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The political economy of environmental regulation: Towards a unifying framework*

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Abstract. There are several theories that attempt to explain various aspects of environmental policy. Building on insights from this theoretical work, and recent advances in our understanding of instrument performance, this paper constructs a more complete theory of environmental regulation. There are two primary contributions of this research. The first is to provide more satisfactory explanations for a number of observed patterns of environmental policy. For example, there is, as yet, no satisfactory theory about the emergence of incentive-based mechanisms, such as marketable permits and effluent fees. The second contribution of this paper is to develop a parsimonious framework for understanding many important aspects of environmental policy. This framework suggests the outputs of environmental policy emerge from a struggle between key interest groups.

1. Introduction

During the last two decades, there has been tremendous growth in the scope of environmental regulation. More chemicals are regulated than ever before. The stringency of regulation has also increased over time, particularly in densely populated areas. Despite the increase in the level of environmental regulation, the dominant approach to regulation has changed very little. In most places, a central regulatory authority sets standards. These standards vary in type, but they typically place stringent emission limits on individual sources.

In addition to standards, governments have made liberal use of subsidies to help promote environmental quality. For example, the U.S. federal government provided large subsidies, in the billions of dollars, to aid in the construction of municipal waste treatment plants. States often provide subsidies and tax incentives to aid in the control of pollution. Indeed, both standards and subsidies have enjoyed widespread use in most developed countries.

Less widespread, but growing in popularity, is the application of tools that economists find more appealing from an economic efficiency perspective. Examples include effluent fees and marketable permits. While the implementa-

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tion of these instruments tends to depart substantially from the textbook versions, the application of these tools has had a marked impact on environmental quality and the costs of achieving environmental goals (Hahn, 1987).

Given the vast array of different approaches to environmental regulation, it is only natural to ask how their selection might be explained or rationalized. The first step in searching for a deeper understanding is to identify patterns in environmental regulation. The second step is to examine underlying forces that might help explain these patterns. The purpose of this paper is to provide simple rationales for many of the patterns that are observed in environmental policy. An understanding of the basic forms that environmental regulation takes will help provide insights into the potential and conditions for regulatory reform.

Several scholars have attempted to understand different aspects of environmental policy using positive political theories. This research will review and build on the insights which have been developed. There are two primary contributions of this paper. The first is to provide more complete explanations for a number of patterns in environmental policy which have not been satisfactorily explained. For example, there is, as yet, no satisfactory theory about the emergence of incentive-based mechanisms, such as marketable permits and effluent fees. This paper develops some formal models which shed light on these issues. The second contribution of this paper is to develop a simple framework for understanding many important aspects of environmental policy. This framework views the outputs of environmental policy as emerging from a struggle between key interest groups.

Positive theories pertaining to the application of environmental regulation are critically examined in Section 2. Section 3 presents a formal analysis aimed at identifying key factors which affect policy design. A series of models are presented which provide insights into the existing standard-setting process, new regulatory approaches, and dominant patterns in environmental policy. Section 4 raises some broader issues related to the construction of a theory of instrument choice. Finally, section 5 reviews the key conclusions and suggests areas for future research.

2. Theories and explanations: A critical appraisal

Before discussing existing positive theories of environmental regulation, it is useful to identify suitable goals for a positive theory. These goals, taken in conjunction with the existing state of the art, will help to suggest a research agenda. Ideally, what would we want from a positive theory of environmental regulation? Like any positive theory, we would hope that it has predictive power. Moreover, it should be able to explain what gets regulated, the methods chosen for regulation, and the likely winners and losers from regulation. While some insights from political theory can be brought to bear on these questions, our knowledge of what will get regulated is quite limited.

In contrast to our rudimentary understanding of what is regulated, our understanding of how things are regulated, and the associated distribution of benefits and costs, is relatively advanced. Indeed, virtually all of the positive theories which have been developed are based on some notion of net benefit maximization either by a single agent or in the context of a mathematical game. Often the single agent represents an interest group. For example, Buchanan and Tullock (1975) argue that firms will prefer emission standards to emission taxes because they result in higher profits. Emission standards serve as a barrier to entry for new firms, thus raising profits of existing firms. Charges, on the other hand, do not preclude entry by new firms, and also represent an additional cost to firms. This argument is based on the view that industry is able to exert its preference for a particular instrument because it is more likely to be well-organized than consumers. Since this seminal article by Buchanan and Tullock, several authors have explored the instrument choice problem using this basic framework (Coelho, 1976; Dewees, 1983; Yohe, 1976). The basic insight of this work is that the preference for standards over taxes depends crucially on the precise nature of the instruments being compared. It also depends on the amount of power that particular interest groups have, and how this power is wielded in the political process.

The influence of different interest groups has been modeled in several ways. Perhaps the most popular (and also the most tractable) is to assume that a single agent, such as a legislator, chooses policies to maximize net benefits. The initial framework for this maximization problem was suggested by Peltzman (1976) in the context of regulation. Recently, Campos (1987) has adapted this framework to the instrument choice problem. He assumes that a legislator chooses the most preferred instrument from a distinct number of alternatives. Campos examines the motivation underlying the choice of price supports or quotas in agriculture. He shows that the answer will, in general, depend on both the demand for the commodity and the nature of the constituency support that the legislator attempts to nurture. In another application of Peltzman's approach, Magat, Krupnick and Harrington (1986) attempt to explain how different groups affect the stringency of standards at different points in the rulemaking process.

A somewhat more abstract approach is taken by Becker (1983) who assumes that groups compete for influence in an attempt to redistribute 'the pie' to their benefit. Becker (1983) has argued that governments will tend to choose mechanisms which are more efficient over those which are less efficient in redistributing revenues from less powerful to more powerful groups. One feature of existing environmental regulation is that it appears to result in high degrees of inefficiency. However, this does not necessarily refute Becker's theory since the inefficiencies may result from interest group pressures. If there is no more efficient means for redistributing revenues given interest group

preferences, then Becker may be right. One problem with Becker's theory, however, is that it may not be testable in its current form because of the difficulty in specifying the influence functions.

While some theories of instrument choice are based on direct redistribution from one group to another, there are others which build on the political decisions to delegate power, and the form of the power which is delegated. Both Fiorina (1982) and McCubbins (1985) have focused on Congress, and attempted to identify conditions under which policies will be delegated. These models are important because they accentuate the role of the legislature in determining the nature of policy. McCubbins and Page (1986) illustrate how many of these ideas can be applied to environmental policy. The authors argue that economic incentive schemes may not be selected because they tend to increase conflict and uncertainty among politicians by providing firms with greater flexibility. While this may be true, there are many instances where the government has opted to use economic incentive schemes for both social and economic policies. Moreover, the use of these approaches is becoming more widespread. Thus, some further explanation about the emergence of these schemes would be helpful.

