Preempting Uncertain Regulatory Threats

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Abstract

Most models of voluntary self-regulatory actions designed to preempt environmental regulations assume certainty regarding the likelihood of the regulatory threat. We examine industry voluntary self-regulatory behavior under uncertainty of two sorts: first, the likelihood that an advocacy group triggers legislative action, and second, the likelihood that legislation passes once a legislative proposal has been put forward. We find that increasing the uncertainty of either type can decrease or *increase* self-regulatory actions. The latter result calls into question conventional wisdom, which suggests that a strong and credible regulatory threat is needed to induce industry to take voluntary self-regulatory actions.

1 Introduction

It is widely recognized that much of the "voluntary" environmental improvement in which companies engage is motivated by regulatory threats. For example, a recent OECD (2003, p. 15) report argues that "The performance of many voluntary approaches would be improved if there were a real threat of other instruments being used if (appropriately set) targets are not met." Similarly, Baranzini and Thalmann (2004, p. 23) note that "VAs are more effective when the environmental authority's bargaining power is stronger. A strong background threat or some reward is needed to prompt emitters to make efforts that are really costly for them." Likewise, Alberini and Segerson (2002, p. 163)

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argue that "The outcome of a voluntary approach is likely to be directly related to the magnitude of the background threat."

In the academic literature there are two influential theoretical models of how "voluntary" corporate environmental improvement depends upon the background regulatory threats facing business. Segerson and Miceli (1998) study negotiated agreements between firms and regulators; they focus on how the background probability of legislative action affects the level of abatement that firms will agree to undertake voluntarily.[1] Maxwell, Lyon and Hackett (2000) study unilateral self-regulation by industry; they focus on how the organizing cost that interest groups must incur to initiate legislation affects the level of abatement that firms undertake voluntarily.[2] Although both papers conclude that stronger regulatory threats often support more voluntary abatement, their conclusions differ in some important ways. For example, Segerson and Miceli (1998) find a monotonic relationship between the probability of legislation and the amount of voluntary abatement, while Maxwell, Lyon and Hackett (2000) find that there may be a highly non-monotonic relationship between the cost of initiating legislation and the amount of voluntary abatement. Unfortunately, the different modeling approaches used in the two papers make it difficult to determine which of their conclusions depend upon specific modeling assumptions and which derive from more robust differences between unilateral and negotiated agreements.

In this paper, we synthesize the models of Segerson and Miceli (1998) and Maxwell, Lyon and Hackett (2000) to create a simple canonical model of voluntary agreements. By employing a unified framework—one that allows for both changes in the likelihood of legislation, and changes in the level of political entry costs—we derive new insights into the difference between negotiated agreements

[1] Segerson and Miceli (1998) also examine the case where regulators can offer a subsidy for voluntary behavior, as well as wield the threat of legislation should firms refuse to take voluntary action. We do not consider subsidy schemes in this paper.

[2] In Maxwell, Lyon and Hackett (2000), if legislation is initiated then the level of abatement mandated by the legislation is a function of the relative political pressure applied by activists and industry members.

and self-regulation.[3] Our analysis shows that the critical difference between the two types of agreements lies in the commitment assumptions made by modelers. In Segerson and Miceli, the regulator can make a credible commitment that if a VA is signed, the legislature will not introduce legislation requiring further improvements. In Maxwell, Lyon and Hackett, the regulator cannot make such a commitment. We show that this difference has some important implications. For instance, under a VA, increases in the probability of legislation always lead monotonically to increases in abatement. Under self-regulation, however, depending upon political entry costs, increases in the probability of legislation may lead firms to *decrease* their level of voluntary abatement. Similarly, under a VA, decreases in political entry costs always lead firms to undertake more abatement. Under self-regulation, however, decreases in political entry costs can lead a firm to cut its voluntary abatement.[4]

Our findings provide guidance for regulators regarding when to offer a negotiated agreement, rather than simply letting industry respond unilaterally to a regulatory threat. The results are somewhat counter intuitive. We find that unilateral action achieves greater voluntary abatement when regulatory threats are strong, that is, when the cost of political entry is low and the probability of passing legislation is high. The only circumstances under which a negotiated agreement achieves greater abatement are when the cost of political entry is low and the probability of legislative passage is moderate. Thus, one cannot simply speak in terms of a one-dimensional "regulatory threat." It is critical to distinguish the two dimensions of the threat that we have identified here, as they have very different implications for policy. It is also essential that regu-

[3] Lyon and Maxwell (2003) build a model in which an advocacy group faces a political entry cost, and in which the passage of legislation is uncertain even after political entry has occurred. Although they examine how voluntary abatement changes with increases in political entry costs, they do not study how voluntary abatement changes as the probability of legislation increases.

