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Voluntary Environmental Agreements: Good or Bad News for Environmental Protection?[1]

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There has been growing interest in the use of voluntary agreements (VAs) as an environmental policy tool. This article uses a simple model to determine whether VAs are likely to lead to efficient environmental protection. We consider cases where polluters are induced to participate either by a background threat of mandatory controls (the "stick" approach) or by cost-sharing subsidies (the "carrot" approach). The results suggest that the overall impact on environmental quality could be positive or negative, depending on a number of factors, including the allocation of bargaining power, the magnitude of the background threat, and the social cost of funds.

I. INTRODUCTION

Historically, policymakers have relied on legislative and regulatory restrictions on polluting behavior to ensure adequate protection of environmental quality.[3] Attention has turned to the use of voluntary agreements (VAs) between regulators and polluters as an alternative to mandatory approaches based on regulation or legislation. For example, in a survey the Commission of the European Communities [9, p. 21] finds that "the use of agreements with industry in the area of environmental policy has become more common in practically all Member States since the beginning of the 1990's." All but one of its 15 member states relied on environmental agreements as a policy tool, with a wide range of applications including water pollution, air pollution, and waste management. Pursuant to the Dutch National Environmental Policy Plan, the Netherlands has concluded more than 100 agreements [9]. The United States has followed the European lead with its own voluntary approaches to pollution control. The most notable of these include the U.S. Environmental Protection Agency's (EPA) 33/50 Program to reduce voluntarily discharges of industrial toxic pollutants [27] and Project XL, which exempts firms from certain mandatory requirements if they demonstrate that they can exceed environmental protection goals through other means [11].

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[3]To a lesser extent, economic incentives, such as taxes, tradeable permits, and environmental liability, have been used. See Hahn [13] for a survey of the use of economic incentive approaches to environmental protection.

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Voluntary agreements can be an attractive alternative to mandatory approaches to pollution control [4, 12]. The European Commission [9] identifies at least three potential benefits of voluntary measures: (1) the encouragement of a pro-active cooperative approach from industry, which can reduce conflicts between regulators and industry, (2) greater flexibility and freedom to find cost-effective solutions that are tailored to specific conditions, and (3) the ability to meet environmental targets more quickly due to decreased negotiation and implementation lags. These benefits imply that voluntary agreements have the potential to reduce both environmental compliance costs and the associated administrative and other transactions costs. However, concerns have been raised about how effective these agreements are likely to be and whether they adequately protect environmental quality [11].

Voluntary agreements can be categorized into two types: (1) those that induce participation by providing positive incentives such as cost-sharing or other subsidies (the carrot approach), and (2) those that induce participation by threatening a harsher outcome (for example, legislation) if a voluntary agreement is not reached (the stick approach). However, as noted by Goodin [12], 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[4] and the Dutch National Environmental Policy Plan.[5]

There is, however, a history of using the carrot approach to environmental protection in certain industries, most notably agriculture. Policies designed to reduce agricultural pollution have historically relied on voluntary participation in soil conservation and other erosion control programs such as the U.S. Conservation Reserve Program. 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]

Despite the 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.[7] Exceptions are Stranlund [25] and Wu and Babcock [31], who compare the use of a voluntary compliance regime with a mandatory regime. However, in these models, the two approaches are compared under the assumption that both yield the same level of environmental protection. Thus, they do not address the important issue of whether reliance on VAs would lead to reduced levels of environmental quality relative to alternative mandatory approaches.

In this article we develop a simple economic model of the interaction between a regulator and a polluter that allows us to examine (1) whether a VA is the likely

[4]See Arora and Cason [1] for an empirical analysis of other factors affecting participation in the 33/50 Program.

[5]As noted by the EC [9, p. 10], ‘‘Implicit [in many agreements] is often the understanding that no legislative action will be proposed if and as long as the agreement works satisfactorily.’’ See Goodin [12] for examples of the use of legislative threats in other contexts.

[6]There is a large literature on the use of cost sharing in agriculture, e.g., [3, 5, 6, 10, 15, 19, 22, 29, 30, 32]. 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 Bookstael [17] for discussions of the interactions between agricultural price support policies and environmental quality.

[7]There is a large literature on the use of voluntary measures in other contexts, e.g., voluntary export restraints in trade. For a recent treatment, see Rosendorff [23].

outcome of that interaction and, if it is, (2) whether the resulting VA leads to efficient environmental protection. We first examine agreements of the second (i.e., stick) type, where there is a background legislative threat that can induce participation. As previously noted, many of the environmental protection agreements that have been successfully negotiated are of this type. We examine the possible equilibrium outcomes and the role that the legislative threat plays in determining the outcome. We also ask whether the level of pollution abatement under a VA is likely to be higher or lower than the level that might have been imposed legislatively, and how it compares to the first best level of abatement. We examine this question under alternative assumptions regarding which party has the bargaining power in negotiations over the level of abatement under the VA.

The results of the first part of the article imply that, because of the potential cost savings, a VA is the equilibrium outcome of the interaction between a polluter and a regulatory agency. However, the agreed upon level of abatement is low if the legislative threat is weak. Thus, in the second part of the article we ask whether (or under what conditions) the regulator would choose to offer a subsidy (i.e., a carrot) to induce participation in a VA entailing a higher level of abatement. To examine the possible use of subsidies, we generalize the model developed in the first part of the article to allow for subsidies along with the legislative threat and examine the roles that the legislative threat and the social cost of funds play in determining the equilibrium outcome. Again we ask how the level of abatement under a VA would compare to the first best level and the level that might have been imposed under the legislative threat under alternative assumptions about the bargaining power of the parties. The results of the general model imply that under a VA a first best level of abatement is possible, but not guaranteed, depending on (i) the magnitude of the background threat, (ii) the social cost of funds, and (iii) the allocation of bargaining power. In addition, we show that the level of abatement under the equilibrium VA could be higher or lower than the level that might have been imposed legislatively.

II. THE PURE THREAT MODEL

II.A. An Overview of the Model

We consider first a pure threat model and we examine the case where the regulator negotiates with a single polluter (firm) or a single representative of an industry.[8] We initially consider the case where the regulator has all of the bargaining power and makes a take-it-or-leave-it offer to the firm. The regulator decides whether or not to offer the firm the opportunity to enter into an agreement under which the firm would "voluntarily" agree to undertake a specified level of pollution abatement, denoted a_V. The firm then decides whether or not to accept the offer. Later, we consider the opposite case where the firm has all of the bargaining power and makes a take-it-or-leave-it offer to the regulator.

