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Voluntary Environmental Initiatives as Collusive Institutions

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1 Introduction

The difficulties a real-world oligopolist experiences in observing its rivals' actions undermine tacit collusion. In consequence, businesses have the incentive to develop or adopt institutions that facilitate monitoring and collusion. Hundreds of firms have engaged in collective initiatives designed to prevent pollution throughout the 1990s. Industrial organizations have developed their own environmental standards, and a considerable number of companies have joined one or more of the voluntary pollution prevention programs designed by the U.S. Environmental Protection Agency (EPA). This paper argues that voluntary pollution prevention initiatives (VIs) function as institutions that may allow firms to attain a level of collusion in the product market as long as the programs' members reports emissions and emissions are technologically linked to output.

Were collusion costless, firms would not invest in pollution prevention in order to coordinate their decisions. However, sustaining collusion requires that firms know when a defection occurs and who is responsible. In practice, such information is imperfect or unavailable. In Green and Porter (1984) when firms do not observe their rivals' output but a stochastic market price, episodes of low prices recur even in the absence of defection. Sustaining collusion is even more difficult if firms receive private signals, for example,or oH(,)-npTj/TT28(t)-0.4(h)-72540Tir.TD-0.002Tc[(r information, coordinates and monitors actions, and provides data on which gram WasteWi$e[3] than nonmembers (Khanna and Damon [999], and Videras and Alberini [999]), and in some programs partners represent a large percent of the industry.[4] In addition, if firms use VIs to coordinate in the product-market, participation should be higher in industries with large barriers to entry. Indeed, industry-wide advertising expenditures are a positive and statistically significant predictor of participation in the program 33/50 (Arora and Cason [996]).

The literature on VIs typically assumes that participation is the result of individual benefit-cost analysis. It is hypothesized that firms benefit from im-

Rather than assuming that reputation and preemption factors are the driving factors in the formation of VIs, in this paper firms trade off the cost of pollution prevention with the benefits of collusion in the product market. Section 2 presents a two-stage model. In stage one (at time zero) the firms decide whether to join a VI and adopt the agreed upon level of pollution prevention. In the second stage (at time periods one and beyond), the firms compete in quantities taking pollution prevention techniques as given.

To analyze to what extent firms' self-interest can be used to improve environmental practices, sections 3, 4 and 5 consider three VI designs that vary on the degree of partnership between the agency and the industry. In a Centralized Voluntary Initiative (CVI) the agency sets both pollution prevention and emissions that are socially optimal under a VI and challenges businesses to join the initiative. Hence, a CVI is the benchmark that provides what the agency could ideally achieve (given the nature of these initiatives) were it not constrained by imperfect information and political considerations. In the second design, a Partially Cen-

Table : Designs of Voluntary Initiatives

Initiative	Pollution prevention	Emissions	Section
	Agency	Agency	3
	Agency	Firms	4
	Firms	Firms	5

2 The model

Members of EPA's voluntary programs ( ) sign a (non-binding) agreement with the agency; (2) designate a manager to oversee implementation and maintain contact with the EPA; (3) establish goals; and (4) identify cost-e ective opportunities to achieve the goals. These requirements impose one-time administrative and set-up costs designated K. Goals are achieved by adopting pollution prevention techniques that lead to emissions reductions. The level of pollution prevention is denoted $!$.[7] The increment in marginal cost of production at prevention level $!$ is denoted $t(!)$. It is assumed that $t_!(!)$

The members' pollution prevention techniques are observable.[9] However, in order to use a VI to coordinate in the product-market the firms need to know their rivals' output. Firms can infer output if in addition to reporting !, firms disclose emissions.[10] It is assumed that the emissions function $e(q, !)$ has the following properties

$$e_q(\cdot) > 0, \quad e_{,e}$$

demand is given by $P : R_+ \quad R_+$. Production cost is $C : R_+ \quad R_+$, where $C(q)$ is assumed to be increasing. To guarantee the existence of an equilibrium that the present value of participation for each firm is greater than or equal to the present value of not accepting the agency's scheme: $"(q, !) \quad (\quad \#)K \quad "^{CN}$.[14] A slack IC constraint would imply that the firms are strictly better o participating in the initiative. Participation gains may result from increments in price whose e ect on profits is not fully o set by the greater cost of pollution prevention.