[4] In Maxwell, Lyon and Hackett (2000), mandatory standards are imposed as additions to any voluntary abatement the firm has already undertaken. In the present paper, we do not explore this possibility, as it would complicate the analysis and would only heighten the effect of regulatory commitment in the model. When the regulator has commitment power, the "add on" aspect of mandatory regulations is irrelevant, while without commitment power, this aspect increases the threat posed by political entry and hence increases the amount of unilateral action the firm must take to preempt such entry.

lators carefully assess whether they actually have the ability to make credible commitments to eliminate the threat of legislation. If credible commitments are impossible, then regulators run the risk of offering firms the chance to obtain some positive publicity by signing an agreement, yet being unable to actually induce any voluntary improvements. We hope that by offering regulators a more discriminating view of how voluntary agreements actually work, they will be able to craft policy that produces more satisfactory outcomes.

The remainder of the paper is organized as follows. Section 2 presents a simple model of voluntary abatement in the face of regulatory threats, analyzing first the case of negotiated agreements, and then turning to industry self-regulation. Section 4 presents a simple example that allows for some illustrative comparisons between the two types of agreements. Section 5 extends the analysis to allow for bargaining between the regulator and the industry when each has an outside option. Section 6 considers an extension in which the probability of legislation is determined endogenously by interest group pressures from industry and environmentalists. Section 7 concludes.

2 The Model

In this section, we present a simple model in which the firm may preempt the imposition of a mandatory regulation. The model includes two players: a polluting firm and a regulator. The firm has a total cost of abatement $c(a)$, where a is the level of abatement achieved, with $c'(a) > 0$ and $c''(a) \geq 0$. The firm's profits are $\pi(a) = -c(a)$. The gross social benefits from abatement are $B(a)$, with $B'(a) > 0$ and $B''(a) \leq 0$. The regulator's objective is to choose a to maximize the net social welfare of abatement, which is given by $W(a) = B(a) + \pi(a)$.[5] Obviously the first-best level of abatement, a^*, is simply

[5] In Maxwell, Lyon and Hackett (2000), stringency of regulation is not determined by a welfare-maximizing regulator but rather by the competition for political influence between interest groups. While we believe this latter perspective is in many ways more realistic, we eschew this level of detail in the present paper to keep our modeling simple and transparent, and to allow us to focus on how commitment and uncertainty affect voluntary environmental abatement.

determined by $c'(a^*) = B'(a^*)$. Hence, if the regulator makes a legislative proposal for mandatory controls, he proposes a^*. We will assume $W(0) = 0$.

The game unfolds in four stages. First, a candidate level of voluntary abatement is determined, either by the firm's unilateral choice or through negotiation between firm and regulator. Second, the firm can make a sunk investment in a level of voluntary abatement a_V. If this is sufficient to preempt political action, then no legislative proposal is put forward, and the game ends. The third stage is reached if the voluntary level is not sufficient to preempt political action, in which case the regulator incurs the fixed cost k of proposing a level a^* of mandatory abatement. In the fourth stage, which is reached if the regulator makes a proposal, the proposal passes with exogenous probability ρ.[6] If the proposal passes, we assume it is enforced perfectly and costlessly.

2.1 Negotiated Agreements

If the fourth stage is reached, the firm's expected profits are

$$E(\pi|0, L) = \rho\pi(a^*),$$

where the 0 denotes that the firm has undertaken zero voluntary action, and the L indicates that a legislative proposal has been made. Similarly, the regulator's expected benefits are $E(W|0, L) = \rho W(a^*)$. At the third stage, the regulator must decide whether these expected benefits are great enough to outweigh the costs of proposing legislation. Assuming this condition is met, the regulator's expected benefits if a negotiated agreement is not reached are $\rho W(a^*) - k$. The minimum level of voluntary abatement that will serve to preempt the legislative proposal is then defined by

$$W(a_{NA}^{\min}) = E(W|0, L) - k.$$

The maximum level of voluntary abatement the firm is willing to undertake is given by

[6] In an earlier version of this paper, we allowed ρ to be an endogenously determined function of lobbying activity by the industry and the green group. Although the analysis was more complicated, the results were qualitatively similar to those reported here.

$$\pi(a_{NA}^{\max}) = E(\pi|0, L). \tag{1}$$

Depending upon the relative bargaining power of the firm and the regulator, some level of voluntary abatement a_{NA} $(a_{NA}^{\min}, a_{NA}^{\max})$ is selected. The following lemma simply establishes the ordering of $a_{NA}^{\min}$ and $a_{NA}^{\max}$.