[8] In this article we do not discuss the complications that can arise when the industry is comprised of a number of firms, such as free-riding, strategic behavior of coalitions within the industry, and intra-industry allocation decisions. Because of these types of problems, the European Commission [9] concludes that VAs are likely to be most effective when the number of parties is limited.

If the firm does not accept the regulator's offer or if no offer is made,[9] 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 necessarily certain. Rather, it is assumed to occur with an exogenous and known probability p $(0 \leq p \leq 1)$,[10] which could reflect uncertainties about the legislative priority that would be given to this issue. The magnitude of p could also reflect the political will regarding the imposition of mandatory controls on a particular industry. For example, historically there has not been much political support for the imposition of mandatory controls in the agricultural sector, suggesting that for this sector p is likely to be small. In contrast, p is likely to be higher for the manufacturing sector, where mandatory restrictions are more common. Alternatively, the background threat could capture situations in which participation in a VA exempts a firm from requirements under some existing legislation, as in Project XL.[11] In this case, the "threat" is certain in the sense that failure to participate ensures that the firm will be subject to the provisions of the legislation. In such cases, $p = 1$. The case where $p = 1$ could also represent a situation in which the regulator has the authority to impose a mandate, because in this case p would be endogenous to the regulatory decision and the regulator would clearly choose $p = 1$.

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 is 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 implementation and compliance. Although 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 and transactions costs for both parties are lower under the voluntary approach than under a legislative mandate. Transactions costs can be lower under the voluntary approach because of reduced reliance on formal legal procedures and reduced conflict [12, 4, 9]. Lower compliance costs reflect the fact that voluntary agreements are generally thought to provide more flexibility in determining the means by which a target level of pollution abatement would be met [9]. This potential cost savings assumes that the mandatory regulations would not use first best (i.e., cost-minimizing) instruments.[12] Historically, environmental policy in the United States has been based on command-and-control regulations,

[9] We assume that the background threat is the same in both cases, although we could easily allow the probability that legislation will be imposed to differ depending on whether a VA was offered (and rejected) or was not offered.

[10] Note the analogy to economic models of litigation and settlement (for a survey, see Miceli [20, Chap. 8]). Specifically, VAs correspond to settlements and the legislative outcome corresponds to trials. Thus, VAs, like settlements, are attractive as ways of saving on transaction costs. Further, the more likely is plaintiff victory at trial (the less likely is a legislative mandate), the more favorable is the outcome of a settlement (VA) for the plaintiff (polluting firm).

[11] See EC [9] for other examples of this type.

[12] See Helfand [16] for a theoretical comparison of alternative regulatory instruments.

i.e., technology standards that dictate specific pollution control technologies that are generally not the least cost means of meeting a given emissions reduction goal.[13] Estimates suggest that the resulting compliance costs are significantly higher than they would be under a cost-minimizing approach (e.g., [26, 28]).[14] There has, however, been a move toward the use of more efficient regulatory instruments. The most notable example is the imposition of performance standards and the allowance of SO_2 emissions trading under the 1990 Clean Air Act Amendments.[15] Clearly, the more efficient the regulatory instrument is, the smaller is the potential compliance cost savings from use of a voluntary agreement.

The potential for cost savings under a VA is captured in the model in the following way. Let $C_i(a)$ denote the compliance and transaction costs borne by the firm under option i,[16] where $i = V$ (voluntary) or $i = L$ (legislative), and let $T_i(a)$ be the transaction costs borne by the regulator under option i. The hypothesized cost advantage of the VA implies that $C_V(a) < C_L(a)$ and $T_V(a) < T_L(a)$ for all a, and that $C'_V(a) < C'_L(a)$ and $T'_V(a) < T'_L(a)$ for all a. Clearly, therefore, $TC_V(a) < TC_L(a)$ 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., $C_i(a) = c_i a$. The implications of this assumption are noted in the following text.

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.[17] When the objectives of the governmental bodies differ from efficiency (e.g., when there is rent seeking or budget-maximizing behavior, or when the regulator is subject to industry capture), there is clearly an additional distortion in the policymaking process. However, we consider the case of a net benefit maximizer in order to establish a baseline regarding the effects of voluntary agreements in the absence of such distortions. Thus, we assume that the regulator's net payoff under the voluntary approach is $NSB_V(a_V) = B(a_V) - TC_V(a_V)$. Similarly, if a voluntary agreement is not negotiated and the legislative threat is exercised, we assume that the legislature will 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

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

[13] See Hahn [14] for a survey of environmental policy in the United States.

[14] Another potential advantage of voluntary agreements is due to asymmetric information between regulators and firms. For example, firms might have better information about abatement costs and least cost pollution control strategies. A possible response to asymmetric information is the use of policy menus based on mechanism design theory. See Lewis [18] for an excellent survey of this approach. The advantage of voluntary agreements in this context is that they allow firms to take advantage of their superior information to design least cost abatement strategies. For simplicity, we ignore information issues in this article and we assume that the regulator knows the cost function for the firm. For a model of voluntary agreements that explicitly incorporates asymmetric information, see Segerson [24].

[15] While the performance standards have led to considerable cost savings, to date trading under these provisions has been limited. See Burtraw [8].

[16] Costs are net of any profits the firm might earn from "being green." If the latter are significant, $C_i(a)$ could be negative.

[17] For a discussion, see Mueller [21].

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 because the legislature would have an incentive to deviate from the threat if it actually had to follow through on it. Thus, if legislation is imposed, it yields a net return to the regulator equal to $NSB_L(a_L^*)$. Because 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 $pNSB_L(a_L^*)$. 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, the firm's expected cost 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 noncompliance.[18]

The decision tree in Fig. 1 summarizes the sequence of events and indicates who the decision maker is at each decision node (R = regulator, L = legislature, F = firm) and the payoffs to the regulator and the firm under the possible

[18] The EC [9] emphasizes the need to structure VAs to ensure compliance. The threat that legislation will be imposed if the terms of the agreement are not met is one means of increasing compliance incentives. A simple treatment of noncompliance 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.

