Preempting Uncertain Regulatory Threats

Thomas P. Lyon* and John W. Maxwell†

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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 well established that much of the "voluntary" environmental improvement in which companies engage is motivated by regulatory threats. For such threats to be taken seriously, there must usually be at least one highly motivated advocacy group willing to undertake the political effort required to push through new regulations. The costs of organizing a political campaign (which we refer to as "political entry costs") can be substantial, both in time and money. The academic literature on regulatory preemption assumes the advocacy group's costs of taking political action are known to firms, who can thus undertake just enough voluntary action to preempt the group's entry into the political arena.[1] This

*Dow Chair of Sustainable Science, Technology and Commerce, University of Michigan Business School, Ann Arbor, MI, 48109. Email: tplyon@umich.edu.

†Kelley School of Business, Indiana University, Bloomington, IN, 47405. Email: jwmax@indiana.edu.

[1] See, for example, Glazer and McMillan (1992), Segerson and Miceli (1998), Hansen (1999), Maxwell, Lyon and Hackett (2000), and Glachant (2003). We recognize that corporate environmental strategy can have a variety of motivations (e.g., raising rivals' costs or influencing

literature has provided valuable insights into corporate strategy and the welfare effects of preemption. In practice, however, firms do not know with certainty the political costs facing advocacy groups. Furthermore, even after advocacy groups organize to enter the political arena, there remains considerable uncertainty regarding whether they will be successful in passing legislation favorable to their cause. There are thus at least two important uncertainties involved with regulatory threats that affect corporate environmental strategy, neither of which has received much academic attention.

The prevailing view among economists and policymakers is that strong regulatory threats are needed in order to induce any significant voluntary action on the part of corporations. For example, in a recent survey paper, Alberini and Segerson (2002, p. 178) conclude that "In sum, when based on a strong and credible regulatory threat and a reliable means of monitoring success, a voluntary approach can provide a mechanism for meeting environmental quality goals both effectively and efficiently." Similarly, a recent OECD (2003, p. 15) 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." Thus, one would expect that when firms face uncertain regulatory threats, they are less motivated to engage in preemptive actions than when the likelihood of regulation is greater. Similarly, we would expect less voluntary abatement when there is uncertainty over whether advocacy groups will get involved on a particular issue. Nevertheless, in practice firms sometimes engage in voluntary environmental improvement even when the apparent threat seems relatively distant or unlikely to materialize. Indeed, according to a recent headline article in *Business Week,* a growing number of U.S. companies are taking steps to reduce their greenhouse gas emissions even though "[t]he Bush Administration flatly rejects Kyoto and mandatory curbs, arguing that such steps will cripple the economy."[2]

future regulations), and that preemption is not always desired by business. Lyon and Maxwell (2004) provide a thorough discussion of possible rationales for voluntary action. Our focus in this paper, however, is on situations where firms desire to preempt regulation.

[2] See Carey (2004), p. 2. One of the more interesting of these efforts is the Chicago

In this paper we focus on how uncertainty surrounding regulatory threats affects the extent of voluntary action. We recognize explicitly that firms are uncertain about the political entry costs facing environmental groups, as well as the likelihood that any proposed legislation will actually pass, and we explore how these uncertainties affect corporate environmental strategy. We find that in many circumstances greater uncertainty can induce firms to undertake more self-regulation. Thus, in contrast to the existing literature, we are able to provide an explanation for corporate self-regulation in areas where there does not appear to be an immediate regulatory threat, such as the activity on climate change mentioned above.[3]

The remainder of the paper is organized as follows. Section 2 presents a simple model of industry self-regulation in the face of regulatory threats. Section 3 analyzes industry's incentives for self-regulation when the political entry costs of environmental groups are known with certainty, but it is uncertain whether political entry by an advocacy group will actually result in new regulations. Section 4 extends the analysis to the more realistic case where industry is uncertain of environmental groups' entry costs. Section 5 concludes.

2 The Model

In this section, we present a simple model in which industry may preempt the imposition of a mandatory regulation. The model includes three players: a polluting industry, a non-governmental organization with "green" preferences, and a regulator. The industry has a total fixed cost of abatement $c(z) = z^2$, where z is the level of abatement achieved. This cost is the sum over all firms in the industry of achieving the aggregate abatement level z. We simplify by abstracting from issues of market structure and assume industry profits are $\pi(z) = -c(z)$. Because abatement is costly, the industry will lobby

Climate Exchange, formed by a group of 28 large companies that have voluntarily committed themselves to reduce greenhouse gas emissions by 4% by 2006, relative to their 1998-2001 baselines. For details on the Exchange, visit www.chicagoclimatex.com.

[3] For a discussion of the various business rationales for action on climate change, see Hoffman (2004).

against legislative proposals for emissions control. The "green" group has utility $U(z) = z$, and will lobby in favor of emissions controls. Finally, the regulator's objective is to choose z to maximize the net social welfare of abatement, which is given by $W(z) = U(z) + \pi(z)$. Obviously the first-best level of abatement, z^*, is simply determined by $c'(z^*) = U'(z^*)$. Hence, if the regulator makes a legislative proposal for mandatory controls at some level M, he proposes $M = z^* = 1/2$.

The game unfolds in three stages. First, industry can choose a level of voluntary abatement V. We shall assume that this represents a sunk investment that cannot be reversed. If this is sufficient to preempt political activity by the green group, then no legislative proposal is put forward, and the game ends. The second stage is reached if the voluntary level is not sufficient to preempt entry by the green group, in which case the group incurs the fixed cost k of entering the political process. If it does so, then the regulator puts forward a legislative proposal for a level $M = 1/2$ of mandatory emissions control. In the third stage, which is reached if the regulator makes a proposal, the proposal passes with exogenous probability ρ.[4] If the proposal passes, we assume it is enforced perfectly and costlessly.

We will suppose the probability distribution over green group entry costs is

$$f(k) = \begin{cases} (1-\alpha)/2 & \text{if } k = K - \epsilon \\ \alpha & \text{if } k = K \\ (1-\alpha)/2 & \text{if } k = K + \epsilon \end{cases},$$

where $\alpha \in [0, 1]$ is a probability and K and ε are simply cost parameters. A convenient aspect of this formulation is that an increase in uncertainty, in the form of a mean-preserving spread, can be generated simply by a reduction in α. Throughout the paper we will consider only cases in which the probability distribution $f(k)$ is either uniform or single-peaked, which implies that $\alpha \geq 1/3$.[5]

The firm's expected profits, *conditional on entry by the green group*, (where

[4] 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.

[5] In an earlier version of the paper, we studied a continuous distribution over entry costs. Results were qualitatively similar to those reported here, but somewhat harder to interpret.

L indicates entry by into the legislative process by the green group) are

$$E(\pi|V,L) = \rho\pi(M) + [1-\rho]\pi(V).$$

Similarly, the green group's expected utility, net of entry costs, is

$$E(U|V,L) = \rho U(M) + [1-\rho]U(V) - k.$$

We will define an indicator variable equal to one if green group entry occurs, with

$$\delta(V|k) = \begin{cases} 0 & \text{if } U(V) > E(U|V,L) - k \\ 1 & \text{if } U(V) < E(U|V,L) - k \end{cases}.$$

Now we can express industry's assessment of the probability that the green group enters by

$$P(V,\alpha,K,\varepsilon) = \alpha\delta(V|K) + ((1-\alpha)/2)\delta(V|K+\varepsilon) + ((1-\alpha)/2)\delta(V|K-\varepsilon). \quad (1)$$

Finally, unconditional expected profits are

$$E(\pi,V) = \pi(V)[1-P(V,\alpha,K,\varepsilon)] + E(\pi|V,L)P(V,\alpha,K,\varepsilon).$$

Our focus in the following section is on the industry's optimal choice of V.