Lemma 1 $a_{NA}^{\min} < a_{NA}^{\max}$

Proof. *We will show this in two steps, showing first that* $a_{NA}^{\max} > \rho a^*$, *and then that* $\rho a^* > a_{NA}^{\min}$. *First, recall that* $c(a)$ *is convex, and hence* $\pi(a)$ *is concave. Then by Jensen's Inequality,* $\pi(\rho a^*) > \rho\pi(a^*) + [1-\rho]\pi(0) \equiv E(\pi|0, L)$. *By the continuity of* $\pi(a)$, *and the fact that* $\pi'(a) < 0$, *there exists some* $a_{NA}^{\max} > \rho a^*$ *such that* $\pi(a_{NA}^{\max}) \equiv E(\pi|0, L)$. *Second, note that* $W(a)$ *is concave because* $B(a)$ *and* $\pi(a)$ *are concave. Then by Jensen's Inequality,* $W(\rho a^*) > \rho W(a^*) + [1-\rho]W(0) \geq E(W|0, L)$. *Note that* $W'(\rho a^*) > 0$, *since* $\rho a^* < a^*$. *Then by the continuity of* $W(a)$, *and the fact that* $W'(a^*) > 0$, *there exists some* $a_{NA}^{\min} < \rho a^*$ *such that* $W(a_{NA}^{\min}) \equiv E(W|0, L) - k$. *Thus,* $a_{NA}^{\min} < \rho a^* < a_{NA}^{\max}$. ■

By definition, a negotiated agreement involves bargaining between the regulator and the industry. We will let $\beta \in [0, 1]$ represent the regulator's bargaining power, and let $a_{NA}^*(\beta)$ be the outcome of the negotiation process. Then $a_{NA}^*(0) = a_{NA}^{\min}$ and $a_{NA}^*(1) = a_{NA}^{\max}$. In order to avoid specifying the details of this bargaining process, we will make the following very mild assumption.

Assumption 1: *In the bargaining game between the firm and the regulator, then for any* β *the outcome* $a_{NA}^*(\beta)$ *is increasing in* $a_{NA}^{\min}$ *and* $a_{NA}^{\max}$.

We now proceed to establish some important properties of the negotiated agreement in a series of propositions. We begin by analyzing the effect of changes in the cost of political entry on the level of voluntary abatement. We will suppress the dependence of $a_{NA}^*(\beta)$ on β when there is no danger of confusion, and simply write a_{NA}^*.

Proposition 2 *There exists a value* $k_{NA}^{blockade}$ *such that for all* $k \geq k_{NA}^{blockade}$, $a_{NA}^* = 0$. *For all* $k \in [0, k_{NA}^{blockade})$, $a_{NA}^* > 0$ *is strictly decreasing in* k.

Proof. Recall that $W(a_{NA}^{\min}) = \rho W(a^*) - k$. It is easy to see that for large enough k, the right-hand side of this expression reaches zero, at which point $a_{NA}^{\min} = 0$. For all values of k below this value, total differentiation reveals that $da_{NA}^{\min}/dk = -1/W'(a_{NA}^{\min}) < 0$. Note that $a_{NA}^{\max}$ is not a function of k, so by Assumption 1, $da_{NA}/dk < 0$. ■

The following Corollary follows immediately.

Corollary 3 *When $k = 0$ there always exists a negotiated agreement that will preempt the legislative threat.*[7]

When $k = 0$, we obtain the same level of a_{NA} as in Segerson and Miceli (1998).[8] As k rises above zero, the negotiated agreement becomes gradually weaker, until at the point where $k = k_{NA}^{blockade}$ the negotiated agreement achieves nothing at all. In particular, note that there is always a continuous erosion in the amount of abatement required under the negotiated agreement as k rises. As will be shown below, this is in sharp contrast to the case of a unilateral commitment, where for small values of k the firm may opt to take no voluntary action, but may undertake voluntary abatement for larger values of k.