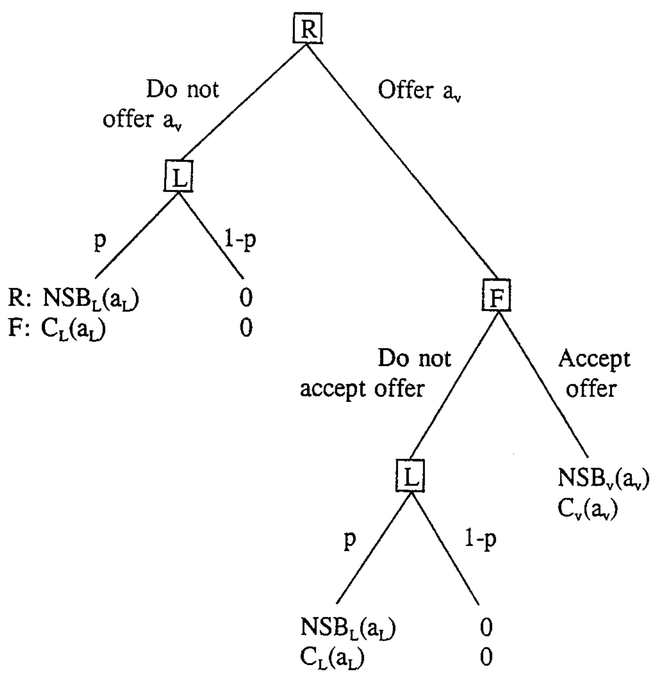


FIG. 1. Sequence of moves by the regulator (R), the firm (F), and the legislature (L). Payoffs are for the regulator (top) and the firm (bottom).

outcomes. 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.

If the regulator offers a voluntary agreement with $a = a_V$, the firm accepts this offer if and only if the expected cost is lower (or at least no higher) 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 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

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

Clearly, $a_V^{\max}$ increases with p. Thus, changes in p (e.g., changes in the political climate over time) can change the firm's incentive to enter into a given VA. Note also 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. In other words, it might be willing to participate in programs such as the EPA's Project XL that seek "supercompliance" by firms.[19]

We now turn to the decision of the regulator under the assumption that the firm would accept an offer if it were made.[20] 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 $(a_V^{\min}, a_o)$ of a_V over which the regulator prefers the voluntary agreement. This range is depicted in Fig. 2, where $a_V^{\min}$ denotes the lower bound of the range, i.e., the minimum value of a_V that the regulator would be willing to offer, and a_o is the maximum acceptable offer. 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 first best level of a_V, i.e., the level that maximizes $NSB_V(a)$ (see Fig. 2) and hence solves the first-order condition,

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

[19] For an alternative model of overcompliance based on the benefits of being "green," see Arora and Gangopadhyay [2].

[20] 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.

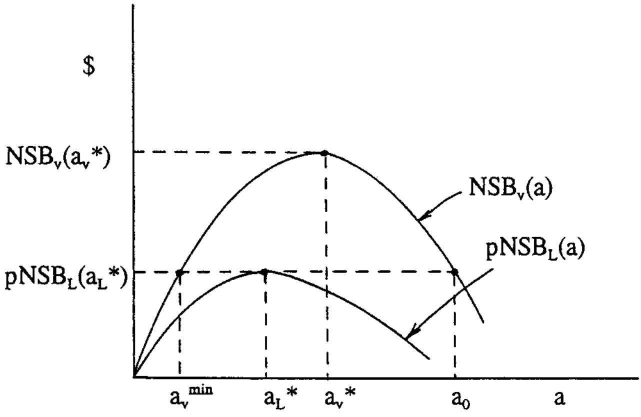


FIG. 2. Range over which regulator will offer a_v.

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

$$a_V^{\min} < a_L^* < a_V^* < a_o. \tag{7}$$

II.B. Equilibrium Outcomes

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

$$a_V^{\min} \le a_V^{\max}, \tag{8}$$

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.[21] Note that a voluntary agreement would never be an equilibrium outcome in the absence of the legislative threat, for if $p = 0$, any positive a_V is acceptable to the regulator but, given (4), 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 $a_V > 0$ is forthcoming.

The legislative threat, it turns out, is also a sufficient condition for a voluntary agreement to be the equilibrium outcome. In particular, we can show that $a_V^{\min} < a_V^{\max}$, i.e., (8) holds, for all $p > 0$, which establishes the following proposition (see the Appendix for a proof):

PROPOSITION 1. *For any $p > 0$, the equilibrium of the game is that the regulator offers a voluntary agreement and the firm accepts the offer.*

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, i.e., "win–win" situation. If both parties engage in optimizing behavior, this potential will be exploited in equilibrium.

[21] We therefore assume that, whenever a mutually beneficial agreement is feasible, it is successfully concluded.

The proposition establishes the existence of a value of a_V that is acceptable to both parties, i.e., a region of mutually beneficial agreements. It does not, however, establish the equilibrium level of a_V, which depends upon the outcome of the bargaining process between the regulator and the firm. However, as shown in the following text, the relative bargaining strengths of the two parties affects not only the allocation of the surplus from the VA but also the efficiency properties of the equilibrium abatement level. To see this, we consider three cases regarding the allocation of bargaining power: (1) the regulator has all of the bargaining power and hence captures all of the surplus, (2) the firm has all of the bargaining power and captures all of the surplus, and (3) the parties share the surplus.

When the regulator has all of the bargaining power, he can make a take-it-or-leave-it offer of a_V to maximize 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.

Type I Equilibrium: $a_V^{\min} < a_V^* < a_V^{\max}$. 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. Because 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. Note that, because $a_V^* > a_L^*$, the level of abatement under the voluntary agreement is higher than the level that would have been imposed legislatively. In other words, the voluntary agreement leads to supercompliance.

Type II Equilibrium: $a_V^{\min} < a_V^{\max} < a_V^*$. Because 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.[22] However, because $a_V^{\max}$ can be greater or less than a_L^*, the level of abatement under the VA in this case can be higher or lower than the level that might have been imposed legislatively. As is seen in the following text, whether it is higher or lower depends on the magnitude of p (among other things). However, Eq. (4) implies that $a_V^{\max} > pa_L^*$ given that $c_L/c_V > 1$. Thus, abatement under the VA is always larger than the *expected level* under the legislative threat.

We summarize the foregoing results in the following proposition.

PROPOSITION 2. (i) *If the regulator has all of the bargaining power, then it is possible that the equilibrium outcome is a voluntary agreement with a first best level of abatement, although the first best is not guaranteed.* (ii) *If the outcome is first best, then the equilibrium level of abatement under the VA exceeds the level that might have been imposed legislatively, implying supercompliance.* (iii) *However, if the outcome under the VA is not first best, then the VA results in an abatement level that is less than the first best level. In this case, the equilibrium level of abatement can be higher or lower than the level that might have been imposed legislatively, though it is higher than the expected level under the legislative threat.*

[22] The result also hinges on the absence of costless side payments. With such payments, Coase's theorem ensures that the outcome of the bargaining process would be the efficient level of abatement.