There have been several stories and theories about the winners and losers from environmental policy. Tucker (1982) argues that the environmental movement in the U.S. primarily serves to enhance the wealth of the privileged class. Ackerman and Hassler (1981) paint a somewhat different picture. Studying the emergence of regulations which required power plants to install scrubbers, the authors argue that a coalition formed among environmentalists and Eastern coal interests. The resulting regulations were very expensive and may actually have lowered environmental quality. The case study is important because it provides evidence that environmental groups may be more concerned with symbols, such as forced scrubbing, than actual environmental outcomes. It also shows how interest groups can form coalitions which yield seemingly bizarre outcomes, yet are perfectly sensible from the viewpoint of the interest groups involved.

There is a debate in the published literature about the extent to which new regulations benefit well-organized interests. Stigler (1971) argues that producers will generally be the beneficiaries of regulation. Rolph (1983) takes issue with this finding, arguing that the existing distribution of property rights is important in shaping new policies, but not finding a systematic trend for new regulations to favor well-organized interest groups, such as producers. Certainly in the area of environmental regulation, the verdict on this issue is out. Welch (1983) and Hahn (1987) argue that the current distribution of property rights strongly affects the design of new incentive-based policies. However, the major beneficiaries of these policies seem to vary from case to case. This should not be particularly surprising since the configuration of interest group influence can also be expected to vary.

Formal tests of theories about the beneficiaries of environmental regulation are just beginning to emerge. Perhaps, the best known theory involves the use of standards to enhance industry profits. After laying out the theory, Maloney and McCormick (1982) present some empirical support based on cotton dust standards and an air pollution ruling affecting smelters. While they argue that the results are consistent with the view that industry benefits from regulations, a detailed analysis of the cotton dust case by Hughes, Magat and Williams (1986) casts doubt on their conclusions.

This review of the state of our understanding of environmental policy choice reveals that virtually all the formal models are based on theories about redistribution and power. The simplest models assume that industry has all the power, and that there is a single decision maker. More elaborate models relax these assumptions. The models help to explain some important stylized facts about the choice of standards over other instruments and the likely beneficiaries of environmental regulation. However, they provide few insights on the conditions under which incentive-based instruments will be chosen, the mechanics of the standard-setting process, and the choice of the form of environmental regulation. The next section adds to this theoretical foundation by addressing a variety of issues in environmental policy related to the selection of instruments and the choice of environmental targets.

3. Towards a more unified theory of environmental policy

Environmental policy is almost always at the source of a great deal of controversy. At the heart of this controversy lie two fundamentally opposing points of view. One, represented by 'industry', usually focuses on the impact of environmental policy on profits. A second, represented by 'environmentalists', is more concerned with the impact of policy on the environment. The reduction of the diverse range of interest group perspectives on environmental policy into two distinct viewpoints is a gross oversimplification. The simplification is made purely in the interest of developing a parsimonious and elegant theory of environmental policy. The purpose of this section is to explore how this view of the world can enlighten many of the choices and patterns that are observed in environmental policy. The first part of the section will examine the logic of the standard-setting process. This will be followed by a discussion of the emergence of alternative regulatory mechanisms which address environmental problems. More general themes in the choice of what is regulated and the level of regulation are taken up in the third part of this section.

One critical simplification that will be used to facilitate the analysis is the assumption that environmental policy is made by a single decision maker or decision making unit, typically represented by a regulator or a legislator.[1]

While this is clearly at odds with reality, it is again made in the interest of simplicity. Moreover, many of the examples presented here could be recast in the form of a mathematical game in which multiple interest groups compete. The unitary actor assumption is consistent with the models developed by Buchanan and Tullock (1975), Fiorina (1982), and Peltzman (1976). Nonetheless, it suffers from the fact that institutions are not explicity factored into the analysis. Typically, Congress is the institution which most scholars are concerned about including in the analysis (see, e.g. Fiorina, 1982; and Page and McCubbins, 1986). However, for many applications in environmental policy, various levels of bureaucracy also play an important role, and one which has not received the attention it deserves. In addition, in the United States, the courts have played a significant role in shaping environmental policy (Melnick, 1983).

3.1. Towards a theory of standard-setting

A useful starting point in addressing issues in instrument choice is to examine how the dominant instrument in environmental policy – the standard – is applied. Surprising as it may seem, there is no generally accepted theory of how regulatory standards are applied. Suppose that a regulator is charged with imposing standards on individual sources until a given environmental objective is met. The regulator must decide how standards will be applied. One way to think about this problem is that the regulator must balance economic objectives against political concerns. Suppose there are two types of standards which can be imposed, one which imposes low economic costs on individual firms, and another which imposes high economic costs. The decision in this case is relatively straightforward. Standards with the lower economic cost will be applied first.[2]

However, suppose that standards also have a political cost attached to them. This cost might result from standards affecting unemployment, plant closure, or environmental quality in the neighborhood of an important politician. Then the regulator needs to rank standards on two dimensions. Table 1 provides a two by two matrix representation of the various alternatives facing the regulator. His preference over these alternatives is reflected in the number in each box. The number '1' represents the most preferred alternative and the number '4' represents the least preferred alternative. Clearly, the regulator's first choice is to impose standards with low political and economic costs. Conversely, the least preferred alternative is represented by standards which impose both high economic and political costs. The remaining two cells in the matrix are more difficult to evaluate, and highlight the nature of the balancing problem. Here, it is assumed that political costs dominate economic concerns

Table 1. How standards are selected by a regulator

	Low economic cost	High economic cost
Low political cost	1	2
High political cost	3	4

for the regulator, and thus, a standard with low political costs and high economic costs is preferred to one with high political and low economic costs. Whether this will always be true depends on the precise nature of the regulator's utility function.

