# SELF-REGULATION AND SOCIAL WELFARE: THE POLITICAL ECONOMY OF CORPORATE ENVIRONMENTALISM*

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## Abstract

We extend the economic theory of regulation to allow for strategic self-regulation that preempts political action. When political ''entry'' is costly for consumers, firms can deter it through voluntary restraints. Unlike standard entry models, deterrence is achieved by overinvesting to raise the rival's welfare in the event of entry. Empirical evidence on releases of toxic chemicals shows that an increased threat of regulation (as proxied by increased membership in conservation groups) indeed induces firms to reduce toxic releases. We establish conditions under which self-regulation, if it occurs, is a Pareto improvement once costs of influencing policy are included.

> While some of the environmental changes now emerging in corporate America are genuine and welcome, a good many are superficial, some are downright diversionary, and a few are being specifically designed to preempt more stringent public policies from emerging. [Brent Blackwelder, President, Friends of the Earth][1]

> In an effort to head off legal restrictions on privately traded derivatives, six of Wall Street's biggest securities firms have agreed

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[1] Bruce Smart, Beyond Compliance: A New Industry View of the Environment (1992).

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> to voluntarily tighten their controls on the most hotly contested aspects of their derivatives sales and trading. [WALL STREET JOURNAL, MARCH 9, 1995][2]

> In today's society any industry as conspicuous as the major home appliance industry is continually faced with the threat of government regulation. In my opinion, the only way to avoid government regulation is to move faster than the government. The alternative to government regulation is judicious self-regulation. [HERBERT PHILLIPS, TECHNICAL DIRECTOR, ASSOCIATION OF HOME APPLIANCE MANUFACTURERS][3]

## I. INTRODUCTION

To economists, ''regulation'' means restraints imposed upon firms by government. In many cases, however, firms voluntarily restrain their own conduct; they ''self-regulate.''[4] Examples include establishment of financial exchanges, licensing of professionals, setting of safety standards, control of entertainment content, advertising restrictions, and voluntary pollution abatement. While self-regulation may have a variety of motives,[5] in this paper we model it as a way to preempt government regulation, examining the conditions under which preemption is possible and, if it occurs, its welfare consequences. We present our analysis in the context of ''corporate environmentalism,'' that is, voluntary adoption of cleaner products or processes, but it should be clear from the above examples that the basic story has broader applicability.

Some intriguing preliminary evidence of self-regulation is presented in

[2] Jeffrey Taylor, Securities Firms Agree to Set Controls on Derivatives, Wall St. J., March 9, 1995, at C1.

[3] Michael S. Hunt, Trade Associations and Self-Regulation: Major Home Appliances, in Regulating the Product: Quality and Variety (Richard E. Caves & Marc J. Roberts eds. 1975).

[4] When self-regulation involves restrictions on quantity or sales territory, the terms ''cartel'' and ''collusion'' are applied, and antitrust investigation may be expected. A large body of economic literature is devoted to identifying when such activities reduce social welfare. For a good overview of this research, see David L. Kaserman & John W. Mayo, Government and Business: The Economics of Antitrust and Regulation (1995).

[5] Self-regulation may increase consumer demand by reducing uncertainty about product quality or ensuring interoperability of the products of different firms. It may enhance employee satisfaction by improving the safety or other quality aspects of the workplace. It may also serve more strategic purposes, such as softening competition or preempting stricter government regulations. If self-regulation is more cost-effective than government regulation, firms might self-regulate even if doing so has no impact on the ultimate level of restraint required.

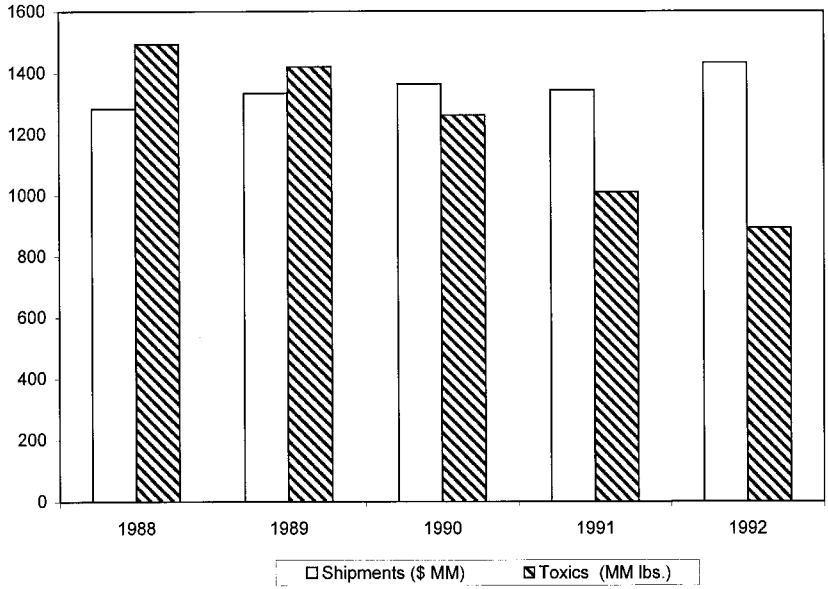


FIGURE 1.—Toxic emissions versus manufacturing shipments

Figure 1, which shows—for the United States over the period 1988–92—total releases of 17 selected toxic chemicals against the dollar value of shipments from the seven main industries emitting these chemicals. While shipments have risen, toxic emissions have dropped off markedly. In fact, the aggregate emissions of these chemicals fell by 40 percent from 1988 to 1992. Changes in government regulation are not driving the reductions, as these emissions are legal. This paper presents a theory of self-regulation in which this voluntary abatement can be explained by increases in the threat of federal and/or state regulation.

While corporate environmentalism is on the rise, it remains controversial.[6] Critics argue that self-regulation provides less environmental protection than does government regulation. The ''Big Three'' automakers' Vehicle Recycling Partnership is limited to creating labeling standards for plastic components and falls well short of the German program of comprehensive automotive disassembly and reuse. Selective cutting in old-growth

[6] For a survey of corporate environmental programs, see Smart, *supra* note 1. The idea that ''pollution prevention pays'' has been widely promoted in the popular and trade press. For example, that firms may engage in the production of ''green'' products to serve a high-margin market niche and that a reputation for cleanliness may ease the burden of plant location can be seen in Frances Cairncross, Costing the Earth (1992).

forests is more environmentally friendly than clear-cutting, but many argue that such forests should not be cut at all. The ''Responsible Care'' program initiated by the Chemical Manufacturers Association (CMA) may be used as a rationale for refusing to adopt more stringent environmental practices; according to Jayne Barnard,[7] at least one CMA member—Union Carbide—has already done just that. Such considerations raise questions about how social welfare is affected when self-regulation preempts government action. Indeed, these questions are the primary motivation for the model we develop. Welfare concerns are likely to become increasingly important, since, as Noah Walley and Bradley Whitehead point out,[8] ''win-win'' situations—in which pollution prevention raises both corporate profits and consumer well-being—are increasingly difficult to find.[9] One of the striking features of our model is the strong welfare analysis that emerges.

We model self-regulation and social welfare in a three-stage game where Cournot oligopolists face the possibility of stricter pollution abatement regulations. Following Gary Becker,[10] we model these regulations as arising from a political influence game between consumers and firms, with consumers favoring stricter abatement regulations than do firms.[11] Following George Stigler and Sam Peltzman,[12] we assume that it is costly for interested parties to organize themselves to enter the political process and to influence policy makers once involved in the political process. In the first stage of our game, symmetric firms choose (possibly zero) levels of voluntary abatement. In the second stage, identical consumers observe the volun-

[7] Jayne W. Barnard, Exxon Collides with the Valdez Principles, 1990 Bus. & Soc'y Rev. 32, at 35.

[8] Noah Walley & Bradley Whitehead, It's Not Easy Being Green, Harv. Bus. Rev., May–June 1994, at 46.

[9] Many of the opportunities for painless Pareto improvements have already been implemented. For example, 3M's ''Pollution Prevention Pays'' program has reduced the company's emissions by over 1 billion pounds since 1975 and has saved 3M roughly $500 million in the process. However, others argue that many recent corporate environmental initiatives have had negative effects on company profits, suggesting that most companies now face sharply rising costs should cleanup standards be further increased; see Walley & Whitehead, *supra* note 8.

[10] Gary S. Becker, A Theory of Competition among Pressure Groups for Political Influence, 98 Q. J. Econ. 371 (1983).

[11] One could also devise a somewhat more complex model that subdivides consumers into groups according to their relative disutilities for price increases and for environmental degradation. Because all consumer groups will on balance align with either the firms (lobbying for weaker regulations) or environmentalists (lobbying for stronger regulations), including additional consumer groups would complicate the modeling but seems unlikely to generate substantial new insights.

[12] George Stigler, The Theory of Economic Regulation, 2 Bell J. Econ. & Mgmt. Sci. 3 (1971); Sam Peltzman, Toward a More General Theory of Regulation, 19 J. Law & Econ. 211 (1976).

tary abatement activity and determine whether to enter the influence game; if they do so, they and the firms exert pressure on government for their desired level of regulations, and an abatement policy is determined. In the third stage, firms play a Cournot production game.

From a methodological viewpoint, our analysis extends the economic theory of regulation in two directions.[13] First, by adding an initial stage of voluntary actions by firms, we allow for the possibility of strategic self-regulation that preempts government action. As a result, we obtain some striking parallels and contrasts with the standard industrial organization literature, which typically takes regulation as either exogenously fixed or a set of controls to be optimized. Second, by modeling explicitly the dimension of product quality (in this case, pollution abatement), we can address directly issues of regulatory efficiency discussed only informally by Becker.

