is why politicians rely on bureaucracies rather than administering policy directly? Elected officials neither have the time nor the expertise to regulate directly. They therefore must rely on bureaucrats to administer regulatory policy.[41]

But bureaucrats may act to satisfy their own ideological preferences or to promote their prospects for post agency employment, or political advancement. This raises the second question; how do politicians control bureaucratic behavior? There are conflicting views of the relationship between Congress and the agencies it oversees. One view promulgated by Niskanen (1971) and Rogerson (1990) is that of an agency who sets the agenda by confronting legislators with choices that they may vote on. For instance, only the EPA has the expertise to identify the feasible alternatives to regulating hazardous substances. Therefore they set the agenda for policy in this area by presenting Congress with a limited set of policy alternatives and a recommendation for a preferred action. Certainly this view has some legitimacy. But the ability of regulatory agencies to dictate policy seems overstated by this argument. After all, Congress does determine the budget, the composition of the staff, and the policy jurisdiction for each agency. It therefore has considerable power to shape the policy that comes out of the bureaucratic process.

A more compelling and more complete explanation of the regulatory relationship is that Congress shapes the behavior of agencies through administrative procedures, Bureaucrats are controlled by carefully structured administrative processes and compliance procedures. These processes are provided for in the rules of Congress and stipulated in the Administrative Procedures and Policy Act.[42]

The point at which Congress exercises control in the regulatory process is important. Congress may intervene, ex post, after policy is enacted. The expost provisions include

[41] See Moe (1984).

[42] See Fiorina (1977, 1981, 1982) for a fundamental development of this view.

monitoring of the agencies' policies, cuts in appropriations and disciplinary sanctions. The political overseer may monitor the agency directly. Alternatively he may rely on police patrols consisting of his constituents to insure the agency is acting in their best interests.[43]

While ex post intervention is necessary it is not the preferred mode of control by political overseers. This is because it is difficult to change the behavior of the agency after it has adopted a particular policy.[44] The preferred method of oversight is to control regulation ex ante before the agency is able to adopt a policy. As one might expect this approach excludes decentralized regulatory policies since the results of these programs are too difficult for politicians to predict and to control. Rather the ex ante control of agencies is accomplished by a variety of structural and administrative procedures which include (but are not limited) to the following.

First, of course, the Congress may intervene directly when an agency fails to act correctly. Florio (1986) details how Congress bypassed the EPA in the 1980's to directly establish the Superfund legislation. The establishment of new source performance standards in the Clean Air Act is another instance where Congress dictated policy outcomes through legislation. It's more often the case that Congress takes a less direct route to control the

---

[43] See McCubbins and Schwartz (1984).

[44] According to McCubbins, Noll, and Weingast (1989) policies are derived by the interaction of the House of Representatives, the Senate and the Executive Branch. The members of these three bodies represent different constituencies and therefore exhibit different policy preferences. Starting from a status quo policy position each of the branches would like the regulatory agency it oversees to adopt policies that are closer to the overseer's preferred position. But if each branch behaves to encourage policy drift, this generates a prisoners dilemma where the agency can play off the different branches of the government against each other. Consequently, political overseers will collectively adopt procedures to discourage policy drift.

process. For instance agency budget appropriations approved by Congress affect the ability of agencies to establish, monitor, and enforce policy. Agencies with small budgets are emasculated and must rely on interested stakeholders to present evidence and conduct analysis.

Another control method of Congress is the evidentiary standards it requires the agency to meet in support of its decisions. These standards reflect the degree of autonomy afforded the agency to depart from existing policy. Also the type and form of evidence which is admissible affects the ability of the agency to establish and enforce environmental policy. Congress may impose evidentiary standards to stack the regulatory deck in favor of a particular outcome. For instance the Toxic Substance Control Act places the burden on the EPA to demonstrate that a chemical is a risk to the environment and to human health. This makes it easier for chemical manufacturers to bring new toxins to the market. and benefits the users of toxins by reducing regulatory costs.[45]

Administrative complexity is another important tool that Congress employs to control regulatory outcomes. Making administrative procedures complex slows the regulatory process and prevents agencies from secretly pursuing policies outside the preferred policy set of the legislators. Administrative complexities also favor well organized and funded stakeholders. Large industrial and commercial concerns who can allocate resources to complying with regulatory requirements may benefit at the expense of poorly funded public interest environmental groups.