This basic paradigm captures the notion that a regulator needs to balance different concerns; however, it does not explicity introduce the concerns of interest groups. To explore difference in viewpoints among interest groups, it is instructive to consider a concrete example. One persistent theme in environmental regulation is that new sources of pollution get regulated more stringently than existing sources. A simple reason often used to explain this observation is that new sources don't 'vote', while existing sources have access to political power. A slightly different, but complementary, way of looking at this problem is offered in Table 2. Suppose a legislator has to choose between low and high standards for new and existing sources of pollution. Instead of showing the preferences of the regulator, Table 2 shows the preferences of two interest groups. Each ordered pair represents the preferences of industry and environmentalists, respectively. Industry is assumed to prefer low standards across the board, because it reduces costs.[3] Environmentalists, on the other hand, prefer high standards across the board. As in the preceding example, the interesting comparisons arise in the low/high cells. For these two cells, both environmentalists and industry exhibit the same direction of preference. Stricter standards for new sources are preferred by both groups to stricter standards for old sources. Industry adopts this preference ranking because lower costs to existing firms are more important than lower costs for new firms. Environmentalists adopt this ranking because they take a long-term outlook on environmental quality and assume that ultimately, environmental quality will be improved by having stricter standards for new firms.

The legislator is expected to balance the concerns of industry and environ-

Table 2. Choice of standards for new and existing sources

		New sources: Low standard	New sources: High standard
Existing sources: Low standard		(1,4)*	(2,2)
Existing sources: High standard		(3,3)	(4,1)

*For each ordered pair, the first coordinate represents industry preference, and the second coordinate represents environmental preference.

mentalists in a way that maximizes net benefits. The choice of a particular cell by the legislator will depend on the utility function. Assuming that both environmentalists and industry have an important effect on this function, it is reasonable to expect that the choice reduces to the low/high cells, since the low/low and high/high are the least preferred alternatives of one group. But if the choice reduces to the low/high cells, the choice is relatively simple for the legislator. The cell with a high standard for new sources and a low standard for existing sources dominates its competitor for both interest groups, and consequently will be selected.

3.2. The movement away from standards

The use of this basic framework can be formalized and used to derive testable predictions. One of the areas which has received very little attention until recently is the emergence of incentive-based mechanisms to address environmental problems. Theories on the political feasibility of these mechanisms and the likely form these mechanisms will take are just beginning to emerge. The early work of Buchanan and Tullock (1975) gave rise to a steady stream of research on explaining the choice of standards. The instrument against which standards were most frequently judged were emissions taxes in their pure form. As several scholars have noted, emissions fees are rarely implemented in ways even remotely resembling their pure form (see, e.g., Brown and Johnson, 1984). Consequently, this instrument choice comparison may not be terribly revealing.

To develop a more realistic theory of instrument choice, it is necessary to

explore how actual instruments behave in practice. The actual performance of incentive-based mechanisms varies widely. For example, the market in lead rights for controlling lead levels in gasoline has performed quite well in terms of efficiency, while the markets for controlling emissions from air pollutants have not performed that well (Hahn and Hester, 1987). Is it possible to account for such differences in performance, and if so, how?

From a theoretical point of view, it is possible to ascribe these differences to several factors. Suppose that industry and environmentalists have preferences over both the nature of instruments used and the overall level of environmental quality. Let M be a variable which characterizes the nature of instruments, and let Q represent the level of environmental quality. Environmental quality is relatively easy to measure, but the nature of instruments needs to be defined. In this case, M represents a single dimension which denotes the degree to which a system is 'market' oriented. When $M = 0$, this corresponds to the case of conventional source-specific standards. When $M = 1$, this corresponds to a 'pure' marketable permits approach. Values of M falling between 0 and 1 represent varying 'degrees' of markets. This may seem like a peculiar concept in that either markets exist or they don't. However, markets are frequently governed by very different rules of exchange, and this variable attempts to capture the extent to which trading is restricted. For example, the market for lead rights would be associated with a value of M close to 1, while the markets for controlling air pollutant emissions would be associated with a value of M much closer to 0. As M increases, the efficiency of the instrument, measured in terms of aggregate reductions in cost savings, is presumed to increase.

The preferences of industry and environmentalists are given by the functions I(M,Q) and E(M,Q), respectively. The problem facing the regulator is to maximize utility, which is assumed to be a linear combination of the preferences of environmentalists and industry.[4] Thus, the regulator will choose M and Q to

$$\underset{M,Q}{\text{Maximize}}\ a\, I(M,Q) + (1\text{-}a)\, E(M,Q). \tag{1}$$

In this problem, and in all subsequent variations of this problem, a is a weighting parameter which is assumed to vary between 0 and 1. The preferences of industry receive a high weight when a is close to 1.

The regulator's choice typically will be constrained by the requirement that the choice of M and Q be acceptable to both interest groups . Acceptability can be determined by whether the new policy is at least as good as the *status quo* for both groups. This requirement could easily be added to the formal constraint set. It is suppressed here in the interest of simplicity.

Assuming the function is differentiable, the first order conditions for an interior maximum are:

$$a\,I_1 + (1-a)E_1 = 0,$$

and

$$a\,I_2 + (1-a)E_2 = 0,$$

where the subscripts on the I and E variables denote partial derivatives with respect to the arguments of the functions. For example, I_1 denotes $\partial I/\partial M$. The first-order conditions state that a weighted sum of the marginal utilities will be 0.

Up to this point, nothing has been assumed about the precise form of the preferences of industry and environmentalists other than that they are differentiable. To understand how M and Q are affected by changes in exogenous parameters, such as a, it is necessary to specify the nature of interest group preferences. In this, and all cases which follow, both industry and environmental preferences are assumed to be 'well-behaved.' In particular preferences are assumed to be representable by strictly concave functions which are twice differentiable. This assumption is made in the interest of simplicity, and because it is plausible for the situations represented here. Strictly concave preferences for industry and environmentalists imply that the regulator's maximization problem, which is a linear combination of these preferences, is also strictly concave.

All that remains to be specified is the exact form of the utility functions. These will vary across the different cases presented here. For this particular case, industry and environmentalist preferences are characterized by the following set of partial derivatives:

$$I_1 > 0,\ I_2 < 0,\ I_{11} < 0,\ I_{22} < 0,\ I_{12} \geq 0, \text{ and}$$
$$E_1 < 0,\ E_2 > 0,\ E_{11} < 0,\ E_{22} < 0,\ E_{12} \geq 0.$$

Industry is assumed to prefer a more market-oriented alternative because it saves money.[5] However, there are decreasing returns to further movements in this direction. Industry prefers lower environmental standards, but again there are diminishing returns. Environmentalists, on the other hand, are distrustful of market alternatives and prefer the current standard-based approach. As the market orientation is lowered (M decreases), the marginal gain from a unit decrease in M is lower. Unlike industry, environmentalists prefer higher levels of environmental quality, but this is also subject to diminishing returns. These assumptions are fairly standard. A critical assumption relates to the cross-partial derivative of both of these functions. In this case, the cross-partial for industry is non-negative. This says that as the environmental quality standard increases, the marginal utility from using a market increases or remains unchanged. This results from the fact that higher levels of environmental quality

are associated with higher gains from trade.[6] For environmentalists, an increase in the environmental standards is assumed not to decrease the attractiveness of using markets. Both of these assumptions are plausible, but not universally true. Thus, it will be necessary to discuss the implications of relaxing them.

