Voluntary Approaches to Environmental Protection:

The Role of Legislative Threats

by

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I. Introduction

Historically, policymakers have relied on legislative and regulatory restrictions on polluting behavior to ensure adequate protection of environmental quality. To a lesser extent, economic incentives, such as taxes, tradeable permits, and environmental liability, have been used.[1] Recently, attention has turned to the use of voluntary agreements between regulators and polluters as an alternative to mandatory approaches based on regulation or legislation. Voluntary agreements can be an attractive alternative to mandatory restrictions since they have the potential to reduce compliance costs by allowing greater flexibility and to reduce administrative and other transactions costs (Baggott, 1986; Goodin, 1986). Notable examples of the recent use of voluntary environmental protection agreements include the U.S. Environmental Protection Agency's 33/50 Program to reduce voluntarily discharges of industrial toxic pollutants (U.S. Environmental Protection Agency, 1992) and the Dutch National Environmental Policy Plan. Voluntary agreements can be categorized into two types: (1) those that induce participation by providing positive incentives such as cost-sharing or other subsidies, and (2) those that induce participation by threatening a harsher outcome (for example, legislation) if a voluntary agreement is not

[1] Economists have often advocated the use of economic incentives rather than regulation, but their prescriptions have not generally been followed. See Hahn (1989) for a survey of the use of economic incentive approaches to environmental protection.

reached. As noted by Goodin (1986), this latter type is not truly voluntary in that the firm is essentially choosing the lesser of two evils. Nonetheless, background threats of legislation appear to be behind many of the successful voluntary agreements that have been negotiated, including the 33/50 Program[2] and the Dutch National Environmental Policy Plan.[3]

Policies based on voluntary agreements have been discussed extensively in other contexts. For example, there is a large literature on the use of voluntary export restraints in trade.[4] There is also a large literature related to policies to reduce agricultural pollution, which have historically relied on voluntary participation in soil conservation and other erosion control programs such as the U.S. Conservation Reserve Program.[5] These programs are almost all of the first type in that they use cost-sharing and other financial inducements (rather than the threat of mandatory restrictions) to try to get farmers to reduce pollution voluntarily.[6]

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[2] See Arora and Cason (1995) for an empirical analysis of other factors affecting participation in the 33/50 Program.

[3] See Goodin (1986) for other examples.

[4] For a recent treatment, see Rosendorff (1996).

[5] See Braden and Lovejoy (1990) for an overview of environmental policy in the agricultural sectors of several countries.

[6] See Norton, et al. (1994) for a discussion of programs based on cost sharing. In some cases, the threat of losing eligibility for agricultural price support programs has been used as an inducement for farmers to participate. See Just and Bockstael (1991) for discussions of the interactions between agricultural price support policies and environmental quality.

Despite the recent interest in the use of voluntary agreements for environmental protection, there has been almost no economic analysis of the use of this policy instrument as compared to alternative instruments. A recent exception is Stranlund (1995), who compares the use of a voluntary compliance regime with a mandatory regime. However, in his model, which is developed primarily in the context of voluntary vs. mandatory recycling, participation in the voluntary program is induced through government cost-sharing. It is thus an example of the first type of agreement noted above.

The purpose of this paper is to provide an economic model of the use of voluntary agreements of the second type, where there is a background legislative threat. As noted above, many of the recent environmental protection agreements that have been successfully negotiated are of this type. The goal is to determine whether a voluntary agreement is likely to be the outcome of the interaction between regulators and polluters, and the role that the legislative threat plays in determining that outcome.

The paper is organized as follows. In the following section, we develop a simple economic model of the interaction between a regulator (or regulatory agency) and a single firm. Given the background legislative threat, the regulator must decide whether to seek a voluntary agreement, and, if one is sought, the firm must decide whether or not to agree to it. Section III presents a characterization of the possible equilibrium outcomes of this interaction. In Section IV, we examine how the severity of the legislative threat affects the likely outcome. Since the legislative threat provides the inducement to participate, it plays a central role in determining the outcome of the process. We then consider in Section V the implications of having multiple polluters that can be a party to the agreement. This creates

the potential for free-riding behavior, and we examine how the terms of the agreement can affect free-rider incentives. While we do not develop a complete model with multiple polluters, we do suggest the implications of extending the model in this direction. Section VI provides concluding remarks.