---

[45] Compare this with the treatment of new drugs under the Federal Food, Drug and Cosmetics Act. Under that Act the burden is placed on pharmaceutical companies to prove that new drugs are safe and effective. This benefits the owners of existing drugs by creating significant barriers of entry for new drugs.

And finally bureaucratic control is provided for in the Administrative Procedures and Policy Act. The act stipulates procedures for enacting policy, including requirements for presenting evidence, procedures for appeal, and the standing of individuals to participate in regulatory affairs. The due process provision which permits input by interested stakeholders in the regulatory process is an essential part of the act. These stipulations hardly provide for a decentralized method for regulating the environment.

V. Summary, Unresolved Issues and Research Directions

A. Environmental Protection with Privately Informed Polluters

I have argued that controlling emissions in a decentralized fashion using effluent charges or marketable permits may not be possible or even desirable. Section III demonstrates that when firms are privately informed about abatement costs, and there is a premium to raising public funds because of fiscal constraints that important modifications to the text book prescriptions for effluent fees and market permits are necessary. The research surveyed in this area indicates that in order to reduce the rents accruing to privately informed polluters that (i) the amount of pollution abatement may be distorted below its efficient level, (ii) nonlinear (rather than linear) emission taxes which vary across firms are implemented, (iii) consequently polluters do not equate their marginal costs of abatement, (iv) in some instances uniform taxes are optimally set equal to zero, and in other instances a polluter is penalized if he abates too much and is rewarded if he pollutes too much, (v) plausible circumstances exist where it is preferable to control the abatement technology rather than tax emissions and (vi) the marginal cost of reducing emissions may decrease when polluters are privately informed about abatement costs.

These counterintuitive findings are explained as strategies to reduce information rents which agents command because of their private knowledge. The application to environmental policy of incentive regulation to overcome information problems is relatively new. There is still much to be learned about how to customize incentive regulation to deal specifically with achieving environmental goals. Some directions for future research in this area are outlined below.

Feasibility of Implementing Nonlinear Taxation

With nonlinear pollution taxes, firms with different costs of abatement are confronted with different marginal pollution prices. The ability of the regulator to price discriminate among different polluters depends on his ability to (i) prevent arbitrage or trading between different polluters (ii) monitor pollution emitted by each firm and (iii) acquire information on the distribution of costs among different polluters. A useful avenue for future work is to assess situations where these conditions are likely to be satisfied to identify favorable opportunities for applying nonlinear emission taxes. What alterations in environmental regulation are required when one or more of the requirements say (ii) or (iii) are only partially satisfied? Of course meeting these requirement is itself a choice variable of the regulator. The regulator needs to decide how many resources to expend on monitoring abatement to improve regulatory performance. How important is it to have disaggregated information of the cost distribution of polluters? How can regulation be designed to obtain this information over time? Is it possible to obtain reasonable good results by offering just a few different emission schedules, rather than a schedule designed for each type of polluter.?

What are the consequences of restricting arbitrage or trade of pollution permits between different firms to insure they face different marginal pollution prices where appropriate?[46]

Environmental Damages and Limited Liability

Besides private information, another obstacle which impedes environmental protection is that the ability to assess polluters in case of environmental disaster is restricted by limited liability provisions in the law. This prevents polluters from fully internalizing the potential costs they cause. It is also requires society to finance part of the costs of environmental disasters with tax dollars which are costly to collect.

One approach to solve this problem recently adopted in some instances in the United States and Europe is to make input suppliers to polluting firms (including banks, etc.) liable for the damage generated by the firm. This requires input suppliers with deep pockets to bear some of the costs of environmental disasters. There are several interesting research questions to address here. Is the cost of risk bearing less for the input suppliers than for society at large? Can the supplier monitor the actions of the firms effectively to protect its risk exposure? Are these risk shifting arrangements likely to preclude input suppliers from dealing with polluting firms? If the price of inputs rises to reflect environmental risks, is this an efficient way to force the firm to internalize the potential costs of environmental disruption?[47]

Regulation and Innovation

To this point I have concentrated discussion on the static effects of environmental policy. However the regulatory effects on incentives to innovate and improve abatement

---

[46] Wilson (1993) provides an excellent discussion of practical implementation issues associated with Nonlinear Pricing.