We turn now to examining changes in ρ, the probability of legislation.

Proposition 4 (Segerson and Miceli Proposition 4) *Assume $k < k_{NA}^{blockade}$. Then regardless of the allocation of bargaining power between the firm and the regulator, then a_{NA}^* is positive and strictly increasing in ρ.*[9]

Proof. Recall that $\pi(a_{NA}^{\max}) = \rho\pi(a^*)$, and equivalently, $c(a) = \rho c(a^*)$. Then totally differentiating and collecting terms yields $da_{NA}^{\max}/d\rho = (c(a^*)/c'(a_{NA}))/(1-$

[7] This proposition is equivalent to Proposition 1 in Segerson and Miceli (1998). Note, however, that unlike those authors we do not assume the firm's costs are linear, nor do we assume that costs for the firm or the regulator are lower under a negotiated agreement than under mandatory legislation

[8] The only difference is that we assume transaction costs are identical for voluntary and mandatory abatement.

[9] This proposition replicates Proposition 4 of Segerson and Miceli (1998), except that they consider only the cases where one party has all the bargaining power.

$\rho) > 0$. Similarly, $W(a_{NA}^{\min}) = \rho W(a^*) - k$, so totally differentiating and collecting terms yields $da_{\min}^{NA}/d\rho = (W(a^*)/W'(a_{NA}^{\min}))/(1-\rho) > 0$. Note that a_{NA} is a result of the bargaining between firm and regulator, and is hence a function of both $a_{NA}^{\min}$ and $a_{NA}^{\max}$, both of which are increasing in ρ. By Assumption 1, $da_{NA}/d\rho > 0$. ■

The foregoing results show that the level of voluntary abatement under a negotiated agreement is a monotonic function of the strength of the legislative threat facing the industry, regardless of whether that threat is expressed in terms of the cost of political entry or the probability of legislation. We will see in the following section that this is quite different than what happens under unilateral industry self-regulation, where the lack of commitment power means that voluntary abatement may be a highly non-linear function of the strength of the legislative threat.

2.2 Unilateral Action

If the fourth stage is reached, the firm's expected profits are

$$E(\pi|a_U, L) = \rho\pi(a^*) + [1-\rho]\pi(a_U),$$

where again L indicates a legislative proposal is made. Note that $E(\pi|a_U, L) = E(\pi|0, L) + [1-\rho]\pi(a_U) < E(\pi|0, L)$, since $\pi(a) = -c(a) < 0$. An important difference between a negotiated agreement and a unilateral commitment is the assumption that the former is negotiated by a regulator with the power to prevent legislation from being proposed. When a firm makes a unilateral commitment, however, the regulator retains the option to propose legislation after the firm undertakes voluntary abatement. Since the regulator cannot commit not to introduce legislation, the firm must undertake enough voluntary abatement to make the regulator uninterested in pursuing further action.

If a legislative proposal is made, the regulator's expected benefits are

$$E(W|a_U, L) = \rho W(a^*) + [1-\rho]W(a_U).$$

At the third stage, the regulator must decide whether these expected benefits

are great enough to outweigh the costs of proposing legislation. The regulator's net benefit of proposing legislation is $E(W|a_U, L) - k$. The minimum level of voluntary abatement that will serve to preempt the legislative proposal is then defined by

$$W(a_U^{\min}) = E(W|a_U^{\min}, L) - k.$$

Preemption is feasible if there exists some a_U such that $W(a_U) \geq \rho W(a^*) + [1 - \rho]W(a_U) - k$. This can be rewritten as $k \geq \rho[W(a^*) - W(a_U)]$. Then we will refer to the minimum level of abatement that will preempt a legislative proposal as $a_U^{\min}(k)$.

The maximum level of voluntary abatement the firm is willing to undertake is given by

$$\pi(a_U^{\max}) = E(\pi|0, L). \tag{2}$$

The firm's optimal level of unilateral abatement is

$$a_U^*(k) = \begin{cases} a_U^{\min}(k) & \text{if } a_U^{\min}(k) < a_U^{\max} \\ 0 & \text{if } a_U^{\min}(k) > a_U^{\max} \end{cases}$$

The following proposition establishes the relationship between k and $a_U^*(k)$ for all values of ρ. Note that although $k_U^{blockade}$ and $a_U^*(k)$ are functions of ρ, we suppress this dependence in our notation in order to keep the exposition as uncluttered as possible.