II. An Overview of the Model

We consider first the case where the regulator would negotiate with a single polluter or firm. (Issues regarding multiple polluters are discussed in Section V.) The regulator must first decide whether or not to offer to the firm the opportunity to enter into a voluntary agreement. Under such an agreement, the firm would "voluntarily" agree to undertake a specified level of pollution abatement, denoted a_V. The firm must then decide whether or not to accept the offer. If the firm does not accept the offer, there is a background threat that a mandatory level of abatement, denoted a_L, will be imposed legislatively. However, the possibility of legislation (even in the event that no voluntary agreement is reached) is not certain. It is assumed to occur with an exogenous and known probability p. An identical threat is assumed to exist if the regulator does not offer a voluntary alternative. In other words, if the regulator does not offer a voluntary agreement or if the firm does not accept one when it is offered, it is assumed that with probability p a mandatory level of abatement a_L will be imposed legislatively. Because we are interested in the negotiations between a regulator and a firm, we treat the legislative decision as

exogenous to the negotiating process and hence do not model it explicitly.[7] The parameter p simply captures the (exogenous) uncertainties about the outcome of the legislative process.

We assume that the benefits of abatement, given by B(a) where $B' \geq 0$, $B'' < 0$, are independent of whether the abatement level is legislatively imposed or undertaken voluntarily. However, the costs of abatement differ in the two cases. The total cost of achieving a given level of abatement are comprised of two parts: (1) the compliance costs, including, for example, the cost of pollution control equipment and any lost profits from reductions in output or changes in production processes, and (2) transactions costs, including, for example, enforcement costs, negotiating costs, and administrative costs associated with compliance. While the compliance costs are borne by the firm, both the regulator and the firm can bear transactions costs.

We assume that, for any given level of abatement, both the total and the marginal compliance costs and transactions costs for both parties are lower under the voluntary approach than under a legislative mandate. Lower compliance costs reflect the fact that voluntary agreements generally provide more flexibility (Goodin, 1986; Baggott, 1986). Transactions costs are lower under the voluntary approach because of reduced reliance on formal legal procedures and reduced conflict (Goodin, Baggott). Let $C_i(a)$ denote the compliance and transaction costs borne by the firm under option i, where i=V (voluntary)

[7] We do, however, make an assumption below about the level of a_L that the legislature would impose were it to impose a mandatory abatement level. In particular, we restrict the legislature to credible threats. See further discussion below.

or i=L (legislative). Likewise, let $T_i(a)$ be the transaction costs borne by the regulator under the two options. The above assumptions imply $C_V(a)<C_L(a)$ and $T_V(a)<T_L(a)$ for all a, and $C_V'(a)<C_L'(a)$ and $T_V'(a)<T_L'(a)$ for all a. Clearly, $TC_V(a)<TC_L(a)$ and $TC_V'(a)<TC_L'(a)$ for all a, where TC_i denotes the total social costs (C_i+T_i) under option i. For simplicity, we assume henceforth that C_i is linear in a for i=V,L, i.e., $C_i(a)=c_ia$. The implications of this assumption are noted below.

We assume that the objective of both the regulator and the legislative body is to maximize (expected) net social benefits. We thus abstract from the political economy of both regulatory and legislative decisionmaking.[8] When the objectives of the governmental bodies differ from social objectives, there is clearly an additional distortion in the policymaking process. However, since this type of distortion is not the focus of our interest here, we abstract from it. Thus, we assume that the regulator's net payoff under the voluntary approach is $NSB_V(a_V)=B(a_V)-TC_V(a_V)$. Furthermore, if a voluntary agreement is not negotiated and the legislative threat is exercised, the legislature will choose to impose the level of a_L that maximizes the net social benefits under legislation, i.e., it will choose a_L to maximize $NSB_L(a)=B(a)-TC_L(a)$. We denote this level of a_L by a_L^*, which satisfies the first-order conditions

$$B'(a_L^*) - TC_L'(a_L^*) = 0. \tag{1}$$

Given the assumption about the legislature's objective, a_L^* is the only credible threat that the legislature can make. A threat to impose any other level of a_L would not be credible since