3 Self-Regulation when Entry Costs are Known

The previous section presented a convenient, tractable model of self-regulation and regulatory threats. Our analysis of the model begins with the case where $\alpha = 1$, that is, where entry costs are known with certainty, and then proceeds in section 4 to study mean-preserving spreads, that is, decreases in α.

Suppose it is common knowledge that the green group's entry cost is K with probability $\alpha = 1$. Then conditional on green group entry into the legislative process, the industry's expected level of abatement is

$$E(z|V,L) = (1-\rho)V + \rho M > V,$$

which is strictly increasing in V. Thus, industry has no incentive to engage in voluntary abatement unless it preempts green group entry.

The green group's expected utility, conditional on entry, is

$$E(U|V,L) = V + \rho(M - V) - k,$$

and its utility if it stays out of the influence game is simply $U(V) = V$. Industry can preempt entry by choosing a level of V such that $U(V) > E(U|V,L)$, which implies

$$k \geq \rho(M - V),$$

or

$$V(k) = M - \frac{k}{\rho}. \tag{2}$$

Thus, the amount of V that is required to preempt the green group is decreasing as the green group's political costs k rise. Indeed, the green group is "blockaded" (that is, entry is never worthwhile) if $1/2 - k/\rho < 0$. From here on, we shall assume the green group's political costs are low enough that it is not blockaded, that is, we assume $k < \rho/2$.

If the industry preempts, its profits are

$$\pi(V(k)) = -\left(M - \frac{k}{\rho}\right)^2. \tag{3}$$

Alternatively, the industry can opt to take no voluntary action, in which case its expected profits are

$$\begin{aligned} E(\pi|0,L) &= \pi(0) - \rho[0 - \pi(M)] \\ &= -\rho M^2. \end{aligned} \tag{4}$$

Preemption is profitable if $\pi(V(k)) > E(\pi|0,L)$. Figure 1 compares these two expressions as ρ goes from 0 to 1. There are three regions of interest. In Region 1, the industry chooses to preempt political entry by the green group. In Region 2, industry elects not to preempt. In Region 3, industry once again finds preemption profitable. The non-monotonic relation between ρ and industry's optimal level of self-regulation is surprising, and calls for some further explanation. Intuitively, when ρ is very small, industry need not do much to preempt. Indeed, for $\rho < 2k$, the green group is blockaded. The point where $\rho = 2k$ can be identified in Figure 1 as the point where the curve $\pi(V(k))$ cuts the horizontal axis. For all values of ρ to the left of this point, the green group is blockaded. For values slightly to the right of this point, preemption is inexpensive and hence profitable, even though the probability that legislation succeeds is small. At the other extreme, when ρ is close to 1, a mandatory regulation requiring industry abatement M is almost certain to be imposed if industry takes no voluntary action, but industry can preempt with $V(k) \approx M - k$. By doing so, industry appropriates most of the green group's political costs through preemptive action. Hence, preemption is once again profitable, though for very different reasons. However, there is an intermediate range of values of ρ, which we label Region 2, for which preemption is not cheap, nor are mandatory regulations highly probable. In this intermediate range, industry does not find preemption worthwhile.

As k rises, the size of Region 2, the region of non-preemption, shrinks. This can be shown by differentiating equation (3), obtaining $\partial\pi(V(k))/\partial k = 2(M - k/\rho)/\rho$, which is positive for all $V(k) > 0$. Thus, for any value of ρ, an increase in k causes profits to rise. One can envision this in Figure 1 by picturing the curve $\pi(V(k))$ shifting upwards with increases in k. Indeed, it is apparent from the Figure that as k continues to increase, there will come a point where the curve $\pi(V(k))$ lies above $E(\pi|0, L)$ for all values of ρ. When this happens, it becomes profitable for industry to preempt for all values of ρ. This does not imply that the green group is blockaded for all values of ρ. The green group is only blockaded for values of ρ that lie to the left of the point where $\pi(V(k))$ cuts the horizontal axis. For larger values of ρ, industry must take some voluntary action to preempt green group entry, but this is profitable if $\pi(V(k)) > E(\pi|0, L)$.

It is worth underscoring that even in this very simple case, where the green group's political entry costs are known, there is a rather complex relationship between the extent of political uncertainty and the amount of voluntary action undertaken by industry. Within either Region 1 or Region 3, in which industry preempts, the level of voluntary preemptive action is increasing with the probability that regulation is imposed. However, starting from Region 1, as ρ increases there is eventually a transition to Region 2, in which preemption is not profitable. Finally, if ρ increases enough to move the situation into Region 3, preemption once again becomes profitable. Overall, there is a surprisingly subtle and non-monotonic relationship between the probability of regulation—given political entry by the green group—and voluntary action by industry. We highlight this relationship in the following proposition.

Proposition 1 *A greater probability of regulation may induce either a greater or lesser level of voluntary abatement by industry.*

4 Self-Regulation with Uncertain Entry Costs

Now let us turn to a second type of uncertainty, that in which the industry is uncertain of green group entry costs. Now it is possible that the industry will choose a level of voluntary action that preempts green group entry for some but not all values of k. Ultimately, we wish to characterize the effects of a mean-preserving spread on the firm's optimal level of voluntary abatement, V^*, that is, we are interested in $dV^*/d\alpha$. We shall approach this task in two steps. First, we characterize analytically some of the features of optimal self-regulation in the context of our model. Second, we present a series of results from a numerical simulation, which give a good intuitive feel for the range of results that can emerge.

4.1 Analytical Results on Self-Regulation

In this section, we establish some general characteristics of the industry's optimal level of self-regulation. We begin with a general characterization of industry profits as a function of self-regulatory action V.

Proposition 2 *Increases in voluntary abatement efforts that do not affect the green group's entry decisions are unprofitable. Thus, there are only four levels of self-regulation that may be optimal for the industry:* $V = 0$, $V(K+\varepsilon), V(K)$, *or* $V(K-\varepsilon)$.

Proof. In this model, increases in V do not affect the outcome of the influence game, once the green group decides to enter. Hence, increases that do not affect entry decisions serve only to reduce expected profits. Thus, expected profits, as a function of V, are declining everywhere except for three points at which there is a discrete upward jump in expected profits; these occur at $V(K+\varepsilon), V(K)$, and $V(K-\varepsilon)$. Hence, these, along with $V = 0$, are the only possible optimal levels of voluntary abatement. ■

Figure 2 illustrates the shape of expected profits as a function of V for an example in which the industry's optimal level of self-regulation is $V(K)$. There are four points to note in the figure, which we have labeled A, B, C, and D. Point A denotes the level of expected profits if industry takes no voluntary action. At points B, C, and D, expected profits "jump" discontinuously upward. These points correspond to levels of voluntary abatement that serve to preempt entry by green groups with entry costs $K+\varepsilon$, K, and $K-\varepsilon$, respectively. In other words, point B corresponds to voluntary abatement level $V(K+\varepsilon)$, point C corresponds to $V(K)$, and point D corresponds to $V(K-\varepsilon)$. As shown in the Proposition, expected profits decline along any segment of the function that does not involve a discontinuous jump.

In the particular example illustrated in Figure 2, industry's optimal level of self-regulation is $V(K)$, which occurs at point C. Intuitively, there is a high probability that entry costs will be at the moderate level, and industry finds it optimal to preempt a green group with this level of entry costs. (Of course, a green group with high entry costs is also preempted.) The probability that entry costs will be low is small enough that it is unprofitable for industry to engage in enough additional voluntary action to preempt even the low-cost green group. (We refer to voluntary abatement in the amount $V(K-\varepsilon)$ as the "full preemption" level of abatement, since this level of abatement is sufficient to ensure the green group is preempted regardless of its level of entry costs.)