Given these assumptions, it is possible to examine how M and Q will respond to changes in industry influence. This will provide insights into the conditions under which markets are likely to emerge. The basic result is given in Proposition 1.[7]

Proposition 1: An increase in industry influence will increase the market orientation of the instrument and reduce the level of environmental quality which is selected.

The intuition behind this result is that as industry influence increases, environmentalist influence decreases. Thus, we will tend to observe more of what industry likes, and less of what environmentalists like. In this case, industry is assumed to like market-oriented alternatives and lower levels of environmental quality, since both can result in higher industry profits.

If the cross partial derivatives are positive or of unknown sign, then Proposition 1 does not hold. However, it is still possible to say something about the effects of a shift in the relative importance of environmentalist and industry preferences. This is summarized in Proposition 2.

Proposition 2: If preferences are well-behaved, an increase in industry influence will result either in a decrease in environmental quality and/or an increase in the market orientation of the instrument.

A similar theory can be used to explain the use of emission fees. Emission fees are primarily used as a means of raising revenues. These revenues are almost always earmarked for improving specific environmental problems associated with the pollutants which are subject to the fee. Only in a few applications have emission fees been shown to have a marked incentive effect.[8] The choice about the type of fees which are selected can be succinctly modeled by assuming that interest groups have well-defined preferences over the size of fees, F, and how they are used, U. Higher levels of fees are associated with higher values of F. Greater earmarking for specific environmental improvements is associated with higher values of U. This yields the following maximization problem for the regulator.

$$\underset{F,U}{\text{Maximize}}\ a\, I(F,U) + (1-a)\, E(F,U) \tag{2}$$

To understand how choices change with different weightings, the preferences need to be defined. Industry and environmentalist preferences are characterized by the following set of partial derivatives:

$I_1 < 0, I_2 > 0, I_{11} < 0, I_{22} < 0$, and
$E_1 > 0, E_2 > 0, E_{11} < 0, E_{22} < 0$.

Industry prefers lower fees to higher fees because fees represent an extra cost of doing business. Environmentalists prefer higher fees because they will reduce pollution either directly, through their impact on firm decisions to pollute, or indirectly, through their impact on expenditures aimed at reducing pollution. Both groups prefer the earmarking of fees – industry, because it increases the credit they can claim for reducing pollution, and environmentalists because they are in favor of activities which promote environmental quality. Both functions reveal diminishing marginal returns in F and U. The cross partial effects are more difficult to predict, and again are key to predicting the effect of shifts in influence on the level of fees and the degree of earmarking. The results of a shift in the relative influence of industry are summarized in Proposition 5.

Proposition 3: An increase in the relative influence of industry will result in a decrease in fees if preferences are independent. An increase in the relative influence of industry will result in a decrease in fees and no change or an increase in earmarking if the cross partials are non-negative and the marginal utility of earmarking for environmentalists does not exceed the marginal utility of earmarking for industry.

If preferences are well-behaved, an increase in industry influence will result in a decrease in fees and/or an increase in earmarking.

Part of this proposition conforms to intuition. As greater influence is given to industry preferences, fees are reduced, since industry prefers lower fees and environmentalists prefer higher fees. The situation with earmarking is less clear, since both groups prefer higher levels of earmarking. There are a variety of fees which are currently in use for activities ranging from aircraft noise to hazardous waste disposal. These fees exhibit wide variations in their effects. Even within particular categories of pollutants, fees vary widely across industries and jurisdictions. This model argues that part of this variation is attributable to the relative influence of industry and environmentalists.

It is worth noting that the structure of this model suggests that earmarking is a very stable feature of the political landscape. Economists have often criticized earmarking because it restricts the flexibility that the government has in

allocating its budget. This argument is not likely to obtain when strong interest groups are interested in claiming credit for state expenditures, especially when the state chooses to impose a special tax on specific industries that are influential.

The two models of fees and market-based activities look at different aspects of choice within these two classes of activities. This provides insights on the nature of instruments that are likely to be chosen within these classes. Frequently, however, both classes of instruments may be considered in the actual application of instruments. An example will illustrate the nature of choices that are involved.[9] The state of Wisconsin is in the process of devising a plan to help address the ozone problem in the southeast portion of the state. The state has generated a surplus of emissions rights for hydrocarbons, one of the major contributors to the formation of ozone. The problem confronting the regulators and legislators is how to allocate this surplus. After considering charging a fee which reflects the marginal cost of a permit, or trying to create a market in permits, the state has opted for a regulatory strategy based on first-come first-serve, with a nominal one-time fee attached to the use of the permits.[10] The decision to adopt this approach can be understood in terms of political costs and benefits. Politicians in this region are very interested in creating jobs, and in particular, jobs which are quite visible. At the same time they are interested in promoting regulatory systems which appear to have a low cost to industry.

The choices open to regulators and politicians are summarized in Table 3. The three basic instruments are presented in the table. The policy which was selected is denoted as first-come first-serve, since this is the most salient feature of the policy. The costs of this policy are not readily apparent to the population at large. They include the cost of generating surplus emissions reductions, and the efficiency cost associated with the fact that the mechanism does not induce firms to search for more efficient approaches to pollution abatement. While the policy does not do well when measured in terms of efficiency, it does quite well on the dimension of visible job creation. It is designed to help accommodate 'blockbuster' projects which would bring large numbers of jobs to a depressed economic region.

In contrast, marketable permits and an emissions fee which is based on the marginal cost of abatement share the opposite characteristics. The costs of these policies are quite visible in the sense that these costs fall directly on industry. Industry can readily identify these costs in terms of tax expenditures or expenditures for permits. The efficiency gains associated with these policies tend to be more diffuse. Moreover, relative to the case of first-come first-serve, job creation is not as visible. No state entity has to be consulted before using these pollution rights, and there is no explicit need to justify the use of these rights on the basis of employment impacts. To the extent that direct job creation

Table 3. Instrument choice when jobs matter

		Visible cost: Low	Visible cost: High
Visible jobs: Low			Marketable permits Emission fees
Visible jobs: High		First – come first – serve	

occurs, much of it may occur through relatively small changes in the use of inputs such as pollution and labor.