The key positive implication of our model is that an increased threat of government regulation induces firms to voluntarily reduce pollution emissions. We examine empirically the massive cuts in U.S. toxic chemical releases since 1988 (illustrated in Figure 1) and the role of potential regulatory entry in stimulating these cuts. We investigate state-level variation in the threat of regulation using panel data on releases of toxic chemicals over the period 1988–92. Our most significant finding is that states with higher initial levels of toxic emissions and larger environmental group membership reduced toxic emissions more rapidly. In this situation, firms have relatively low marginal abatement costs, consumers value abatement highly, and consumer organizing costs are low. Since the threat of mandatory regulation is high while the marginal cost of self-regulation is relatively low, it makes good sense for firms to engage in voluntary emissions reductions.

In addition to the foregoing positive predictions and empirical results, we also derive some striking normative results. We show that interest group rivalry (the influence game) produces weaker pollution regulation than is socially optimal. Nevertheless, we show that when the costs of influencing policy are included, if voluntary abatement occurs then it represents a Pareto improvement over the status quo. More important, social welfare under preemption also Pareto dominates that which would have arisen from the influence game, had it been played.

Our analysis has two implications for public policy. First, it lends support to an antitrust policy allowing industries to coordinate on voluntary abatement strategies, since such coordination increases beneficial self-regulation. Second, it raises questions about government financing of consumer inter-

[13] Although there is a vast literature on the economics of regulation, we take the ''economic theory of regulation'' to mean the strand of the literature associated with the work in Stigler, *supra* note 12; Peltzman, *supra* note 12; and Becker, *supra* note 10.

vention into the political process: if consumer involvement becomes too easy, firms may eschew voluntary abatement, with the result that both they and consumers are worse off than when consumer involvement was difficult.

Before proceeding, we briefly contrast our paper with related work in the literature.[14] Despite the ubiquity of self-regulation, the phenomenon has received little attention from economists. There have been several interesting case studies and institutional analyses[15] and a few papers that apply a vertical product differentiation framework to model the idea that firms voluntarily reduce pollution to attract ''green'' consumers.[16] Seema Arora and Tim Cason[17] study empirically which types of firms are most likely to participate in government programs aimed at voluntary abatement.

In a more strategic vein, Ronald Braeutigam and James Quirk and Thomas Lyon[18] analyze models wherein a regulated firm voluntarily reduces its price to avoid a rate review that would cut rates even further. Similarly, Amihai Glazer and Henry McMillan[19] show that the threat of price

[14] It is important to note that our paper differs sharply from some earlier work on corporate strategy in the regulatory arena. For example, that firms may benefit from regulation if it raises marginal cost more than average cost, thereby increasing firms' producer surplus can be seen in Michael Maloney & Robert McCormick, A Positive Theory of Environmental Quality Regulation, 35 J. Law & Econ. 99 (1982). In our model, marginal costs do not change with output, so firms do not have the Maloney and McCormick motive for seeking regulation. Indeed, in our model, firms self-regulate only to avoid government regulation. In addition, because we assume an oligopoly structure with no entry, firms have no incentive to lobby for regulation in order to increase entry barriers.

[15] For example, see Regulating the Product: Quality and Variety (Richard E. Caves & Marc J. Roberts eds. 1975); Mitchell Y. Abolafia, Self-Regulation as Market Maintenance, in Regulatory Policy and the Social Sciences (Roger G. Noll ed. 1985); Stephen Craig Pirrong, The Self-Regulation of Commodity Exchanges: The Case of Market Manipulation, 38 J. Law & Econ. 141 (1995); and Ian Ayres & John Braithwaite, Responsive Regulation: Transcending the Deregulation Debate (1992).

[16] See Seema Arora & Subhashis Gangopadhyay, Toward a Theoretical Model of Emissions Control, 28 J. Econ. Behav. & Org. 289 (1995), for a presentation of a model where firms voluntarily reduce emissions of pollutants to attract ''green'' consumers. A similar analysis that shows that voluntary reductions generally cannot achieve the socially optimal level of abatement can be seen in Mark Bagnoli & Susan G. Watts, Ecolabeling: The Private Provision of a Public Good (1995). For a vertical differentiation model with minimum quality standards that shows that high-quality firms may have incentives to act strategically so as to shape future regulatory requirements, see Stefan Lutz, Thomas P. Lyon, & John W. Maxwell, Quality Leadership When Regulating Standards Are Forthcoming, J. Indus. Econ. (forthcoming).

[17] Seema Arora & Tim Cason, An Experiment in Voluntary Environmental Regulation: Participation in EPA's 33/50 Program, 28 J. Envtl. Econ. & Mgmt. 271 (1995).

[18] Ronald R. Braeutigam & James P. Quirk, Demand Uncertainty and the Regulated Firm, 25 Int'l Econ. Rev. 45 (1984); Thomas P. Lyon, Regulation with 20-20 Hindsight: Heads I Win, Tails You Lose? 22 RAND J. Econ. 581 (1991).

[19] Amihai Glazer & Henry McMillan, Pricing by the Firm under Regulatory Threat, 107 Q. J. Econ. 1089 (1992).

regulation may induce a monopolist to price below the unregulated monopoly level. Our analysis is related to these earlier strategic analyses but richer in several important respects. We consider an oligopolistic industry in which consumers have both price and nonprice (for example, pollution) concerns. We model explicitly the incentives of interest groups (producers and consumers) to expend resources on lobbying for their preferred policies and allow the stringency of regulations to be determined endogenously. We complement our theoretical analysis with empirical evidence from a unique panel data set that provides support for our theoretical predictions. Finally, we assess the social welfare implications of regulatory preemption and address policy questions about appropriate antitrust treatment of self-regulation and about government subsidy of consumer intervention in the political process.

Our results are also related to the literature on entry deterrence.[20] In a sense, our oligopoly invests in pollution control to deter ''entry'' by consumers to the influence game. Unlike standard entry deterrence models, however, here the ''fat-cat'' strategy—under which investment raises the rival's welfare in the event that entry occurs—is effective in preempting entry.[21] The reason is that in ordinary deterrence games staying out yields the potential entrant a fixed reservation level of profits. Here, in contrast, consumers' utility of staying out of the influence game rises as firms invest. Welfare-enhancing preemption is possible because as voluntary abatement increases, consumers' utility of staying out rises faster than the utility of entering.[22]

The remainder of the paper is organized as follows. Section II presents the model, while Section III develops two key propositions about the conduct of firms and of consumers. Section IV establishes welfare results and explores policy implications. Section V examines our positive hypotheses using cross-sectional data on the 50 U.S. states, while Section VI concludes and discusses directions for future research. All proofs are presented in the Appendix.

## II. The Model

In this section we present a three-stage model of voluntary pollution control. For simplicity, we assume symmetric firms, and we do not discount

[20] For a good overview, see Jean Tirole, The Theory of Industrial Organization (1989).

[21] Tirole, *supra* note 20, § 8.3, presents a taxonomy of business strategies based upon animal analogies such as the ''fat-cat effect'' and the ''puppy dog ploy.''

[22] Note also that, unlike Richard Gilbert & Xavier Vives, Entry Deterrence and the Free Rider Problem, 53 Rev. Econ. Stud. 71 (1986), or Shabtai Donnenfeld & Shlomo Weber, Limit Qualities and Entry Deterrence, 26 RAND J. Econ. 113 (1995), our oligopolists never have an incentive to engage in excessive (that is, Pareto-dominated levels of) entry deterrence, since individual firms do not obtain private benefits from voluntary abatement.

payoffs over time. The sequence of moves in the model is as follows. First, firms choose a level (possibly zero) of voluntary pollution control that is assumed to be binding. For example, it could be built into the production technology, or firms could sell a conservation easement to an environmental group (for example, the group buys the right to dictate a production technology to the firms, such as selective rather than clear-cut logging) or irrevocably link their image to voluntary abatement through advertising. Second, firms and consumers (who receive utility from the good but disutility from pollution) engage in interest group rivalry for the purpose of influencing pollution control policy. Third, after pollution control policy has been determined, firms produce and sell output in a Cournot oligopoly. We focus on the case in which consumers will successfully lobby for new regulations if the firms take no voluntary action, since there is no other motive for voluntary action in the model. As is standard in multistage games, subgame perfection is achieved by solving the model in reverse chronological order; hence the exposition below is presented from a backward-induction perspective.

### *Stage 3: Output Market Equilibrium*

In the last stage of the game, $N^{f}$ identical firms engage in Cournot-style quantity rivalry in an industry featuring pollution externalities.[23] Firm $i$ chooses an output level $q_i$, and the firms face industry demand curve $P(Q)$, where $Q = \sum_i q_i$; we will also use the notation $Q_{-i} = \sum_{j \neq i} q_j$. Firms install a pollution control input, in the amount $Z$, which is the sum of a voluntary choice $Z^{V}$ from stage 1 and mandatory control level $Z^{M}$ from stage 2 of the game.[24] Firms are then confronted with per-unit output cost $c(Z)$ that is constant with regard to output and a fixed capital cost $k(Z)$, both of which are increasing and convex in $Z$. In order to focus on the strategic aspects of voluntary abatement, we assume the costs of self-regulation and government regulation are equal and are only a function of $Z$.[25] Given $Q_{-i}$, firm $i$'s problem is to

$$\max_{q_i} [P(Q_{-i} + q_i) - c(Z)]q_i - k(Z). \tag{1}$$

[23] By assuming homogeneous products, we in effect assume that consumers cannot observe the emissions of an individual firm, though they may be able to observe aggregate environmental damage (for example, air quality in the Los Angeles basin or water quality in the Great Lakes).

[24] Because the firms are symmetric, the level of $Z$ determined in stages 1 and 2 of the game is the same for all firms and we treat it as a scalar; we avoid vector notation for notational simplicity.

[25] Obviously self-regulation looks even better if it is cheaper than government regulation.