From the perspective of industry strategy, there is always the option of undertaking so much voluntary action that preemption is assured. This strategy has the appeal that it eliminates the risk of entry by the green group, but it also carries with it the high upfront costs of engaging in substantial amounts of self-regulation. Alternatively, the industry can save on self-regulatory expenses, but it then faces a greater risk that entry will occur. How it trades off the upfront costs of voluntary abatement against the reduced risk of entry depends upon the underlying parameter values of the problem. The interplay of the full set of possible parameter values makes it difficult to obtain simple and general results regarding the effect of marginal increases in uncertainty on self-regulation. Nevertheless, it is possible to identify sufficient conditions for industry to engage in full preemption, regardless of the probability distribution over entry costs.

Proposition 3 *If* $\frac{\varepsilon}{K} < \rho\left(\frac{1-\alpha}{2}\right)$ *then industry finds it profitable to undertake full preemption, that is, to invest in enough voluntary abatement to assure that for any possible level of political entry costs, the green group does not enter the political influence game.*

Proof. If industry preempts the low-cost group (and hence all possible groups), profits are

$$\pi(V(K-\varepsilon)) = -(M - \frac{K-\varepsilon}{\rho})^2.$$

If industry preempts the medium-cost (and the high-cost) group, expected profits are

$$E(\pi(V(K))) = -(M - \frac{K}{\rho})^2 \left[1 - \rho\left(\frac{1-\alpha}{2}\right)\right] - M^2\rho\left(\frac{1-\alpha}{2}\right).$$

If industry preempts only the high-cost group, expected profits are

$$E(\pi(V(K+\varepsilon))) = -(M - \frac{K+\varepsilon}{\rho})^2 \left[1 - \rho\left(\frac{1+\alpha}{2}\right)\right] - M^2\rho\left(\frac{1+\alpha}{2}\right).$$

Each of these expressions represents a weighted average between $\pi(M)$ and $\pi(V(k))$ for some value of k. Let $\overline{V}(k)$ denote industry's *expected* level of abatement given it undertakes enough voluntary abatement to preempt an environmental group with entry cost k. (The expectation reflects the possibility that the green group has lower entry costs than k, and that mandatory regulations are imposed that force industry to invest in further abatement.) Then a bit of algebra shows that

$$\overline{V}(K) = M - \frac{K}{\rho}\left[1 - \rho\left(\frac{1-\alpha}{2}\right)\right]$$

and

$$\overline{V}(K+\varepsilon) = M - \frac{K+\varepsilon}{\rho}\left[1 - \rho\left(\frac{1+\alpha}{2}\right)\right].$$

Because of the concavity of $\pi(k)$, Jensen's Inequality implies

$$E(\pi(V(K))) < \pi\left(\overline{V}(K)\right)$$

and

$$E(\pi(V(K+\varepsilon))) < \pi\left(\overline{V}(K+\varepsilon)\right).$$

Clearly the industry will elect to fully preempt, that is to choose $V = V(K-\varepsilon)$, if $\pi(V(K-\varepsilon)) > \pi\left(\overline{V}(K)\right)$ and $\pi(V(K-\varepsilon)) > \pi\left(\overline{V}(K+\varepsilon)\right)$. Sufficient conditions for this to occur are that

$$V(K-\varepsilon) < \overline{V}(K) \tag{5}$$

and

$$V(K-\varepsilon)) < \overline{V}(K+\varepsilon) \tag{6}$$

Inequality (5) implies that full preemption is more profitable than preempting the medium-cost group if

$$M - \frac{K-\varepsilon}{\rho} < M - \frac{K}{\rho}\left[1 - \rho\left(\frac{1-\alpha}{2}\right)\right],$$

or

$$\frac{\varepsilon}{K} < \rho\left(\frac{1-\alpha}{2}\right).$$

.Similarly, inequality (6) implies that full preemption is more profitable than preempting only the low-cost group if

$$M-\frac{K-\varepsilon}{\rho}<M-\frac{K+\varepsilon}{\rho}\left[1-\rho\left(\frac{1+\alpha}{2}\right)\right],$$

or

$$\frac{\varepsilon}{K}<\frac{\rho\left(\frac{1+\alpha}{2}\right)}{2-\rho\left(\frac{1+\alpha}{2}\right)}.$$

Since we assume the distribution over entry costs is single-peaked, we know $\alpha \geq 1/3$. This in turn implies $\rho(1-\alpha)/2 \leq \rho/3$. It also implies $\rho\left(\frac{1+\alpha}{2}\right)/\left[2-\rho\left(\frac{1+\alpha}{2}\right)\right] > \rho/(3-\rho)$. Since $\rho/(3-\rho) > \rho/3$, the above conditions imply that if the sufficient condition for full preemption to dominate medium preemption is met, then full preemption also dominates preempting only the high-cost group. ■

Examining the expression $\frac{\varepsilon}{K} < \rho\left(\frac{1-\alpha}{2}\right)$ provides additional insight into the conditions under which full preemption is optimal. To begin with, full preemption is optimal when there is a relatively narrow range of possible values for green group entry costs, that is, ε/K is small. Otherwise, given the convexity of the abatement cost function, it may be prohibitively costly for the industry to preempt the low-cost green group. Full preemption is also more attractive when the probability ρ that a regulatory proposal passes is high; conversely, as ρ goes to zero, full preemption becomes unattractive. Finally, full preemption is more attractive when α is small, that is, when there is a fairly uniform distribution over the possible green group entry costs. If most of the probability mass is concentrated on the moderate level of entry costs, as occurs when ρ is close to unity, then the threat of entry by a low-cost group is too small to justify the increased voluntary abatement needed to preempt it.

We turn now to characterizing the effects of increased uncertainty over green group entry costs. We have already pointed out that the profitability of full preemption does not depend upon the distribution of entry costs. Similarly, if the green group is not blockaded for any possible level of entry costs, then $E(\pi(0))$ is also invariant with respect to α. Hence, we can focus our attention on how $E(\pi(V(K)))$ and $E(\pi(V(K+\varepsilon)))$ change with α. The next proposition characterizes these relations.

Proposition 4 *A mean-preserving spread in the distribution of green group entry costs (i.e., a decrease in α) causes $E(\pi(V(K)))$ to fall and $E(\pi(V(K+\varepsilon)))$ to rise. Furthermore, $E(\pi(V(K+\varepsilon)))$ rises faster than $E(\pi(V(K)))$ falls.*

Proof. Observe that

$$E(\pi(V(K))) = \pi(V(K))[1-(1-\alpha)/2] + E(\pi|V(K),L)(1-\alpha)/2,$$

so

$$\begin{aligned} \frac{\partial E(\pi(V(K)))}{\partial \alpha} &= \frac{\pi(V(K)) - E(\pi|V(K),L)}{2} \\ &= \frac{\rho[M^2-(V(K))^2]}{2} < 0. \end{aligned}$$

Similarly,

$$E(\pi(V(K+\varepsilon))) = \pi(V(K+\varepsilon))(1-\alpha)/2 + E(\pi|V(K+\varepsilon),L)(1+\alpha)/2,$$

so

$$\begin{aligned} \frac{\partial E(\pi(V(K+\varepsilon)))}{\partial \alpha} &= \frac{-[\pi(V(K+\varepsilon)) - E(\pi|V(K+\varepsilon),L)]}{2} \\ &= \frac{-\rho[M^2-(V(K+\varepsilon))^2]}{2} > 0. \end{aligned}$$

Since $V(K) > V(K+\varepsilon)$, it is apparent that

$$\left|\frac{\partial E(\pi(V(K+\varepsilon)))}{\partial \alpha}\right| > \left|\frac{\partial E(\pi(V(K)))}{\partial \alpha}\right|.$$

■

The proposition examines what happens as α falls, which means the probability that the green group has the moderate level of entry costs falls, while the probability that the group has either a low or a high entry cost rises. The proposition shows that as α falls, the profitability of taking enough voluntary action to preempt both the groups with moderate and high costs falls. This should not be too surprising, since the likelihood that entry costs are moderate is falling. Put another way, there is an increasing risk that the industry faces a low-cost green group, in which eventuality a moderate level of voluntary abatement will be insufficient to preempt entry; as a result, moderate self-regulation becomes less profitable. At the same time, the profitability of cutting back on voluntary action, and doing only enough to preempt the group with high entry costs, is rising. Again, this is intuitive, since there is a growing chance that entry costs will be high, and that a low level of voluntary action will be sufficient to preempt entry.