[47] Boyer and Laffont (1994) have begun an initial analysis of some of these issues.

technologies is arguably more important over the long run. Evaluating policies to induce innovation in abatement technologies raises special issues as firms who succeed in innovation may collect monopoly rents by licensing their new technology to other firms. However, the cost of licensing for other firms impedes the rate of adoption. This raises the question of whether firms will adopt the best available abatement technologies at an efficient rate? Is there are role for government mandated technology standards to overcome this problem? Do increases in emission taxes and charges lead to the socially efficient rate of innovation as is often claimed? [48]

Alternative arrangement to private R&D and licensing arrangements also need to be evaluated. For instance, what are the relative advantages of relying on the government to develop new abatement technologies? Are government funded innovation prizes with mandatory licensing requirements a desirable alternative to current licensing arrangements? Can the government induce desired rates of innovation by requiring manufacturers to meet stricter conservation and emission standards overtime. This strategy has been adopted in the setting of CAFE standards. Can the government credibly commit to enforce these standards if manufacturers fail to meet their technology goals?

Monitoring Environmental Performance

I briefly discussed some of the ways in which pollution may be controlled when one can't readily observe emissions and monitoring is costly. Most analysis of emissions control assume that the regulator can commit to a monitoring strategy whereby he checks the firm's performance with some probability. In equilibrium the threat of monitoring induces the firm to select the desired level of abatement. But, as several researchers have remarked, there

[48] Biglaiser and Horowitz (1994) provide an analysis of some of these issues.

is no incentive for the regulator to monitor given the firm is complying.[49] How then does the regulator commit to monitoring? Or phrased another way, "Who monitors the monitor?" One approach to resolving this issue is to recognize that regulatory agencies are frequently rewarded based on their success at identifying non complying parties.[50] Therefore agencies are more likely to monitor firms if the regulations are designed so that in equilibrium firms are out of compliance some fraction of the time. Insuring that the regulator carries out his announced policy is also related to issues of how one prevents the regulator from being captured by industry interests, which we reviewed briefly in section III

Experimental Economics

Laboratory research of how different institutions and market arrangement perform has proliferated in recent years. Experimental investigations are a good way to explore the efficiency and distributional properties of alternative arrangements for controlling pollution. For instance several recent experimental studies have been used to assess the properties of the EPA auction for emission permits provided for under the Clean Air Act Amendments.[51] These investigations reveal an inability of the EPA auction to allocate permits efficiently, and predict that the auction will provide inaccurate price signals to the market. It seems likely that policy makers will rely on experimental analysis of new environmental regulations and market institutions to predict efficiency properties to an increasing extent.

---

[49] For instance see Swierzbinski (1994) in the context of pollution monitoring and Melumad and Mookherjee (1989) in the context of income tax audits.

[50] The IRS compliance division is instructed to allocate auditing resources to raise revenues from fines levied against tax payers who are out of compliance.

[51] For example see Isaac (1993), Franciosi et al. (1990), Ledyard and Szakaly-Moore (1993).

B. Positive Theories of Regulatory Choice

In contrast to section III, positive theories of regulatory choice are analyzed in section IV We concluded from reviewing the literature on public choice and political theories of administrative design that decentralized methods for pollution control are unlikely to be favored instruments. Emission fees and marketable permits are designed to minimize the costs of achieving a given level of environmental quality with a minimal amount of regulatory control and intervention. However, this is not a desirable outcome from the viewpoint of special interests or political overseers. Stakeholders in the environmental process will predictably support policies that benefit their personal interests, not minimize costs. And political overseers will not value decentralized processes which run on automatic pilot without their input or influence.

A Positive Theory of Instrument Choice

The development of a positive theory of instrument choice in environmental regulation continues to elude researchers. This is despite many noble attempts by talented researchers to develop such a theory and the obvious importance and value such a theory would have.[52] I believe that developing a comprehensive theory which accurately predicts the use of environmental instruments in the endless variety of political and economic circumstances which may arise is too ambitious of an undertaking. We may learn more instead from continuing to examine important case studies like the Magat and Krupnick (1986) investigation of EPA decision making.