Defining social welfare as the sum of consumer and producer surplus minus the dollar value of environmental damages, the agency chooses q and ! that solve

$$\text{Max} \quad W(nq, !) = \int_0^{nq} P(z)dz \quad nC(q) \quad nqt(!) \quad nK \quad ne(q, !)$$

$$\text{subject to:} \quad "(q, !) \quad (\quad \#)K \quad "^{CN}.$$

The Lagrangian is:

$$L(nq, !) = \int_0^{nq} P(z)dz \quad nC(q) \quad nqt(!) \quad nK \quad ne(q, !)$$
$$\$["(q, !) \quad (\quad \#)K \quad "^{CN}].$$

The first-order conditions of the problem are:

$$\frac{\%L}{\%q} \quad n[P(nq) \quad C_q(q) \quad t(!) \quad e_q(q, !)] \quad \$[nqP'(nq) + P(nq) \quad C_q(q) \quad t(!)] = 0,$$
$$\frac{\%L}{\%!} \quad nqt_!(!) \quad ne_!(q, !) + \$qt_!(!) = 0,$$
$$\$ \quad 0, \quad "(q, !) \quad (\quad \#)K \quad "^{CN}, \quad \$["(q, !) \quad (\quad \#)K \quad "^{CN}] = 0.$$

I also assume that it is not feasible to alter the structure of the market.

Let $!^o$ and q^o be the socially optimal levels of pollution prevention and output that solve the conditions above.[15] The following lemma states under what circumstances the agency sets the IC constraint binding.

Lemma 1

ff $\$ > 0$ $e_q(q^o, !^o) > P(nq^o) \quad C_q(q^o)$
$t(!^o)$

Were marginal environmental benefits less than the reduction in market surplus, the initiative would not be implemented. If marginal environmental benefits of reducing output are larger than the marginal e ect on market surplus then it is socially optimal to increase ! and extract the firms' participation gains so long as the IC constraint is not violated.

Consider the solution corresponding to a nonbinding IC constraint, that is, $\$ = 0$. The optimal levels of output and prevention are given by

$$P(nq^o) \quad C_q(q^o) \quad t(!^o) \quad e_q(q^o, !^o) = 0, \tag{2}$$

$$e_!(q^o, !^o) = q^o t_!(!^o). \tag{3}$$

Equation (2) indicates that at the socially e cient output and pollution prevention levels, the net market surplus that is lost as a result of a marginal reduction in q is equal to its marginal benefit on environmental quality. Note that if the market quantity distortion and the marginal environmental benefit of reducing q balance out at $(q^o, !^o)$ then condition (2) implies that q^o maximizes the industry's

Socially optimality refers here to the levels that can be attained in any voluntary initiative. Note also that I assume that the equilibrium is symmetric, stationary and credible.

joint-profits given !. Equation (3) shows that the marginal benefit of increasing ! is equal to the marginal cost borne by the firms.

Suppose now that $ > 0, that is, the firms' participation gains are entirely extracted. The optimal levels of output and prevention are given by the sy.2(s)55.4($)Tj5(f)-361 5(o given. The agency observes prevention practices and emissions of member firms and chooses ω that solves

$$\text{Max} \quad W(nq^{*}(\omega), \omega) = \int_{0}^{nq^{*}(\omega)} P(z)dz - nC(q^{*}(\omega)) - nq^{*}(\omega)t(\omega) - nK - ne(q^{*}(\omega), \omega),$$

where $q^{*}(\omega)$ maximizes joint-profits given ω. The first-order condition

$$-e_{\omega}(q^{*}(\omega), \omega) - q^{*}(\omega)t_{\omega}(\omega) + \frac{dq^{*}(\omega)}{d\omega}[P(nq^{*}(\omega)) - C_q(q^{*}(\omega)) - t(\omega) - e_q(q^{*}(\omega), \omega)] = 0 \tag{6}$$

indicates that the marginal benefit of increasing ω and reducing emissions is equal the marginal costs borne by the firms plus the net effect on social welfare weighed by the impact of ω on the industry's output.

Let $\hat{\omega}$ be the level of pollution prevention that solves (6). To facilitate the comparison with the CVI, rearrange (6) as follows:

$$-e_{\omega}(q^{*}(\hat{\omega}), \hat{\omega}) = q^{*}(\hat{\omega})t_{\omega}(\hat{\omega}) + \frac{dq^{*}(\hat{\omega})}{d\omega}[nq^{*}(\hat{\omega})P'(nq^{*}(\hat{\omega})) + e_q(q^{*}(\hat{\omega}), \hat{\omega})], \tag{6'}$$

where I have used condition ( ) to express the net effect on social welfare of reduced output as the sum of environmental benefits plus the market quantity distortion.

4.1 Partially Centralized versus Centralized Initiative

Proposition 1

!

fi

If marginal environmental benefits and market quantity distortion balance out, then the agency's interest and the industry's coincide, that is, conditions (2) and ( ) are identical and $q^o(!) = q^{"}(!)$ given !. Furthermore, the net cost of increasing ! that it is borne by society as a whole is zero, while social optimality requires the marginal benefit of increasing !

that allows businesses to coordinate their choices. The disclosure by the agency of per-firm emissions allows firms to identify deviations from the agreement.

