Staff Paper

POLITICAL ECONOMY AND POLLUTION REGULATION: INSTRUMENT CHOICE IN A LOBBYING ECONOMY

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Introduction

In this paper we use a political-economy model of environmental regulation to study alternative regulatory instruments. Agents with opposing interests in policy choices engage in "rent-seeking" and "lobbying" type activities. The behavior of the regulatory agency is endogenously determined as the result of a non-cooperative game between interest groups vying to influence policy in their favor.[1]

This "political economy" approach contrasts with much of traditional environmental economics, in which the behavior of governments is posited to involve interventions to rectifying market failures so as to attain Pareto efficiency. It is apparent, however, that real political-economic systems do not operate in this fashion. To provide a more complete basis for designing environmental policies, rent-seeking behavior should be considered.

Economic "lobbying" and "rent seeking" models arose from research on regulation and on trade policies. The pioneering effort of Stigler (1972) explained government regulation as the result of industries "purchasing" favorable regulations via campaign contributions. Similar ideas were applied to trade policies by Tullock (1967), who recognized that individuals spend resources to garner the rents created by distorting tariffs.

The existence of rent-seeking activity has important welfare implications. Government policy creates rents and activity to create and capture these rents is socially costly. Tullock (1967) noted that resources devoted to applying political pressure to obtain favorable policy outcomes should be added to the welfare costs of the interventions themselves.[2]

We contrast environmental regulation via price controls (emission taxes) and quantity controls (emission standards), with and without rent-seeking, in general equilibirum. Because the model is quite complex, analytical results are not forthcoming. We provide computed equilibria for an example economy. Hence, our paper is more illustrative than definitive. But our example does demonstrate that price and quantity instruments provide different incentives for lobbying. [3]

Since our model incorporates an externality, the government interventions we study have both positive and negative impacts. Here, welfare comparisons are made between market allocations that are inefficient (and perhaps also viewed as unfair), and allocations that arise with government activity to improve efficiency (and equity), but subject to rent seeking. It is unclear *a priori* which allocation is preferred. Thus, society is faced with a trade-off between the need to redress market failures and the fact that the means by which to do so inevitably admit manipulation of the rent-seeking sort.

A Model of Rent Seeking and Environmental Policy

Ours is a general equilibrium model of a closed economy. All agents in the economy have identical preferences over both market goods and environmental quality. Agents differ in their policy objectives because they differ in their sources of income: one set of individuals is endowed only with labor, while the other set is endowed with both labor and shares in the profits of firms. The instruments we study differentially alter profits, and hence incomes, thereby differentially affecting the two groups.

The government in our model is assumed to set pollution regulations as if it maximizes its own objectives, represented by a weighted sum of the utilities of the agents. Agents "lobby" in order to alter the weights in the government's objective function, and thereby to alter the regulatory choices made. We use the "pressure function" introduced by Becker to provide a stylized representation of the institutions through which political influence is exerted. Pressure is generated by expenditures of resources and in response to this pressure the government changes the relative weights placed on consumers in its objective function. We do not describe how lobbying determines the weights in detail, but merely treat the process as a "black box."[4]

All agents are endowed with an equal amount of labor, measured in time. In what follows, time will also be money, since we choose the wage rate as the numeraire. Some agents additionally receive a share of firm profits. Agents owning only labor we call laborers; those owning labor and profit shares we call capitalists. Agents are indexed by $i = c$ (for consumer/laborers) and $i = f$ (for consumer/firm-owners). There are n_c identical laborers and n_f identical capitalists; each of the latter receives $1/n_f$ of the aggregate profits of firms.

There are two goods in the economy. One, denoted by x, generates pollution when produced; the other, denoted by y, is pollution-free. There are n_x identical firms producing x and n_y firms producing y. The only explicit input in this model, labor, is indexed by L_x and L_y when used to produce x and y respectively. There is, in the background, a fixed input in the x industry which generates decreasing returns to labor. The profits claimed by the capitalists are rents to this fixed factor. We keep this fixed input implicit, and do not include it in the notation. The firms solve standard profit maximization problems. Competitive conditions are assumed for both the input and output markets.

The production of y is not regulated since there is no market failure problem. Therefore, a representative firm in the y industry simply maximizes its profits subject to the production function $y = g(L_y)$. A representative firm in y industry solves:

$$\max_{L_y} p_y\, g(L_y) - w\, L_y \tag{1}$$

where p_y is the market price of good y and w is the wage rate. We let $\pi_y(p_y, w)$ denote the firm's indirect profit function.

A representative firm in the polluting x industry chooses an input level to maximize profits subject to the production function $x = f(L_x)$ and an emission function $e = h(L_x)$, given environmental regulation policies. Firms in this industry face one of two kinds of pollution regulation: price regulation or quantity regulation. Under price regulation a tax τ is imposed on emissions. Under quantity regulation an emission standard $h(L_x) \leq \bar{e}$ must be met.[5] The firm is assumed to take the regulations as given.

Under price regulation, the representative firm in the x industry solves:

$$\max_{L_x} p_x\, f(L_x) - w\, L_x - \tau\, h(L_x) \tag{2}$$

where p_x is the market price of good x and τ is the effluent charge. Let $\pi_x(p_x, w, \tau)$ be the firm's indirect profit function under price regulation. Under quantity regulation, the firm solves:

$$\begin{gathered} \max_{L_x} p_x\, f(L_x) - w\, L_x \\ s.t. \quad e = h(L_x) \leq \bar{e} \end{gathered} \tag{3}$$

where $\bar{e}$ is the emission standard. Let $\pi_x(p_x, w, \bar{e})$ be the profit function under quantity regulation.