Designing Administrative Procedures

From a theoretical viewpoint it is important to understand how politicians design the administrative processes to insure their most preferred environmental policy outcome is

[52] For instance see Hahn (1989a, Chpt 4 and 1989b).

achieved. This theory, developed by McCubbins, Noll, Weingast (1987, 1989) and others, views the process in terms of a Political Science Theory of Agency. Politicians design procedures for delegating environmental policy decisions to regulators and interest groups, who are better endowed and informed to investigate different policy options. While the political overseer may not know which is his most preferred policy in each case, he can design procedures to "stack the deck" to favor his preferred constituency. This is done by assigning the burden of proof and stipulating procedural requirements to favor particular interests.

With a few important exceptions most of the work in this area is still largely descriptive.[53] A formalization of the insights gleaned from this work remains to be developed. One possible approach is to model the regulatory process as a game of disclosure or persuasion.[54] In such a game respondents present evidence to the regulator (e.g. EPA) to support their request to introduce a possibly toxic chemical into the marketplace. Other stakeholders including the respondent's competitors and consumers may also disclose information to the regulator about the chemical. Relying on the information presented by the stakeholders, the regulator then decides whether or not to permit the chemical to be marketed. The regulator's decision balances the costs of making a type one error (banning a valuable product from the market) off against the cost of making a type two error (permitting a harmful substance to be consumed).

The equilibrium to this game may be analyzed to study how the political overseer tilts the outcome of the regulatory process his way. Possible instruments available to the overseer include assignment of the burden of proof, allocation of resources to the regulatory agency,

---

[53] See Austen-Smith and Wright (1992) and Gilligan and Krehbiel (1987)

[54] See Lewis and Poitevin (1994), Lippman and Seppi (1993) and Milgrom and Roberts (1986).

the ability of Congressional oversight committees to review, appeal and overturn regulatory decisions. More generally "these rules of the game" determine the costs and the payoffs to different parties from participating in the regulatory process. In effect one can choose administrative procedures to optimally select parties for participation based on their preferences and their ability to collect and disseminate information.

Affects of International Agreements on Domestic Policy

Another question which has surfaced in recent negotiation of NAFTA and the GATT is how international trade agreements affect domestic environmental policy. Some observers suggest that environmental regulation may be selected to favor a country's trading position.[55] On the other hand countries may face political pressure at home to pursue particular environmental policy, and whether the country is actually constrained or behaving opportunistically is private information.[56]

Recent international environmental agreements (IEA's) including the Montreal Protocol on substances that deplete the ozone layer also affect domestic policy on the environment. Questions arise as to how to enforce IEA's. What kinds of trade embargoes or sanctions exist to punish or prevent member from reneging on agreements.?[57] How is the balance between command and decentralized environmental controls influenced in the context of IEA's? For instance Schelling has suggested that agreements among signatory countries to develop pollution reduction technology may be easier to obtain than inducing life style changes within each country.

---

[55] See Porter (1991) and Shrybman (1990) for a cross section of different views on this.

[56] See Feenstra and Lewis (1991) for one approach to modeling this.

[57] See Barrett (1994b).

Appendix

The profit for a firm of type β who selects a regulatory option intended for type β' is given by

(a1) $\pi(\beta'|\beta) = T(\beta') - C(q(\beta'),e(\beta'),x(\beta'),\beta)$

Incentive compatibility requires that $\pi(\beta) \equiv \pi(\beta|\beta) \geq \pi(\beta'|\beta)$ for all β, β'. Differentiating (a1) with respect to β, and recognizing that firm's will choose their most preferred option from the menu, $\{T(\beta),q(\beta),e(\beta),x(\beta),\}$ (assuming $\{T(\beta),q(\beta),e(\beta),x(\beta),\}$ is differentiable) yields,

(a2) $\pi'(\beta) = -C_\beta(q(\beta),e(\beta),\beta,x(\beta)) > 0$

Further since all types must earn non negative profits, and since profits are increasing in β it follows that minimization of rents and incentive compatibility requires that $\pi(\underline{\beta}) = 0$ and