Proposition 5 *As k increases from zero, $a_U^*(k)$ is a non-monotonic function such that: (a) There exists a $k_U^{blockade}$ such that for $k > k_U^{blockade}$ the firm chooses $a_U^*(k) = 0$. (b) For any ρ, there exists a value $\widehat{k}(\rho) \in (0, k_U^{blockade})$ such that for $k < \widehat{k}(\rho)$ the firm chooses $a_U^*(k) = 0$. (c) For $k \in [\widehat{k}(\rho), k_U^{blockade})$ the firm chooses $a_U^*(k) > 0$ and $da_U^*/dk < 0$.*

Proof. (a) The value $k_U^{blockade}$ is defined such that the regulator makes no legislative proposal, even if the firm takes no voluntary action. That is,

$k_{blockade} = \rho W(a^*)$. For any $k > k_{blockade}$ making a legislative proposal is not worthwhile. (b) For $k < k_{blockade}$, preemption is feasible if there exists some a_U such that $W(a_U) \geq \rho W(a^*) + [1-\rho]W(a_U) - k$. This can be rewritten as $k \geq \rho[W(a^*) - W(a_U)]$, which defines the minimum preemptive level of abatement $a_U^{\min}(k)$ as the value that sets $k = \rho[W(a^*) - W(a_U^{\min}(k))]$. Totally differentiating $k = \rho[W(a^*) - W(a_U^{\min})]$ shows that $a_U^{\min}(k)$ is decreasing in k. It is easy to see that $a_U^{\min}(0) = a^*$. Note that $\pi(a_U^{\min}(k))$ is decreasing in $a_U^{\min}(k)$ and $a_U^{\min}(k)$ is decreasing in k, so $\pi(a_U^{\min}(k))$ is increasing in k. Further, $\pi(a_U^{\min}(0)) = \pi(a^*) < E(\pi|0,L) = \rho\pi(a^*) + [1-\rho]\pi(0) < \pi(0) = \pi(a_U^{\min}(k_U^{blockade}))$. Hence, at $k = 0$ the firm prefers to take no preemptive abatement, and by extension, for any value of ρ there exists a $\widehat{k}(\rho)$ such that preemption unprofitable for $k < \widehat{k}$. (c) For $k \in (\widehat{k}(\rho), k_U^{blockade}]$, $\pi(a_U^{\min}(k)) > E(\pi|0,L)$ and the firm prefers to preempt legislation by choosing $a_U^{\min}(k) \geq 0$. Hence, for $k \in (\widehat{k}, k_U^{blockade}]$, the firm preempts with abatement $a_U^{\min}(k)$ which is declining in k, with $a_U^{\min}(k_U^{blockade}) = 0$. ■

The Proposition shows that unilateral self-regulation and negotiated agreements respond very differently to changes in political entry costs. While negotiated agreements exhibit a smooth monotonic relationship between k and voluntary abatement, the relationship is non-monotonic for unilateral abatement. The fundamental difference is that when the firm acts unilaterally, the regulator retains the option to initiate legislation after the firm takes its unilateral action. Whether the firm decides to preempt a legislative proposal is simply a matter of costs and benefits. When the regulator's cost of initiating legislation is small, the firm must undertake a lot of voluntary abatement in order to preempt. But if the probability of legislative passage is small, then the benefits of preemption are low. As a result, the firm does not find it profitable to preempt the legislative proposal.

To see this more clearly, consider a case where $\rho = .5$ and a value of k that is very close to zero. If the firm wants to preempt a legislative proposal, it must choose a level of voluntary abatement that is very close to a^*. But doing

so makes no sense, because legislation has only a 50% chance of passage, even if it is proposed. If the firm took no voluntary action, the expected level of abatement that would be required by legislation is well below a^*, so preempting a legislative proposal is simply not worthwhile.