We assume that government sets regulations as if it maximizes a weighted sum of the indirect utility functions of the agents in the economy (the indirect utilities are derived below). The weights in the government's objective function are l^i for $i = c, f$. Letting V^i be the indirect utility function for agents of type i, regulations are set as if they solve

$$\max_{\tau \text{ or } \bar{e}} n_c I^c(\ell^c, \ell^f)V^c + n_f I^f(\ell^c, \ell^f)V^f \tag{4}$$

The values I^i, $i = c, f$, are weights that define the government's preference ordering.[6] These weights are influence functions whose arguments are determined by political pressure resulting from lobbying. Let ℓ^i be effort devoted to lobbying by agents of type i, $i=c,f$. Following Becker (1983), let ψ^i be a political pressure function for type-i agents, which is a function mapping lobbying into political influence. Then the weights in the government's objective function are given by $I^i = I^i(\psi^c(\ell^c,\ell^f),\psi^f(\ell^c,\ell^f)) = I^i(\ell^c,\ell^f)$.

Once agents have chosen ℓ^i, the weights in the government's objective function are determined by the political pressure generated by lobbying. The resulting policy choice is a pollution tax function $\tau(\ell^c,\ell^f)$ or emission standard function $\bar{e}(\ell^c,\ell^f)$. Given these choices and maximizing behavior by firms, profits $\pi_x(.)$ and $\pi_y(.)$, and total emissions $E(\ell^c,\ell^f)$ are determined.

Consumers choose both consumption of the two goods and lobbying effort. Lobbying takes time away from working. Since there is no leisure in the model, a choice of lobbying also determines labor supply. Consumers act competitively in the purchase of goods and the supply of labor, taking p_x, p_y, and w as given. Income is equal to labor income, plus a share of firm profits (if the consumer is a capitalist), plus any tax revenues from pollution taxes (if a price instrument is used by the government). Thus, if L is the labor endowment, income for a type-i consumer, m^i, is

$$m^i = w\,(L - \ell^i) + J^i[\tau(\ell^c,\ell^f)\,E\,(\ell^c,\ell^f)\,(n_c + n_f)] + K^i\,(n_x\,\pi_x + n_y\,\pi_y)/n_f \tag{5}$$

Here, J^i is a characteristic function which equals one if the government uses price regulation and equals zero if it uses quantity regulation, and K^i is a characteristic function which equals one if $i = f$ and equals zero if $i = c$. The term $\tau\ E\ /(n_c + n_f)$ is each consumer's tax revenue rebate under the price instrument.

Letting x^i and y^i be consumption of the two goods, we assume that type-i consumers act as if they solve

$$\max_{(x^i,y^i,\ell^i)} U(x^i, y^i, E(\ell^i,\ell^{-i}))$$
$$s.t.\ p_x x + p_y y \leq m^i,$$

where ℓ^{-i} is lobbying by agents of the other type.

Here, n_x, n_y, n_c, n_f, p_x, p_y L, and w are exogenous parameters.[7] We also suppose that each type of agent takes the lobbying of the others, ℓ^{-i}, as given. Hence, we suppose that the agents hold Nash conjectures about lobbying, and play a one-shot, non-cooperative game in their lobbying choices. The function from lobbying levels to policy choices ($\tau(.)$ or $\bar{e}(.)$) and the resulting emission level $E(.)$ also are taken as given by the consumers, and these functions are assumed to be common knowledge once they are announced by the government. We let $V^i(p_x,p_y,w,m^i(.),E(.)\ ;\ell^{-i})$ be i's indirect utility function.

Regulations and Equilibrium

We assume that the government announces a per-unit effluent charge function $\tau(\ell^c, \ell^f)$ if imposing price regulation or an emission standard function $\bar{e}(\ell^c, \ell^f)$ if using quantity regulation. After the government announcements, agents take the policy function as given and each chooses a non-negative level of lobbying contribution with which to influence the effluent charge or emission standard.[8] The government then imposes environmental policies. The policy functions maximize the government's preferences, with the arguments of its objective function (indirect utilities) determined in decentralized equilibrium via market clearing. Once the policy function is announced the government does nothing further to influence agents' choices, other than implement the promised policy.

By solving the firms' maximization problems the supply functions for goods x and y are known to the government, as are demands for labor. Consumers determine demands for goods x and y. The supply of labor is $n_c\,(L^c - \ell^c) + n_f\,(L^f - \ell^f)$, the aggregate time endowment minus time spent lobbying. The prices for labor, good x, and good y are then determined by the market clearing conditions that demands must equal supplies in each market.

By Walras law, we may normalize one price to be unity; we take labor to be the numeraire. Therefore, the time consumers spend on lobbying is also the monetary expense of lobbying. Lobbying generally diverts scarce resources from "directly" productive activity (production) into "directly unproductive" activity. However, in our model, lobbying alters policies to redress a market failure, and therefore lobbying potentially is beneficial. Lobbying regarding pollution regulation might be considered "indirectly productive."

Coggins, Graham-Tomasi, and Roe (1991) provided conditions under which a lobbying equilibrium can be shown to exist in an exchange economy where government policies determine relative prices. Their conditions could be applied to this model with some modification to incorporate production. Among others, the conditions imposed are that (1) the influence function, I, defined as I^c/I^f, is continuous, positive, concave, and increasing (resp. convex and decreasing) in ℓ^c (resp. ℓ^f), (2) the production functions, f and g, are concave, (3) the emission function, h, is convex, and (4) the utility functions, are strictly quasi-concave with respect to their arguments. Coggins et al. also impose a condition called "own good bias" in which agents always consume more of the good with which they are endowed. Such a condition here would have capitalists consuming more of x than y. To rule out corner solutions, we assume that the utility functions and technology always permit an interior maximum.