(a3) $$\pi(\beta) = \int_{\underline{\beta}}^{\beta} -C_\beta(q(\tilde{\beta}),e(\tilde{\beta}),x(\tilde{\beta}),\tilde{\beta})\, dF(\tilde{\beta})$$

The regulator maximizes the expected sum of producer and consumer surplus, assuming that consumers pay the utility directly with transfers. The expression for expected total surplus is

(a4) $$V = \int_{\underline{\beta}}^{\bar{\beta}} \{U(q(\beta),e(\beta) - \lambda T(\beta) + T(\beta) - C(q(\beta),e(\beta),\beta,x(\beta))\}dF(\beta)$$

where $\lambda > 1$ is the cost of raising public funds. Substituting for $T(\beta)$ from (a1), employing (a3), and integrating by parts, one can rewrite (a4) as

$$\text{(a4')} \quad V = \int_{\underline{\beta}}^{\bar{\beta}} \{U(q(\beta),e(\beta)) - \lambda C(q(\beta),e(\beta),\beta,x(\beta))$$

$$+ (\lambda-1)C_{\beta}\{q(\beta),e(\beta),\beta,x(\beta)\}(1-F(\beta)/f(\beta))\}dF(\beta)$$

which corresponds with the expression in [RP] in the text.

Bibliography

Austen-Smith and Wright. Social Choice and Welfare. , 1992.

Baron, D.P. "Regulation of Prices and Pollution under Incomplete Information." Journal of Public Economics, (1985a).

Baron, D.P. "Noncooperative Regulation of a Nonlocalized Externality." Rand Journal of Economics, Vol. 16 (1985b), pp. 553-568.

Barrett, S. "Strategic Environmental Policy and International Trade." forthcoming in Journal of Public Economics (1994a).

Barrett, S. "Self-Enforcing International Environmental Agreements." forthcoming in Oxford Economic Papers (1994b).

Barthold, T.A. "Issues in the Design of Environmental Excise Taxes." Journal of Economic Perspectives, Vol. 8 No. 1 (1994), pp. 133-151.

Baumol, W.J. and Oates, W.E. The Theory of Environmental Policy, 2nd ed., Cambridge MA: Cambridge University Press, 1991.

Besanko, D. "Performance Versus Design Standards in the Regulation of Pollution." Journal of Public Economics, Vol. 34 (1987), pp. 19-44.

Biglaiser, G. and Horowitz, J.K. "Pollution Regulation, Innovation Licensing, and Incentives for R&D." Working Paper, University of North Carolina at Chapel Hill, 1994.

Bovenberg, A.L. and Goulder, L.H. "Integrating Environmental and Distortionary Taxes: General Equilibrium Analysis." Conference on Market Approaches to Environmental Protection, Stanford University, 1993.

Boyer, M. and Laffont, J.-J. "Environmental Risk and Bank's Liability." mimeo, 1994.

Buchanan, J.M. and Tullock, G. "Polluters' profits and political response: Direct controls versus taxes." American Economic Review, Vol. 65 (1975), pp. 139-147.

Cairncross, F. "The Environment: A Survey." The Economist, Vol. 323, No. 7761 (1992), pp. S5-S24.

Clarke, E. "Multipart Pricing of Public Goods." Public Choice, Vol. 8 (1971), pp. 19-33.

Coelho, P. "Polluters' Profits and Political Response: Direct Control Versus Taxes: Comment." American Economic Review, Vol. 66 (1976), pp. 976-978.

Cooter, R. "The Cost of Coase." Journal of Legal Studies Vol. 11 (1982), pp. 1-34.

Crandall, R. Controlling Industrial Pollution: The Economics and Politics of Clean Air. Washington, DC: The Brookings Institute, 1983.

Crocker, T.D. "The Structuring of Atmospheric Pollution Control Systems." The Economics of Air Pollution, ed. Harold Wolozin, pp. 61-68. New York: W.W. Norton & Co., Inc., 1966.

Cropper, M.L. and Oates, W.E. "Environmental Economics: A Survey." Journal of Economic Literature, Vol 30 (1992), pp. 675-740.

Dales, J.H. Pollution Property and Prices: An Essay in Policy-Making and Economics, Toronto: University of Toronto Press, 1968.