Proposition 4 suggests the possibility that—starting from an initial point where green group entry costs are K with certainty— a mean-preserving spread might cause $E(\pi(V(K)))$ to fall to the point where full preemption becomes the most profitable option for the industry. This would imply that greater uncertainty over green group entry costs induces the industry to undertake more voluntary action. Alternatively, the expected profits from preempting only the high-cost group might rise to the point where preempting only this group is optimal. In this case, greater uncertainty would lead the industry to take less voluntary action. These two contradictory effects make it impossible to ascertain in general whether a mean-preserving spread on entry costs will induce industry to take more or less voluntary action. Instead, the results are always conditional on particular parameter values. The following section uses numerical simulation to shed light on just how uncertain entry costs affect self-regulation.

4.2 Numerical Simulations

In this section we present a series of numerical simulation results that illustrate the range of possible effects that may result from a mean-preserving spread over green group entry costs. Throughout the results, we let $\varepsilon = 0.05$ and $\rho = 0.9$. In the first three cases we consider, we let $K = 0.17$, and in the second set of three cases, we let $K = 0.05$. These values ensure that preemption is both feasible and potentially profitable, and that the green group is not blockaded (that is, preempted with zero voluntary action) when entry costs are at their maximum of $K+\varepsilon$. For each set of three cases, we begin with $\alpha = .99$, which is effectively the certainty case, and then explore the implications of gradually reducing α to 0.66 and then to 0.33, which implies a series of mean-preserving spreads around the expected value of green group entry costs. In each case, we plot the value of expected profits as a function of the level of voluntary abatement chosen by the firm.

Consider first Figure 3, with $\alpha = 0.99$, which is the (effective) certainty case. Expected profits are maximized at $V = 0.32$, which is just great enough to preempt green group entry. Note that expected profits are declining continuously for all $V > 0.32$. From the firm's perspective, further increases in V beyond the preemption level simply cut into profits without producing any additional benefits. Similarly, expected profits are declining continuously for all $V < 0.32$. The only benefit from self-regulation in this model occurs if green group entry is preempted.

Turn now to Figure 4, with $\alpha = 0.66$. Now the expected profits curve displays three discrete jumps in expected profits. Each jump reflects an increase in V that was just sufficient to preempt entry by a green group group with a particular entry cost. Thus, $V = 0.26$ is just enough to preempt entry by a green group entry with organizing cost $K+\varepsilon$, $V = 0.32$ is just sufficient to preempt entry by a group with cost K, and $V = 0.37$ is sufficient to preempt even a group with cost $K-\varepsilon$. Although there are discrete upward jumps in profits at each of these points, the most profitable level of self-regulation is $V = 0.32$, just as it was for the certainty case. This amount of self-regulation is sufficient to preempt the green group if it turns out to have either medium or high entry costs. The additional self-regulation that would be required to preempt even a green group with low entry costs is just not worth it given that there is only a 16.5% chance of this outcome (it occurs with probability $(1-\alpha)/2 = 0.165$.)

Figure 5 presents the case where $\alpha = 0.33$. Now there is a 33% chance that the green group has low entry costs, and it is profitable for the firm to select

$V = 0.37$ and preempt the green group for all possible levels of entry costs.

The sequence of outcomes we have discussed above clearly shows it is possible for increased uncertainty on green group entry costs to induce industry to undertake more voluntary abatement. This result seems counterintuitive at first, but upon reflection it is less surprising. We started from a situation in which preempting a group with entry cost K was profitable if $\alpha = 1$. As α falls, $V(K)$ is still sufficient to preempt both the moderate- and high-cost types of group. Still, it is increasingly likely that this level of self-regulation will fail to preempt entry, since the probability that entry costs are low is increasing in α. Since ρ is high, entry by the low-cost type of group is a serious threat, and when α is small enough, industry finds it profitable to undertake additional voluntary measures to preempt entry by the low-cost group.

Our second sequence, based on the case where $K = 0.05$, illustrates a very different situation. For this sequence of cases, $K = \varepsilon = 0.05$, which means that the low-cost green group can only be preempted if industry elects to set $V = .5$, which is the level that would be required if mandatory regulations were imposed. Since green group entry costs for the low-cost group are zero, the group otherwise will always have incentives to enter with the hope that its presence will lead to the passage of new regulations. Thus, if industry takes any voluntary action at all, its only viable options are to either preempt both the moderate- and the high-cost groups, or to preempt the high-cost group only. Given these strategic options, the primary effect of decreasing α, from the industry's perspective, is to increase the probability that industry faces the high-cost group.

With these considerations in mind, consider now Figure 6, with $K = 0.05$ and $\alpha = 0.99$, which is the (effective) certainty case. Expected profits are maximized at $V = 0.45$, which is just great enough to preempt entry. As before, expected profits are declining continuously for all $V < 0.45$ and for all $V > 0.45$, illustrating once again that the only benefit from self-regulation in this model occurs if green group entry is preempted.

Turn now to Figure 7, with $\alpha = 0.66$. Now the expected profits curve displays two discrete jumps in expected profits. Each jump reflects an increase in V that was just sufficient to preempt entry by a green group group with a particular entry cost. Thus, $V = 0.39$ is just enough to preempt entry by a green group entry with organizing cost $K + \varepsilon$, and $V = 0.45$ is just sufficient to preempt entry by a group with cost K. As can be seen in the figure, there is no third jump, since $V = 0.5$ is needed to preempt the low-cost group. Although there are discrete upward jumps in profits at each of these points, the most profitable level of self-regulation is $V = 0.45$, just as it was for the certainty case. This amount of self-regulation is sufficient to preempt the green group if it turns out to have either medium or high entry costs. The additional self-regulation that would be required to preempt even a green group with low entry costs is not profitable given there is only a 16.5% chance of this outcome.

Figure 8 presents the case where $\alpha = 0.33$. Now there is a 33% chance that the green group has high entry costs, and it is profitable for the firm to select $V = 0.39$ and only preempt a high-cost green group. Taken together, Figures 6-8 show that a mean-preserving spread in the probability distribution over entry costs can cause industry to reduce its level of self-regulation. This result contrasts sharply with the way increased uncertainty affected behavior in Figures 3-5. The only difference between the two sequences of results is that in Figures 6-8, $K = 0.05$ instead of $K = 0.17$ as was true for Figures 3-5. Nevertheless, this change in K reverses the directional effect of increased uncertainty over entry costs. Intuitively, in the latter set of figures, it is very costly for industry to preempt entry by even the high-cost group, since the baseline level of K is quite low, and since abatement costs are convex, the marginal cost to the industry of undertaking greater amounts of abatement is high. In addition, the payoff from increases in voluntary action is limited because a low-cost green group effectively cannot be preempted. With the benefits of preemption reduced, and the costs increased, it should not be too surprising that uncertainty has different effects than in the first set of figures.[6]

[6] Although we do not present a figure to illustrate the point, it is certainly possible for

We summarize the key results from our simulations in the following proposition.