Price Regulation

While the entire equilibrium is determined simultaneously, for expository reasons we initially treat the consumers' lobbying levels ℓ^i, $i = c, f,$ as parameters. Using the conditional (on lobbying) indirect utility functions, the government's effluent charge rule can be characterized by the following first order condition:

$$\begin{aligned} \sum_{i=c,f} n_i I^i (dV^i/d\tau) = \sum_{i=c,f} n_i I^i & ((\partial V^i/\partial p_x)(\partial p_x/\partial \tau) \\ & + (\partial V^i/\partial p_y)(\partial p_y/\partial \tau) \\ & + (\partial V^i/\partial m^i)(\partial m^i/\partial \tau) \\ & + (\partial V^i/\partial E)(\partial E/\partial \tau)) = 0 \end{aligned} \tag{7}$$

An increase in the effluent charge may have positive and negative effects on a consumer. The increase in τ will lower the production in x and this, in turn, will bid up the price of x, which has a negative effect on indirect utility. The increase in τ will also bid up the price of y, since y and x must be substitutes in a two-good model. Therefore, the price effect of a tax increase is negative. The effect of a tax increase on laborers' disposable income depends on the magnitudes of the tax increase and the emission decrease, as these determine the consumers' tax rebate. Through the reduction in emissions, an increase in τ will increase consumers' utility. The conflict between laborers and capitalists arises from the income term, since capitalists receive a share of profits of firms. From (7), a solution to the government's tax problem exists only if $dV^c/d\tau$ and $dV^f/d\tau$ are of opposite signs; we assume that this is the case.[9]

A Nash equilibrium for the lobbying economy under price regulation is a set of outcomes $((x^{*i}, y^{*i}, \ell^{*i})^{i=c,f}, x^*, y^*, L_x^*, L_y^*, e^*, p_x^*, p_y^*, w^*, \tau^*)$ such that: i) producers solve their profit-maximization problems taking prices and regulations as given, ii) consumers solve their maximization problem taking prices, the lobbying levels of other consumers, and the government policy function mapping lobbying into emissions taxes as given, iii) the government chooses the emission tax function to maximize its preferences, taking the lobby levels of consumers as given, and iv) goods and labor markets clear. The following conditions characterize an equilibrium (assuming second order sufficient conditions hold as well).

First, we have the profit maximization conditions

$$p_x^* f'(L_x^*) - w^* - \tau^* h'(L_x^*) = 0; \quad \textbf{(8)}$$

$$p_y^* g'(L_y^*) - w^* = 0; \quad \textbf{(9)}$$

Next, regarding consumers' choices we have

$$(\partial U^i/\partial_x^i)/(\partial U^i/\partial_y^i) = p_x^*/p_y^* \quad \textbf{(10)}$$

$$p_x^* x^{i*} + p_y^* y^{i*} = w^* (L^i - \ell^i) + n_x \tau^* e^* / (n_c + n_f) + K^i (n_x \pi_x^* + n_y \pi_y^*) / n_f \quad \textbf{(11)}$$

$$(dV^i / d\tau)(\partial \tau^* / \partial I)(\partial I / \partial \ell^i) = w^*. \quad \textbf{(12)}$$

Here, $\pi_j^* = p_j^* j - w^* L_j^* - H_j \tau^* h(L_x^*)$ *for* $j = x, y,$, with

$$H_j = \begin{cases} 0, \text{ if } j = y \\ 1, \text{ if } j = x. \end{cases}$$

The government chooses optimal taxation, so that τ^* solves (7). Finally, all markets must clear, so that

$$\sum_{i=c,f} n_i x^{i*} = n_x x^*, \quad \textbf{(13)}$$

$$\sum_{i=c,f} n_i y^{i*} = n_y y^*, \quad \textbf{(14)}$$

Quantity Regulation

$$\sum_{j = x, y} n_j \, L_j^* = \sum_{i = c, f} n_i \, (L^i - \ell^{i*}). \tag{15}$$

Considering only binding emission constraints, we have $h\,(L_x) = \bar{e},$. Since h is invertible, L_x and hence x can be solved for as functions of $\bar{e}$. The government utilizes this information to set the emission standard according to the following first order condition:

$$\sum_{i = c, f} n_i \, I^i \, (dV^i \,/\, d\bar{e}) = \sum_{i = c, f} n_i \, I^i \, ((\partial V^i \,/\, \partial p_x) \, (\partial p_x \,/\, \partial \bar{e}) + (\partial V^i \,/\, \partial p_y) \, (\partial p_y \,/\, \partial \bar{e}) \tag{16}$$
$$+ (\partial V^i \,/\, \partial m^i) \, (\partial m^i \,/\, \partial \bar{e}) + (\partial V^i \,/ \partial E) \, (\partial E \,/\, \partial \bar{e})) = 0.$$

A loosening of the emission standard may have positive and negative effects on a consumer. Through the externality effect, both types of consumers are made worse off by a more lax standard. If the standard is loosened, it will increase the output of x and therefore lower the price of x, which has a positive effect. The effect of a looser standard on consumers' utility through the price of y is also positive because of the substitution effect between x and y. The income effect is zero for laborers. The income effect for capitalists may be positive or negative, depending on the relationship between profits and the emission standard.

Laborers are better off and capitalists are worse off under a tighter emission standard if the profits of the firm decrease with the lowering of the emission standard. In this case, laborers will lobby for a tighter emission standard and capitalists will lobby for looser standard. This is as expected. However, it is possible that profits increase with a tightening of the emission standard. Paradoxically, in this case, laborers will lobby for a looser standard, while capitalists will lobby for a tighter one.

The Nash equilibrium of the lobbying economy under quantity regulation, $((\hat{x}^i, \hat{y}^i, \hat{\ell}^i)^{i=c,f}, \hat{x}, \hat{y}, \hat{L}_x, \hat{L}_y, \hat{e}, \hat{p}_x, \hat{p}_y, \hat{w}, \bar{e})$, is similar to (8)-(15), with the following modifications:

(8)′ $\hat{L}_x = h^{-1}(\bar{e}), \hat{x} = f(h^{-1}(\bar{e}))$ and $\hat{e} = \bar{e}$

(11)′ $\hat{p}_x \hat{x}^i + \hat{p}_y \hat{y}^i = \hat{w}(L^i - \hat{\ell}^i) + K^i(n_x \hat{\pi}_x + n_y \hat{\pi}_y) / n_f$

(12)′ $(\partial V^i / \partial e)(\partial \hat{e} / \partial I)(\partial I / \partial \ell^i) = \hat{w}$

The Nash equilibrium under quantity regulation is characterized by (8)′, (9), (10), (11)′, (12)′, and (13)-(16); we will call them (8)′-(16)′.