In short, these two policies are associated with highly visible costs and jobs with low visibility. This is just what politicians don't want. On the other hand, the first-come first-serve policy has the desired characteristics. It appears to be relatively low in cost and promotes the highly visible forms of job creation. The lesson to be learned from this example is that there may be strong forces working at the local level to impede the development of incentive-based alternatives. However, this is not universally true. Indeed, in cases where abatement costs and potential cost savings are relatively high, and jobs are relatively less important in the political calculus, the appearance of market-based alternatives is more likely.

3.3. Broader patterns in environmental regulation

While the preceding arguments highlight the use of various instruments in meeting environmental quality objectives, much of the struggle in the environmental area concerns the choice of an objective itself. Often, objectives are selected which are not met. For example, Congress once called for eliminating all discharges into navigable waterways by 1985. In addition, Congress has repeatedly mandated standards for air pollutants which were not met in the specified time frame. The Clean Air Act was amended in 1977 because it did not meet certain goals such as the standard for ozone. Over a decade later, this same act still needs to be amended because the target has not been met. This consistent pattern of falling short of the stated target suggests that legislators may not really intend for the target to be met in the specified time frame. It

is worthwhile exploring the possibility that a key motiviation for adopting such goals is rooted in their symbolic value.

The general importance of symbols in politics is well-known (Edelman, 1964). They provide benefits for politicians who are interested in mobilizing specific constituencies. They can also provide benefits to those constituencies as well. These general insights still leave some important unanswered questions pertaining to the use of symbols in environmental regulation. For example, what motivates the consistent pattern of behavior where targets are frequently not met in the specified time frame? Alternatively, why are laws and regulations passed which appear to be quite stringent, but the incentive to comply with these laws based on existing monitoring enforcement capabilities is quite low?

A partial answer to these questions can be found by examining the payoff to different interest groups. Environmentalists may want a high symbolic value for environmental quality for several reasons. First, it may signify a long-term commitment to a goal. Thus, standards are set either at the limits of technological feasibility or beyond the realm of what is currently feasible. Implementation then proceeds at a much slower pace, and only a small fraction of resources are allocated to monitoring and enforcement activities. Another explanation is that symbols can help influence the preference structure and values of individuals. Thus, environmentalists may want future generations to be imbued with an environmentalist ethic. Industry, on the other hand, may be opposed to symbols, in the sense that symbols can affect actual targets over the long term; higher actual targets are frequently associated with higher costs.[11]

These contrasting attitudes towards symbols can be illustrated in a simple model. Consider a two period model where industry and environmentalists can negotiate over the level of environmental quality. They have two variables over which they can negotiate – the actual level of environmental quality level, Q, and the target level, S. Suppose, for simplicity, that the symbolic target in period 1 becomes the actual level in period 2. The regulator selects values for Q and S in the first period. These values then determine the actual value for Q in the second period. The value of S in the second period is assumed to be equal to the actual level achieved in the second period. Table 4 elaborates on this possibility. Each ordered pair gives the value of Q and S respectively. Two cases are examined in the table. The point is to compare a case where actual environmental quality does not vary across periods against one in which environmental quality increases with time. In the first case, the regulator sets $Q = Q^1$ and also picks a value of $S > Q^1$. This results in a second period actual value of S. In the second case, the regulator chooses a value for $Q = Q^2$ and $S = Q^2$, so the actual environmental quality does not change in the second period. Now suppose that $S > Q^2 > Q^1$. Which option does the regulator choose? Again, this

Table 4. An example of the feedback effect between the stated target and the actual level

Period 1		Period 2
$[Q^1, S]$	→	$[S, S]$
$[Q^2, Q^2]$	→	$[Q^2, Q^2]$

depends on the underlying preferences of industry and environmentalists. However, one could easily imagine values for the parameters which result in choosing the first strategy. A relatively low actual level in period 1 would result in lower costs for industry. These costs would have to be weighed against the higher costs in period 2. The low environmental quality in period 1 might not be of major concern to environmentalists if the ultimate level which was achieved was high. This is consistent with the view that environmentalists may implicitly choose to heavily discount the present in favor of the future.

Up to this point, the focus in this section has been on explaining specific aspects of instrument choice in environmental policy. One of the important themes that arises in the implementation of virtually all environmental policies is that they are multifaceted. Indeed, almost every incentive-based system involves the use of several instruments. For example, some type of standard lies at the heart of most environmental regulatory systems, even those which feature fees and marketable permits. Moreover, a system of monitoring and enforcement is required to ensure that most systems will achieve some degree of compliance. Given the pervasive use of multiple instruments, there is a need to explain this phenomenon. Perhaps, the simplest explanation for this phenomenon is that the implementation of most environmental policies requires several steps. These steps include defining the general problem, providing specific guidelines to firms and ensuring that firms will meet these guidelines (e.g., see Bohm and Russell, 1985; Hahn and McRae, 1982). It is unreasonable to think that a single instrument is likely to be suited to the myriad of tasks involved in implementing an environmental policy. This is true regardless of whether a philosopher-king implements the environmental policy or the policy is implemented by mere mortals governed by political forces. In both cases, the use of multiple instruments will tend to be the rule rather than the exception. A simply way of thinking about multiple instruments is by adopting the conventional paradigm used in environmental economics. Imagine that there are benefits and costs associated with using different configurations of instruments. The regulator or legislator chooses a set of instruments to maximize a prescribed political objective function. This will involve trading off between the cost of using additional instruments and their marginal

benefits (e.g., see Hahn, 1986). Thus, the problem of using multiple instruments can be conveniently described in terms of the conventional maximization calculus used here.

The preceding analysis has couched the instrument choice problem in terms of a regular or legislator maximizing a political support function or balancing the competing claims of industry and environmentalists. This paradigm was helpful in three general areas. First, it added to our understanding of the standard-setting process by providing insights on how standards are likely to be implemented. Second, it was useful in identifying conditions under which incentive-based instruments will emerge, and identifying the type of incentive-based instruments that are likely to be adopted. Finally, it was useful in explaining some broader patterns in environmental regulation.