When the firm has all of the bargaining power, it can hold out for an offer that gives it all of the surplus from the agreement (in effect, the firm makes the take-it-or-leave-it offer). Clearly, in this case, the outcome of the bargaining process will be $a_V^{\min}$ which, combined with the fact that $a_V^{\min} < a_L^* < a_V^*$ (see (7)), establishes the following proposition.

PROPOSITION 3. *If the firm has all of the bargaining power, then a first best outcome is not possible in equilibrium. Rather, the equilibrium outcome is a voluntary agreement with an abatement level that is less than the first best level and less than the level that might have been imposed legislatively.*

It should be clear from the previous discussion that if the parties share the surplus (as would be the case, for example, under the Nash bargaining solution), then the equilibrium level of abatement is between $a_V^{\min}$ and a_V^* in a Type I equilibrium and between $a_V^{\min}$ and $a_V^{\max}$ in a Type II equilibrium. In this case, the abatement level under a voluntary agreement is less than the first best level of abatement, but it may be greater than the level that might have been imposed legislatively.

II.C. The Role of the Legislative Threat

We noted previously that when a first best outcome is possible, whether it is achieved in equilibrium depends on the magnitude of the legislative threat, p. 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. Similarly, (1) implies that a_L^* is independent of p. Given this, (4) implies that $a_V^{\max}$ is linear and increasing in p.[23] Furthermore, it can be easily shown that $a_V^{\min}$ is an increasing and convex function of p. We graph a_V^*, $a_V^{\max}$, and $a_V^{\min}$ as functions of p in Figs. 3a and 3b. Given (7), the graphs show that $a_V^{\min} < a_V^*$ for all p (including $p = 1$). In addition, they assume that $NSB_V(0) = 0$, so that at $p = 0$, $a_V^{\min} = a_V^{\max} = 0$. The graphs show two possible configurations. The darkened segments in each graph show the equilibrium levels of a_V under the voluntary agreement for the case where the regulator has all of the bargaining power.

Figure 3a 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 Fig. 3a it is clear that the level of abatement that results under the equilibrium voluntary agreement decreases as p decreases. Thus, for small p, a voluntary agreement is forthcoming, but the agreed upon level of abatement is small because the legislative threat is weak.

Figure 3b illustrates a configuration under which the $a_V^{\max}$ curve is steeper than it was in Fig. 3a. 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

[23] 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 Fig. 3, depending on the relative curvatures of the two curves.

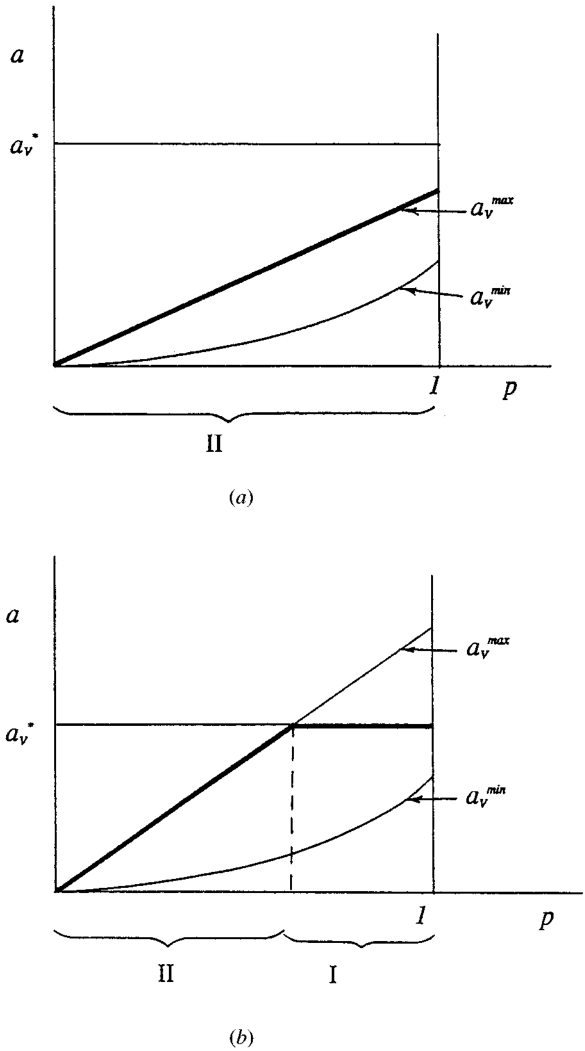


FIGURE 3

voluntary agreement is negotiated regardless of the level of p because 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^*. 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.[24]

[24]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.

Recall that when all of the bargaining power lies with the firm instead of the regulator, the equilibrium level of abatement is $a_V^{\min}$. In this case, the equilibrium abatement is clearly increasing in p as well (though it is everywhere below a_V^*). We can thus state the following proposition.

PROPOSITION 4. *Regardless of whether the regulator or the firm has the bargaining power, when the equilibrium outcome is not a first best, an increase in the magnitude of the legislative threat increases the agreed upon level of voluntary abatement.*

III. A COMBINED SUBSIDY–THREAT MODEL

The results in the previous section imply that, although 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 is still reached, but the agreed upon level of abatement is quite low, regardless of which party has the bargaining power. Given these results, in this section we ask whether (or under what conditions) the regulator might want to use the carrot approach (in combination with the stick) to induce participation in a VA by subsidizing the firm for some or all of the costs it incurs.

III.A. An Overview of the General Model

To capture the possibility that a subsidy could be used, we assume that the regulator's offer now takes the form of a pair (a_V, S), where S is the subsidy that the regulator agrees to pay to the firm if it voluntarily chooses a level of abatement of a_V. Note that this is a generalization of the model in the previous section, which implicitly assumes that $S = 0$.[25] Thus, the decision tree in Fig. 1 continues to depict the basic structure of the problem, except that the payoffs if an offer is accepted become

$$\text{Regulator:} \quad B(a_V) - c_V a_V - \lambda S, \tag{9a}$$

$$\text{Firm:} \quad c_V a_V - S, \tag{9b}$$

where $\lambda > 0$ is the social cost of the subsidy. This parameter could reflect the deadweight loss that results from the need to raise the revenue for the subsidy through distortionary taxes. Alternatively, it could reflect other costs of using subsidies, such as political costs or incentives for excessive entry into the subsidized industry [7]. For simplicity, we assume here (and throughout the remainder of the analysis) that $T_V = T_L = 0$, because positive transactions costs for the government do not affect our qualitative results.

Given an offer (a_V, S), the firm will accept the offer if and only if

$$c_V a_V - S \leq p c_L a_L^*, \tag{10}$$

or, equivalently, if and only if

$$S \geq c_V a_V - p c_L a_L^*. \tag{10'}$$

[25] It is obviously also a generalization of a pure subsidy model under which $p = 0$.