The Effects of Price Regulation and Quantity Regulation

It is well-known that in the model above, absent lobbying, both price and quantity regulatory instruments can achieve a Pareto efficient outcome, and the resulting prices, outputs and emissions can be the same under these regulations.[10] If one is interested only in efficiency, prices and quantities are equivalent instruments under certainty. Of course, the income effects of regulations play an important role in determining the distribution of well-being among consumers. The distribution of well-being of across agents is different under the two instruments because of their differential effects on disposable incomes, arising through the tax revenues rebated to the consumers, and through the impact of taxes on firm profits under price regulation.

The equivalence in efficiency terms between price and quantity instruments does not hold in this model with rent-seeking. By studying the government effluent charge and emission standard rules, (7) and (16), and the conditions that characterize the equilibria (7)-(15) and (8)′-(16)′, it can be seen that, in general, $x^* \neq \hat{x}$ and $e^* \neq \hat{e}$.. Naturally, the outcomes of regulations in a non-trivial lobbying economy are different from a first-best outcome.

Unfortunately, the complexity of the equilibrium conditions makes it difficult to verify these conjectures analytically. We investigate these issues by means of an example economy in next section.

It is important to distinguish the "first-best," "second-best," and "third-best" outcomes in our model. A competitive equilibrium in an economy with externalities is inefficient. For example, the competitive equilibrium might be at point A in Figure 1. Supposing that policies are chosen to maximize a social welfare function, such as the weighted sum of indirect utilities, but without lobbying, then pollution taxation or an emission standard, combined with lump-sum redistribution of income, can move the society to the welfare-maximizing allocation, which perforce lies on the utility possibility frontier (e.g. point B on U^1 in Figure 1). The economy now is in its first-best situation.

In our model instruments are set as if by a self-interested environmental regulator. The regulator's preferences take the form of a social welfare function (ignoring lobbying for the moment), but the outcomes cannot be first-best since redistribution does not take place in a lump-sum manner. Instead, environmental policies are used to achieve both environmental and distributional goals. Ignoring the resource cost of lobbying, a first-best outcome is achieved only when the weights used in the regulator's objective function happen to take on values such that only environmental regulation, and not redistribution, is needed. Such weights are called Negishi weights.[11] In general, without lump-sum transfers, the regulatory outcome is second-best.

When the political activities of rent-seeking agents are considered, the production and hence utility possibility frontiers shrink inward (e.g. to U^2 or U^3 in Figure 1) because lobbying activities remove resources from production and also because the government uses second-best redistributive instruments. A lobbying equilibrium is "third-best" due to these two sources of inefficiency. If neither lump-sum instruments nor a "political technology" that rules out lobbying are available, the lobbying equilibrium in our model is "constrained efficient," since the regulation is maximizing the weighted sum of indirect utilities.[12] Points such as B generally are unobtainable.

Individuals may be better off or worse off in the lobbying equilibrium relative to the competitive equilibirum. If the lobbying equilibirum is represented by points C or D, then one agent is better off while the other is worse off. If point E is the lobbying equilibrium utility pair, then both agents are better off in the lobbying economy than without government regulation, while if the utility pair is point F they are both worse off.

An Example Economy

As it stands the equilibrium of the model is too complex for us to obtain definitive results analytically (other than existence). In this section we use an example economy to draw comparisons between lobby-free economies and lobbying economies, and between and price regulation and quantity regulation in lobbying economies. Details regarding the example are available upon request.[13]

Utility functions are assumed to be $U = x + \ln x + y - \alpha E$, for all consumers, where E $(= n_x e)$ is the total emissions in the economy and $\alpha > 0$ is the marginal disutility of emissions. The demand functions are $x^i = 1/(p-1)$ and $y^i = m^i / p_y - p / (p-1)$, $i = c, f$, where p_y is the price of good y and p is the relative price of good x. Note that the demand function for the polluting good does not incorporate an income effect in this example. We conjecture that including an income effect would increase differences between price and quantity regulations.

The production technology of the polluting industry, x, is assumed to be $x = f(L_x) = L_x^{1/2}$ and the emission function is $e = h(L_x) = L_x$. For the pollution-free industry, y, the technology is assumed to be $y = g(L_y) = L_y$. The price of labor, w, is unity. Because of the specification of the production technology $p_y = w \equiv 1$ and $\pi_y = 0$.[14]

The indirect utility functions are

$$V^i = 1/(p-1) + \ln[1/(p-1)] + m^i - p/(p-1) - \alpha n_x e. \tag{17}$$

Throughout, we assume that $n_x = 10$, $n_c = 17$, and $n_f = 10$.[15]

Competitive Equilibrium

In the competitive equilibrium no regulations are imposed. The supply function of good x in this case is $x = p/2$. The equilibrium price is determined by the market clearing condition: $(n_c + n_f)/(p-1) = n_x p/2$,. Solving this for p, we easily compute x, pollution emissions, and π_x. Income can then be computed, and y determined. Indirect utilities then follow. The results are summarized in Table 1 (column 5).

First-Best Regulation

First-best policies can be acheived by maximization of any social welfare function that is increasing in utilities, when combined with suitable lump-sum transfers. When lump-sum transfers are not available, there will be no need for redistribution, and a first-best outcome will be achieved, only when appropriate weights (the Negishi weights) are used in the environmental regulator's objective function. In our economy, no redistribution is needed and first-best policies can be obtained by maximizing the following welfare function:[16]

$$W = (n_c/(n_c + n_f))\, V^c + (n_f/(n_c + n_f))\, V^f \tag{18}$$

Optimal effluent charges or emission standards are found by equating the decentralized equilibrium conditions to conditions characterizing Pareto efficiency, obtained by solving

$$
\begin{aligned}
\max_{x^c y^c x^f y^f} \quad & x^c + \ln x^c + y^c - \alpha n_x e \\
s.t. \quad & x^f + \ln x^f + y^f - \alpha n_x e \geq u^{f*} \\
& n_x x = n_c x^c + n_f x^f \\
& n_x L = n_c (L^c - y^c) + n_f (L^f - y^f) \\
& x = L^{1/2} \\
& e = L.
\end{aligned}
$$

The allocations attained under first-best price and quantity regulations are summarized in Table 1, columns 1 and 2 respectively. Of course, the first-best price and quantity allocations are the same except for the distribution of well-being between capitalists and laborers.