[8] For a discussion, see Mueller (1989).

the legislature would have an incentive to deviate from the threat if it had to actually follow through on it. Thus, if legislation is imposed, it yields a net return to the regulator equal to $NSB_L(a_L^*)$. Alternatively, if legislation is not subsequently imposed (i.e., the threat is not realized), the net return to the regulator is zero. Since in the absence of a voluntary agreement legislation is imposed only with probability p, the expected net return to the regulator if a voluntary agreement is not negotiated is $pNSB_L(a_L^*)$.[9] Note that a_L^* maximizes this expression as well.

The payoffs for the firm are simply the negative of the costs they incur under the two options. If a voluntary agreement is negotiated, the firm incurs a cost of $C_V(a_V)$. Conversely, if a voluntary agreement is not negotiated, it faces a cost of either $C_L(a_L^*)$ if legislation is subsequently imposed or zero if it is not. Thus, the firm's expected cost when a voluntary agreement is not negotiated is simply $pC_L(a_L^*)$. Note that this assumes the firm will comply with the terms of the voluntary agreement or the legislative mandate. We thus abstract from the potentially important issue of non-compliance. A simple treatment of non-compliance that assumes that a firm would comply with some exogenous probability could be easily built into the model and would not change the qualitative results. Endogenizing the compliance decision would make the model more realistic but would also complicate the analysis. We leave this extension for future work.

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[9] Note that $p<1$ reflects uncertainties in the political process regarding the legislature's ability or desire to impose any legislation, rather than uncertainties about what its objective would be if it were to act. These uncertainties could reflect, for example, uncertainty about the legislative priority that would be given to this issue or uncertainty about the fixed political costs associated with mandatory restrictions.

The decision tree in Figure 1 summarizes the sequence of events as well as who the decisionmaker is at each decision node (R=regulator, L=legislature, F=firm) and the payoffs to the regulator and the firm under the possible outcomes. Since we treat the probability that legislation will be imposed as exogenous, the tree depicts two basic decisions: (1) the regulator decides whether or not to offer a voluntary agreement a_V, and (2) the firm decides whether or not to accept the agreement.

Our goal is to determine whether a voluntary agreement would emerge as the equilibrium outcome of the decision tree and to examine the characteristics of that outcome. In particular, we ask whether there exist values of a_V (i.e., offers that the regulator could make) such that the solution to the tree is that the regulator makes the offer and the firm accepts it. We solve the problem through backward induction, beginning with the decision of the firm, assuming that an offer has been made.

If the regulator offers a voluntary agreement with $a=a_V$, the firm will accept this offer if and only if the expected cost is lower (or at least no more) under the voluntary agreement than under the legislative threat, i.e., if and only if

$$C_V(a_V) \leq pC_L(a_L^*), \tag{2}$$

or, equivalently (given the assumed linearity of C_V and C_L), if and only if

$$c_V a_V \leq pc_L a_L^*. \tag{3}$$

Given exogenous values for p and the cost parameters, (3) determines a maximum value of a_V that the firm would be willing to accept, denoted a_V^{max} and defined by

$$a_V^{max} = p(c_L/c_V)a_L^*. \tag{4}$$

For any $a_V > a_V^{max}$, the firm would reject the offer since its expected costs would be lower under the legislative threat. Conversely, for any $a_V < a_V^{max}$, it is better off accepting the offer than facing the possibility of legislation. Note that the possibility that $a_V^{max} > a_L^*$ cannot be ruled out. Because costs are lower under the voluntary agreement, the firm may actually be willing to accept voluntarily an abatement level that is higher than that which might be imposed legislatively.