4. Modelling issues

The theory presented here has focused on some central aspects of environmental policy. It also has left out some very important parts of the problem. For example, the issue of subsidies was not explicitly addressed. The political motivation underlying subsidies is fairly well understood. Subsidies enable politicians and bureaucrats to take credit for supplying specific benefits to their constituencies. A good example from the field of environmental regulation is the huge subsidy for municipal sewage waste treatment plants (Arnold, 1979). While it is easy to understand the general use of subsidies in the political process, relatively little is known about the determination of subsidy levels and the geographic distribution of subsidies. Becker (1983) suggests a model for income transfer that sheds some light on the features of subsidies, but the model is not suited to answering questions about their observed levels. The problem of geographic distribution of political 'pork' such as subsidies is still the subject of heated debate (Ferejohn, 1974; Arnold, 1979). These unresolved questions about subsidies point out an important limitation of the modeling approach that has been adopted in this paper. It does not take advantage of many of the important *institutional* features which shape regulatory policy (Noll, 1983; Weingast, 1981). Nonetheless, it can be helpful in addressing certain parts of the subsidy issue. In the case of municipal waste treatment plants, for example, there has been a marked tendency on the part of the federal government to provide major subsidies for capital expenditures, but to require states to shoulder the operation and maintenance costs. This can be modeled in terms of the payoff to a single congressman, who gets most of his credit up front, with the initial ground breaking ceremony for the plant.

Providing a more comprehensive theory of environmental policy design will require a careful look at the institutions which shape this design. The impor-

tance of the organization of the Congress and comparable legislative institutions in other countries has been pointed out by several scholars (e.g., see Fenno, 1973; Noll, 1983). Other scholars have tended to focus on the importance of the bureaucracy and the courts (Melnick, 1983; Wilson, 1980). Relatively few studies have been done which examine how these organizations have helped shape the type of instruments discussed in this paper. Hahn and Hester (1989) have argued that forces within the bureaucracy had a major impact on the development of the 'emissions trading' policies by the Environmental Protection Agency (EPA). In the case of market-based reforms, there appears to be an important role played by both academics and 'bureaucratic entrepreneurs' who are trying to take credit for new ideas.

Liroff (1986) has chronicled some of the divergent views that exist in EPA. There is an important difference between parts of the agency dedicated to implementing programs (the 'progaram offices') and the part of the agency dedicated to evaluating policy (the 'policy office'). Program offices are interested primarily in implementing their regulatory mandate. Crudely speaking, they get evaluated on producing regulations. The policy office, on the other hand, does not have a specific regulatory mandate. Members of this office get evaluated on their attempts to produce more efficient regulation. Not surprisingly, the impetus for both major marketable permit programs has tended to come from the policy office and other parts of the government interested in promoting more efficient forms of environmental regulation (Hahn and Hester, 1987). Nonetheless, both the program office for managing air pollution and the policy office have had major impacts on actual rules regarding the trading of rights to emit air pollutants. This suggests that bureaucratic incentives can and do play an important role in affecting the emergence and design of policies.[12]

At the same time, it would be misleading to imply that bureaucracy shapes policies independently of either the Congress or key interest groups. Indeed, the bureaucracy is constantly trying to gather support for its actions from all of these groups. Analysis of actual applications of environmental instruments suggests that the bureaucracy is not necessarily best viewed as a passive agent that carried out the wishes of Congress.

The relationship between the bureaucracy and other political institutions may be critical for determining policy outcomes. Several scholars have commented on the differences in the importance and style of bureaucracies across countries (e.g., see Brickman, Jasanoff and Ilgen, 1985). While it is clear that bureaucracies differ, it is less clear how this substantively affects policy outcomes. However, bureaucracies that are seen as agents of the ruling party (when there is one), may develop quite different policies than bureaucracies that have to balance the interests of an executive and legislative branch dominated by different parties. The reason is that politicians will face different

payoffs in the two cases. In the case where legislators and the executive are dominated by different parties, legislators may try to use the bureaucracy in ways that make the executive look bad.

There is another very important sense in which the bureaucracy matters in considering problems in instrument choice. The preceding formal analysis was built on the assumption that certain tradeoffs could be made among different dimensions of policy. Trading, and the nature of trading, is likely to be constrained by the design of political institutions. This includes the design of legislative institutions, the courts and bureaucracies. In the case of EPA, for example, issues in monitoring and enforcement are carried out largely independently of standard-setting. This means that there is little opportunity to effect trades on these issues at the bureaucratic level. Thus, the principal opportunity for 'trading' in this area would be at the legislative level. This example illustrates that a careful analysis of organizational design can provide insights into the potential for bargaining as well as the likely arena in which bargaining will take place.

Another important issue related to the study of bureaucracies is that of delegation. There has been a great deal of study of legislative delegation of authority (Aranson, Gellhorn and Robinson, 1982; Fiorina, 1982). However, it is important to recognize that bureaucracies have choices in what they delegate to other bureaucracies. For example, EPA's recent revision of its trading policies made it easier for state environmental agencies to develop programs with less federal oversight. Moreover, there is evidence that decreased levels of oversight are associated with increases in the efficiency of emissions trading (Hahn and Hester, 1989). It would be useful to have a theory of why bureaucracies delegate in some instances and not others, and the expected effects of delegation in terms of efficiency and equity. Such a theory could be built on existing legislative theories of delegation (e.g., see McCubbins, 1985).

The preceding discussion reveals that instrument choice, like many other political decisions, is driven by a wide array of interest groups both in and outside of government. Yet the formal modeling approach used here focuses on a single, or representative, decision maker. This is obviously a gross oversimplification. Nonetheless, it is useful for helping to understand some of the broad outlines of environmental policy. Moreover, more realistic attempts to include the interrelationships among key groups influencing instrument choice decisions quickly leads to an analytical quagmire. In the past, scholars have attempted to deal with this problem by modeling salient aspects of the institutional process that are analytically tractable, such as the committee structure in Congress. The institutionalist approach is quite useful when the institution being modeled is the driving force behind the problem. However, it can also be quite misleading if the institution represents only one of many key actors in the decision making process. For example, in many of the cases examined here, the

bureaucracy was seen as the prime mover or a major participant in many of the key decisions. Thus, detailed modelling of institutions other than the bureaucracy may lead to only marginal gains in understanding these decisions. The point is not the institutional analysis is not needed, but rather that great care should be exercised in choosing the appropriate institutional focus.

This entire paper has been devoted to constructing a more complete theory of instrument choice. This theory has been built using two important assumptions: First, that different policy instruments can be distinguished on the basis of their distributive implications; and, second, that the set of available instruments can be specified. Given the nature of the theory, it cannot be expected to distinguish between instruments that have similar distributive consequences. This observation points to an important limitation of existing theories of instrument choice. To the extent that instrument choice is motivated by reasons which do not have distributional consequences, the theory does not contribute to our understanding. However, there is a deeper problem with theories of instrument choice that relates to the second building block on which the theory rests. The assumption that the feasible space of instruments can be specified is problematic. Certainly, instruments that are being used can be identified. Sometimes, it is also possible to identify instruments that were considered at some point in the decision process, but were not selected. However, defining the entire feasible space of instruments is virtually impossible. At best, we can hope to get a reasonable grasp of political constraints that limit on the choice of instruments.