Dasgupta, P.S., Hammond, P.J. and Maskin, E.S. "On Imperfect Information and Optimal Pollution Control." Review of Economic Studies, Vol 47 (1980), pp. 857-860.

Dewatripont, M. and Roland, G. "Economic Reform and Dynamic Political Constraints." Review of Economic Studies Vol. 59 (1992), pp. 703-730.

Dewees, D.N. "Instrument Choice in Environmental Policy." Economic Inquiry, Vol. 21 (1983), pp. 53-71.

Encinosa, W. "Common Agency with Externalities." University of Florida Working Paper, 1994.

Farrell, J. "Information and the Coase Theorem," Journal of Economic Perspectives, (1987) 113-129.

Feenstra, R. and Lewis, T.R. "Negotiated Trade Restrictions with Private Political Pressure." Quarterly Journal of Economics. (1991).

Feenstra, R., Lewis, T.R. and Ware, R. "Eliminating Price Controls: A Political Economy Perspective." Journal of Public Economics. (1989).

Fiorina, M. Congress: Keystone of the Washington Establishment. New Haven: Yale University Press, 1977.

Fiorina, M. "Congressional Control of the Bureaucracy: A Mismathc of Incentives and Capabilities." in Congress Reconsidered, L. Dodd and B. Oppenheimer, eds. 2nd edition. Washington DC: Congressional Quarterly Press, 1981.

Fiorina, M. "Legislative Choice of Regulatory Forms: Legal Process or Administrative Process?" Public Choice, Vol. 39 (1982), pp. 33-36.

Florio, J.J. "Congress as Reluctant Regulator: Hazardous Waste Policy in the 1980's." Yale Journal on Regulation, Vol. 3 (1986), pp. 351-382.

Franciosi, R., Isaac, M., Pingry, D., and Reynolds, S. "Marketable Acid Rain Emissions Permits: An Investigation of Revenue Neutral Auctions." Working Paper, University of Arizona, 1990.

Gilligan, T. and Krehbiel, K. "Collective Decision-Making and Standing Committees: An Informational Rationale for Restrictive Amendment Procedures." Journal of Law, Economics and Organization. Vol. 3 (1987), pp. 287-335.

Groves, T. "Incentives in Teams." Econometrica, Vol. 41 (1973), pp. 617-631.

Hahn, R.W. "Market Power and Transferable Property Rights." Quarterly Journal of Economics, Vol. 99 (1984), pp. 753-765.

Hahn, R.W. A Primer on Environmental Policy Design. New York: Harwood Academic Publishers, 1989a.

Hahn, R.W. "Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders." Journal of Economic Perspectives Vol. 3 (1989b), pp. 95-114.

Hahn, R.W. and McGartland, A. "The Political Economy of Instrument Choice: An Examination of the U.S. Role in Implementing the Montreal Protocol." Northwestern University Law Review, Vol. 83 (1989), pp. 592-611.

Hahn, R.W. and Noll, R.G. "Designing a Market for Tradeable Emissions Permits." in W. Magat, ed., Reform of Environmental Regulation. Cambridge MA: Ballinger, 1982.

Hahn, R.W. and Noll, R.G. "Barriers to Implementing Tradable Air Pollution Permits: Problems of Regulatory Interactions." Yale Journal on Regulation, Vol. 1 (1983), pp. 63-91.

Hahn, R.W. and Stavins, R.N. "Incentive-Based Environmental Regulation: A New Era from an Old Idea?" Ecology Law Quarterly Vol. 18 (1991), pp. 1-42.

Hahn, R.W. and Stavins, R.N. "Trading in Greenhouse Permits: A Critical Examination of Design and Implementation Issues." Global Climate Policy, eds. William Clark and Henry Lee. Cambridge, MA: Harvard University Press, 1993.

Huber, P. "The Environmental Liability Dilemma." CPCU Journal, (1987), pp. 206-216.

Isaac, R.M. "The Scope for Laboratory Experiments in Research on Marketable Pollution Permits." Center for Economic Policy Research Paper No. 383 (1993).

Kelman, S. "Economists and the Environmental Muddle." Public Interest Summer 1981, pp. 106-123.