We now turn to the decision of the regulator under the assumption that the firm would accept an offer if it were made.[10] In this case, the regulator will propose a voluntary agreement if and only if the net social benefits under the agreement would be at least as large as the expected net social benefits if an agreement were not offered, i.e., if and only if

$$NSB_V(a_V) \geq pNSB_L(a_L^*). \tag{5}$$

This condition implicitly defines a range of a_V over which the regulator prefers the voluntary agreement. This range is depicted in Figure 2, where a_V^{min} denotes the lower bound of the range and a_o denotes the upper bound. Given $TC_L(a_L^*) > TC_V(a_L^*)$ and $TC'_L(a_L^*) > TC'_V(a_L^*)$, it follows that a_L^* lies within this range. Furthermore, a_V^* also lies in this range, where a_V^* is the level of a_V that maximizes $NSB_V(a)$ and hence solves the first-order condition

$$B'(a) - TC_V'(a) = 0. \tag{6}$$

Clearly, $a_L^* < a_V^*$ since marginal costs are higher under the legislative approach. Hence,

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[10] In the case where the firm would not accept the offer, the regulator would be indifferent between making the offer (and having it rejected) and not making it, assuming that the process of making the offer is essentially costless.

(7) $$a_V^{min} < a_L^* < a_V^* < a_o.$$

a_V^{min} denotes the minimum value of a_V that the regulator would be willing to offer. For any $a_V<a_V^{min}$, the regulator would prefer to have the legislative threat. For $a_V>a_V^{min}$ (but still less than a_o), the regulator prefers the voluntary agreement. In particular, if the regulator could get the firm to agree to a_L^* voluntarily, it would prefer to do so because of both the cost savings and the assurance that abatement will be undertaken. (Recall the legislation is not certain.) Better still, it would prefer an agreement at the level a_V^*, since implementing a_V^* voluntarily is the first-best outcome (i.e., it results in the highest possible net social benefits (see Figure 2)).

III. Equilibrium Outcomes

The above characterization of regulator and firm behavior establishes that, under optimizing behavior, a necessary and sufficient condition for the equilibrium of the game to be a voluntary agreement is that

(8) $$a_V^{min} \leq a_V^{max},$$

i.e., the minimum value of a_V the regulator is willing to offer is less than or equal to the maximum value the firm is willing to accept. Note that a voluntary agreement would never be an equilibrium outcome in the absence of the legislative threat. If p=0, any positive a_V is acceptable to the regulator but no positive value of a_V is acceptable to the firm. Hence, it is the legislative threat that creates the possibility that a voluntary agreement with $a_v>0$ will be forthcoming.

The legislative threat is also a sufficient condition for a voluntary agreement to be the equilibrium outcome. In particular, it can be shown that $a_v^{min}<a_v^{max}$, i.e., (8) holds, for all $p>0$, which establishes the following proposition.

Proposition: For any $p>0$, the equilibrium of the game is that the regulator offers a voluntary agreement and the firm accepts the offer.

Proof: Given (8), we need only show that $a_v^{min}<a_v^{max}$ for all $p>0$. To show this, note that

(9) $B(a_v^{max})-T_v(a_v^{max}) = B(p\cdot c_L/c_v\cdot a_L^*)-T_v(p\cdot c_L/c_v\cdot a_L^*)$

$> B(p\cdot a_L^*)-T_v(p\cdot a_L^*) > p\{B(a_L^*)-T_v(a_L^*)\} > p\{B(a_L^*)-T_L(a_L^*)\}.$

The first inequality follows from the fact that $c_L>c_v$ and $B(a)-T_v(a)$ is increasing at a_L^*, the second follows from the strict concavity of $B(a)-T_v(a)$, and the third follows from the fact that $T_v(a)<T_L(a)$ for all a. Subtracting $c_v a_v^{max}=p\cdot c_L\cdot a_L^*$ from the first and last expression and using the definition of a_v^{min} yields

$B(a_v^{max})-T_v(a_v^{max})-c_v a_v^{max} > B(a_v^{min})-T_v(a_v^{min})-c_v a_v^{min}$,

which implies $a_v^{max}>a_v^{min}$ since NSB_v is increasing at a_v^{min}.