Proposition 5 *A mean-preserving spread on green group entry costs can induce either an increase or a decrease in industry's choice of voluntary abatement level.*

The simulation results clearly establish that increased uncertainty in green group entry costs can lead to either increased or decreased levels of self-regulation by industry. In general, the simulations suggest that uncertainty is more likely to increase self-regulation when the underlying level of K is high, so that it is costly for the green group to enter. This result is striking when placed within the extant literature on environmental self-regulation. As we have noted, the consensus of this literature suggests that, in order to induce self-regulatory action, regulatory threats must be strong and credible. We have illustrated here that even when regulatory threats appear relatively weak and uncertain industry might be motivated to take self-regulatory action. While this result challenges the prevailing consensus, it is important to point out that the threat of regulation still plays an important role in this result. When K is high, a mean preserving spread works to raise the likelihood of entering the legislative game (since the existence of a low entry-cost green group is more likely) and if ρ is high then this possibility represents a threat to industry.

5 Conclusions

It has become conventional wisdom that a strong and credible regulatory threat is needed to induce industry to take voluntary self-regulatory actions. In this paper we have examined the robustness of this conclusion to 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

industry to find it optimal to take no voluntary action in some circumstances. Indeed, changing ρ from 0.9 to 0.8 in the second set of figures would induce industry to eschew voluntary abatement altogether. With the reduced regulatory threat that this change implies, industry simply finds it too costly to attempt preemption.

put forward. Our analysis was conducted using a model that was deliberately structured so that voluntary actions are driven solely by the threat of regulation. This allows us to isolate the effects of uncertainty on self-regulatory actions. We have found that uncertainty creates nonmonotonicity in industry self-regulatory actions. Specifically, we have found that for a given probability of legislative action (conditional upon entry into the legislative process) increased uncertainty regarding the possibility that legislative action is triggered, may increase or decrease industry self-regulatory actions. Similarly we find that when industry is certain about the costs its rival must incur to trigger legislative action, increases in the likelihood of legislation may increase or decrease the level of self-regulatory activity industry will undertake.

The central message of our paper is that one should be cautious about the robustness of convention wisdom concerning the link between the strength and credibility of regulatory threats and the resulting levels of self regulation. In addition to this message our model generates several outcomes that merit further examination. First, our results concerning changes in ρ, suggest that during the "policy life cycle" (in which ρ rises overtime) we may see (preemptive) voluntary action early on, followed by a period of industry quiescence, and then a second burst of activity later in the life cycle. Further study of this phenomenon might help explain why some voluntary actions are met with applause by green groups, while other are met with skepticism. As the importance of environmental issues develop at difference speeds across different jurisdictions, our results might be used to gain insight into different levels of voluntary behavior across different jurisdictions (such as states) at the same time.

Finally, our results suggest that a green group that is expected to be unlikely to act prefers to generate additional uncertainty, while one that is likely to act wants to reduce uncertainty about its actions.[7] A further examination of this result might allow one to gain insight into the "professionalization" of the environmental movement: professional groups want to make their actions

[7] For a detailed examination of the strategic use of uncertainty by *industry* to preempt regulation see Lyon and Maxwell (2004 *forthcoming).*

predictable, while enthusiastic amateurs (e.g., Eco-terrorist groups) want to seem unpredictable. Similarly, a green group with a "broad" portfolio of issues (Sierra Club) may be unable to enter on most issues; it would then prefer to raise uncertainty about its future actions and claim to care about all of the many items in its portfolio equally. A narrowly-focused group (e.g., National Audubon Society, and National Parks Conservation Association) would prefer to be predictable.

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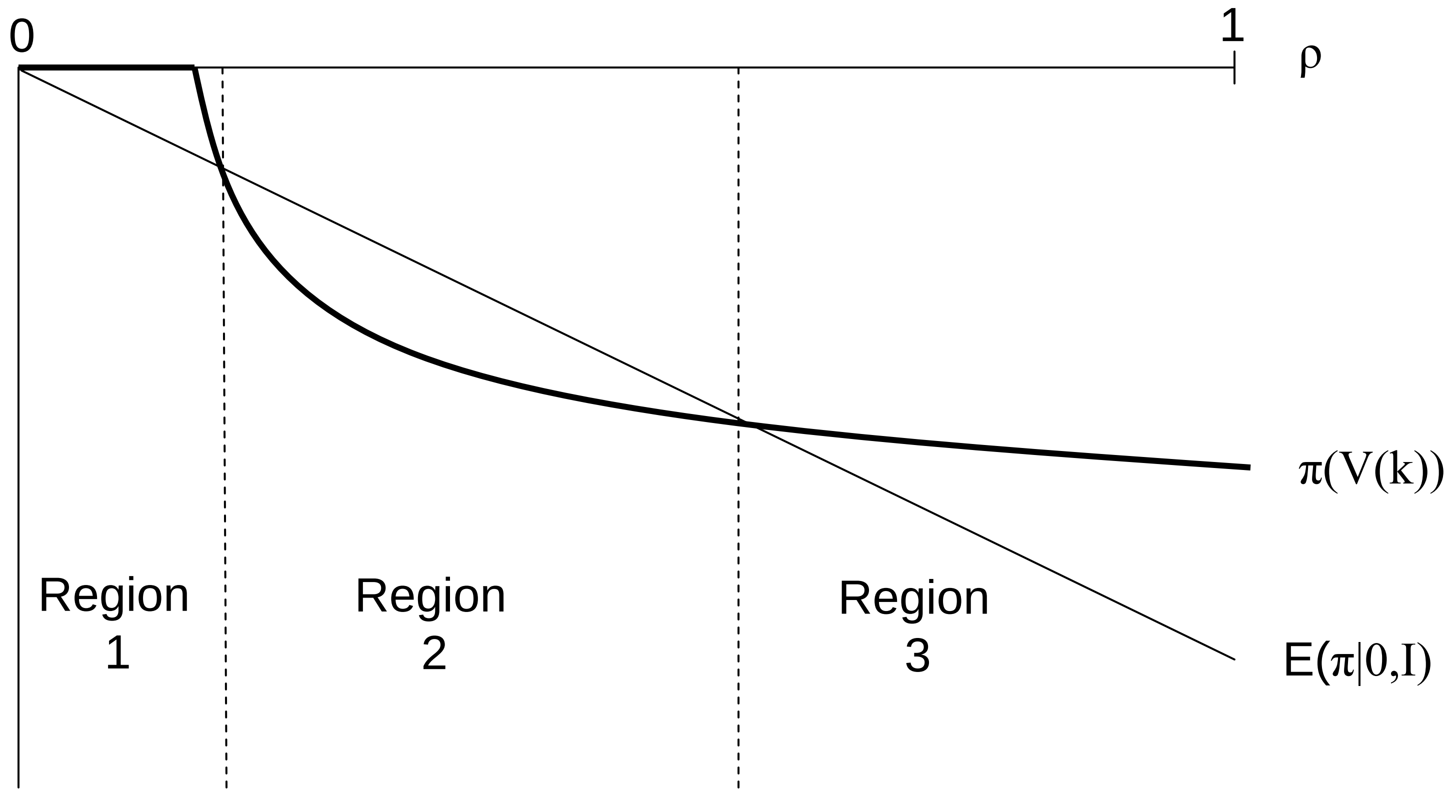