This raises the question of how to judge a theory of instrument choice, and one on which surprisingly little has been written. Certainly, one would like a theory that predicts what instruments are likely to be chosen under different conditions. It would also be useful to know what instruments are not likely to be chosen. The real art in developing a theory of instrument choice enters in defining the choice set. Until recently, the choice set has been defined more by theory than by empirical realities. Thus, for example, Buchanan and Tullock (1975) choose to 'explain' the choice of standards by choosing what, upon closer inspection, appears to be an unlikely alternative. At a minimum, a theory of instrument choice should try to explain important characteristics of instruments that exist in the real world. To the extent possible, it should place instruments in the feasible space that are 'reasonable' competitors to existing instruments.

Related to the issue of defining the feasible set is the vexing problem of defining precisely what is meant by an instrument. For practical reasons, it would be useful to define instruments that are measurable, and which are likely to have systematic effects on policy outputs. From a theoretical standpoint, instruments can only be distinguished on the basis of their distributional properties. Consequently, in theory, it is often possible to design standard and tax

systems that are indistinguishable. 'Different' instruments may have similar political payoffs, and therefore may not be different in terms of their theoretical properties. The point is that words like 'standard' and 'tax' have meaning in terms of the theory only to the extent that they imply a particular distributional outcome. While it is useful to retain the general terminology, I also believe it is important to be very clear about the precise nature of the comparisons. For example, Buchanan and Tullock (1975) do not show why industry has a marked preference for standards over taxes. They show why industry has a marked preference for a very specific standard over a very specific tax.

In addition to being careful about instrument definition within a particular class, such as standards or taxes, problems can arise in making distinctions among classes. For example, to what extent should instruments such as standards and taxes be distinguished from monitoring and enforcement mechanisms? Ideally, it would be nice to merge many of these classes to do more global comparisons of instruments. Unfortunately, in many cases, the problems become analytically intractable. Thus, it is necessary to break the problem of instrument choice into manageable cases. The advantage of doing this is that it enables us to clearly understand the political and economic forces acting on one particular part of the problem. The disadvantage is that the separation may be artificial. Monitoring and enforcement mechanisms are inextricably linked to the choice of using pricing and quantity approaches for regulating pollution. In constructing theories of instrument choice, it is important to be cognizant of how these linkages can affect the validity of the theory.

5. Conclusions and areas for future research

This paper has illustrated that some relatively simple models of instrument choice can help explain important elements of environmental regulation. While developed primarily to explain themes in environmental policy, many of the theories have broader applicability. For example, the theories of standard-setting are relevant to the general field of regulation. The basic framework using competing interest groups was helpful in explaining the process of standard-setting, the emergence of new regulatory approaches, and some broad patterns in environmental regulation.

The theory of instrument choice is still in its infancy. There are many ways in which it could be extended. Earlier, the issue of why bureaucracies choose to delegate certain types of tasks was suggested as an area for study. A more general question that has intrigued economists relates to the relative efficiency of policy choices made by political institutions. At present, there is widespread agreement that there is no reason to presume that government policies will be efficient (Becker, 1983; Shepsle and Weingast, 1984). However, very little is

known about the degree to which government policies are likely to deviate from an efficient solution (assuming such solutions can be defined) in specific instances.

This paper has suggested one vehicle through which efficiency can enter into the choice of incentive-based instruments. However, this is an area that needs a great deal more elaboration. One important factor affecting the efficiency of various regulatory approaches is the ability to monitor and enforce sidepayments. For example, in the case of health and safety, it may not be possible to induce labor unions to agree to broader regulation which is less stringent because there is no way of effecting the necessary payoffs. In the case of environmental problems, there may be no way to get industry to agree to a broader scope for toxic substance policy because they have no assurances that the resulting regulations will not be draconian. Political constraints on law makers will impose substantial barriers towards moving to more efficient short-run policies. For those scholars interested in fashioning more efficient policies, the challenge still remains to identify conditions under which such policies are likely to emerge. The models on this subject to date are very general and also lead to highly ambiguous results. Perhaps, it is necessary to trade off some generality for a better understanding of the performance of specific policies. Hopefully, this paper represents a first step towards this end.

Notes

1. The motivations of regulators are rarely the same as elected officials. Nonetheless, elected officials can exert a great deal of control over regulators through a variety of oversight mechanisms, such as budget allocations and hearings. In the subsequent analysis, the objectives of the two groups are assumed to be identical.
2. In the interest of simplicity, the distribution of economic costs across firms is ignored. One view of environmental regulation that has achieved some popularity in the economics literature is that firms use this regulation to increase industry profits or raise rival's costs. There is no question that some firms and industries will try to use the regulatory process in a strategic manner (Maloney and McCormack, 1982; Owen and Braeutigam, 1978). For example, recently the automobile companies and oil companies have been engaged in an argument over who should be required to install control equipment related to reducing automobile emissions. In the interest of brevity, I have chosen not to explore these strategic issues in detail. However, they are certainly important, and they do help to explain some differences between old and new source regulation.
3. To the extent that new source standards serve as a barrier to entry, industry might value this option more highly. However, this switching of industry preferences does not change the basic analysis.
4. In the formal analysis which follows, the word 'regulator' will be used. However, it should be understood that the regulator could be a politician or a bureaucrat at any level of government.
5. This is clearly an oversimplification. It assumes that the degree of market orientation is a good proxy for cost savings, and does not address distributional issues. For example, the distribution

of savings across firms could be important for strategic reasons, and could have a tremendous impact on how individual firms feel about a proposed change. Moreover, it is reasonable to assume that industry will prefer systems that are more familiar, even if their expected cost is higher.

6. This assumption is consistent with most simulation studies I have seen over the region of interest (e.g., see Hahn and Noll, 1982). Note, however, that as the overall level of emissions approaches 0, then industry will probably feel differently. To see this consider the extreme case where the emission limits are 0. Then all firms have the same emission standard, and a market adds no flexibility in this case.
7. All proofs are provided in the appendix.
8. See Hahn (1987) for a review of the literature on fees and an assessment of their effects.
9. This section draws heavily on analysis contained in Hahn (1988).
10. Interestingly, first-come first-serve is used quite frequently in the initial allocation of many types of property rights. For example, businesses locating in relatively clean areas are typically allowed to locate there without purchasing emission rights until the surplus in emission rights is exhausted. These businesses do have to comply with existing state and federal standards.
11. A third possibility not captured here is that the symbol itself may have intrinsic value, separate from its effects on preferences or physical outputs. This possibility is not considered explicitly in the formal analysis though it could easily be incorporated.
12. It is also quite possible that the training of the individuals charged with developing policies can affect their form. Indeed, some scholars have argued that the general use of command and control approaches as opposed to incentive-based approaches can be explained, in part, by the fact that lawyers, and not economists, typically exert greater control over policy outputs. Lawyers see command and control as a concrete way of addressing environmental issues (Kneese and Schultze, 1975). I think this argument has merit. Professional training clearly affects the way we approach problem solving. Within the context of the models considered here, this would suggest that the utility function of the hypothetical decision maker depends on his or her profession.