The intuition for this proposition is that the cost savings that are possible under a voluntary agreement create the potential for a mutually beneficial agreement. If both parties engage in optimizing behavior, this potential will be exploited in equilibrium.

The proposition establishes the existence of a value of a_V that is acceptable to both parties. It does not establish the level of a_V that would be offered. Given that the regulator

is the one who makes the offer, we assume that the regulator can choose a_V and that he chooses the level of a_V that maximizes his payoff subject to the constraint in (8). Under this assumption, two different types of equilibria are possible, corresponding to the following two cases: (I) $a_V^{min} < a_V^* < a_V^{max}$, and (II) $a_V^{min} < a_V^{max} < a_V^*$. We examine each in turn.

Case I: $a_V^{min} < a_V^* < a_V^{max}$. Under this case, any value of a_V satisfying $a_V^{min} < a_V < a_V^{max}$ is preferred by both parties to threat of the legislative alternative. Since a_V^* satisfies this condition and also maximizes NSB_V, the regulator will offer (and the firm will accept) a_V^*. Thus, the equilibrium outcome is a voluntary agreement with the first-best level of abatement.

Case II: $a_V^{min} < a_V^{max} < a_V^*$. Since a_V^* does not lie between a_v^{min} and a_v^{max}, if the regulator were to offer a_V^*, the firm would reject the offer and the outcome would revert to the legislative threat. Therefore, the best the regulator can do is to offer a_V^{max}, yielding a voluntary agreement with a level of abatement that is less than the first-best level. Note that it is the need to induce the firm to accept the offer voluntarily that leads to the reduction in efficiency.

IV. The Role of the Legislative Threat

Which of the two possible equilibria results depends, of course, on the parameters of the benefit and cost functions and on the probability that legislation would be imposed. Since it is the legislative threat that creates the possibility of a voluntary agreement, we focus here on the role played by the magnitude of that threat as reflected in the probability p. In particular, we examine how p affects the type of equilibrium that results.

To examine how p affects the equilibrium outcome, we must first determine the effect of p on the three variables that determine the equilibrium, namely, a_V^*, a_V^{max} and a_V^{min}. From (6), it is clear that a_V^* is independent of p, i.e., the first-best level of a does not depend on the magnitude of the background threat. Similarly, (1) implies that a_L^* is independent of p. Given this, (4) implies that a_V^{max} is linear and increasing in p.[11] As the likelihood of legislation increases, the maximum value of a_V that the firm would be willing to accept increases as well.

The effect of p on a_V^{min} can be found by implicitly differentiating $NSB_V(a_V^{min})-pNSB_L(a_L^*)=0$ to get

$$\partial a_V^{min}/\partial p = NSB_L(a_L^*)/NSB_V'(a_V^{min}) > 0 \quad (9)$$

and

$$\partial^2 a_V^{min}/\partial p^2 = -[NSB_L(a_L^*)]^2 NSB_V''(a_V^{min})/[NSB_V'(a_V^{min})]^3 > 0. \quad (10)$$

Hence, a_V^{min} is increasing in p, implying that an increase in the likelihood that legislation will be imposed increases the minimum a_V that the firm is willing to offer. a_V^{min} is also a convex function of p.

We graph a_V^*, a_V^{max}, and a_V^{min} as functions of p in Figures 3(a) and 3(b). Given that (7) must hold for all p (including p=1), the graphs depict the functions only over the range where $a_V^{min}<a_V^*$. In addition, they assume that $NSB_V(0)=0$, so that at p=0 $a_V^{min}=a_v^{max}=0$. The

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[11] This result depends on the assumption that the firm's cost function under a voluntary agreement is linear. This assumption simplifies the analysis but does not generally change the qualitative results. Allowing C_V to be nonlinear would, however, introduce the possibility of more "switching" between equilibria in Figure 3, depending on the relative curvatures of the two curves.

graphs show two possible configurations and the equilibria under each. The darkened segments show the equilibrium levels of a_V under the voluntary agreement.