The combinations (a_V, S) that are acceptable to the firm, i.e., that satisfy (10′), can be graphed in (a_V, S) space. The boundary of this region is a straight line with a slope of $c_V > 0$, S-intercept of $-pc_L a_L^* < 0$, and a_V-intercept of $a_V^{\max} = p(c_L/c_V)a_L^* > 0$ (see Fig. 4a). Note that changes in p cause a parallel shift in this line (an increase in p shifts the line down, thereby increasing the acceptable region), while changes in λ have no effect on it. In addition, if we impose the constraint that $S \geq 0$, i.e., we do not allow the regulator to tax the firm when a voluntary agreement results in a net gain for the firm, then the acceptable region for the firm is bounded below by the horizontal axis to the left of the a_V-intercept, $a_V^{\max}$.

Similarly, the combinations of a_V and S that are acceptable to the regulator, i.e., that result in a net benefit that is at least as great as the expected net benefit under the legislative threat, are defined by

$$B(a_V) - c_V a_V - \lambda S \geq p\{B(a_L^*) - c_L a_L^*\}, \tag{11}$$

or, equivalently,

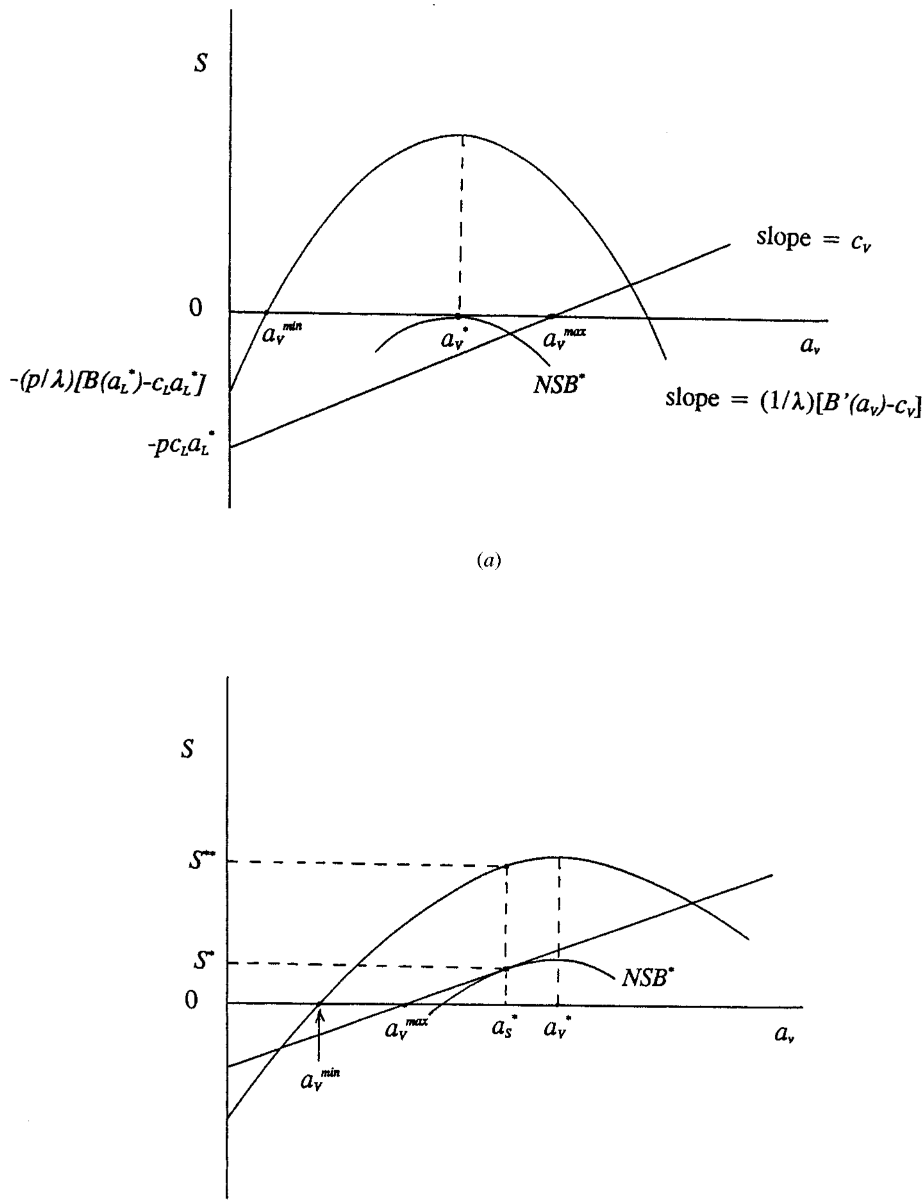
$$S \leq \frac{1}{\lambda}\{B(a_V) - c_V a_V - p(B(a_L^*) - c_L a_L^*)\}. \tag{11′}$$

This defines a region in (a_V, S) space whose boundary has a slope of $(1/\lambda)\{B'(a_V) - c_V\}$, S-intercept of $(-p/\lambda)\{B(a_L^*) - c_L a_L^*\}$, and a_V-intercept of $a_V^{\min} > 0$ (see Fig. 4a). Note that an increase in p will cause a parallel shift downward in this boundary, thereby decreasing the acceptable region for the regulator. In contrast, an increase in λ will rotate the boundary, pivoting around the a_V-intercept. As λ goes to infinity, the boundary approaches the a_V-axis since no positive subsidy is acceptable to the regulator if the social cost of funds is infinite.

The fact that $a_V^{\max} > a_V^{\min}$ for all $p > 0$ (as established in Proposition 1) implies that there always exists some combination (a_V, S) that is acceptable to both the firm and the regulator. Thus, under optimizing behavior by both parties, the equilibrium outcome will always be a voluntary agreement. However, when a subsidy is available, there are several alternative configurations for the set of mutually acceptable combinations of a_V and S, because we are no longer restricted to points on the horizontal axis.

Figure 4a depicts a case where the first best abatement level (a_V^*) is mutually acceptable even without a subsidy, i.e., the point $(a_V^*, 0)$ lies in this region. In Fig. 4b, the first best abatement level is mutually acceptable but only with a positive subsidy. Finally, Fig. 4c depicts the case where there is no subsidy level that makes the first best abatement level mutually acceptable.[26] Thus, in this case, a first best is not attainable in equilibrium. Note that the magnitudes of p and λ determine which case holds. For example, an increase in p, which shifts both boundaries downward, can result in a move from Fig. 4b to 4a. Likewise, an increase in λ, which pivots the regulator's boundary but does not affect the firm's boundary, can result in a move from Fig. 4b to 4c.