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Appendix

This appendix contains formal proofs of the three propositions.

Proof of Proposition 1: An increase in industry influence is represented by an increase in a. It suffices to show that $\partial M/\partial a > 0$ and $\partial Q/\partial a < 0$. Total differentiation of the first order conditions resulting from (1) yields:

$$\begin{bmatrix} aI_{11} + (1-a)E_{11} & aI_{12} + (1-a)E_{12} \\ aI_{12} + (1-a)E_{12} & aI_{22} + (1-a)E_{22} \end{bmatrix} \begin{bmatrix} \mathrm{dM} \\ \mathrm{d}Q \end{bmatrix} = \begin{bmatrix} (E_1 - I_1)\mathrm{d}a \\ (E_2 - I_2)\mathrm{d}a \end{bmatrix}$$

This problem can be solved by inverting the matrix. The assumptions on the preferences of environmentalists and industry insure that the matrix of second-order derivatives is negative definite. Inversion yields the following sign pattern:

$$\begin{bmatrix} \mathrm{dM} \\ \mathrm{dQ} \end{bmatrix} = \begin{bmatrix} - & +/0 \\ +/0 & - \end{bmatrix} \begin{bmatrix} -\mathrm{d}a \\ +\mathrm{d}a \end{bmatrix}$$

This sign pattern implies $\partial M/\partial a > 0$ and $\partial Q/\partial a < 0$.

Proof of Proposition 2: The proof relies on the fact that the function being maximized is negative definite. Note that the effect of a change in a on industry utility is given by the expression:

$$\frac{\partial I}{\partial a} = \mathrm{I}_1 \frac{\partial M}{\partial a} + \mathrm{I}_2 \frac{\partial Q}{\partial a}$$

Since $\mathrm{I}_1 > 0$ and $\mathrm{I}_2 < 0$, it suffices to show that $\partial I/\partial a > 0$.

Define 'det A' to be the determinant of the matrix of second order partials. Solving explicity for the effects of a change in a yields:

$$\frac{\partial M}{\partial a} = (1/\det \mathrm{A})\,[(a\mathrm{I}_{22} + (1-a)\mathrm{E}_{22})\,(\mathrm{E}_1 - \mathrm{I}_1) - (a\mathrm{I}_{12} + (1-a)\mathrm{E}_{12})(\mathrm{E}_2 - \mathrm{I}_2)], \text{ and}$$

$$\frac{\partial Q}{\partial a} = (1/\det \mathrm{A})\,[(a\mathrm{I}_{12} + (1-a)\mathrm{E}_{12})(\mathrm{E}_1 - \mathrm{I}_1) + (a\mathrm{I}_{11} + (1-a)\mathrm{E}_{11}(\mathrm{E}_2 - \mathrm{I}_2)]$$

Multiplying $\partial M/\partial a$ by I_1 and $\partial Q/\partial a$ by I_2, and adding gives the following expression for $\partial I/\partial a$:

$$(a/\det \mathrm{A})\,\{\mathrm{I}_2(\mathrm{E}_2 - \mathrm{I}_2)\,\mathrm{I}_{11} - [(\mathrm{E}_1 - \mathrm{I}_1)\mathrm{I}_2 + (\mathrm{E}_2 - \mathrm{I}_2)\mathrm{I}_1]\,\mathrm{I}_{12} + .\mathrm{I}_1(\mathrm{E}_1 - \mathrm{I}_1)\,\mathrm{I}_{22}\}. \qquad (3)$$

Since I is strictly concave and twice differentiable, the quadratic form associated with the Hessian of I is negative definite. This implies that the associated quadratic form is negative. Through suitable manipulation, (3) can be related to a quadratic form. The first order conditions associated with (1) imply:

$$\mathrm{E}_j = [a/(a-1)]\,\mathrm{I}_j \text{ for } j = 1,2.$$

Substitution into (3) yields:

$$[a/((a-1)\det \mathrm{A})]\,\{\mathrm{I}_2^2\,\mathrm{I}_{11} + 2\mathrm{I}_1\mathrm{I}_2\,\mathrm{I}_{12} + \mathrm{I}_1^2\,\mathrm{I}_{22}\}$$

after factoring $(1/(a-1))$. The first expression, $[a/((a-1)\det \mathrm{A})]$, is less than 0 since $a \in (0,1)$ and

det A > 0. The second expression is a quadratic form. To see this define the vector $(h_1,h_2) = (I_2, -I_1)$. Then the bracketed expression takes the form $h_1^2 I_{11} + 2h_1h_2 I_{12} + h_2^2 I_{22}$. Since $(h_1,h_2) \neq 0$, and the quadratic form is negative definite, this implies that the expression in brackets is less than 0. Multiplying the two negative expressions together yields the result that $\partial I/\partial a > 0$.

Proof of Proposition 3: The first part of the proposition can be derived by totally differentiating the first order conditions. The results, not shown here, are the same as for Proposition 1, except that M and Q are replaced by F and U. Assuming the cross partials for industry and environmentalists are 0 yields the following sign pattern:

$$\begin{bmatrix} dF \\ dU \end{bmatrix} = \begin{bmatrix} - & 0 \\ 0 & - \end{bmatrix} \begin{bmatrix} + & da \\ ? & da \end{bmatrix}$$

This implies $\partial F/\partial a < 0$.

Assuming that the cross partials are non-negative and the marginal utility of earmarking for environmentalists does not exceed the marginal utility of earmarking for industry yields:

$$\begin{bmatrix} dF \\ dU \end{bmatrix} = \begin{bmatrix} - & +/0 \\ +/0 & - \end{bmatrix} \begin{bmatrix} + & da \\ -/0 & da \end{bmatrix}$$

This sign pattern implies $\partial F/\partial a < 0$ and $\partial U/\partial a \geq 0$.

The proof used to show that an increase in industry influence will result either in a decrease in fees and/or an increase in earmarking is precisely analogous to the proof used for Proposition 2 and will not be repeated here.