Lobbying Equilibria

The lobbying-ecobomy allocations are derived by solving the entire program outlined in the previous section. We use the political pressure/influence function $I = I^c(\ell^c,\ell^f)/I^f(\ell^c,\ell^f) = \ln(\ell^c/\ell^f)$

We use the following algorithm to compute equilibria. First, we derive the supply function for x. In the case of price regulation, this is $p / 2 (1 + \tau)$, while under quantity regualtion it is $\bar{e}^{1/2}$. These supply functions are substituted into the market-clearing equation for x, from which p_x is obtained, as a function of τ or $\bar{e}$. With values for p, L, n_x, n_c, and n_f, conditional indirect utilities are computed, for given lobbying levels.

Second, we compute the value of the government's objective function for a given relative influence weight, I. We arbitrarily select a number in (0,1) and assign it to I^c. I is then calculated as $I = (n_c/n_f)(I^c/(1-I^c))$.. Since τ or $\bar{e}$ is a function of I, we can derive $d\tau/dI$ or $d\bar{e}/dI$, from the first-order conditions for regulatory choices for the government's problem (7).

Next, we know that consumers choose lobbying to maximize conditional (on lobbying) indirect utility, given the policy derivatives $d\tau/dI$ or $d\bar{e}/dI$, where $I = \ln(\ell^c/\ell^f)$. Thus, optimal lobbying can be computed from the first-order conditions for the problem $\max_{\ell^i} V(\ell^i ; \ell^{-i})$, $i=c,f$.

Finally, given the lobbying choices, we compute $\ln(\ell^c/\ell^f)$. If this corresponds to the I at the originally chosen I^c, we stop, as we have found an equilibirum. Otherwise, we chose a new value of I^c.

The allocations at the lobbying equilibrium under price and quantity regulations are summarized in Table 1, columns 3 and 4 respectively.

Comparisons and Summary

Because of the existence of an externality, the competitive equilibrium is inefficient. This is clear from the numerical example summarized in Table 1. For $\alpha = 0.5$, 1, and 2, the competitive equilibrium is Pareto dominated by the first-best regulations. The first-best relative prices, consumption, and production of good x are identical under price and quantity regulations. However, consumers' indirect utilities are different under different instruments via their disposable incomes. Laborers are better off under first-best price regulation and capitalists better off under first-best quantity regulation.

Turning now to lobbying economies, interestingly, the competitive equilibirum is Pareto dominated by the lobbying equilibirum for $\alpha = 0.5$, 1, and 2. Thus, lobbying is productive in this sense. However, the competitive equilibrium is Pareto noncomparable with the lobbying equilibrium when $\alpha = 0.01$.

In contrast to first-best regulations, the relative prices, production of the polluting good, x, and the emission level, e, are different under the alternative regulations in lobbying economies. When they would be the same can be shown as follows. First, note that there is an effluent charge T corresponding to each emission standard $\bar{e}$ such that the resulting prices, outputs, and emission levels are identical. The relationship between T and $\bar{e}$ can be found by equating the price functions under price and quantity regulations. For our example economy, we have

$$T = (n_c + n_f + n_x\,\bar{e}^{1/2} - 2\,n_x\,\bar{e})\;/\;2\,n_x\,\bar{e}. \qquad \textbf{(19)}$$

If T were the effluent charge for the lobbying equilibrium, the first order conditions for solving for the effluent charge function $\bar{e}(\ell',\ell)$ and emission standard function $\bar{e}(\ell',\ell)$ would be identical. However, in our economy there is a difference, after manipulation, of

$$n_x\,\bar{e}^{1/2}\,(n_c + n_f)\,(1 - 4\,\bar{e}^{1/2})((n_c\,I + n_f) - n_c + n_f)). \qquad \textbf{(20)}$$

Price and quantity regulations are equivalent (except for income distribution as noted above) if and only if this term is zero is zero, i.e., $\bar{e} = 1/16$ or $I = 1$. First-best price and quantity regulations are equivalent since the latter condition is satisfied ($I = 1$ at the Negishi weights in our economy).

For our sample economy neither of these conditions is satisfied for any of the chosen values of α. Therefore, we conclude that price and quantity regulations result in different outcomes if lobbying activities are allowed. The relative difference between price and quantity regulations for different α's is proportional to $(1 - 4\,\bar{e}^{1/2})$ because the equilibrium I is independent of α in our model with no income effects. The percentage differences in output, emission levels, and prices under price regulation and under quantity regulation are summarized in Table 2. The differences are fairly small for $\alpha = 0.5$, 1, and 2, but are large when $\alpha = 0.01$,. This is because the $(1 - 4\,\bar{e}^{1/2})$ is close to zero for the first three cases but this is quite different from zero for a very small marginal disutility of pollution.

Except for the case of a very low marginal disutility of the externality (α = 0.01), lobbying activities result in lower effluent charges and higher emission standards with comparison to first-best regulations, i.e., regulations are loosened in lobbying economies. Therefore, total output of the pollution generating good and total emissions are higher.

The net effects of the loosening of the regulations in lobbying economies, relative to first-best ones, generally are ambiguous, although it is clear that the externality is aggravated. A reduction in the effluent charge increases the production of good x and lowers its price, which is beneficial. The effect of the increase in emissions on tax revenues depends on the magnitudes of the decrease in the tax rate and the increase in emissions. The effect on the profits of firms of a reduction in effluent charge also generally is ambiguous, depending on the magnitudes of the price decrease, the output increase, the input increase, the tax decrease, and the emission increase. But by assumption, the profit effect is the only conflict between the two interest groups, therefore the profit effect is assumed to be positive when the pollution regulations are relaxed.