Kelman, S. "Economic Incentives and Environmental Policy: Politics, Ideology, and Philosophy." in T.C. Schelling ed., Incentives for Environmental Protection, Cambridge: MIT Press, 1983, pp. 291-331.

Klibanoff, P. and Morduch, J. "Decentralization, Externalities, and Efficiency." Working Paper, MIT and Harvard University, 1994.

Kwerel, E. "To Tell the Truth: Imperfect Information and Optimal Pollution Control." Review of Economic Studies, Vol. 44 (1977), pp. 595-601.

Laffont, J.-J. "Regulation of Pollution with Asymmetric Information." Working Paper No. 24, Institut d'Economie Industrielle, Universite des Sciences Sociales de Toulouse, February 1993.

Laffont, J.-J. "Regulation, Moral Hazard and Insurance of Environmental Risks." Working Paper GREMAQ and IDEI, Toulouse, June 1994.

Laffont, J.J. and Tirole, J. "Using Cost Observation to Regulate Firms." Journal of Political Economy, Vol. 94 (1986), pp. 614-641.

Laffont, J.J. and Tirole, J. "The Politics of Government Decision Making: A Theory of Regulatory Capture." Quarterly Journal of Economics, (1993a).

Laffont, J.J. and Tirole, J. "Environmental Policy, Compliance and Innovation." European Economic Review. Vol. 37 (1993b).

Laffont, J.J. and Tirole, J. "Pollution Permits and Compliance Strategies." Working Paper, IDEI, Toulouse (1993c).

Laffont, J.J. and Tirole, J. "A Note on Environmental Innovation." Working Paper, IDEI, Toulouse, June 1994.

Ledyard, J. and Szakaly-Moore, K. "Designing Organizations for Trading Pollution Rights." Social Science Working Paper # 838, California Institute of Technology (1993).

Lewis, T.R. and Poitevin, M. "The Disclosure of Information in Regulatory Proceedings." Working Paper, University of Florida (1994).

Lewis, T.R. and Sappington, D. "Incentives for Conservation and Quality-Improvement by Public Utilities." American Economic Review (1992a).

Lewis, T.R. and Sappington, D. "Allocating Pollution Permits and Other Scarce Resource Rights Under Limited Information" (1992b)

Lewis, T.R. and Sappington, D. "Using Markets to Allocate Pollution Permits and Other Scarce Resource Rights Under Limited Information." forthcoming in Journal of Public Economics, (1994).

Lippman, B. and Seppi, D. "Robust Inference in Communication Games with Partial Provability." Working Paper, Queen's University and Carnegie Mellon University (1993).

Magat, W., Krupnick, A. and Harrington, W. Rules in the Making: A Statistical Analysis of Regulatory Agency Behavior. Washington DC: Resources for the Future, 1986.

Makowski, L. and Mezzetti, C. "The Possibility of Efficient Mechanisms for Trading an Indivisible Object." Journal of Economic Theory, Vol 59, No. 2 (1993), pp. 451-465.

Maloney, M.T. and McCormick, R.E. "A positive theory of environmental quality regulation." Journal of Law and Economics, Vol. 25 (1982), pp. 99-123.

Maskin, E. and Riley, J. "Input Versus Output Incentive Schemes." Journal of Public Economics. Vol. 28 No. 1 (1985), pp. 1-23.

McCubbins, M.D. and Schwartz, T. "Congressional Oversight Overlooked: Policy Patrols vs. Fire Alarms." American Journal of Political Science, Vol. 28 (1984), pp. 165-179.

McCubbins, M., Noll, R. and Weingast, B. "Administrative Procedures as Instruments of Political Control." Journal of Law, Economics, and Organization, Vol. 3 (1987), pp. 243-277.

McCubbins, M., Noll, R. and Weingast, B. "Structure and Process, Politics adn Policy: Administrative Arrangements and the Political Control of Agencies." Virginia Law Review, Vol. 75 (1989), pp. 431-482.

Melumad, N. and Mookherjee, D. "Delegation a Commitment: The Case of Income Tax Audits." Rand Journal of Economics. Vol 20 (1989), pp. 139-163.

Menell, P.S. "The Limitations of Legal Institutions for Addressing Environmental Risks." Journal of Economic Perspectives, Vol. 5(3) (1991), pp. 93-114.