The next subsection uses the solution concept of subgame perfection to calculate the equilibria in the infinite-horizon quantity game.[16] Subsection 5.2 determines the Nash equilibrium in !.

5.1 Equilibria in the repeated market game

Let "¨(!) be single-period profits earned by each individual firm at q¨ that solves equation ( ); and "^{d}(!) the single-period payo for a firm when cheating optimally against the cartel. Note that

Since I have assumed that $t_!(0) = 0$ and $e_!(q, 0) > 0$, it follows that $!^{"} > 0$, prevention practices that it would be if emissions (with respect to q) and preven-

First, consider the case in which the market's quantity distortion and marginal environmental benefits balance out at the optimum. The agency's and the firms' solution for $q(!)$ given ! coincide, (2) = ( ). Social optimality requires the marginal benefit of higher prevention levels to be set equal to the marginal cost to the firms of adopting those levels. In a DVI, however, the firms set $!^{"}$ such that the cost borne by the firms is less than the marginal environmental benefit of increasing !. Therefore, (3) $\neq$ (7′). Compare now conditions (5) and (7′). The equations are identical except for the term $nq^{o}P'(nq^{o})$ in (5) that captures the agency's concern with market quantity distortion. Were $!^{o} = !^{"}$ and $q^{o} = q^{"}$ then the left-hand side of (5) would be less than its right-hand side. In sum, either the firms agree upon a level of ! that is lower than the level that equalizes marginal benefit and marginal costs of pollution prevention or the fi

If at $(q^{"}(\hat{!}), \hat{!})$, marginal environmental benefits are less important than the quantity distortion, social optimality would require the agency to set a $\hat{!}$ lower than otherwise by condition (5). Since the firms agree upon a level of ! such that the cost borne by the firms is less than the marginal environmental benefi

Three designs are analyzed to study what extent of industry's involvement in policy decision making is welfare-enhancing. Were it possible for the agency to gather accurate information about pollution prevention technologies and verify compliance with technology standards, a Partially Centralized Voluntary Initiative would be preferred over a Decentralized Voluntary Initiative since the agency could in that instance set prevention levels that approximate those that achieve social e ciency. However, if it is believed that the fi

acknowledges output reduction as a genuine way to prevent emissions. For example, the 33/50 program second report reveals that part of AT&T's reductions of its 33/50 chemicals were due to "decrease production levels at several of the company's plants" (USAEPA [992]). The condition would be satisfied in a perfectly competitive market since the quantity distortion is zero. Welfare gains from reduced output levels, $\frac{\$W(nq,0)}{\$q}\frac{dq}{d!} = \quad ne_q(q,0)\frac{dq}{d!}$, are then strictly positive. However, the larger the quantity distortion in the market the more environmentally damaging production activities and the more e ective pollution prevention e orts must be for a VI to increase welfare.

9 Appendix C: Proofs

1

If $\$ = 0$ then $P(nq^o) \quad C_q(q^o) \quad t(!^o) = e_q(q^o, !^o)$ by the first-order condition $\frac{\$L}{\$q} = 0$. If $P(nq^o) \quad C_q(q^o) \quad t(!^o) = e_q(q^o, !^o)$ then either $\$ = 0$ or $P(nq^o) \quad C_q(q^o) \quad t(!^o) = \quad nq^oP'(nq^o)$ and $\$ > 0$. Now, $P(nq^o) \quad C_q(q^o) \quad t(!^o) = \quad nq^oP'(nq^o)$ and $\$ > 0$ would imply by equation (5) that $\quad e_!(q^o, !^o) = 0$ which is ruled out by the properties of the emissions function. Therefore, if $P(nq^o) \quad C_q(q^o) \quad t(!^o) = e_q(q^o, !^o)$ then $\$ = 0$. ■

1

Case (i): Consider the case in which $\$ > 0$ in the CVI. Suppose that $q^"(\hat{!}) = q^o$ and $\hat{!} = !^o$. In that case, $P(nq^o) \quad C_q(q^o) \quad t(!^o) = \quad nq^oP'(nq^o)$ and $\quad e_!(q^o, !^o) =$ by (5), which is ruled out by the properties of the emissions function.
Case (ii): Consider the case in which $\$ = 0$ in the CVI. Suppose that $q^"(\hat{!}) = q^o$ and $\hat{!} = !^o$. Then, conditions ( ) and (2) are equal. Furthermore, $\quad nq^"(\hat{!})P(nq^"(\hat{!})) = e_q(q^"(\hat{!}), \hat{!})$ so that conditions (3) and (6′) coincide. ■

From the first-order condition of the cartel's problem, equation ( ), equation (6) can be written as

$$\frac{e_!(q^"(!^"), !^")}{e_q(q^"(!^"), !^")} = \frac{q^"(!^")t_!(!^")}{(n \quad)[q^"(!^")P'(nq^"(!^")]}$$

References

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[2] USEPA (