[26] Note that Fig. 4a corresponds to Case I in Section II.B, whereas Figs. 4b and 4c correspond to Case II.

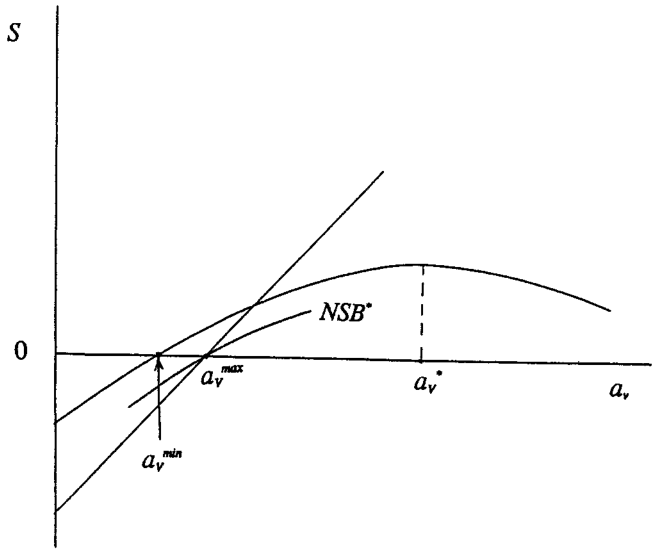


(b)

FIGURE 4

II.B. *Equilibrium Outcomes*

Given the region of mutually acceptable (a_V, S) combinations, we now ask which combination is the equilibrium outcome. Again, we consider two alternative allocations of bargaining power. Under the first case, the regulator has all of the bargaining power and makes a take-it-or-leave-it offer of (a_V, S) to maximize net



(c)

FIG. 4—*Continued*

social benefits. He thus chooses a_V and S to solve

$$\begin{aligned} \text{Maximize} \quad & B(a_V) - c_V a_V - \lambda S \\ \text{subject to:} \quad & \text{(i) } c_V a_V - S \leq p c_L a_L^*, \\ & \text{(ii) } S \geq 0. \end{aligned} \tag{12}$$

Three alternative solutions are possible, depending on which of the constraints in (12) are binding at the optimal solution. We first describe these three types of equilibria and then we turn to the question of the conditions under which each one would arise.

Type I. If at the optimal solution only constraint (ii) is binding, then the solution to (12) is $(a_V^*, 0)$, i.e., the regulator offers the first best level of abatement without any subsidy. An equilibrium of this type occurs whenever the first best is mutually acceptable at $S = 0$. It is illustrated in Fig. 4a, where the isobenefit curve NSB^* represents the highest level of net social benefits attainable given the set of mutually acceptable offers. Because no subsidy is offered, this corresponds to the Type I equilibrium described in Section II.B.

Type II. If at the optimal solution both constraints (i) and (ii) are binding, then the solution to (12) is $(a_V^{\max}, 0)$, i.e., the regulator offers the maximum level of a_V that the firm is willing to accept without a subsidy. An equilibrium of this type is illustrated in Fig. 4c, and corresponds to the Type II equilibrium described in Section II.B.

Type III. If at the optimal solution only constraint (i) is binding, then the solution to (12) is (a_S^*, S^*), where a_S^* solves

$$B'(a_V) = (1 + \lambda) c_V, \tag{13}$$

and $S^* = c_V a_S^* - p c_L a_L^* > 0$. Note that a_S^* is a decreasing function of λ, because $\partial a_S^* / \partial \lambda = c_V / B'' < 0$. An equilibrium of this type is illustrated in Fig. 4b. Recall that in Fig. 4b there is a subsidy level at which the first best level of abatement a_V^* was mutually acceptable. However, given $\lambda > 0$, a_V^* is not optimal. In other words, if participation in the voluntary agreement must be induced through a (costly) subsidy, then it is not optimal to choose a level of abatement that balances the marginal benefits and costs of pollution abatement alone. In addition, the regulator would want to take into account the cost of funds. As a result, he would choose a lower level of abatement, i.e., $a_S^* < a_V^*$ when $\lambda > 0$. Further, the more costly is the subsidy (i.e., the higher is λ), the lower is the level of abatement and the corresponding subsidy that the regulator would offer. Note finally that, even though a subsidy is paid in this case, if $p > 0$ the amount of the subsidy is less than the cost of the voluntary agreement to the firm. Thus, the subsidy constitutes a form of ‘‘cost-sharing’’ rather than full compensation for the costs imposed on the firm.

It should be clear from the preceding discussion that the results summarized in Proposition 2 hold for the subsidy−threat model as well, i.e., when the regulator has all of the bargaining power, a first best outcome is possible but not guaranteed. Thus, allowing use of a subsidy does not change this basic result, even when there is a subsidy at which the first best level would be mutually beneficial. Rather, it simply allows for the possibility of a Type III equilibrium, under which the regulator could do better by offering a cost-sharing subsidy. As shown in the following text, whether the equilibrium outcome is of this type depends on the magnitudes of p and λ.

Before turning to the determinants of the equilibrium, we examine the possible equilibrium outcomes if all of the bargaining power lies with the firm rather than the regulator. In this case, the equilibrium outcome solves

$$\begin{aligned} &\text{Minimize} && c_V a_V - S \\ &\text{subject to:} && \text{(i) } B(a_V) - c_V a_V - \lambda S \geq p\{B(a_L^*) - c_L a_L^*\} \\ & && \text{(ii) } S \geq 0. \end{aligned} \tag{14}$$

Because the slope of the firm’s isocost lines is positive (i.e., $\partial S / \partial a_V = c_V > 0$), it should be clear from the graphs in Fig. 4 that, when the firm has all of the bargaining power, the equilibrium is never a first best outcome, i.e., the first part of Proposition 3 holds for the subsidy−threat model as well. Even when a positive subsidy could induce the firm to accept a VA with the first best level of abatement (Fig. 4b), the firm would not choose this combination. In other words, even though there is a subsidy level that would make the firm better off with a VA requiring a_V^* than with the legislative threat (with no possibility of a cost-sharing subsidy), the firm can do better for itself by choosing a smaller subsidy and a correspondingly lower level of abatement. Although the firm does not bear the social cost of funds directly (the objective function in (14) is independent of λ), it recognizes that the subsidy is costly to the regulator and is able to exploit this cost to its own advantage. As a result, it chooses a level of abatement that optimally balances the social benefits and costs of abatement (including the social costs of inducing abatement through the subsidy). Of course, it extracts a higher price (i.e., demands a higher subsidy) for this level of abatement than would have been paid if the regulator had the bargaining power. Specifically, the subsidy is now given by S^{**} in Fig. 4b, which gives all of the surplus from the VA to the firm.[27]

Because the type of equilibrium that results depends on the parameters of the model (in particular, p and λ), we can summarize the impacts of bargaining power in the following proposition.