It is important to compare the preceding logic with what happens under a negotiated agreement, where we assume the regulator can make a credible commitment not to make a legislative proposal after the firm undertakes voluntary abatement. If the regulator only gets "one bite at the apple," then he realistically must compare the *expected* level of abatement that would be forthcoming from a legislative proposal against what he can get *for sure* from the firm's voluntary action. When the probability of legislative passage is only 50%, the regulator is willing to accept a level of voluntary abatement that is well below a^*. Of course, if the regulator can go back on his word and initiate a legislative proposal after the firm invests in voluntary abatement, then he has incentives to do so if k is small. In other words, the negotiated agreement is not dynamically consistent, and its success depends critically upon the regulator's commitment power. If he does not have the ability to make a credible commitment, then the model of section 2.1 does not apply. In this case, the model of the present section is a better description of the political realities of the situation.[10]

It is worth noting that in practice, Ansolabehere, de Figueiredo and Snyder (2003) find that expenditures on political activity tend to be small relative to the value at stake. Thus, it is reasonable to suppose that there are many situations in which the size of k is small relative to the value of the benefits at stake. In such situations, firms may be unwilling to self-regulate, but negotiated agreements remain feasible, assuming regulators can make credible commitments.

Turn now to an analysis of how unilateral voluntary abatement changes with

[10] The foregoing discussion presents one of the key results of Maxwell, Lyon and Hackett (2000), who show how there can be a non-monotonic relationship between unilateral abatement and k. In their model, the level of mandatory abatement emerging if legislative entry occurs depends upon the outcome of a political influence game whose results are determined endogenously. They find that if the equilibrium resource expenditures in the influence game are moderate then the non-monotonic relationship holds. However, if equilibrium influence expenditures are high, then the relationship is monotonic and the firm preempts even as k goes to zero.

ρ. First we define the minimum preemptive level of abatement $a_U^{\min}(\rho, k)$ as the value that sets

$$k = \rho[W(a^*) - W(a_U^{\min}(\rho, k))]. \tag{3}$$

The following Lemma identifies some important properties of the minimum preemptive level of abatement.

Lemma 6 *$a_U^{\min}(\rho, k)$ is increasing in ρ and decreasing in k, with $a_U^{\min}(0, k) = 0$ and $a_U^{\min}(1, k) = W^{-1}(W(a^*) - k)) < a^*$.*

Proof. *Totally differentiating (3) reveals that $a_U^{\min}(\rho, k)$ is increasing in ρ and decreasing in k. It is easy to see that $a_U^{\min}(0, k) = 0$ and $a_U^{\min}(1, k) = W^{-1}(W(a^*) - k)) < a^*$.* ■

Lemma 6 establishes the intuitive point that the level of abatement needed to preempt increases with the strength of the regulatory threat, which itself is increasing in ρ and decreasing in k. We turn now to characterizing a_U^*, the level of voluntary abatement that the firm will choose in order to maximize profits. We begin by exploring the situation when k is small, which leads to some surprising results.

Proposition 7 *There exists some $\widetilde{k}$ such that for $k \in (0, \widetilde{k})$ there exist $\underline{\rho}$ and $\overline{\rho} > \underline{\rho}$ such that preemption is profitable for $\rho < \underline{\rho}$ and for $\rho > \overline{\rho}$, and not for $\rho \in (\underline{\rho}, \overline{\rho})$. More specifically, (a) for $\rho < k/W(a^*)$ the firm preempts by choosing $a_U^* = 0$, (b) for $\rho \in (k/W(a^*), \underline{\rho})$ the firm preempts by choosing $a_U^* = a_U^{\min} > 0$, (c) for $\rho \in (\underline{\rho}, \overline{\rho})$ the firm chooses $a_U^* = a_U^{\min} = 0$ and does not preempt, and (d) for $\rho \geq \overline{\rho}$ the firm preempts by choosing $a_U^* = a_U^{\min} > 0$.*

Proof. (a) For any strictly positive k, it is possible to find a range of values of ρ small enough that regulatory action is blockaded. Action is blockaded if $k > \rho W(a^*)$, or alternatively, if $\rho < \widehat{\rho}(k) \equiv k/W(a^*)$. (b)-(d) We can show that $\underline{\rho}$ must exist for small enough k. Consider ρ just slightly greater than $\widehat{\rho}(k) \equiv k/W(a^*)$. We know that $a_U^{\min}(\widehat{\rho}(k)) = 0$ and hence $\pi(a_U^{\min}(\widehat{\rho}(k))) =$