Perhaps unexpectedly, when α = 0.01, the emission standard is tightened if lobbying activities are allowed. The effects of lobbying activities in this case are different from the other cases discussed above, because profit is a decreasing function of the emission standard in this scenario.[17] Laborers are worse off while capitalists are better off with a lower standard, so that the former group lobbies for a higher standard and the latter group lobbies for a lower standard. The result is consistent with the other cases in the sense that capitalists are better off in the lobbying economy of our example -- in the competition between the interest groups, the capitalists win.

In equilibrium, both laborers and capitalists spend significantly more resources on lobbying under quantity regulation than under price regulation (see Tables 1 and 2). However, the lobbying expenditures are small as a proportion of the labor endowment.[18]

Under quantity regulation, the competition between the two interest groups makes both groups worse off (as compared to first-best welfare levels) when they lobby in order to influence the policy level (column 2 of Table 3). This coincides with the Tullock-type prisoner's dilemna result. However, this outcome does not generally hold in our model. A counterexample is the case of price regulation. Under price regulation, laborers are worse off but capitalists better off if they are allowed to lobby, relative to first-best price regulation (column 1 of Table 3).

Given that we are in a lobbying economy, laborers prefer price regulation while capitalists prefer quantity regulation (column 3 of Table 3). However, society as a whole suffers welfare losses under quantity regulation relative to price regulation because of the relatively larger amount of resource loss from lobbying activities and the disutility of more emissions.

The model might be extended to one that includes higher level lobbying activities - lobbying over instruments. Suppose that a different government authority (such as a legislature) sets the regulatory instrument independently of the government agency (e.g. the Environmental Protection Agency) which determines the level of the regulation, given the specified instrument. An individual might not only expend resources lobbying the environmental agency in order to alter the levels of the regulation, but also lobby the higher governmental authority to regarding the choice of regulatory instrument. In our example,[19] laborers are willing to expend up to 0.4621, 0.5221, 0.5255, and 0.6225 units of time to ensure the use of the price instrument when α = 0.01, 0.5, 1, and 2, respectively. Capitalists, on the other hand, will expend up to 0.2088, 0.8842, 0.8876, and 0.8834 when α = 0.01, 0.5, 1, and 2, respectively, in order to ensure a quantity regulation situation. Note that, if the higher level choice is determined solely by lobbying contributions, quantity regulation is chosen in all cases except when the marginal disutility of pollution is very low.[20]

Conclusions

In this paper we have compared environmental policy instruments when agents lobby regarding their implementation. Our paper is quite restricted in scope, and our results, obtained via an example, are far from definitive.

Generally it can be expected that differences between agents in their economic endowments and political power determine the magnitude of lobbying effort. If agents are very similar, they may devote substantial resources to lobbying in order to countervail one another's influence, while if they are very different, it is likely that the less favored group will acquiesce to the favored, and the latter then need not engage in substantial lobbying.[21] It might be conjectured that the agents are more similar with price regulation, and hence they lobby less than they do with quantity regulation, under which class differences were exacerbated in our model. This is an important area for further research.

We have not incorporated many of the potential sources of differences between agents in their preferences and their endowments. Since our example demand system did not exhibit income effects in the demand for the polluting good, differences between the agents also had minimal impacts on the resulting equilibria. Nor have we explored important power differentials between them.

Note that the polluters in our model are homogeneous, and therefore we introduced no inefficiency from the failure of uniform standards to equate marginal abatement costs across polluters. As well, ours world had full and symmetric information among agents. It would be of some interest to compare efficiency losses of instruments across sources of inefficiency in more "realistic" settings. Here, we have simply compared, in a very limited number of simulations, first-best instruments to those embodying both lobbying inefficiencies and second-best redistributive impacts. However, our results seem to indicate that lobbying matters in the evaluation of alternative policy instruments. Thus, it appears that further research along these lines may be warranted.