PROPOSITION 5. *There exists a region of* (λ, p) *space over which the abatement level reached under a voluntary agreement optimally balances social benefits and costs of abatement, including the social costs of the subsidy, regardless of which party has the bargaining power. Outside of this region, the abatement level reached under the agreement when the firm has the bargaining power is always strictly less than the level reached when the regulator has the bargaining power.*

Thus, there is a region over which the allocation of bargaining power affects only the distribution of the surplus from the VA. Outside of this region, however, it affects both the distribution of the surplus and the agreed upon level of abatement, i.e., it has both distributional and efficiency effects.[28]

III.C. The Role of the Legislative Threat and the Social Cost of Funds

As noted earlier, the type of equilibrium that emerges under either allocation of bargaining power depends on the magnitudes of p and λ. In this section, we illustrate this dependence. Because of space constraints, we focus solely on the case where the regulator has the bargaining power.

Figure 5 partitions (λ, p) space into three regions that correspond to the three types of equilibria that are possible when the regulator has the bargaining power. The boundary between the Types I and II equilibria is implicitly defined by $a_V^{\max}(p) = a_V^*$, or explicitly by $p = (c_V a_V^*)/(c_L a_L^*)$.[29] Because this boundary is independent of λ, it is a vertical line. Similarly, the boundary between the Types II and III equilibria is implicitly defined by $a_S^*(\lambda) = a_V^{\max}(p)$, which is a downward-sloping straight line with a p-intercept at the point where $a_V^* = a_V^{\max}(p)$.

The partition in Fig. 5 can be used to examine how the equilibrium level of abatement under the voluntary agreement varies with changes in λ and p and also the conditions under which the regulator chooses to use a subsidy in combination with the legislative threat to achieve an agreement. Clearly, if p is sufficiently high, then the equilibrium outcome is the first best level of abatement without any subsidy regardless of the magnitude of λ. Recall that this level of abatement exceeds the level that might have been imposed under the background threat (a_L^*).

[27] If the parties share the surplus in this region, then the outcome is an abatement level a_S^* and a subsidy somewhere on the vertical segment between S^* and S^{**} in Fig. 4b.

[28] This result is consistent with Coase's theorem. In the region over which the allocation of bargaining power has only distributional effects, the lower bound on the subsidy is not binding and hence complete bargaining is possible. However, outside of this region, the use of a VA actually results in a net benefit for the polluter because of the potential cost savings. Thus, in this region, complete bargaining would require a negative S when the regulator has all of the bargaining power, i.e., a net payment from the polluter to the regulator. Because we rule out this possibility by restricting $S \geq 0$, when the constraint is binding the Coase theorem does not apply.

[29] The partition in Fig. 5 assumes $(c_V a_V^*)/(c_L a_L^*) < 1$. If this were not true, then the area for the Type I equilibrium would not exist.

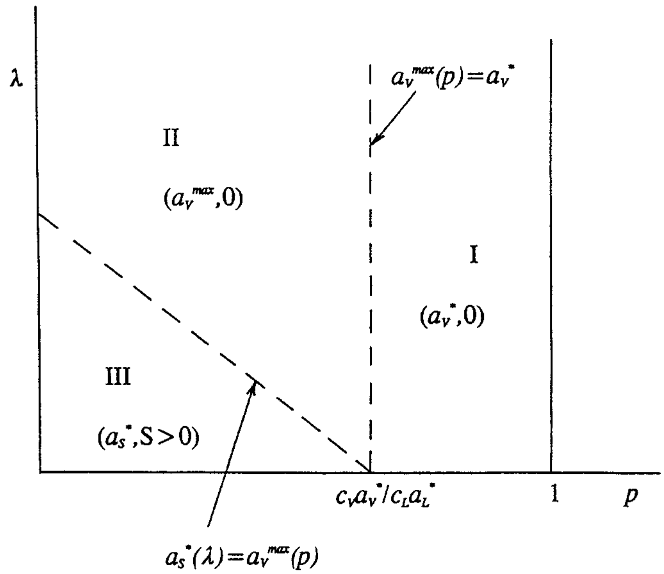


FIGURE 5

Thus, even if a subsidy is available, it is not used if the legislative threat is strong enough.

However, when the threat is not sufficiently strong (i.e., when p is "low"), then the equilibrium level of abatement depends on the magnitude of λ, as shown in Fig. 6. If λ is sufficiently small (relative to p), the regulator offers a subsidy to induce the firm to agree to a higher level of abatement than it would have been willing to agree to without the subsidy ($a_V^{\max}$). This is the situation in which use of the subsidy can improve on the outcome that would have emerged solely from the legislative threat. Recall from Section II that when the legislative threat is weak, the equilibrium level of abatement under the voluntary agreement is low. When λ

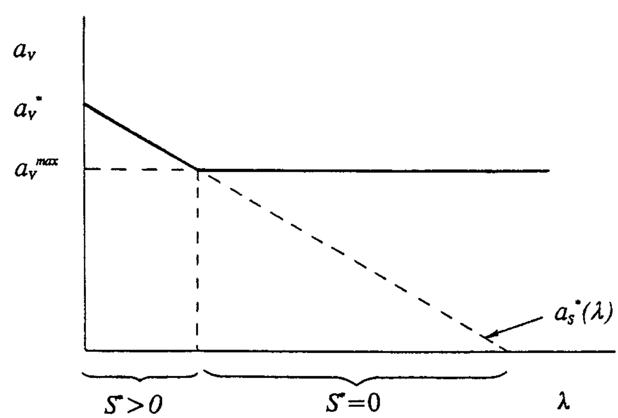


FIG. 6. Low *p*.

is small, it is optimal for the regulator to induce a higher level of voluntary abatement by using the subsidy.

Consider next how the equilibrium level of abatement varies with changes in p, given the availability of a subsidy to induce additional abatement. As can be seen from Fig. 5, when λ is sufficiently high, although the subsidy is available, it is not used and hence the relationship between the equilibrium a_V and p is the same as that depicted in Fig. 3.[30] However, if λ is sufficiently low, then for low p the regulator will choose a_S^* and offer the firm a subsidy. However, as the background threat increases and the maximum abatement level the firm is willing to accept without a subsidy increases, the regulator relies solely on the threat and does not offer a subsidy. The resulting relationship between the equilibrium level of abatement and p is depicted in Fig. 7.