In the symmetric Cournot-Nash equilibrium,[26] firms have equal outputs, defined by

$$q_i^* = -\frac{[P(Q^*) - c(Z)]}{P'(Q^*)}; \tag{2}$$

aggregate quantity traded is $Q^* = N^f q_i^*$, and the market clearing price is $P(Q^*)$. Henceforth we shall drop the subscript ''*i*,'' as in equilibrium all firms are identical. There should thus be no confusion in proceeding to use subscripts to indicate derivatives. Equilibrium earnings per firm, given $Q^*$, are $\pi^N(Z)$, where the superscript ''N'' indicates that no influence costs are included at this stage. Note that our convexity assumptions on costs imply

$$\pi_Z^N = -c_Z q^* - k_Z < 0$$

and

$$\pi_{ZZ}^N = -c_{ZZ} q^* - k_{ZZ} < 0.$$

*Stage 2: Influence Game*

Following Becker,[27] we model pollution control policy as the outcome of rival ''influence inputs'' being transformed through political institutions. In our model there are two interest groups: one is made up of the $N^f$ firms whose costs are increased by additional pollution control restraints, while the other is made up of $N^c$ consumers who purchase the good produced by the firms and who also have disutility over pollution emitted by the firms. All individuals and firms allocate influence inputs noncooperatively.[28] Firms, if they enter the influence game, always attempt to influence policy makers to reduce mandatory pollution control (the per-firm resources they allocate for this purpose are referred to by the variable $l$).[29] While consumers care about their consumer surplus from buying the good produced by firms, and thus oppose higher prices, they also have disutility over pollution. Thus it is possible for firms to choose a level of voluntary abatement sufficiently high that consumers would actually prefer less than the voluntary level of pollution control. This is never profitable for firms, however,

[26] We assume the existence of a unique pure-strategy equilibrium. For conditions guaranteeing that such an equilibrium exists and further references on the subject, see Tirole, *supra* note 20, at 224–26.

[27] Becker, *supra* note 10.

[28] While environmental groups and trade associations may coordinate the collection of funds from members, we emphasize the fact that the financial contributions of members are made individually and on a noncooperative basis.

[29] Because firms are symmetric and there is no possibility of entry, it is not profitable to lobby for stricter regulations as a means of raising rivals' costs.

so consumers—if they enter the political process—always allocate resources (in the amount of $m$ per person) to influence policy makers to choose more pollution control.

Following Stigler and Peltzman[30] we assume that consumers wishing to influence the process of policy formation must bear in the aggregate a fixed cost $F(N^c)$; each of the identical consumers then bears a cost $f(N^c) = F(N^c)/N^c$ if the consumer group enters the influence game. In the present context, individuals must inform themselves of the implications of pollution control for their well-being[31] and of the efficacy of various feasible policy remedies. Individuals of similar interests must then coordinate on a mutual lobbying strategy. We will refer to these various costs collectively as organizing costs. Firms face similar tasks, but their organizing costs are typically less than those of consumers, since assessing the costs of regulation to the firm is usually much easier than assessing the health and aesthetic benefits to consumers, and the number of firms in an industry is typically very small relative to the number of consumers. Without loss of generality, then, we normalize firms' cost of organizing to zero.

Since the $N^f$ firms are identical, aggregate firm resources allocated to political pressure are $L = N^f l$. Similarly, the $N^c$ consumers devote $M = N^c m$ aggregate resources to pressure activities if they choose to incur the fixed cost of entering the political process. We represent the influence process through a function $Z^M(M, L)$ that gives the mandatory abatement level as a function of influence inputs; when the firm undertakes voluntary abatement, total abatement is then $Z(M, L) = Z^V + Z^M(M, L)$.[32] We assume $Z_M > 0$, $Z_L < 0$, $Z_{MM} < 0$, and $Z_{LL} > 0$. (We will often suppress the dependence of $Z$ on influence for notational ease.)

Consider a representative firm's optimization problem in the influence game. Firm $i$, given the influence choices of the other parties ($M$ by consumers, $L_{-i}$ by the other firms), must choose influence input $l$ to maximize

$$\pi^N(Z^V + Z^M[M, L_{-i} + l]) - l. \tag{3}$$

A firm's optimal choice of $l$ is given by the following equation:

$$\pi^N_Z Z_l = 1. \tag{4}$$

[30] Stigler, *supra* note 12; Peltzman, *supra* note 12.

[31] These costs are often very high due to the incomplete state of scientific knowledge and its inaccessibility to those who are not experts in the relevant fields.

[32] The additive form of $Z(M, L)$ is consistent with the application of a regulatory design standard requiring all firms to utilize a prescribed abatement process regardless of their existing emissions levels. As will be seen in proposition 2, this gives oligopolistic firms an incentive to free ride on industry-wide self-regulatory efforts, since they can gain a cost advantage by refusing to take voluntary abatement measures.

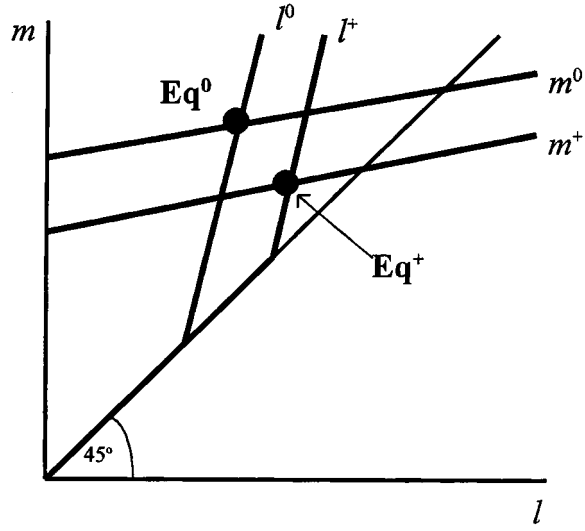


FIGURE 2.—Firm ($l$) and consumer ($m$) reaction functions in the influence game

Consumers are utility maximizers and choose their per-person lobbying expenditures $m$ independently. Utility falls as the price of the good rises and the total amount of pollution in the environment increases. Since firms are symmetric, we let $d = f(Z, q)$ be the total environmental degradation caused by an individual firm and $D = D(N^{\mathrm{f}}, Z, q)$ be the total amount of degradation. Recognizing that $q^*$ is chosen by firms in stage 3 and that the number of firms is fixed, we suppress the dependence of $D$ on $q$ and $N^{\mathrm{f}}$, and the total welfare of a consumer is then

$$U^{\mathrm{N}}[P(Z), D(Z)] - m. \tag{5}$$

A consumer's optimal choice of $m$ is given by the following equation:

$$(U^{\mathrm{N}}_P P_Z + U^{\mathrm{N}}_D D_Z) Z_m = 1. \tag{6}$$

Using the shorthand notation $U^{\mathrm{N}}(Z) \equiv U^{\mathrm{N}}[P(Z), D(Z)]$, (6) can be simplified to $U^{\mathrm{N}}_Z Z_m = 1$. We assume $N^{\mathrm{N}}_{ZZ} < 0$; note that $N^{\mathrm{N}}_Z$ is initially positive but declines and so can become negative.

Equations (4) and (6) generate reaction functions $l^*(m, Z^{\mathrm{V}})$ and $m^*(l, Z^{\mathrm{V}})$ for firms and consumers, respectively, in the influence game. We shall assume that $Z_{ML} \cong 0$, which ensures that the reaction functions are upward sloping, as illustrated in Figure 2, indicating that lobbying expenditures are strategic complements. We also assume that regulation never mandates an increase in pollution; as a result, firms will curtail their expenditures on in-

fluence when $Z^M(M, L)$ reaches zero. This effect is shown in the figure for the case where firm and consumer pressure is equally effective: firms' reaction curves are the upper envelope of the 45-degree line and the $l^*(m, Z^V)$ function that would apply if regulations could force firms to become dirtier. Equilibrium levels of pressure are $l^e(Z^V) \equiv l^*(m^e, Z^V)$ and $m^e(Z^V) \equiv m^*(l^e, Z^V)$.

*Stage 1: Voluntary Pollution Control*

Prior to the interest group rivalry process that generates pollution control policy, firms can choose a level (possibly zero) of voluntary pollution control. Let $Z(Z^V) \equiv Z^V + Z^M(Z^V)$ and assume that $Z(0) > 0$, which avoids the uninteresting case in which the external costs of pollution to consumers are too small to generate any legislative requirements for pollution control. Firms thus choose $Z^V$ to maximize the following equilibrium profit function:

$$\pi^I(Z^V) = \pi^N[Z(Z^V)] - l^e(Z^V), \tag{7}$$

where the superscript ''I'' indicates that profits are measured net of influence costs. We also denote consumer utility, net of influence costs, by

$$U^I(Z^V) = U^N[Z(Z^V)] - m^e(Z^V).$$

A crucial effect of voluntary abatement is to change the outcome of the influence game. It is straightforward to establish how the players' reaction curves shift as $Z^V$ rises. Totally differentiating (4) and (6) and gathering terms yields

$$\frac{dl^*}{dZ^V} = \frac{-\pi_{ZZ}Z_l}{\pi_{ZZ}Z_l^2 + \pi_Z Z_{ll}} > 0$$

and

$$\frac{dm^*}{dZ^V} = \frac{-U_{ZZ}Z_m}{U_{ZZ}Z_m^2 + U_Z Z_{mm}} < 0.$$

Thus, self-regulation makes the firms ''tough'' in the influence game while also making consumers ''soft.''[33] Figure 2 illustrates the shifts in consumer and firm reaction functions in response to an increase in voluntary abatement. Functions superscripted with a zero represent reaction functions when the level of voluntary abatement is zero, while those represented with a plus superscript are reaction functions resulting from a positive level of volun-

[33] For further discussion of the terms ''tough'' and ''soft'' in multistage commitment games, see Tirole, *supra* note 20, at 327.

tary abatement. With positive voluntary abatement, a consumer's reaction function shifts downward, reflecting a reduced marginal value of further emissions control. At the same time, a firm's reaction function shifts outward, reflecting a higher marginal cost of further control. Note, however, that the lower portion of the firm's reaction curve does not shift. This reflects the constraint that firms are not allowed to become ''dirtier,'' so they just match consumer expenditures on influence once the level of mandatory abatement falls to zero.