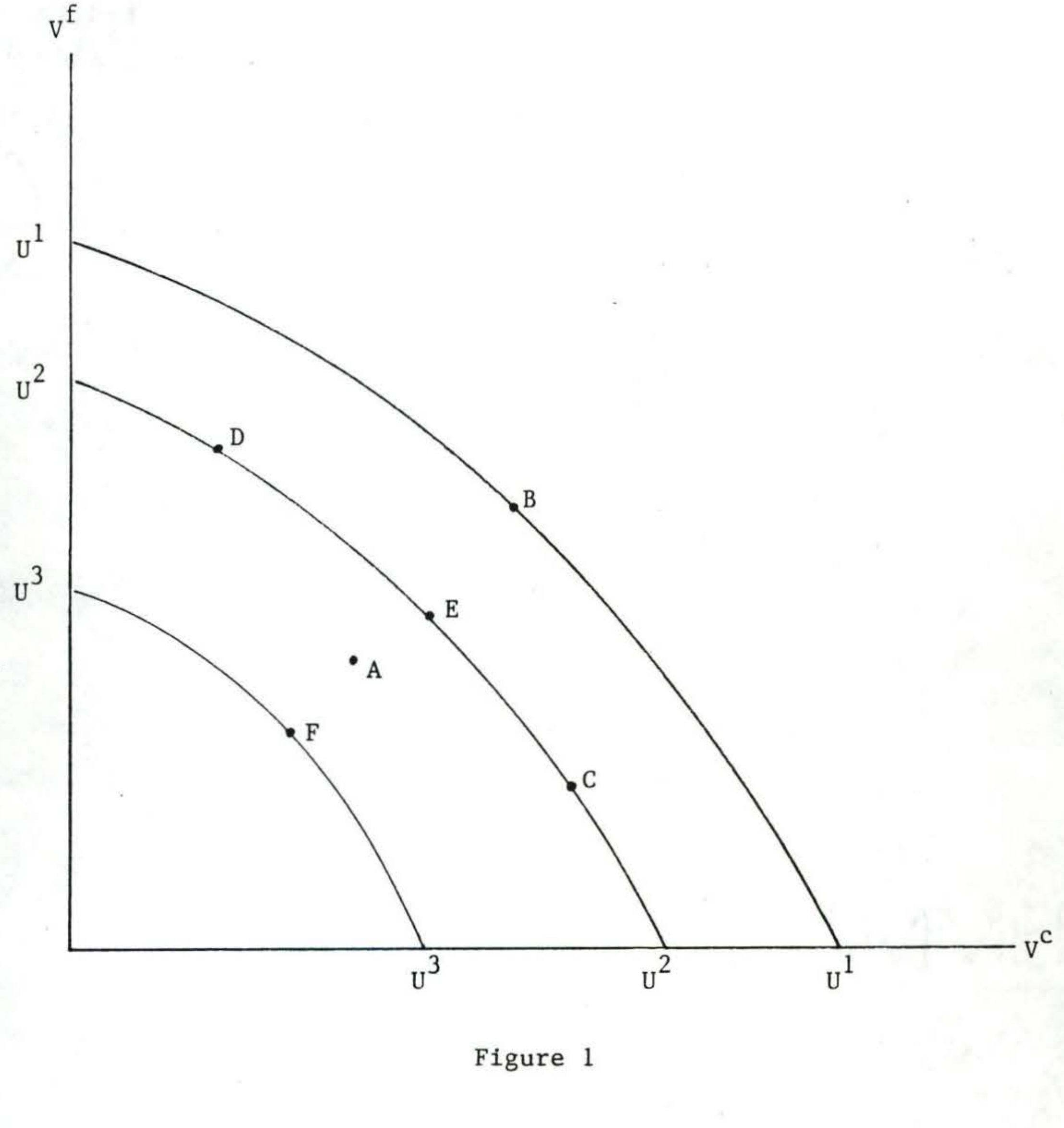

Figure 1

Table 1. Lobbying Equilibria and First-best Outcomes Under Price and Quantity Regulations

	1stP[a]	1stQ	LP	LQ	CE
τ					
$\alpha=0.01$	0.27000		0.15263		
$\alpha=0.5$	13.5000		13.02826		
$\alpha=1$	27.000		26,33059		
$\alpha=2$	54.000		53.04767		
$\bar{e}$					
$\alpha=0.01$		1.55374		1.17979	
$\alpha=0.5$		0.10439		0.10679	
$\alpha=1$		0.05230		0.05373	
$\alpha=2$		0.02601		0.02665	
x					
$\alpha=0.01$	1.24649	1.24649	1.32065	1.08618	1.43849
$\alpha=0.5$	0.32286	0.32286	0.32855	0.32678	1.43849
$\alpha=1$	0.22869	0.22869	0.23159	0.23179	1.43849
$\alpha=2$	0.16128	0.16128	0.16274	0.16325	1.43849
$e(=L_x)$					
$\alpha=0.01$	1.55374	1.55374	1.74411	1.17979	2.06924
$\alpha=0.5$	0.10439	0.10439	0.10794	0.10679	2.06924
$\alpha=1$	0.05230	0.05230	0.05363	0.05373	2.06924
$\alpha=2$	0.02601	0.02601	0.02645	0.02665	2.06924
P					
$\alpha=0.01$	3.16608	3.16608	3.04445	3.48578	2.87697
$\alpha=0.5$	9.36285	9.36285	9.21795	9.26244	2.87697
$\alpha=1$	12.8065	12.8065	12.6588	12.6485	2.87697
$\alpha=2$	17.7410	17.7410	17.5912	17.5391	2.87697
ℓ^c					
$\alpha=0.01$			0.00000483	0.224549	
$\alpha=0.5$			0.0005014	0.002143	
$\alpha=1$			0.0002547	0.002654	
$\alpha=2$			0.0001278	0.002116	
ℓ^f					
$\alpha=0.01$			0.00000312	0.1149696	
$\alpha=0.5$			0.0003343	0.0001429	
$\alpha=1$			0.0001698	0.001769	
$\alpha=2$			0.0000852	0.001410	
V^c					
$\alpha=0.01$	3.2271	3.0717	3.2091	2.7470	3.1634
$\alpha=0.5$	1.8762	1.3550	1.8743	1.3522	-6.9716
$\alpha=1$	1.5314	1.0084	1.5304	1.0049	-17.3216
α-2	1.1821	0.6619	1.1816	0.5591	-38.0136
V^f					
$\alpha=0.01$	5.2004	5.4645	5.2194	5.4282	5.2326
$\alpha=0.5$	3.3876	4.2736	3.3887	4.2729	-4.9064
$\alpha=1$	2.9957	3.8848	2.9962	3.8838	-15.2524
$\alpha=2$	2.6128	3.4972	2.6130	3.4964	-35.9444
Social Welfare[b]					
$\alpha=0.01$	3.9572	3.9570	3.9529	3.739	3.9290
$\alpha=0.5$	2.4354	2.4349	2.4346	2.4329	-5.5736
$\alpha=1$	2.0732	2.0727	2.0727	2.0701	-16.5556
$\alpha=2$	1.7115	1.7110	1.7112	1.6459	-37.2480

[a] 1st P, and 1st Q are first-best price regulation and quantity regulation; LP and LQ are lobbying price and quantity regulation; and CE is competitive equilibrium.

[b] Social welfare is $(17/27)\ V^c + (10/27)V^f$

Table 2 **Differences of Price and Quantity Regulations** (%)

	α = 0.01	α = 0.5	α = 1	α = 2
% difference in x $[((\lvert \hat{x}* - \hat{x} \rvert / \hat{x})\ *100\%]$	21.59%	0.54%	0.09%	0.31%
% difference in e $[((\lvert \hat{e}* - \hat{e} \rvert / \hat{e})\ *100\%]$	47.83%	1.08%	0.18%	0.74%
% difference in p $[((\lvert \hat{p}* - \hat{p} \rvert / \hat{p})\ *100\%]$	12.66%	0.48%	0.08%	0.30%
% difference in ℓ^c $[(((\ell^c - \ell^c*)/\ell^c)\ *100\%$	100%	76.60%	90.40%	93.96%
% difference in ℓ^f $[(((\ell^f - \ell^f*)/\ell^f)\ *100\%]$	99.98%	76.60%	90.40%	93.96%

[a]starred variables are those under price regulation; hatted variables are those under quantity regulation.