$\pi(0) > E(\pi|0, L)$. We also know that $a_U^{\min} > 0$ for $\rho > \widehat{\rho}(k)$, and that for unilateral action

$$\frac{da_u^{\min}}{d\rho} = \frac{k}{\rho^2 W'(a_U)}.$$

Substituting in for $\widehat{\rho}(k) \equiv k/W(a^*)$ we have

$$\left.\frac{da_u^{\min}}{d\rho}\right|_{\widehat{\rho}(k)} = \frac{W(a^*)^2}{kW'(a_U)}.$$

For small k this slope becomes arbitrarily large as long as $lim_{a\to 0} W'(a) < \infty$. But we know that

$$\frac{\partial \pi(a_U^{\min}(\rho))}{\partial \rho} = \frac{\partial \pi(a_U^{\min}(\rho))}{\partial a} \frac{\partial a_U^{\min}(\rho)}{\partial \rho},$$

so we can make $\pi'(\rho)$ arbitrarily large by making k arbitrarily small. Thus, as k becomes small, $\widehat{\rho}(k) \to 0$ and $\pi(0)$ becomes very close to $E(\pi|0, L)$. Then if we make $\pi'(\rho)$ arbitrarily large and negative, then we can find a ρ such that $\pi(a_U^{\min}(\rho)) < E(\pi|0, L)$. From Lemma 6, we know that when $\rho = 1$ we have $\pi(a_U^{\min}(\rho)) > E(\pi|0, L) = \pi(a^*)$. Because $\pi(a_U^{\min}(\underline{\rho}))$ is continuous, there must exist $\underline{\rho}$ and $\overline{\rho}$ such that $\pi(a_U^{\min}(\underline{\rho})) = E(\pi|0, L)$ and $\pi(a_U^{\min}(\overline{\rho})) = E(\pi|0, L)$ and that $\pi(a_U^{\min}(\rho)) > E(\pi|0, L)$ for $\rho < \underline{\rho}$, $\pi(a_U^{\min}(\rho)) < E(\pi|0, L)$ for $\rho \in (\underline{\rho}, \overline{\rho})$, and $\pi(a_U^{\min}(\rho)) > E(\pi|0, L)$ for $\rho > \overline{\rho}$. ■

Proposition 7 shows that there is a complicated non-linear relationship between unilateral abatement and ρ when political entry costs are small. When ρ is very small, political entry is not worthwhile, even when the firm undertakes no voluntary action. As ρ increases, the firm can preempt with a small amount of voluntary abatement, and it finds it profitable to do so. And at high levels of ρ, the regulatory threat is strong and the firm finds it profitable to preempt. What is surprising, however, is that there exists a range of moderate values of ρ for which preemption is not profitable. The firm's voluntary abatement level is thus a non-monotonic function of ρ. This result arises from the curvature of the profit function with respect to ρ which changes from concave to convex. Intuitive explanations of this result are still under investigation. See the appendix to this draft version of the paper.

The following proposition above establishes the result that, for k sufficiently large, unilateral self-regulatory abatement is rising in the threat of regulation as measured by the likelihood of the passage of the legislative proposal.

Proposition 8 *There exists some* $\widetilde{k}$ *such that for* $k \in (\widetilde{k}, k_U^{blockade})$, *preemption is profitable for all* ρ *and* $da_U/d\rho > 0$.

The preceding two proposition establish not only a highly non-linear relationship between the optimal level of self-regulation and the regulatory threat. They also establish the fact that voluntary behavior differs with respect to changes in the two different aspects of the threat. Thus, we cannot discuss the "strength of the regulatory threat" in a unidimensional context when considering policy advice.

3 Comparing Unilateral and Negotiated Agreements

In this section we compare the performance of unilateral and negotiated agreements. We begin by noting that $a_{NA}^{\max} = a_U^{\max}$, which is apparent from noting that (1) and (2), which are identical. We then establish the following proposition comparing $a_{NA}^{\min} = a_U^{\min}$.

Proposition 9 *For any given values of* k *and* ρ, *if* $a_U^* > 0$, *then* $a_U^{\min} \geq a_{NA}^{\min}$.