## III. Conduct of Firms and Consumers

In this section, we analyze the behavior of firms and consumers in the model presented above. We are particularly interested in the question of when preemption via voluntary abatement is profitable. Antitrust law in the United States makes illegal all collusive attempts to restrict sales quantity or raise price. To the best of our knowledge, however, these laws do not preclude firms from cooperating to increase their levels of voluntary pollution abatement.[34] In fact, firms often use trade associations to self-regulate via uniform product and production standards; for example, a recent survey of firms that emit toxic pollutants found that companies were more likely to participate in pollution programs sponsored by the firm's trade association.[35] Proposition 1 establishes conditions under which firms' profits can be enhanced by cooperative voluntary pollution abatement that preempts mandatory controls.[36]

Proposition 1. There exists a range of consumer fixed costs of organizing on which a perfectly collusive oligopoly chooses a positive level of voluntary abatement and thereby preempts consumer intervention in the regulatory process. Let $f_{Z^{V}_{max}}$, $f_{blockade}$ be this range. Then $f_{Z^{V}_{max}} \geq 0$, and for $f_{Z^{V}_{max}} < f(N^{c}) < f_{blockade}$ the firm's choice of $Z^{V}$ is decreasing in $f(N^{c})$; for $f(N^{c}) > f_{blockade}$, consumer intervention is ''blockaded,'' that is, preempted with $Z^{V} = 0$.

[34] See George Bittlingmayer, The Application of the Sherman Act to the Smog Agreement, 32 Antitrust Bull. 371 (1987), for a discussion of a case in which automobile manufacturers were charged with colluding to reduce research and development expenditures on pollution abatement technologies. We discuss this case further in Section IV.

[35] In surveying a group of firms, some of which participated and some of which declined to participate in the EPA's voluntary ''33/50'' program, it is noted in U.S. Environmental Protection Agency, Developing the Next Generation of the U.S. EPA's 33/50 Program: A Pollution Prevention Research Project (Helen Clark ed. 1996), that ''[o]ne of the most significant findings of our study was the identification of a potentially more positive response from some companies for a pollution prevention program sponsored by the company's trade association.''

[36] Proofs of propositions 1 and 2 are straightforward but tedious; they are available upon request from the authors.

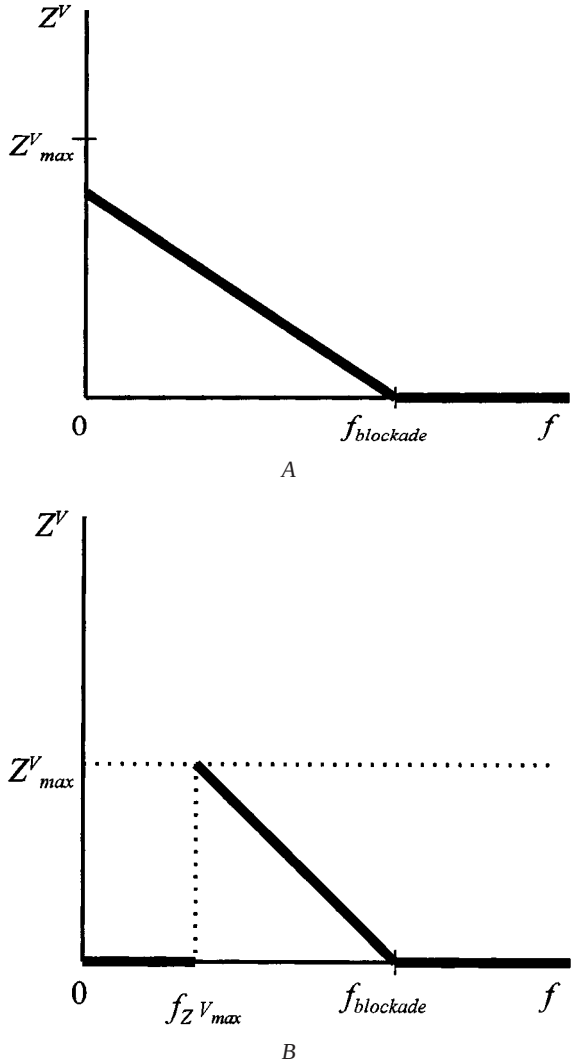


FIGURE 3.—*A*, Optimal voluntary abatement $Z^V$ if preemption is profitable, even when consumer fixed costs $f$ are zero; *B*, Optimal voluntary abatement $Z^V$ if preemption is unprofitable when consumer fixed costs $f$ are zero.

The basic intuition of the proposition is simple: political costs drive a wedge between the consumer utility of voluntary abatement and mandatory abatement, and firms can take advantage of this wedge to preempt regulation. The relationship between the industry's optimal choice of $Z^V$ and the level of fixed costs faced by consumers is illustrated in Figures 3*A* and 3*B*.

The term $Z^{V}_{max}$ is the maximum voluntary abatement level for which successful preemption is more profitable than choosing $Z^{V} = 0$ and fighting the influence game. There is a corresponding level of consumer fixed costs such that $Z^{V}_{max}$ is just sufficient to preempt; we denote this level by $f_{Z^{V}_{max}}$. For organizing costs above $f_{Z^{V}_{max}}$, preemption is always profitable, and the requisite level of voluntary abatement declines with $f$. Of course, if fixed costs are large enough, that is, $f \geq f_{blockade}$, consumers will decide not to lobby even if $Z^{V} = 0$; in this case we say that entry is blockaded.

Whether $f_{Z^{V}_{max}} > 0$ is ambiguous in general. The two parts of Figure 3 represent two possible patterns for low levels of consumer fixed organizing costs.[37] In Figure 3*A*, the bold line depicts voluntary abatement for the case when $f_{Z^{V}_{max}} \leq 0$, in which case the level of voluntary abatement declines monotonically from the level it takes on when $f(N^{c}) = 0$. In Figure 3*B*, $f_{Z^{V}_{max}} > 0$, so it is unprofitable to preempt when consumer fixed costs are zero; in this case the bold line shows that no voluntary abatement is observed unless $f \geq f_{Z^{V}_{max}}$. In this latter case, there is a sharp drop in voluntary abatement if consumer fixed costs fall below $f_{Z^{V}_{max}}$.

It is important to emphasize that, in general, consumer fixed costs are not necessary for preemption to occur. Whether preemption is profitable at $f(N^{c}) = 0$ (and hence which of the foregoing cases applies) depends on the magnitude of equilibrium consumer influence costs $m^{e}(Z^{V})$: if these are high enough, then preemption can be profitable even if consumers' fixed organizing costs are zero. These influence costs, in turn, depend on the curvature of the profit and utility functions. Consumer expenditures on influence tend to be high when $U_Z$ is large and/or $U_{ZZ}$ is small, since then the marginal consumer benefit of further abatement is high and declines slowly. Consumer lobbying costs also tend to be high when $\pi_Z$ and/or $\pi_{ZZ}$ is large, since in this case abatement rapidly becomes very costly to the firms, and they will fight hard to avoid mandatory abatement. In any event, as long as organizing costs are above $f_{Z^{V}_{max}}$, voluntary abatement declines with $f$.

While firms may be able to preempt collusively, it is not obvious that preemption is possible when firms must select voluntary abatement levels noncooperatively. The following proposition addresses this issue. While a continuum of asymmetric preemption equilibria exist, we choose to focus on symmetric equilibria for simplicity and clarity.

PROPOSITION 2. Symmetric preemption by a noncooperative oligopoly is possible for $f(N^{c}) \in [f_{Z^{V}_{NC}}, f_{blockade}]$, where $f_{Z^{V}_{NC}} > f_{Z^{V}_{max}}$.

When the firms cannot coordinate on voluntary abatement, free riding occurs. At the collusive level of voluntary abatement, any given firm prefers to eschew voluntary abatement and allow the influence game to occur. By

[37] Numerical examples show that either case can easily occur.

so doing, it enjoys at no cost the reduced level of mandatory abatement made possible by its rivals' voluntary abatement activities. In addition, it gains a cost advantage relative to its rivals because it does not undertake the (costly) voluntary action. As a result, the collusive level of voluntary abatement cannot be sustained as a noncooperative equilibrium. Nevertheless, the threat of mandatory abatement in the second stage of the game will still support an equilibrium with some degree of noncooperative preemption. The key point is that for small enough voluntary abatement levels, firm $i$ is willing to match or exceed the levels undertaken by the other firms, since its action is pivotal to preempting regulation. Thus preemption will still occur for large consumer fixed costs, but there are some lower levels of $f(N^c)$ for which preemption would have occurred collusively but not noncooperatively, that is, $f_{Z_{NC}^V} > f_{Z_{max}^V}$.

Our results in proposition 2 contrast sharply with those of Richard Gilbert and Xavier Vives and Shabtai Donnenfeld and Shlomo Weber,[38] who find that oligopolies have incentives to provide excessive levels of output or quality when engaging in entry deterrence. The key difference is that in those models, firms derive private benefits from contributing to the ''public good'' of entry deterrence, while in our model contributions carry private costs but not private benefits.

One might think that as the number of firms, $N^f$, increases, growing free-rider problems would make preemption more difficult. In our model, however, whether preemption occurs depends upon two factors: (1) the firms' ability to coordinate sufficient voluntary abatement (''supply'') and (2) the level of voluntary abatement required to preempt consumer entry into the political process (''demand''). The supply of preemption falls with $N^f$, since free-rider problems plainly worsen. The demand for preemption, however, depends on the mandatory abatement level determined in the influence game, which is a function of aggregate lobbying activity and may either rise or fall with the number of firms. With respect to the firms' pressure activities, for example, Peltzman[39] shows that firms' aggregate influence rises and eventually falls as the number of firms grows, but one cannot predict in general whether an additional group member strengthens or weakens the group's ability to apply political pressure. Thus, there is no theoretical presumption that voluntary abatement is more likely in industries with only a handful of producers. Interestingly, the empirical work of Arora and Cason[40] finds that voluntary abatement is actually more likely to occur in unconcentrated industries.