Figure 3(a) illustrates a configuration under which a Type II equilibrium results for all values of p. Recall that under a Type II equilibrium, the regulator offers (and the firm accepts) a_V^{max}, which is less than the first-best level a_V^*. From Figure 3(a) it is clear that the level of abatement that results under the equilibrium voluntary agreement decreases as p decreases. Thus, even for small p, a voluntary agreement will be forthcoming, but the agreed upon level of abatement will be small because the legislative threat is weak, with $a_V=0$ when $p=0$.

Figure 3(b) illustrates a configuration under which the a_V^{max} curve is steeper than it was in Figure 3(a). Under this configuration, low values of p lead to a Type II equilibrium but high values of p can result in a Type I (first-best) equilibrium. A voluntary agreement is negotiated regardless of the level of p since both parties can benefit from reaching such an agreement. However, if p gets sufficiently large, the firm is even willing to accept an agreement at the first-best level of abatement a_V^*. Recall that $a_V^*>a_L^*$. Thus, in this case, the cost advantage of implementing the abatement through a voluntary agreement rather than legislatively is sufficiently great that the firm is actually willing to accept a level of abatement that is higher than the level that might be imposed legislatively. This equilibrium is only possible, however, for sufficiently large p.[12]

[12] Of course, the steeper is a_V^{max} (ceteris paribus), the wider is the range of p over which a Type I equilibrium would result.

The above discussion yields the following conclusion. While any positive legislative threat is sufficient to ensure a voluntary agreement, the agreed upon level of a_V is related directly to the magnitude of the threat. Thus, with a very weak threat (low p), a voluntary agreement will still be reached, but the agreed upon level of abatement will be quite low. In particular, it could be lower than the level that might be imposed legislatively (a_L^*). However, if p is large enough, it is possible (though not guaranteed) that a first best outcome will result. If it does, the agreed upon level of abatement (a_V^*) will exceed the level that might have been imposed legislatively.

V. Multiple Firms

The above analysis assumed that the regulator was negotiating a possible agreement with a single firm, and the outcome of the negotiating process depended only on the accept or reject decision of that firm. In reality, a regulator may be trying to negotiate an agreement with more than one firm, as, for example, when there are multiple polluters contributing to a given environmental hazard. In this section, we begin to explore the implications of extending the analysis to include multiple firms. We focus first on the accept/reject decisions of the firms assuming that an offer has been made. We then note how these decisions are likely to affect the decision of the regulator regarding whether or not to offer an agreement, and at what level. A full integration of the two problems is left for future research.

The incentives of firms involved in the negotiating process depend crucially on the regulator's policy regarding the terms of the agreement. We consider two alternative

policies, and limit our discussion to the case of two firms. (An extension to more than two firms is straightforward.) Under the first policy, as long as one of the firms accepts the voluntary agreement, the agreement will be implemented and the legislative threat removed.[13] However, because the agreement is voluntary, it would only be binding for the firm that has agreed to it. Clearly, this policy will lead to free-rider behavior. Under the second policy, the agreement is implemented only if all (here, both) firms agree to it, i.e., unanimous agreement is required. If either firm does not agree, the offer is essentially rejected. While this solution will avoid the free-riding problem, it reduces the likelihood that a voluntary agreement will be reached.

Figure 4 depicts the payoff matrix for the two firms under the first policy, where the first entry in each box is the cost (negative payoff) for firm 1 and the second entry is the cost for firm 2 under that outcome. Since we focus here on the accept/reject decisions rather than the choice of a_V, we suppress the arguments of the cost functions and simply interpret the costs to be the costs incurred by the firms for some given (here unspecified) level of a_V.[14] We ask which of the possible outcomes constitute a Nash equilibrium. Because the answer

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[13] Because we have essentially a static model, we assume that the legislative threat is removed permanently. As noted by Baggott (1986), it is often the case that a voluntary approach is followed by mandatory restrictions if the voluntary approach is proving to be insufficient. Thus, the legislative threat remains even after the voluntary agreement has been implemented. While this is a potentially important issue here, we leave a consideration of it for future research.