Figure 1: Value of Preemption as the Probability of Regulation ρ Rises

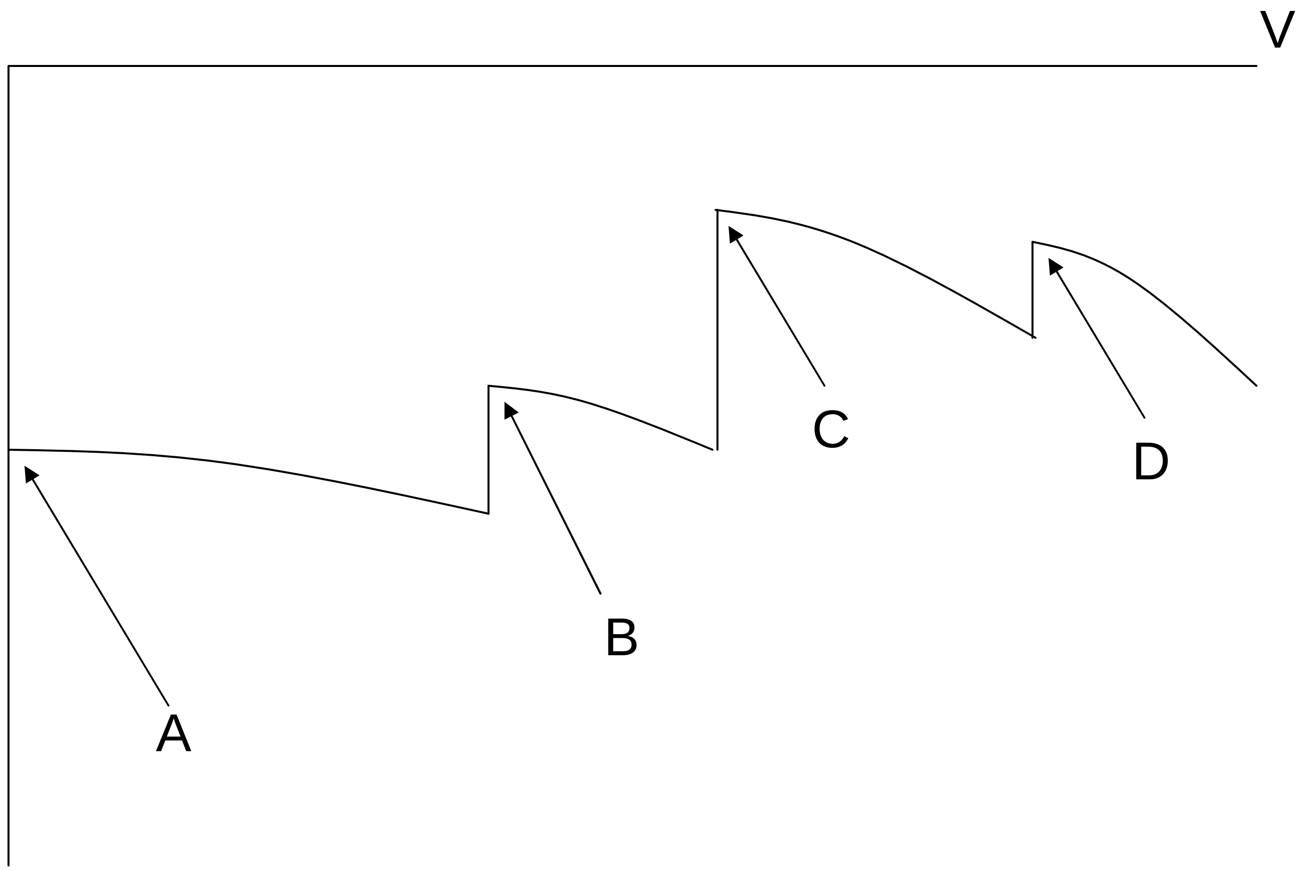

Figure 2: Expected Profits as a Function of Voluntary Abatement

Figure 3: Expected Profits as a Function of Voluntary Abatement
K = 0.17, ε = 0.05, ρ=0.9, α = 0.99

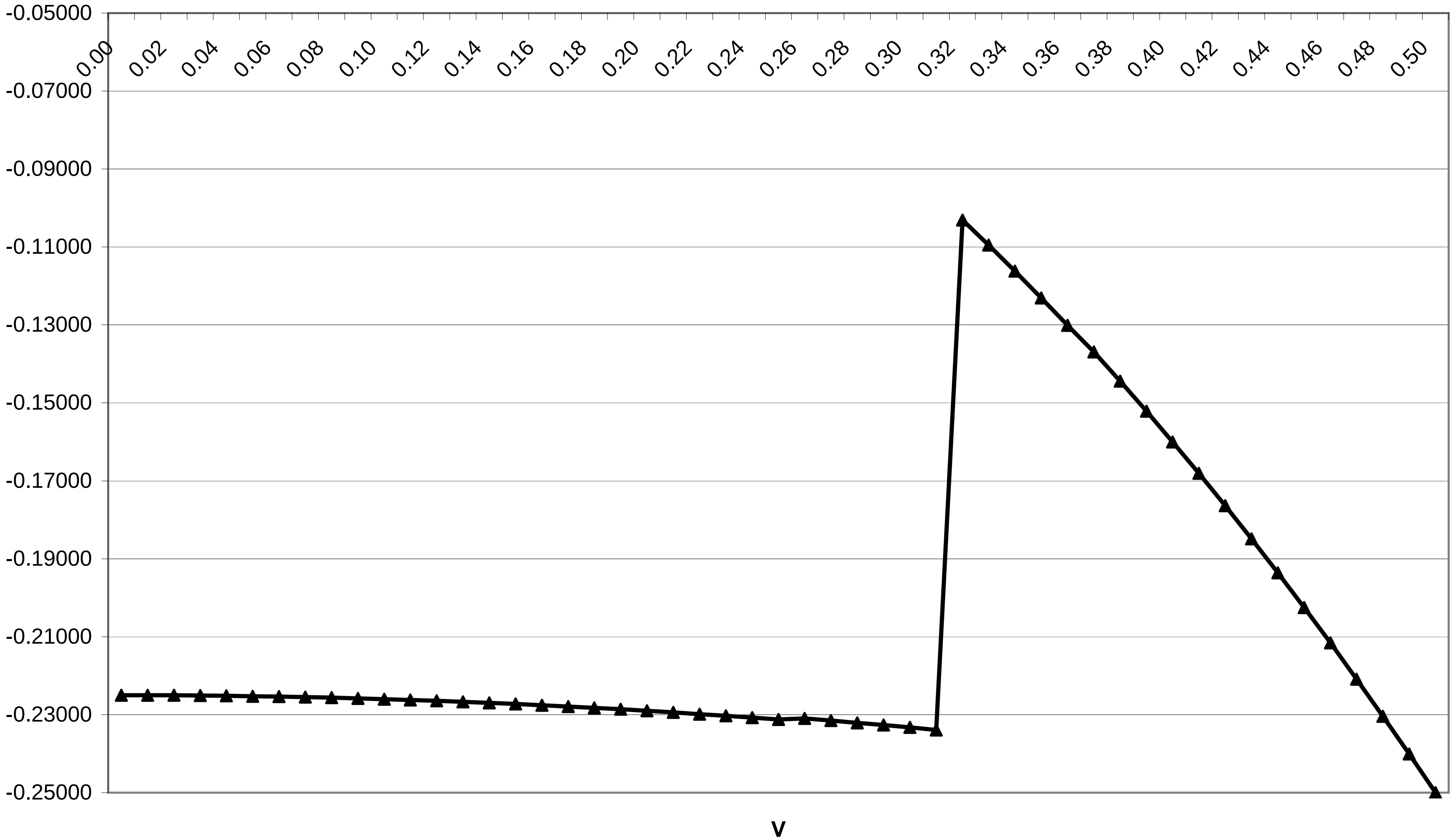

Figure 4: Expected Profits as a Function of Voluntary Abatement
K = 0.17, ε = 0.05, ρ=0.9, α = 0.66