[38] Gilbert & Vives, *supra* note 22; Donnenfeld & Weber, *supra* note 22.

[39] Peltzman, *supra* note 12.

[40] Arora & Cason, *supra* note 17.

To sum up, the results of this section identify conditions under which firms can profitably preempt, taking advantage of the wedge that lobbying and organization costs drive between voluntary and mandatory abatement. Lobbying costs alone may not be enough to support preemption, and thus a strictly positive level of fixed organizing costs may be required for preemption to be profitable. In either case, once preemption becomes profitable, the equilibrium level of voluntary abatement declines monotonically with consumer organizing costs. The threshold level of consumer organizing costs at which preemption becomes profitable is higher when firms act noncooperatively than when they coordinate on voluntary abatement.

## IV. Welfare Implications

In this section, we assess welfare from two perspectives. First, we establish a benchmark for the socially optimal amount of pollution control and compare it against the outcome of the influence game; we then examine whether self-regulation results in a move toward the social optimum. Second, we examine the more limited, but perhaps more important, question of whether voluntary pollution control Pareto dominates the outcome of the influence process when there is no voluntary abatement.

A welfare-maximizing social regulator would choose $Z$ to maximize

$$N^{\mathrm{f}}\pi^{\mathrm{N}}(Z) + N^{\mathrm{c}}U^{\mathrm{N}}(Z), \tag{8}$$

yielding

$$\frac{\pi_Z^{\mathrm{N}}}{U_Z^{\mathrm{N}}} = -\frac{N^{\mathrm{c}}}{N^{\mathrm{f}}}. \tag{9}$$

On the other hand, equations (4) and (6) imply that the equilibrium of the influence game is characterized by[41]

$$\frac{\pi_Z^{\mathrm{N}}}{U_Z^{\mathrm{N}}} = \frac{Z_m}{Z_l}. \tag{10}$$

The social optimum, given by (9), differs in two ways from the equilibrium of the influence game. First, the welfare maximum weights firms and consumers equally. As a result, equation (9) does not include the relative impact of lobbying expenditures, unlike the equilibrium result shown in (10). Because the effectiveness of lobbying is subject to diminishing returns, the group that spends more on lobbying will be worse off in the influence game than in the welfare maximum. Second, the welfare maximum reflects the

[41] Recall that $Z_l < 0$, so the right-hand side of (10) is negative.

relative number of firms and consumers (as can be seen in the right-hand side of (9)), but the equilibrium result does not.[42] The reason for the second difference is that the influence game reflects our assumption that all players make their influence decisions noncooperatively. Thus, each consumer or firm equates the last dollar of lobbying expenditures to his own individual marginal benefit from a change in the level of abatement. The effects of that marginal expenditure on other parties are ignored, however, so free-rider effects distort the equilibrium away from the welfare maximum. Free-rider problems increase with the number of members in an interest group, so relative to the welfare maximum, the influence game is biased toward the group with the smaller number of members.

It is important to note that both effects—diminishing returns to lobbying and free-rider problems—work against consumer interests. We focus on the case where without voluntary abatement, consumer involvement leads to some pollution regulation; that is, consumers in the aggregate devote more resources to lobbying than do firms. Because of diminishing returns to lobbying, the influence game is worse for consumers than the welfare maximum is. In addition, we assume there are more consumers than firms, so consumers face worse free-rider problems, further reducing consumer welfare in the influence game. We state the foregoing observations as proposition 3.[43]

PROPOSITION 3. If an industry has more consumers than firms, and will in equilibrium face some regulatory requirements for pollution control, the political influence game generates less abatement than is socially optimal.

It is indeterminate in general whether self-regulation moves the level of pollution control closer to the socially optimal level. Proposition 1 guarantees the existence of a preemptive level of abatement if $f(N^c)$ is large enough. As $f(N^c)$ tends toward $f_{\text{blockade}}$, this preemptive level goes to zero and consequently will be lower than the total abatement that would result from the influence game alone. Conversely, when $f(N^c)$ is low, firms may self-regulate to a level beyond what would result from the influence game in order to economize on lobbying costs.

A more meaningful question, however, is whether voluntary abatement improves welfare beyond what it would have been with no voluntary abate-

[42] Of course, the number of firms and consumers still affects the equilibrium of the influence game through the left-hand side of (10), as discussed above.

[43] In a model of multiple interest groups, one might wonder if environmentalists could impose regulations more stringent than socially optimal. This is unlikely in our interest group model, however. Assuming that there are more environmentalists than corporations, environmentalists would still suffer greater free-rider problems than firms. Furthermore, consumers who do not care about the environment would side with firms, strengthening firms in the influence game. Thus, the conditions that give rise to proposition 3 would continue to hold.

ment. In order to address this question, we first establish a lemma that will provide a sufficient condition for the welfare effects of self-regulation to be positive. The key requirement is that positive or negative ''complementarities'' between the influence inputs of the two groups (as measured by the magnitude of $Z_{ml}$) are not too great. As Becker points out,[44] there is no a priori rationale for either a positive or negative sign on these complementarities, and we take no position as to their sign, simply considering limits on their magnitude.

LEMMA. There exists $\varepsilon > 0$ such that if $|Z_{ml}| < \varepsilon \ \forall \ (m, l)$, then as $Z^V$ increases, $Z(Z^V)$ rises, $m^e(Z^V)$ falls, and $l^e(Z^V)$ rises.

As we noted in Section II, voluntary abatement shifts the reaction curves of consumers and firms in the influence game, making consumers ''soft'' and firms ''tough.'' The lemma provides a simple sufficient condition under which the direct effects of voluntary abatement on each interest group's lobbying expenditures (holding the rival's expenditures constant) are greater than the strategic effects (mediated through a change in the rival's expenditures). When the conditions of the lemma hold, it is straightforward to show that voluntary abatement raises consumer welfare, relative to the case where firms undertake no voluntary abatement.

PROPOSITION 4. If preemption occurs, and the conditions of the lemma hold, then both consumer welfare and profits are increased, relative to their levels were government regulation imposed in the absence of voluntary abatement.

If the industry chooses to preempt, then preemption must be profitable. It is less obvious that consumers are better off; it is not enough simply to show that consumers are better off at $Z = Z^V$ than at $Z = 0$. It is necessary to establish that consumers are better off than they would have been *if no voluntary abatement had taken place and they had lobbied for standards* $Z(0)$ that might have been stricter than $Z^V$. The argument proceeds in two steps. First, observe that as long as consumers enter the influence game, they are always better off when firms have engaged in voluntary abatement. This is so because total abatement increases with $Z^V$ and consumers' lobbying expenditures decrease with $Z^V$, as shown in the lemma. Together the two effects must raise consumer welfare. Second, observe that if the firm preempts, it chooses a voluntary abatement level $Z^V$ such that consumers are just indifferent between entering the influence game to obtain $Z(Z^V)$ and avoiding the influence game altogether. However, the preceding point shows that consumers prefer the influence game with $Z^V > 0$ to the influence game with $Z^V = 0$. Thus, if consumers allow themselves to be pre-

[44] Becker, *supra* note 10, at 376.

empted by some $Z^V > 0$, they must be better off than they would have been had they fought to impose standards on an industry with no voluntary abatement.

Proposition 4 has two main policy implications. First, it supports allowing industry to coordinate on a choice of pollution limits, as long as the strategic effect of self-regulation on consumers' lobbying effectiveness is not too great. As proposition 2 indicates, in some situations firms acting noncooperatively will choose not to engage in voluntary abatement but would do so if they could coordinate their actions. Proposition 4 shows that welfare would be enhanced by such coordination, as long as $Z_{ml}$ is not too large. In this context, antitrust prosecution of ''collusion'' will reduce welfare. It is worth noting that as part of the 33/50 Program, the EPA has convened several conferences on voluntary abatement that ''promoted collaborative action and partnerships among the conference participants.''[45]

Previous work suggests that cooperative pollution control activity by industry does not always have a benign effect. For example, Steve Hackett[46] finds that research and development by industry members to reduce the cost of more stringent pollution abatement technology may be motivated by the opportunity for successful innovating firms to lobby for more stringent industrial regulation and thus raise their rivals' costs. Anticipating this, industry members can organize a pollution control research joint venture to slow the pace of innovation in lower cost pollution abatement technology. In fact, as discussed in detail by George Bittlingmayer,[47] the Department of Justice successfully prosecuted a consent decree with the Automobile Manufacturer's Association for using a research joint venture formed in the 1950s to slow the adoption of more stringent pollution control devices on automobiles. Appropriate antitrust treatment must be sophisticated if it is to distinguish between these different motivations for cooperative pollution control activities by industry.

A second implication of our analysis is that government should not necessarily subsidize consumer involvement in the regulatory process. State regulatory agencies have increasingly taken to funding branches with names like ''Division of Ratepayer Advocates'' or ''Office of Consumer Counsel'' to intervene in utility rate cases. These actions appear designed to offset the high costs to consumers of intervening in the regulatory process, and indeed

[45] See Terry Davies & Jan Mazurek, Industry Incentives for Environmental Improvement, ch. 1, at 12 (1996).

[46] Steve Hackett, Pollution-Controlling Innovation in Oligopolistic Industries: Some Comparisons between Patent Races and Research Joint Ventures, 29 J. Envt'l Econ. & Mgmt 339 (1995).

[47] George Bittlingmayer, *supra* note 34.

our analysis shows that such subsidies can shift the policy regime from one of no government regulation (because consumer organizing costs are too high) to one of preemption. Our results, however, also indicate that these efforts may unintentionally make consumers worse off by substituting government regulation for less costly industry self-regulation. The fixed cost of organizing implicitly commits consumers to an ''acceptable'' level of self-regulation beyond which they will not enter the political process. If organizing costs fall too low, this commitment may be eroded and firms may find preemption unprofitable; by proposition 4 this may make consumers worse off.