[14] The choice of a_V will determine the relative magnitudes of the costs for the two firms, and hence the relevant case below. While at this point we do not need to specify whether or not the regulator can offer different a_Vs to the different firms, this would be a important factor in the regulator's choice of a_V.

to this question hinges on the relative magnitudes of the costs, we consider four possible cases.

Case (a): $C_V^1 < pC_L^1$ and $C_V^2 < pC_L^2$. In this case, both firms individually prefer the voluntary agreement, since it results in lower costs for them. However, each has an incentive to free-ride on the other firm, since if the other firm accepts and it rejects, it can reap the benefit of the voluntary agreement (avoidance of legislation) without incurring any cost. Thus, there are two possible Nash equilibria: (Accept, Reject) and (Reject, Accept). Under either equilibrium, the voluntary agreement is implemented but only one firm participates in the agreement. It is not possible to determine which firm participates in equilibrium.

Case (b): $C_V^1 < pC_L^1$ and $C_V^2 > pC_L^2$. The outcome under this case is similar to Case (a) in that a voluntary agreement is implemented but only one firm participates. However, now it is possible to identify which firm participates (firm 1), since there is only one Nash equilibrium, namely, (Accept, Reject). Since firm 1 has lower costs under the agreement, it prefers the agreement and is thus willing to accept regardless of what firm 2 does. Firm 2, on the other hand, has higher costs under the agreement and thus would prefer the legislative alternative to the voluntary agreement, although its first choice is clearly to have to comply with neither. Given that firm 1 will accept the agreement regardless of firm 2's decision, firm 2 can avoid any compliance costs by rejecting the agreement. Hence, firm 2 free-rides on firm 1's willingness to accept the agreement.

Case (c): $C_V^1 > pC_L^1$ and $C_V^2 < pC_L^2$. This is comparable to Case (b) except that now firm 1 is the free rider.

Case (d): $C_V^1 > pC_L^1$ and $C_V^2 > pC_L^2$. In this case, neither firm wants the agreement, and the only Nash equilibrium is (Reject, Reject). The outcome is the legislative option, where participation by both firms is mandatory if legislation is imposed.

We now contrast the above equilibrium outcomes to the outcomes that would result under the second policy under which unanimous adherence to the voluntary agreement is needed to forestall the legislative threat. The payoffs under this policy are shown in Figure 5. The difference between Figures 4 and 5 is the payoffs that result if one firm accepts and one firm rejects the agreement. Under the previous policy, the agreement was still implemented even though it had only partial acceptance, whereas under this policy it is not.

Case (a): $C_V^1 < pC_L^1$ and $C_V^2 < pC_L^2$. As before, under this case, both firms benefit from the voluntary agreement, but here there is no free-rider problem. If one firm tries to free ride (by rejecting the agreement), the deal will collapse and the outcome will be the legislative threat. Thus, both firms have an incentive to accept the agreement, and (Accept, Accept) is a Nash equilibrium. Note that (Reject, Reject) is also a Nash equilibrium. However, if the firms make their decisions sequentially rather than simultaneously (so that the firm that decides first knows that the firm that follows will be aware of his decision), then (Reject, Reject) will not be a sub-game perfect equilibrium. It is thus likely that (Accept, Accept) will be the equilibrium strategy. In equilibrium, the voluntary agreement will be implemented and both firms will participate. This is in contrast to the outcome under the previous policy, where the agreement was implemented but only one firm participated and the other was a free rider. Hence, under case (a), the second policy can

eliminate the free rider problem.