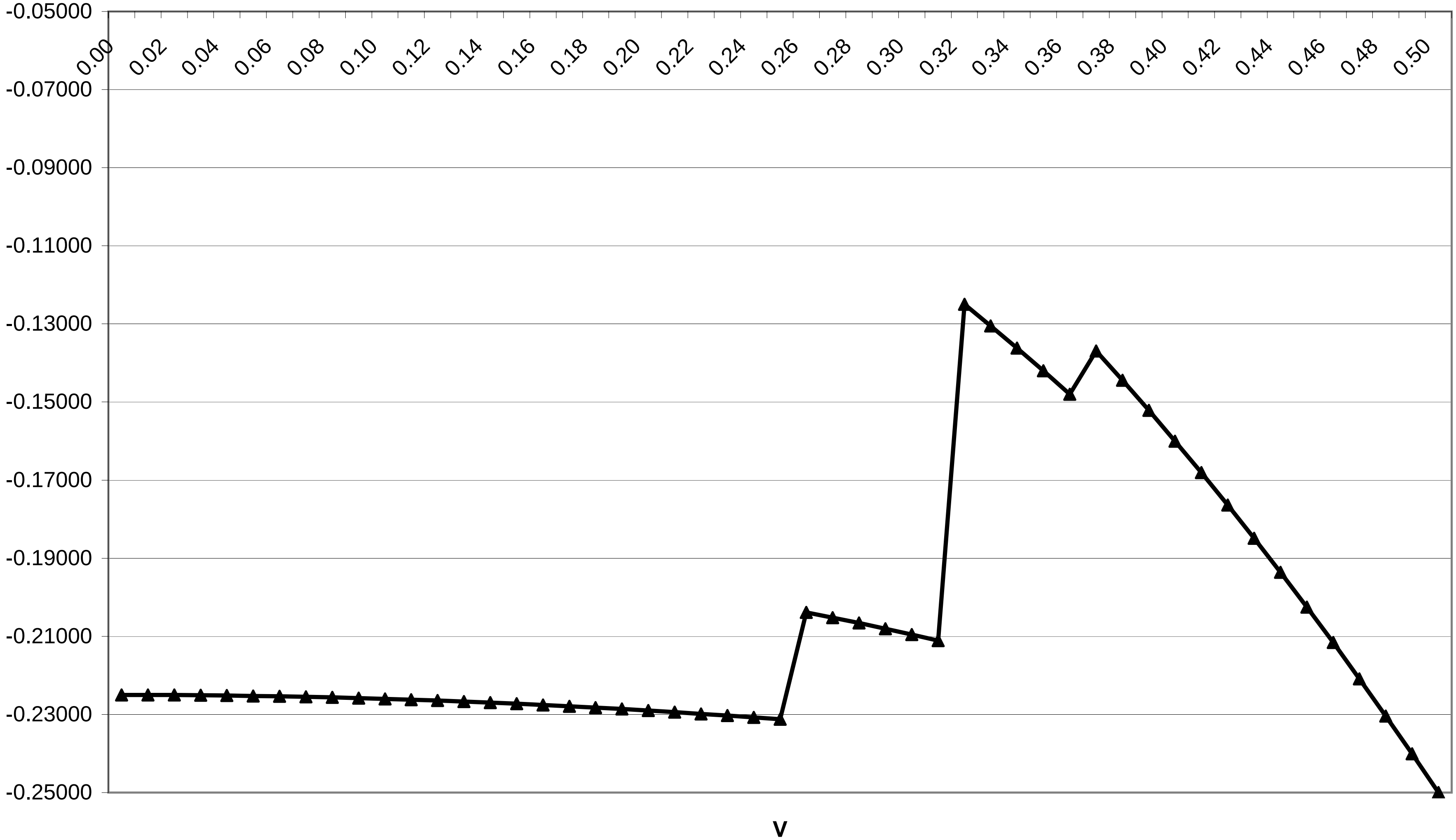

Figure 5: Expected Profits as a Function of Voluntary Abatement
K = 0.17, ε = 0.05, ρ=0.9, α = 0.33

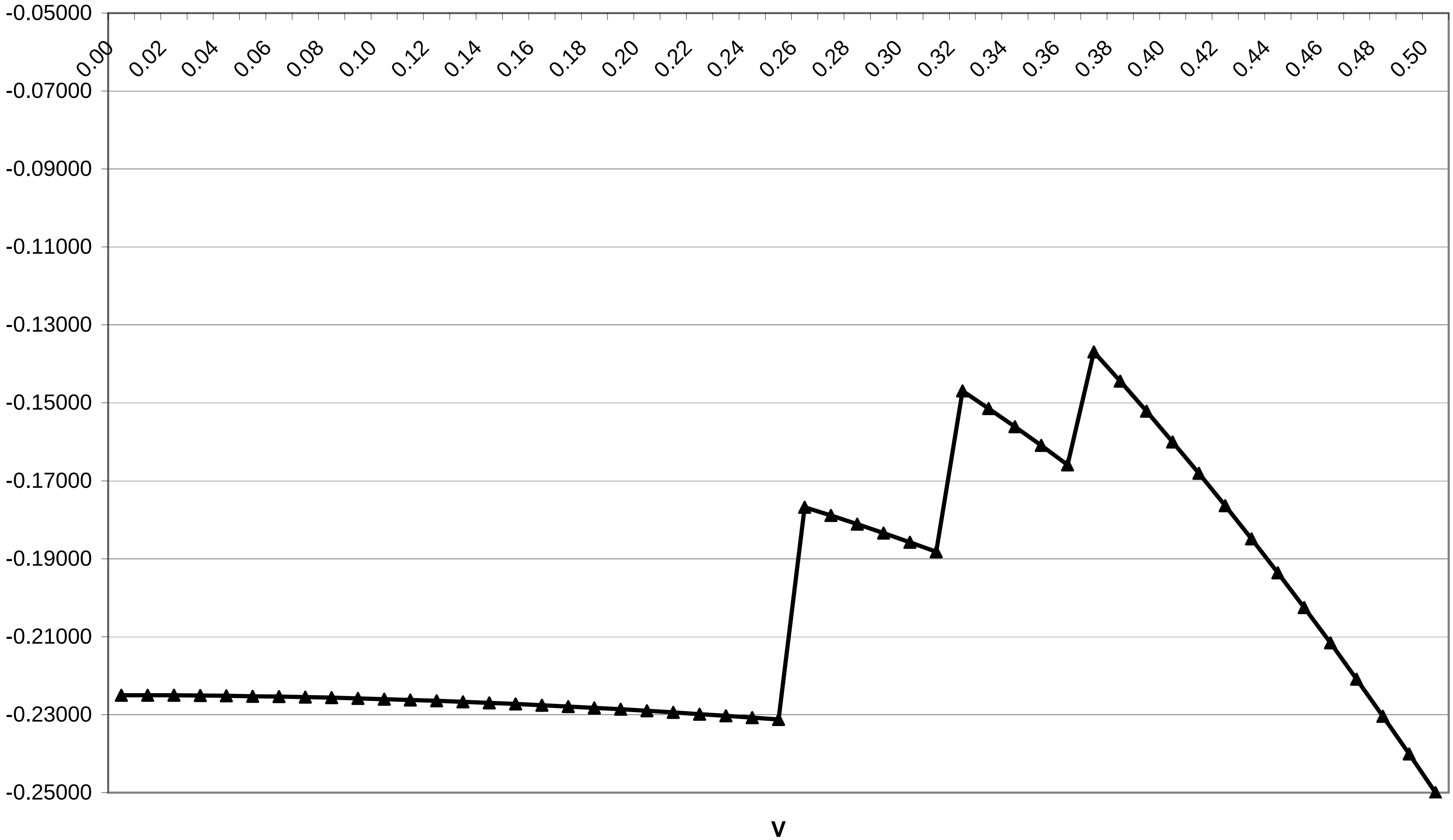

Figure 6: Expected Profits as a Function of Voluntary Abatement
K = 0.05, ε = 0.05, ρ=0.9, α = 0.99