Our analysis also identifies a linkage between the effects of antitrust and regulatory policy. Granting industry the right to collude on pollution control lowers the threshold of consumer organizing costs below which self-regulation becomes unprofitable. Thus, for any given $f(N^c)$, antitrust policy allowing such cooperation reduces the danger that regulatory subsidization of consumer political action will undermine self-regulation.

## V. Toxic Chemical Releases and the Threat of Regulation

In the preceding sections, we have presented a theoretical model of self-regulation and used it to assess the welfare consequences of such voluntary corporate actions. In this section, we test empirically the main positive implication of the model, namely, that firms engage in more self-regulation when they perceive a greater threat of government regulation. To do so, we use what is to our knowledge the only existing data set on corporate self-regulation, namely, the Environmental Protection Agency's Toxic Release Inventory (TRI), which is described in more detail below. We use the TRI data on toxic chemical releases to see if firms engage in more voluntary pollution abatement in states that pose a greater threat of regulation.[48]

Our goal is to explain changes in the rate of toxic emissions over time, controlling for the underlying economic activity that generates these emissions. Toxic chemicals are of special interest because of their potentially

[48] A variety of factors may affect the rate of emissions reductions. For example, it is difficult to distinguish the potential role of technological change in making abatement less costly. There is no reason to believe that states differ in their access to new technology, however, so this factor is unlikely to explain cross-sectional variation in abatement. Another potential factor is the role of ''green'' consumers who are willing to pay a premium for environmentally friendly products. As is discussed below, however, most of the industries releasing our toxic chemicals produce intermediate products such as chemicals, plastics, or metals, which are not directly purchased by consumers and are unlikely to be greatly affected by ''green'' consumer demand. Furthermore, products produced in a given state need not be sold there, so green consumers are unlikely to have a significant effect on voluntary abatement in their home state.

important health impacts, recent improvements in the availability of public data on toxic releases, and the threat of both federal and state regulation. Starting in 1987, the Environmental Protection Agency (EPA) stepped up its collection of toxics data as a result of Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA). This law mandates that companies report releases of over 400 different toxic chemicals, many of which are otherwise unregulated. It applies to all manufacturing facilities that have 10 or more employees and that manufacture or process more than 25,000 pounds or use more than 10,000 pounds of any of the reportable chemicals. The EPA makes this information available to the public through the TRI. The first year for which data are available is 1987; this information was released to the public in June of 1989.

Our theory, of course, predicts that the release of the TRI would in itself significantly lower the information costs faced by consumer and environmental groups, thereby increasing the threat of regulation faced by firms and increasing the incentives for self-regulation. In fact, there have been massive cuts in emissions since 1987, ranging from 38 to 51 percent for different classes of chemicals,[49] although it is impossible to determine the role of the TRI in stimulating these reductions since data were not available before its release. James Hamilton[50] did find that the stock value of firms reporting TRI releases fell by $4.1 million on the day the pollution data were first released. Furthermore, Shameek Konar and Mark Cohen[51] found that firms that faced the largest stock price decline upon the initial release of the TRI to the public subsequently reduced their emissions more than their industry peers. These findings are consistent with the notion that the TRI reduced information costs and increased the threat of regulation, although the authors of these papers do not attempt to establish the chain of causation that links stock value to environmental performance.

Our empirical analysis focuses on reductions over the period 1988–92 in total toxicity-weighted releases of 17 key toxic chemicals per producer price index (PPI)-deflated dollar value of shipments.[52] Emissions of the

[49] Davies & Mazurek, *supra* note 45, at 15.

[50] James T. Hamilton, Pollution as News: Media and Stock Market Reactions to the Toxics Release Inventory Data, 28 J. Envt'l Econ. & Mgmt. 98 (1995).

[51] Shameek Konar & Mark A. Cohen, Information as Regulation: The Effect of Community Right to Know Laws on Toxic Emissions, 32 J. Envt'l Econ. & Mgmt. 109 (1997).

[52] In February 1991, the EPA announced the 33/50 Program, a voluntary scheme designed to induce firms to cut their emissions of 17 key toxic chemicals 33 percent by 1992 and 50 percent by 1995, relative to a 1988 baseline, by providing some favorable publicity and some limited technical assistance. The EPA has been criticized for the program's weak incentives (there are no penalties for failure to participate or failure to achieve the stated

TABLE 1

17 KEY TOXIC CHEMICALS

| | NONCANCER RISK VALUE[a] | |
|---|---|---|
| | Inhalation ($\mu g/m^3$) | Ingestion (mg/kg/day) |
| 1,1,1-Trichloroethane | 1,000 | .5 |
| Benzene | 60 | N.A. |
| Cadmium | .01 | .0005 |
| Carbon tetrachloride | 40 | .0007 |
| Chloroform | 300 | .01 |
| Chromium | N.A. | .005 |
| Cyanide | N.A. | .02 |
| Dichloromethane | 300 | .06 |
| Lead | .15 | .0000785 |
| Mercury | .3 | .0003 |
| Methyl ethyl ketone | 1,000 | .6 |
| Methyl isobutyl ketone | 80 | .08 |
| Nickel | .05 | .02 |
| Tetrachloroethylene | 40 | .01 |
| Toluene | 400 | .2 |
| Trichloroethylene | 600 | N.A. |
| Xylene (mixed isomers) | 200 | 2 |

NOTE.—N.A. = not available.

[a] These measures provide a standardized estimate of the amount of a given substance that must be inhaled or ingested in order to produce a given risk of harmful health effects.

toxic chemicals we study are currently legal, but these chemicals have been identified by the EPA as ''high priority'' chemicals. These chemicals are listed in Table 1, along with information on their relative toxicities. Some but not all of the chemicals have been identified as potential carcinogens, so in order to standardize our risk measure across chemicals, we have focused on noncancer risks from inhalation and ingestion.[53]

To control for the important link between production and pollution, we

goals) and for overstating its results. Nevertheless, the existence of the program may have signaled an increased threat of federal regulation for these chemicals: emissions of the 33/50 chemicals fell 42 percent from 1991 to 1994, while emissions of all other TRI chemicals fell only 22 percent. For an overview of the performance of the 33/50 Program, see Davies & Mazurek, *supra* note 45.

[53] Risk assessment data are taken from www.scorecard.org, a website on toxic chemical emissions maintained by the Environmental Defense Fund. To create our toxicity weighting, we divided each chemical's risk value by the average risk value for all 17 toxic chemicals for both inhalation and ingestion. We then averaged these two normalized values across inhalation and ingestion risk. A few chemicals had a risk value for only inhalation or ingestion, but not both, in which case we simply used the one measure available.

collected data on the value of shipments for the seven two-digit manufacturing industries responsible for over 70 percent of the releases of our 17 toxic chemicals. These industries are chemicals (SIC Code 28), petroleum refining (29), rubber and plastics (30), primary metals (33), fabricated metals (34), electrical equipment (36), and transportation equipment (37). We deflated the dollar value of shipments for each industry by the industry-specific PPI generated by the Bureau of Labor Statistics. The shipments data and other data we use are summarized in Table 2.

We include a number of variables expected to shift the marginal benefits and costs of abatement and to affect consumer information and organizing costs. Our independent variables can be broken into six major categories: (1) geographic/climatic data, (2) socioeconomic data, (3) industry characteristics, (4) general business climate, (5) legal climate, and (6) state attitudes toward the environment.

We include three control variables that characterize the geographic and climatic situation in each state: water area, mean elevation, and average July temperature; we also include land area indirectly through a variable measuring population density per square mile. We have no strong prior hypotheses regarding the effects of the first three variables but include them because they may cause states to vary in their vulnerability to emissions of pollutants.[54] For example, states with large surface water areas may face greater health threats from water-borne toxic emissions, but alternatively they might also be able to absorb greater levels of toxic emissions without health dangers; hence we simply include the variable as a control. With regard to population density, however, we do have a clear hypothesis: we expect that the pressure to reduce toxic emissions is greater in densely populated states, since the potential harm from toxic emissions is higher there.

We include a number of socioeconomic variables in addition to population density. We use per capita income and educational attainment (percentage of residents with college degrees or higher), expecting both variables to increase the demand for pollution abatement. In addition, we collected data on the number of members in the Sierra Club and the Natural Resources Defense Council per capita in each state. Higher levels of this variable are expected to increase the pressure for pollution abatement, since environmental group members presumably place high marginal values on abatement, in addition to having an existing organizational structure that lowers the fixed costs of organizing to press for toxics regulation. We also construct an interaction term equal to the product of the state's initial emis-

[54] Vernon J. Henderson, State Attitudes towards Air Quality Regulation (1994), finds that states with large land areas and low mean elevations incur greater expenditures on pollution abatement.