Table 3. Changes in Indirect Utilities (%)

	$\frac{\text{LP-1P}^{a}}{\text{LP}}$	$\frac{\text{LQ-1Q}}{\text{LQ}}$	$\frac{\text{LQ-LP}}{\text{LQ}}$	$\frac{\text{LP-CE}}{\text{LP}}$	$\frac{\text{LQ-CE}}{\text{LQ}}$
V^c					
α=.01	-.56%	-11.82%	-16.82%	1.42%	-15.16%
α=.5	-.10%	-.21%	-38.61%	471.96%	615.57%
α=1	-.07%	-.35%	-52.29%	1231.83%	1823.71%
α=2	-.04%	-18.39%	-111.34%	3317.13%	6899.07%
V^f					
α=.01	.36%	-.67%	3.85%	-.25%	3.6%
α=.5	.03%	-.02%	20.69%	244.79%	214.83%
α=1	.02%	-.03%	22.85%	609.06%	492.72%
α=2	.01%	-.02%	25.27%	1475.6%	1128.04%
Social Welfare[b]					
α=.01	-.11%	-5.83%	-5.72%	.81%	-6.91%
α=.5	-.03%	-.08%	-.07%	3.29%	3.29%
α=1	-.04%	-.23%	-0.13%	8.99%	9%
α=2	-.018%	-3.96%	-3.97%	22.77%	23.63%

[a]1st P, and 1st Q are first-best price regulation and quantity regulation; LP and LQ are lobbying price and quantity regulation; and CE is competitive equilibrium.

[b]Social welfare is (17/27) V^c + (10/27)V^f

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Endnotes

1. Thus, our work contrasts with the regulation literature that supposes cooperative behavior (e.g. Spulber, 1989) and the "bureaucratic behavior" literature in which the regulator, while not benevolent, is not subject to direct manipulation by agents.

2. Considerable effort has been directed to establishing the likely magnitude of these rent-seeking costs. See Coggins (1992) for an overview and recent contribution.

3. Lee (1988) has studied a political-economic model of environmental regulation. His model considers rent-seeking over the revenues from pollution taxation, with a fixed proportion of this revenue "wasted" by rent-seeking. Lee does not study the relationship between price and quantity instruments and rent-seeking. Buchanan and Tullock (1975) contrast price and quantity controls in a political-economy model of pollution regulation. While they use a substantially different model than ours, the results generally are in accord. Rent-seeking has also appeared in a model by Misolek (1988) of a monopolist which pollutes. Magat et al. (1986) apply the Peltzman (1976) model in the context of environmental regulation. All these are partial equilibrium models, and they ignore some of the general equilibirum influences with which we are concerned.

4. These functions could summarize lobbying (e.g. Tullock, Krueger, Bhagwati, Findlay and Wellisz; and Applebaum and Katz), or voting (e.g. Mayer, Young and Magee), or some other mechanism.

5. In this simple one-input model with homogeneous emitters the effect of an effluent charge is the same as the effect of an output tax, and optimal taxation or a uniform emission standard across firms can achieve an efficient allocation. A more general specification would consider a vector of inputs and firm heterogeneity, but this unnecessarily complicates the model for our purposes.

6. Note that the government is not another agent in the economy with its own preferences, income, and demands to enter market clearing equations; the "as if" assumption is important in interpreting our model.

7. Without further discussion of how agents form a coalition, we assume that the consumers know that through the power of their coalition, their lobbying activities will affect their tax rebate when they choose their lobbying efforts, i.e., they consider tax consequences of actions.

8. Note that the form of the regulatory contract is not optimized by the government. Rather, we examine particular institutional structures. In future research, the structure itself should be made endogenous. See Laffont and Tirole for some work along these lines.

9. One might also allow the utility functions to be different for different interest groups.

10. In an economy with a unique equilibrium.

11. These weights will be computed below in our example economy. In a different lobbying economy, Roe and Graham-Tomasi discuss such weights, due originally to Negishi.

12. This is different from the way that lobbying for distortionary policies (e.g. tariffs and quotas) has appeared in international trade models (see, for example, Tullock [1967], Krueger [1974], and Findlay and Wellisz [1983].

13. Contact Professor Tomasi for a copy of the computer program, written in Gauss, which computes equilibria in our economy.

14. Notice that the profit of the y industry, π_y is zero under this production technology.

15. The numbers of pure labor and capitalistic labor are determined from the "Individual Income Tax Returns, 1987" data. Total number of laborers is the number of returns whose income sources are salaries and wages, which is approximately 91,000,000 in 1987. The capitalistic labor further earns income from dividends and sales of capital assets. There were approximately 34,000,000 such returns in 1987. The relative number of laborers and capitalists labor is (91,000,000 - 34,000,000) / 34,000,000 = 1.7. By rescaling, n_c and n_f are assumed to be 17 and 10.

16. The relative population numbers are the Negishi weights since the marginal utility of income is one in our example.

17. In our sample economy, $\partial\pi \,/\, \partial\bar{e} = 1/2\ \bar{e}^{1/2} - 1$. Profit is an increasing function of $\bar{e}$ when $\bar{e}$ is less than 1/4 and is a decreasing of $\bar{e}$ if $\bar{e}$ is greater than 1/4. From Table 1, we know that $\bar{e}$ is less than 1/4 when $\alpha = 0.5$, 1, and 2 and is greater than 1/4 when $\alpha = 0.01$.

18. This is not the only possible measure of the severity of lobbying in our economy. Other rent dissipation measures might be relevant here; see Coggins (1992) for a discussion of alternative approaches.

19. The assumption that the choice of the higher government agency is discrete (either an effluent charge or an emission standard) makes it difficult to discuss the effects of the higher level lobbying more generally, since the choice depends on the numerical outcomes of indirect utilities under different instruments.

20. Of course, the legislature might also consider other aspects of the instrument choice problem in addition to political concerns. If it is motivated purely by utilitarian objectives, then it would always choose price regulation, so long as it considers that the level of the instrument is subject to lobbying.

21. These remarks are guided by the simulation results of Coggins (1992). Perhaps other conclusions could be drawn with other examples.