Milgrom, P. and Roberts, J. "Relying on the Information of Interested Parties." Rand Journal of Economics, Vol 17 (1986), pp. 18-32.

Milgrom, P. and Roberts, J. Economics, Organization and Management. Englewood Cliffs, NJ: Prentice Hall, 1992.

Moe, T. "The New Economics of Organization." American Journal of Political Science, Vol. 28 (1984), pp. 739-777.

Myerson, R.B. "Incentive Compatibility and the Bargaining Problem." Econometrica, Vol. 47 (1979), pp. 61-73.

Myerson, R.B. and Satterthwaite, M.A. "Efficient Mechanisms for Bilateral Trading." Journal of Economic Theory, Vol. 29 (1983), pp. 265-281.

Niskanen, W.A. Bureaucracy and Representative Government . Chicago: Rand McNally, 1971.

Niskanen, W.A. "Bureaucrats and Politicians." Journal of Law and Economics, Vol. 18 (1975), pp. 617-643.

Noll, R. "The Political Foundations of Regulatory Politics." Journal of Institutional and Theoretical Economics, Vol. 139 (1983), pp. 377-404.

Oates, W.E., Portney, P.R. and McGartland, A.M. "The Net Benefits of Incentive-Based Regulation: A Case Study of Environmental Standard Setting." American Economic Review, Vol. 79(5) (1989), pp. 1233-1242.

Pashigian, B.P. "The Political Economy of the Clean Air Act: Regional Self-Interest in Environmental Legislation." Center for the Study of American Business, Formal Publication No. 51, Washington University (1982).

Peltzmann, S. "Toward a More General Theory of Regulation." Journal of Law and Economics, Vol. 19 (1976), pp. 211-240.

Porter, M. E. "America's Green Strategy." Scientific American. April (1991), p. 168.

Rogerson, B. "On the Optimality of Menus of Linear Contracts." Working Paper, Northwestern University, March 1987.

Rogerson, B. "Quality Vs Quantity in Military Procurement." American Economic Review, Vol. 80 (1990), pp. 83-92.

Ruff, L. "The Economic Common Sense of Pollution." The Public Interest, No. 19 (1970), pp. 69-85.

Shrybman, S. "International Trade and the Environment: An Environmental Assessment of the General Agreement on Tariffs and Trade." The Ecologist. Vol. 20, No. 1 (1990), pp. 30-34.

Smith, F. "Superfund: A Hazardous Waste of Taxpayer Money." Human Events, August 2, 1986, pp. 662-664, 671.

Spulber, D.F. "Optimal Environmental Regulation under Asymmetric Information." Journal of Public Economics, Vol. 35 (1988), pp. 163-181.

Stavins, R.N. "Clean Profits: Using Economic Incentives to Protect the Environment." Policy Review, Vol. 48 (1989), pp. 58-63.

Stavins, R.N. "Taxes, Tradeable Permits, and Global Climate Change." Issues in Science and Technology, 1992, forthcoming.

Stavins, R.N. "Transaction Costs and the Performance of Markets for Pollution Control." Working Paper, Harvard University, 1994.

Stigler, G. "The Economic Theory of Regulation." Bell Journal of Economics, Vol. 2 (1971), pp. 3-21.

Swierzbinski, J.E. "Guilty Until Proven Innocent -- Regulation with Costly and Limited Enforcement." forthcoming in Journal of Environmental Economics and Management (1994).

Tietenberg, T.H. Emissions Trading: An Exercise in Reforming Pollution Policy, Washington DC: Resources for the Future, 1985.

Tietenberg, T.H. Environmental and Natural Resource Economics. Harper Collins, 1992.

Tirole, J. "Collusion and the Theory of Organizations." Working Paper No. 9, Institut d'Economie Industrielle, Universite des Sciences Sociales de Toulouse, January 1992.

Wilson, R. Nonlinear Pricing. Oxford University Press, 1993.

Yandle, B. "Bootleggers and Baptists -- The Education of a Regulatory Economist." Regulation, Vol. 7 (1983), pp. 12-16.

Yohe, G. "Polluter's Profits and Political Response: Direct Control Versus Taxes: Comment." American Economic Review, Vol. 66 (1976), pp. 981-982.