TABLE 2

SUMMARY STATISTICS

| Variable | Definition | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| Tox/Value 1988 | Toxicity-weighted pounds of 17 toxic chemicals released per $1,000 of shipments (deflated) from seven key manufacturing industries in 1988 | 151.647 | 485.827 | .786 | 3,031.53 |
| Tox/Value 92–88 | Change in Tox/Value from 1988 to 1992 | −43.697 | 258.093 | −1,425.69 | 933.939 |
| Population Density | Population per square mile average for 1988 to 1992 | .166 | .233 | .001 | 1.042 |
| Water Area | Surface water area of state in square miles | 5,039 | 13,027 | 145 | 86,051 |
| Mean Elevation | Mean elevation of state in feet | 543.1 | 552 | 18 | 2,074 |
| Temperature | July daily maximum temperature | 86.154 | 6.164 | 62.7 | 105.9 |
| Greens/Capita | Members of NRDC and Sierra Club per thousand state residents, averaged over 1988–92 | 2.233 | 1.318 | .494 | 7.11 |
| Income | State income per capita in $1987 averaged over 1988–92 | 13,947 | 2,244.5 | 9,972 | 20,158.8 |
| Education | Percentage of state population with a bachelor's degree or higher in 1990 | 19.754 | 3.71 | 12.3 | 27.2 |
| LCV 1985–90 | League of Conservation Voters' rating of state's congressional delegation over 1985–90 | 50.718 | 18.301 | 9.9 | 90.4 |
| Policy Initiatives | Institute for Southern Studies' index of state performance on 67 policies | 44.76 | 14.4 | 23.1 | 77.4 |
| Spending on Air Quality | Per capita spending in fiscal 1988 for state programs to administer clean air laws | 1.113 | .741 | .26 | 3.87 |
| Strict | = 1 if state imposed strict liability for toxic waste cleanup in 1991 or before | .72 | .45 | 0 | 1 |
| Lawyers per Capita | Number of lawyers per thousand population in 1990 | 2.646 | .874 | 0 | 1 |
| Right to Work | = 1 if state has a right-to-work law | .42 | .496 | 0 | 1 |
| Plants | Number of plants emitting our 17 selected toxic chemicals in 1988 | 261.35 | 263.461 | 5 | 1,049 |
| Shipments | Real value of shipments from seven key manufacturing industries ($millions) | 26.5 | 33.9 | .156 | 147 |

sions per unit shipment level in 1988 and its environmental group membership per capita. Our expectation is that initially dirty states with high environmental group membership will face strong political pressures to reduce emissions.

Several variables capturing industry characteristics in each state are included. We include the real value of manufacturing shipments from our seven key industries as a control variable, but without a clear sign prediction. On the one hand, high shipments indicate an industry that may have considerable political power that it can use to resist regulatory threats. On the other hand, high shipments may mean that industry is viewed as having ''deep pockets'' that can be tapped through additional regulatory requirements or through lawsuits or just that industry can better afford investments in voluntary pollution abatement. Another included variable is the number of plants emitting our 17 key toxic chemicals, as a measure of the coordination problem facing industry in a given state. While we also gathered data on the number of firms emitting these chemicals, the two measures have a correlation coefficient of 98.4 percent, so we decided not to include both measures. Since coordination issues within a firm presumably increase with the number of plants the firm operates, we chose to use the former measure. We also include as an independent variable the toxicity-weighted emissions in each state in 1988. If we assume that the marginal cost of abatement is increasing, currently dirty states should have relatively low marginal costs of abatement, so these states should find emissions reduction easier than do other states.

The variables described thus far provide a set of ''shifters'' that strengthen or weaken the latent political pressure for corporations to self-regulate. Each of these variables affects the marginal benefits of abatement to state residents, the marginal costs of abatement to firms, or the information and organization costs faced by state residents who wish to pressure corporations to reduce their toxic emissions. If these variables prove significant, this supports our thesis that the threat of interest group action can drive firms to self-regulate. It is also of interest, however, to understand exactly how these interest group pressures are transmitted to firms. States differ substantially in terms of their overall business climate, the legal precedents they operate under, and their propensity to pass environmental regulations. The next three sets of variables we introduce attempt to capture these three types of state characteristics, so as to gain insight into the mechanisms through which latent political pressure is transmitted. For example, environmentalists may impose new state regulations on toxic emissions, or they may sue a company for liability under the federal Comprehensive Environmental Response, Compensation and Liabil-

ity Act (CERCLA), under state versions of CERCLA, or under common law.[55]

To characterize a state's overall business climate, we follow Thomas Holmes[56] and use the presence or absence of a ''right-to-work'' law as indicative of how favorable a state is as a business location.[57] We expect probusiness states (those with a right-to-work law) to pose less of a threat of government regulation and hence to observe less corporate self-regulation.

A state's legal climate is characterized here by two variables. First, we use 1990 census data on the number of lawyers per capita as a measure of the overall threat of litigation in a given state. Second, we include a dummy variable indicating whether a state has a law imposing strict liability in toxic waste cleanup cases.[58] By creating legal precedents requiring polluters to bear pollution damages, such laws encourage legal action against polluters and should encourage firms to handle toxic substances with greater care. If either of these variables is significant in the regressions to follow, this supports the hypothesis that at least a portion of interest group pressure is transmitted through the threat of litigation, not just through the threat of direct regulation.

We also include four measures of a state's political climate with specific reference to environmental issues: (1) the League of Conservation Voters rating for the state's congressional delegation over the period 1985–90, (2) a composite index of state policy initiatives compiled by the Institute for Southern Studies, (3) a measure of state and local funds spent on air quality management in fiscal year 1988, and (4) a variable indicating whether a state had a law as of 1991 promoting cuts in toxic chemical production at its source (even though these laws do not require facility plans or detailed reporting).[59] Each of these variables provides additional insight into a given state's propensity to support measures protecting the environment.

[55] According to Gerald W. Boston & M. Stuart Madden, Law of Environmental and Toxic Torts: Cases, Materials and Problems (1994), the most frequently used theories of legal liability in environmental and toxic torts cases are nuisance, trespass, negligence, strict liability for abnormally dangerous activities, and statutory strict liability.

[56] Thomas J. Holmes, The Effect of State Policies on the Location of Manufacturing: Evidence from State Borders, 106 J. Pol. Econ. 667 (1998).

[57] These laws ensure nonunion employees the right to work at companies within the state, thus reducing the bargaining power of unions.

[58] For a presentation of an interesting empirical analysis of states' hazardous waste liability regimes, see Anna Alberini & David Austin, On and Off the Liability Bandwagon: Explaining State Adoptions of Strict Liability in Hazardous Waste Programs, 15 J. Reg. Econ. 41 (1999).

[59] These last four measures are from Bob Hall & Mary Lee Kerr, 1991–92 Green Index: A State-by-State Guide to the Nation's Environmental Health (1991).

Inspection of the data reveals Montana to be a clear outlier, with far higher emissions per unit of shipments in 1988 than any other state. Even more striking, Montana shows a sharp increase in emissions per unit shipments over time that is unique among the 50 states. Recall that our theoretical analysis shows that consumers may effectively be blockaded from the political process when their costs of producing political pressure are too high. The data suggest that Montana is such a state, apparently immune from the pressures present in the rest of the United States. Given these concerns, we include a dummy variable for Montana to account for its unique status.

Our regression analyses of toxic releases per value of shipments are presented in Table 3. The first estimation includes all the variables discussed above. It explains 98 percent of the variation in toxic reductions across states. Heteroscedasticity is controlled for by using White-corrected standard errors. Although many of the variables in the regression are not statistically significant, several provide insight into the forces behind voluntary abatement of toxic emissions. Two of the geographic/climatic variables prove significant. States with greater water areas reduced toxic emissions less rapidly over time, as did states with higher average July temperatures.

Turning to the socioeconomic variables, we find that higher population density is associated with greater voluntary abatement, although the relationship is not statistically significant. Similarly, high-income states saw greater abatement, but again the relationship was statistically insignificant. In fact, only one of the socioeconomic variables proved significant, namely, the interaction between initial emissions level and environmental group membership. Its coefficient is negative and significant at the .005 percent level. As expected, initially dirty states with large environmental memberships experience substantial pressure to reduce emissions. This provides strong evidence that the political salience of initial emissions levels depends critically on the strength of state environmental group membership.

Two variables indicating industry characteristics produced interesting results. States with a greater number of plants in our seven selected industries engaged in significantly less abatement, consistent with the hypothesis that coordination and free-rider problems become worse as the number of facilities to be coordinated rises. In addition, states with a higher level of manufacturing shipments—controlling for the number of plants—reduced emissions faster. This suggests that states where firms have ‘‘deep pockets’’ face a greater threat of more stringent policies toward toxic emissions or are simply better able to afford abatement.

To a substantial extent, the structural variables that shift the costs and benefits of self-regulation enter the regression as expected, supporting our basic model of preemptive self-regulation. Our attempt to determine the

TABLE 3

REDUCTIONS IN TOXIC EMISSIONS/VALUE OF SHIPMENTS: 1988–92

| Variable | (1) | (2) |
|---|---|---|
| MT dummy | 2,941.751** | 2,917.615** |
| | (21.415) | (47.493) |
| Water Area | .00129+ | .00102 |
| | (1.824) | (1.643) |
| Mean Elevation | .00127 | |
| | (.114) | |
| Temperature | 5.4107+ | 4.9466+ |
| | (1.827) | (1.679) |
| Population Density | −.7561 | |
| | (−.039) | |
| Income | −.0029 | |
| | (−.657) | |
| Greens/Capita | 11.4223 | 12.0738* |
| | (1.504) | (2.334) |
| Education | .0447 | |
| | (.018) | |
| Greens × (Tox/Value 1988) | −.2783** | −.2847** |
| | (−6.974) | (−31.983) |
| Number of Plants | .0577+ | .05669+ |
| | (1.782) | (1.711) |
| Shipments | −.634* | −.613* |
| | (−2.255) | (−2.062) |
| Tox/Value 1988 | −.0224 | |
| | (−.171) | |
| Right to Work | 9.8227 | 5.7535 |
| | (.938) | (.550) |
| Strict Liability | 7.9086 | 9.600 |
| | (.937) | (1.104) |
| Lawyers per Capita | 1.5183 | |
| | (.234) | |
| LCV 1985–90 | .2647 | |
| | (.717) | |
| Policy Initiatives | .3332 | |
| | (.898) | |
| Spending on Air Quality | 8.9101 | 6.3541 |
| | (1.362) | (1.110) |
| Toxic Cuts Dummy | −2.5369 | |
| | (−.317) | |
| Constant | −504.7815+ | −470.1004+ |
| | (−1.868) | (−1.745) |
| Observations | 50 | 50 |
| Adjusted $R^2$ | .9791 | .9834 |

NOTE.—Values in parentheses are *t*-statistics.

+ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

precise pathways through which political pressure is exerted fared less well. Our measure of overall business climate has a positive coefficient, indicating that states with pro-business attitudes (as proxied by the presence of a right-to-work law) saw less voluntary pollution abatement. The result was not statistically significant, however. Neither of our measures of legal climate were significant, nor were the measures of state policies toward the environment.

We have a small sample, and some of our explanatory variables are highly correlated with one another. It is thus possible that some economically significant variables are imprecisely estimated in regression (1) and appear statistically insignificant. Hence, we present in estimation (2) the results of sequentially eliminating the least significant independent variables in each category of explanatory variables. The results are largely unchanged from those in estimation (1). One difference is that the number of environmental group members per capita becomes significant. Note that two steps are needed to interpret the effect of environmental group membership when both this term and the interaction term are taken into account, since the marginal effect of more environmental group members enters the regression through both terms. Using estimation (2), we see that the marginal impact on abatement of an increase in membership is now equal to (12.0738 − .2847 × Tox/Value 1988). The sample mean of toxic releases/value in 1988 was 151.647 pounds of toxicity-weighted chemicals per thousand dollars of shipments. Evaluated at this level, an increase in state environmental group membership of one member per thousand state residents reduced the level of toxic emissions by 31.1 toxicity-weighted pounds per thousand dollars of shipments.[60]

Overall, then, we identify three main factors that explain toxic reductions over time. First, and most important, is the presence of strong environmental group membership in a state with high emissions levels. In this situation, firms have relatively low marginal abatement costs, consumers value abatement highly, and consumer organizing costs are low. The threat of mandatory regulation is high while the cost of self-regulation is low, so it makes good political-economic sense for firms to engage in voluntary emissions reductions. Second, states with a smaller number of plants enjoy greater levels of voluntary emissions reduction; in these states, firms are better able

[60] We also performed a regression, not presented here, that included a variable interacting the presence of a right-to-work law with the initial level of toxicity-weighted emissions per value of shipments; this variable was intended to parallel our other interaction variable. The results confirm that states with pro-business attitudes engage in less voluntary pollution abatement and that states with larger environmental group membership show more voluntary abatement.

to overcome free-rider problems. Third, states with higher values of manufacturing shipments enjoy greater voluntary abatement.

Our results indicate that latent political pressure does indeed encourage firms to undertake voluntary self-regulating actions and that firms are more responsive to such pressures when the costs of coordination are low. We are unable to shed much light on the precise mechanisms by which pressure is transmitted, however. All measures of state political climate—including measures of overall business climate, legal climate, and the state's propensity for environmental regulation—were statistically insignificant. Given the complex nature of the political environment, and the limited power of a pure cross-sectional analysis of the 50 states, this is perhaps not surprising. Future research exploring exactly how environmental groups create political threats would be a valuable contribution.

## V. Conclusions and Extensions

We have developed a model in which firms can use self-regulation to preempt government-imposed regulations. When it is costly for consumers to organize and to influence the political process, firms can match the net utility consumers expect from regulatory controls with a lower level of voluntary controls and can thereby deter consumer groups from mobilizing to enter the political process. As the threat of regulation grows, for example, because of reductions in consumers' informational and organizational costs, self-regulation becomes more stringent. Furthermore, our theory shows that firms cannot use self-regulation to undermine consumers' threat of imposing mandatory regulations; as a result, when self-regulation preempts government action, both firms and consumers are better off.

Evidence on recent reductions in toxic chemical emissions is consistent with the positive predictions of our thesis. When Congress reauthorized Superfund in 1986, Title III of the legislation required companies to report their emissions of over 300 toxic chemicals, thereby dramatically lowering consumer information costs. In our framework, after this data began to be collected, total releases of toxic chemicals should have dropped significantly. This hypothesis cannot be tested directly, since the data were not collected prior to the passage of the law, but the massive cuts in emissions since 1987 (ranging from 38 to 51 percent for different classes of chemicals) are certainly consistent with our model's predictions. Furthermore, the EPA's voluntary 33/50 Program, initiated in 1991, may have signaled a greater threat of federal regulation for the 17 chemicals it encompasses (which are also the ones we examine here); emissions of these 17 chemicals fell 42 percent from 1991 to 1994, while emissions of the other TRI chemicals fell by 22 percent, further suggesting that the threat of regulation mat-

ters. Finally, we use the new data on toxic releases to examine how state-level variation in the threat of regulation affects incentives for voluntary abatement. Our most striking finding is that states with high initial emissions levels along with strong environmental group membership generate more voluntary pollution abatement. In these states, firms have relatively low marginal abatement costs and face consumers who highly value marginal improvements in environmental quality and are already well-organized to apply political pressure. The cost of self-regulation is low while the threat of government regulation is high, so voluntary abatement is a sound business decision.

There are many potentially interesting extensions of our model. For example, if firms sink investment in a technology with an upper limit on pollution control capability, then they must scrap that technology and adopt a new one if standards exceed the current technology's limit. Stiffer standards would thus be highly costly, and preemption would be more likely when such a technology is used. Allowing for asymmetric firms and for voting behavior would also be interesting extensions of the model, as would research on whether alternative forms of threatened regulations are equally attractive targets for preemption. For example, a threatened pollution tax might elicit more voluntary abatement than a threatened system of tradeable permits, especially if the latter involved grandfathering provisions protecting existing firms.

Another promising direction is a marriage of our interest group model with a vertical product differentiation model, in which voluntary abatement attracts customers willing to pay a premium for environmentally friendly products. Stefan Lutz, Thomas Lyon, and John Maxwell[61] study a vertical differentiation model with minimum quality standards set by a welfare-maximizing regulator. Combining their framework with our political economic analysis should allow for a rich set of results.

## APPENDIX

*Proof of Lemma.* Note first that

$$\frac{dm^{e}}{dZ^{V}} = \left(\frac{\partial m^{*}}{\partial l}\frac{\partial l^{*}}{\partial Z^{V}} + \frac{\partial m^{*}}{\partial Z^{V}}\right)\Bigg/\left(1 - \frac{\partial m^{*}}{\partial l}\frac{\partial l^{*}}{\partial m}\right)$$

and similarly that

$$\frac{dl^{e}}{dZ^{V}} = \left(\frac{\partial l^{*}}{\partial m}\frac{\partial m^{*}}{\partial Z^{V}} + \frac{\partial l^{*}}{\partial Z^{V}}\right)\Bigg/\left(1 - \frac{\partial l^{*}}{\partial m}\frac{\partial m^{*}}{\partial l}\right).$$

[61] Lutz, Lyon, & Maxwell, *supra* note 16.

These expressions show that the equilibrium change in lobbying levels as a function of $Z^V$ depends on the shift in the player's own reaction curve as well as the movement along his reaction curve caused by the shift in the rival's reaction curve. Letting $\lambda \equiv 1 - (\partial m^*/\partial l)(\partial l^*/\partial m)$, we note that $\lambda > 0$ because the reaction curves are assumed to be stable. We can now write $dm^e/dZ^V = (\theta/\lambda)(dZ/dZ^V)$ and $dl^e/dZ^V = (\phi/\lambda)(dZ/dZ^V)$ and some expansion of terms yields

$$\theta = \frac{U^I_{ml}}{U^I_{mm}} \frac{\pi^I_{ZZ} Z_l}{\pi^I_{ll}} - \frac{U^I_{ZZ} Z_m}{U^I_{mm}}$$

and

$$\phi = \frac{\pi^I_{lm}}{\pi^I_{ll}} \frac{U^I_{ZZ} Z_m}{U^I_{mm}} - \frac{\pi^I_{ZZ} Z_l}{\pi^I_{ll}}.$$

Now we can write $dZ/dZ^V = 1 + dZ^M/dZ^V = 1 + Z_m(dm^e/dZ^V) + Z_l(dl^e/dZ^V) = 1 + Z_m(\theta/\lambda)dZ/dZ^V + Z_l(\phi/\lambda)dZ/dZ^V$. Rearranging terms yields $dZ/dZ^V = 1/(1 - Z_m\theta/\lambda - Z_l\phi/\lambda)$. Thus, sufficient conditions for $dZ/dZ^V > 0$ are $\theta < 0$ and $\phi > 0$.

Next, note that $U^I_{ml} = U^I_{ZZ} Z_m Z_l + U_Z Z_{ml}$, and if $Z_{ml} = 0$, then $U^I_{ml} = U^I_{ZZ} Z_m Z_l$. Substituting this into the expression for $\theta$ and noting that $\pi^I_{ll} = \pi^I_{ZZ}(Z_l)^2 + \pi^I_Z Z_{ll}$, we obtain

$$\theta = \frac{-U^I_{ZZ} Z_m}{U^I_{mm}} \frac{\pi_Z Z_{ll}}{\pi^I_{ll}} > 0.$$

Similar reasoning yields

$$\phi = \frac{-\pi^I_{ZZ} Z_l}{\pi^I_{ll}} \frac{U^I_Z Z_{mm}}{U^I_{mm}} > 0.$$

Hence $dZ/dZ^V > 0$. Furthermore, $dm^e/dZ^V = (\theta/\lambda)(dZ/dZ^V) < 0$ and $dl^e/dZ^V = (\phi/\lambda)(dZ/dZ^V) > 0$. All the above arguments will still go through for $Z_{ml}$ of sufficiently small absolute value. Q.E.D.

*Proof of Proposition 4.*—If the firms preempt, they choose $Z^V$ so that

$$U^N(Z^V) = U^N[Z(Z^V)] - m^e(Z^V) - f(N^c).$$

Note that the lemma shows that $m^e(Z^V) < m^*(0)$ and that $Z(Z^V) > Z(0)$, so $U^N[Z(Z^V)] > U^N[Z(0)]$. Therefore

$$U^N(Z^V) = U^N[Z(Z^V)] - m^e(Z^V) - f(N^c) > U^N[Z(0)] - m^e(0) - f(N^c).$$

Q.E.D.

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