Proof. *Voluntary action under self-regulation is governed by the equation* $W(a_U) = \rho W(a^*) + (1-\rho)W(a_U) - k$, *and the minimum preemptive level of voluntary action under a negotiated agreement is governed by* $W(a_{NA}) = \rho W(a^*) - k$. *Since* $W(a)$ *is increasing in* a *and* $\rho W(a^*) + (1-\rho)W(a_U) - k > \rho W(a^*) - k$, *it is immediate that* $a^U \geq a_{NA}^{\min}$. ■

The proposition makes the point that if self-regulation produces a positive level of voluntary action, then the preemptive level of action under self-regulation is greater than the minimum level of voluntary abatement that would be accepted by the regulator under a negotiated agreement. This suggests that

in some situations, unilateral action is more socially desirable than a negotiated agreement. However, the social desirability of unilateral action depends upon β, k, and ρ. If the regulator has a strong bargaining position, then a negotiated agreement may produce more abatement than a unilateral agreement. Furthermore, there are some values of k and ρ for which the firm finds it unprofitable to undertake any self-regulatory action at all. In these cases, a negotiated agreement may produce outcomes that are more socially desirable than self-regulation. For example, this may occur when k is relatively small and ρ is moderate. We now proceed to consider these conditions in more detail.

As we showed in section 3, as the regulator's bargaining power increases, a^*_{NA} increases, approaching $a^{\max}_U$ as β approaches unity.

Proposition 10 *For any given values of k and ρ, if $a^*_U > 0$, then there exists some $\widehat{\beta}$ such that $a^*_{NA} > a^*_U$.*

Proof. *If $a^{\min}_U > a^{\max}_U$ then $a^*_U = 0$, so if $a^*_U > 0$ then we know that $a^*_U = a^{\min}_U < a^{\max}_U = a^{\max}_{NA} = a^*_{NA}(1)$. Hence as $\beta \to 1$, $a^*_{NA}(\beta) \to a^{\max}_U > a^{\min}_U = a^*_U$.* ■

The two foregoing propositions imply that—assuming both instruments generate positive levels of voluntary abatement—unilateral action produces more abatement than a negotiated agreement when the regulator's bargaining power is weak but less abatement than a negotiated agreement when the regulator's bargaining power is strong. This is an important factor in determining when each instrument is socially desirable, but it is not sufficient to settle the issue of instrument choice. We must also consider the conditions under which each instrument generates a positive level of voluntary action.

Propositions 2 and 4 establish that if $k < k^{blockade}_{NA}$ then $a^*_{NA} > 0$ for all $\rho \in (0, 1]$. However, Propositions 5 and 7 show that $a^*_U = 0$ is possible for some positive values of k and ρ. Thus in considering the choice of optimal policy instrument we obtain the immediate result that under the conditions which generate no self-regulatory action it is good to offer a negotiated agreement.

In order to offer advice on instrument choice more broadly, one must carefully consider the source of the regulator's bargaining power β. It is natural to assume that β will be large precisely when k is small and ρ is large. Our preceding results the suggest that when k is large and ρ is small, unilateral action may be preferable over a negotiated agreement (especially if there are transactions costs which are high with the negotiated agreement). On the other hand it would appear that when k is small and ρ is large a negotiated agreement would be the policy instrument of choice. However, these are precisely the circumstances under which the regulator's ability to preempt subsequent legislative action are most in doubt.

These observations suggest that the range of circumstances under which a negotiated agreement is the preferred policy instrument might be less than one would initially suspect. They also call in to question the widely held view that negotiated agreements are likely to perform best when the threat of regulation is strong. The results also suggest that when the cost of a legislative proposal is low and the likelihood of legislation is high, a legislature might want to undertake actions that would enhance the regulators commitment power.

4 Conclusions

This paper had attempted to develop a common setting within which two popular policy instruments involving voluntary behavior can be examined. In dosing so we were able to highlight the fundamental difference between unilateral and negotiated voluntary agreements. Namely, a negotiated agreement is likely to produce tangible benefits only if the regulator can commit not to legislate firm actions following the singing of the agreement. It would be interested to compare the performance of negotiated agreements across different regulatory settings. For example, it appears to be the case in Europe that regulators have greater autonomy, implying a greater commitment powers, than is the case in the United States.

Importantly, our model highlights the fact that the regulatory threat facing

firms is not unidimensional, and firm unilateral behavior may respond differently to differences in the two dimensions of regulatory threat we identify. This has important implications for policy and also for empirical examinations of unilateral agreements, or other self-regulatory behavior.

Further examination of the explanation for differences in unilateral behavior with respect to changes in the probability of legislation are needed. Greater insight into the non-monotonic abatement response with respect to changes in this behavior may generate new policy insights. It may also be interesting to directly link the bargaining power of the regulator to k and ρ.

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