Case (b): $C_V^1 < pC_L^1$ and $C_V^2 > pC_L^2$. The first policy led to a free rider problem under this case as well. The voluntary agreement was implemented but only one firm (here firm 1) participated. While firm 1 still prefers the voluntary agreement, under the second policy the voluntary agreement is not an equilibrium outcome. Because firm 2 prefers the legislative option and that is the default option (i.e., the option implemented if the two parties disagree), firm 2 will always want to reject. Thus, the only possible Nash equilibria are (Accept, Reject) and (Reject, Reject). Since at least one party rejects, the agreement is not implemented. Instead, the regulator must rely on the legislative option, under which participation by both firms will be mandatory. This is in contrast to the result under the previous policy, where the voluntary agreement was implemented but only one firm participated.

Case (c): $C_V^1 > pC_L^1$ and $C_V^2 < pC_L^2$. This case is comparable to Case (b) except that now firm 1 prefers the legislative option.

Case (d): $C_V^1 > pC_L^1$ and $C_V^2 > pC_L^2$. Here, neither firm wants the voluntary agreement. The equilibrium outcome is identical to the outcome under the previous policy, namely, the Nash equilibrium is (Reject, Reject) and the equilibrium outcome is the legislative option with both firms participating if legislation is passed.

The discussion above focuses on the alternative outcomes that are possible under various configurations of the costs of the two firms. It should be clear that the regulator can affect the outcome in two different ways. The first is through the choice of a_V (not considered explicitly in this section). The level of a_V will determine which of the four cases

(a)-(d) is relevant. Second, the regulator can affect the outcome through the terms of the agreement, in particular, through the specification of what will happen if only one (or a subset) of firms agrees. In addition, the desirability of alternative outcomes is likely to depend on the heterogeneity across firms and the incentive for free riding. For example, in Case (b), we cannot say unambiguously whether getting a voluntary agreement with only one firm participating is better or worse (in terms of expected social net benefits) than having the legislative outcome under which both firms would be forced to comply with the legislation. In this case, while the second policy eliminates the free rider problem, it also eliminates the possibility of using a voluntary agreement, which ceteris paribus results in lower costs compared to the legislative option.

VI. Conclusion

Policymakers are increasingly turning to voluntary agreements as an alternative to the traditional legislative or regulatory approaches to environmental protection, because of their potential to save on compliance, administrative, and other transaction costs. Such agreements have been used extensively in other contexts, but have not historically been a mainstay in environmental policy design. Thus, there is very little economic analysis of voluntary environmental protection agreements. This paper has developed a simple model of interaction between a regulator and a polluting firm that can be used to determine whether a voluntary agreement to reduce pollution is likely to be successfully negotiated. Since in practice the inducement for firms to participate in such agreements is often the desire to avoid mandatory legislative or regulatory restrictions, we focus on the role of this

background threat. In particular, we examine how this background threat influences both the maximum level of abatement that the firm would be willing to undertake voluntarily and the minimum level that the regulator would be willing to accept as a substitute for possible legislation.

The results suggest that given the potential savings under a voluntary agreement, such an agreement will always be the equilibrium outcome of the interaction between the regulator and the firm. However, the agreed upon level of abatement will be directly related to the magnitude of the threat. Thus, for weak threats, a voluntary agreement would be negotiated but the level of abatement under the agreement is likely to be low. In particular, it could be much lower than the level that is threatened to be imposed legislatively. (The agreement still produces a net gain, however, as a result of cost savings.) In contrast, for high p, a first best outcome is possible, although not guaranteed. Under the first best outcome, the agreed upon level of abatement would exceed the level under the background threat.

When a regulator must try to reach agreement with multiple firms, there are at least two ways in which the regulator can influence the outcome, namely, through the proposed level of voluntary abatement and through the terms of the agreement (particularly with regard to whether unanimity is required). While requiring unanimity can eliminate free-rider problems, it also reduces the likelihood that a voluntary agreement will be reached. Depending on the choice of the proposed abatement level and the relative costs, there is a potential tradeoff between these two effects. Thus, we cannot unambiguously say whether having a voluntary agreement with only a subset of the polluting firms participating is

better or worse than having mandatory restrictions, since even though the mandatory controls would entail higher costs, all firms would be required to comply.

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