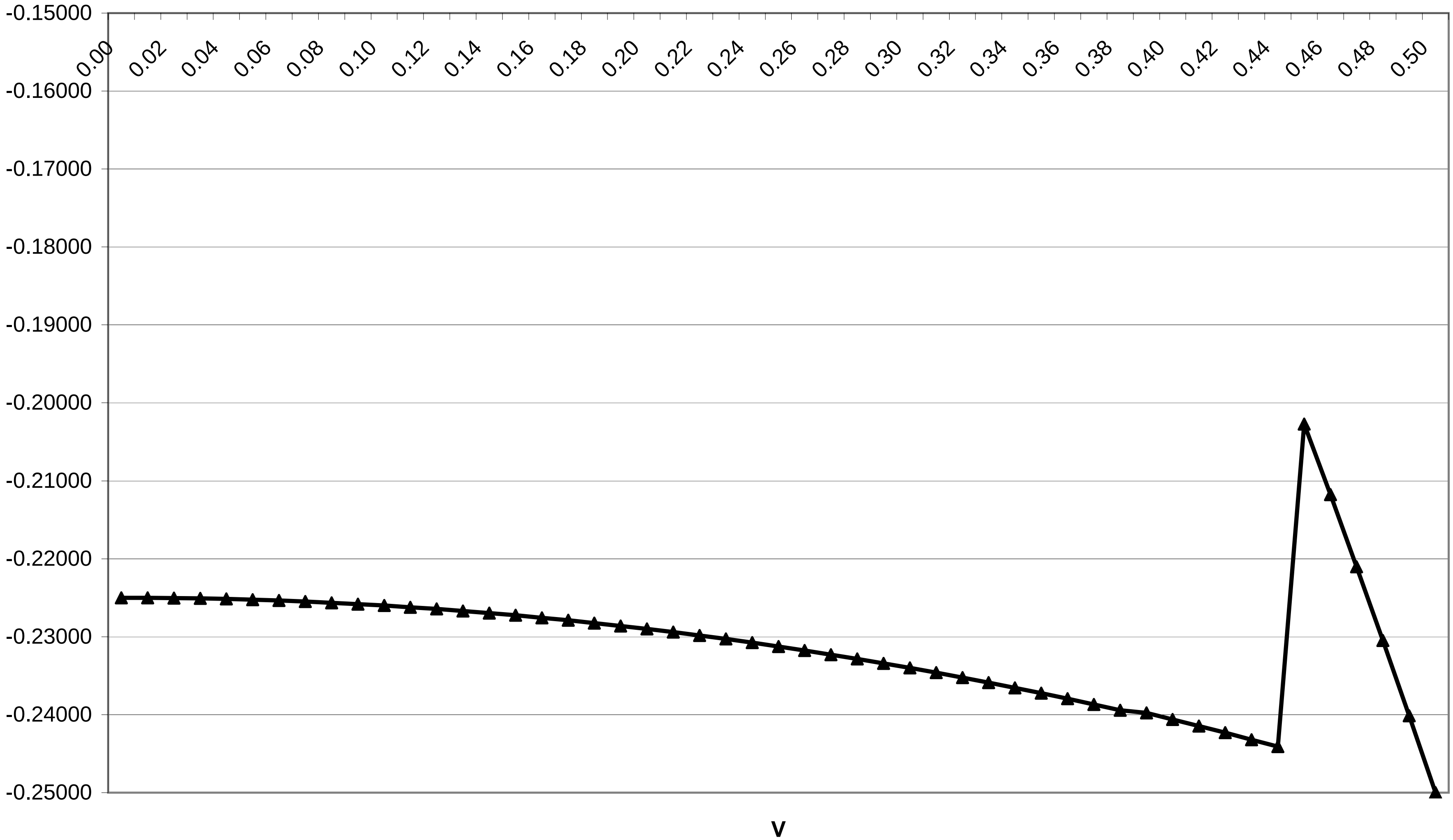

Figure 7: Expected Profits as a Function of Voluntary Abatement
K = 0.05, ε = 0.05, ρ=0.9, α = 0.66

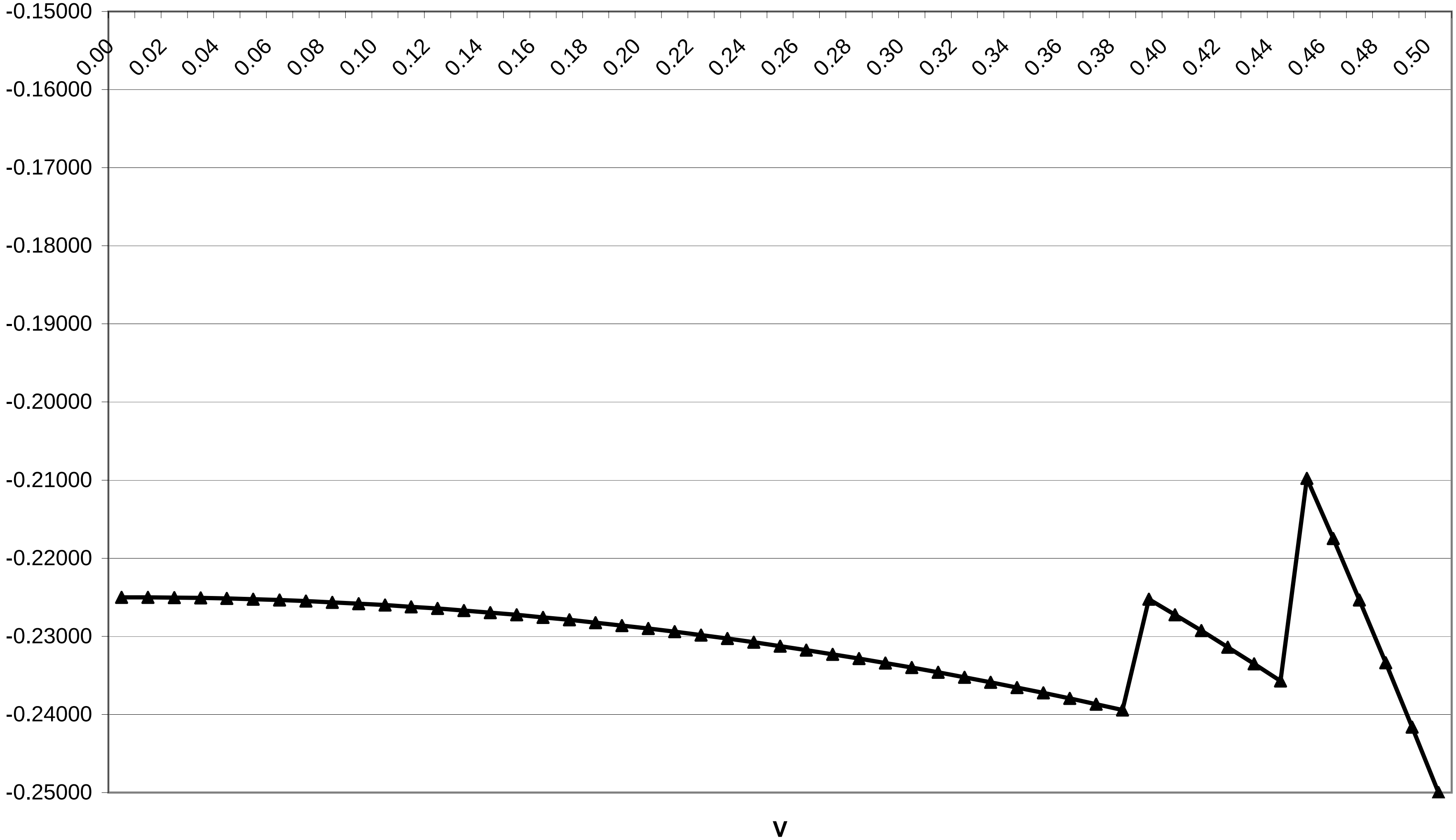

Figure 8: Expected Profits as a Function of Voluntary Abatement
K = 0.05, ε = 0.05, ρ=0.9, α = 0.33