The previous analysis suggests that the regulator is more likely to try to induce participation in voluntary programs to reduce pollution through the use of subsidies when, for example, the political will for imposing mandatory controls is very weak and the political or other costs of using subsidies is low. The historical reliance on voluntary cost-sharing programs to reduce agricultural sources of pollution (primarily surface and groundwater pollution) seems consistent with this prediction of the model.

IV. 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 has been very little economic analysis of voluntary environmental protection agree-

[30] Specifically, because Fig. 5 assumes $a_V^{\max} = a_V^*$ at some $p < 1$, the corresponding figure is Fig. 3b.

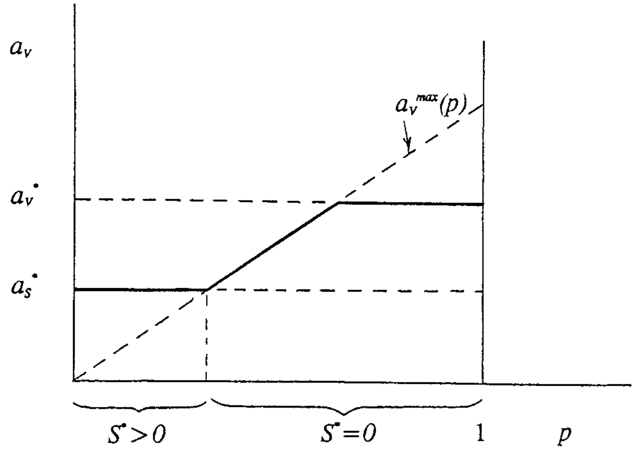


FIG. 7. Low λ.

ments. The few articles that do exist have not addressed the important question of how the level of abatement under a VA is likely to compare to the first best level or the level that might have been imposed mandatorily.

This article 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, and, if so, what the equilibrium level of abatement under the agreement would be under alternative assumptions regarding the allocation of bargaining power between the two parties. 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, even when the firm is not offered a subsidy. However, the agreed upon level of abatement will depend upon (i) the allocation of bargaining power between the regulator and the firm, (ii) the magnitude of the background threat, and (iii) the social cost of funds. In particular, when the regulator has all of the bargaining power, it is possible that the equilibrium level of abatement under a VA is a first best level. In this case, the level of abatement undertaken voluntarily will exceed the level that might have been imposed legislatively, implying supercompliance. The possibility of such an outcome is more likely when the legislative threat is strong, as, for example, when a voluntary agreement exempts a firm from mandatory requirements under existing legislation (so that $p = 1$). This could explain the supercompliance sought under the EPA's Project XL.[31]

For weak threats, a voluntary agreement would still be negotiated. However, the level of abatement under the agreement is likely to be low. In particular, even though the VA results in a net social gain, the level of abatement is likely to be lower than the first best level and could be much lower than the level that is threatened to be imposed legislatively (although it is always higher than the expected level under the legislative threat). Thus, reliance on voluntary agreements (rather than mandatory regulations) could imply reduced levels of environmental quality relative to what might have been achieved legislatively. In such cases, if the social cost of funds is low, an increase in social welfare could be achieved by offering a cost-sharing subsidy to induce participation in a VA with a higher level of abatement than would have been possible without the subsidy. Use of subsidies in such cases seems consistent with reliance on voluntary cost-sharing programs to induce reductions in agricultural sources of pollution.

If the firm has all of the bargaining power, then a VA always results in an equilibrium level of abatement that is lower than the first best level. In the absence of a subsidy, the level of abatement will also be less than the level that might have been imposed legislatively. Again, the agreed upon level might be increased through use of a subsidy if the social cost of funds is low. In fact, it is possible that the firm would agree to the same level of abatement (a level that balances social benefits and social costs, including the costs of the subsidy) that would have been offered by the regulator if the regulator had the bargaining power. However, depending on the magnitude of the legislative threat and the social cost of funds, the firm might use its bargaining power to negotiate a level of abatement that is lower than this (second best) level.

[31] The actual success of Project XL has been limited to date. See Davies and Mazurek [11] for an evaluation.

Overall, the results of this analysis suggest that the effect that the recent increase in the use of voluntary agreements is likely to have on environmental quality depends on a number of factors. It is possible that the overall impact could be positive or negative relative both to the first best level of abatement and the level that might have been achieved legislatively. Thus, although VA's could offer potential cost savings for both regulators and firms and hence could generate increases in expected social welfare, concerns about reductions in environmental quality are likely to be justified if the background threat is small, subsidies are costly, and firms have substantial bargaining power. However, with a strong background threat or low-cost subsidies, VA's might protect the environment at least as well as, and in some cases more than, optimal legislative mandates, while at the same time realizing cost savings for both regulators and firms.

APPENDIX

Proof of Proposition 1. Given (8), we need only show that $a_V^{\min} < a_V^{\max}$ for all $p > 0$. We consider two cases. First, suppose that $pc_L/c_V \geq 1$. The definition of $a_V^{\max}$ in (4) implies that $a_V^{\max} \geq a_L^*$ in this case. Combining this with the fact that $a_L^* > a_V^{\min}$ from (7) (and Fig. 2) proves that $a_V^{\max} > a_V^{\min}$.

Now suppose $pc_L/c_V < 1$, which implies that $a_V^{\max} < a_L^*$. To prove that $a_V^{\max} > a_V^{\min}$ in this case, note that

$$\begin{aligned} B(a_V^{\max}) - T_V(a_V^{\max}) &= B\left(\frac{pc_L a_L^*}{c_V}\right) - T_V\left(\frac{pc_L a_L^*}{c_V}\right) \\ &> B(pa_L^*) - T_V(pa_L^*) > p\{B(a_L^*) - T_V(a_L^*)\} \\ &> p\{B(a_L^*) - T_L(a_L^*)\}. \end{aligned}$$

The first inequality follows from the fact that $c_L > c_V$ and that $B(a) - T_V(a)$ is increasing over the range $[0, a_L^*]$; the second inequality follows from the strict concavity of $B(a) - T_V(a)$; and the third inequality follows from the fact that $T_V(a) < T_L(a)$ for all a. Subtracting $c_V a_V^{\max} = pc_L a_L^*$ 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 $a_V^{\max} > a_V^{\min}$ because NSB_V is increasing at $a_V^{\min}$.

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