Environmental Mechanism Designs in a New Order of Regulatory Capitalism

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Abstract

Complexity of environmental programs is most apparent with information asymmetries, making the design of efficient mechanisms particularly challenging. As developed theoretically in this paper, a new regulatory capitalism paradigm mating voluntary agreements with environmental education can produce outcomes at least as efficient as voluntary agreements alone. Such a design exploits a key difference between voluntary agreements versus educational programs in terms of their impact on agents' incentive compatibilities. Specifically, in a principal-agent model, voluntary agreements are associated with an incentive-compatibility constraint, whereas educational programs are not. The efficient bundle will likely consist of a set of education programs and voluntary agreements. With the new order of regulatory capitalism, it is time to concentrate on removing barriers yielding inefficient mono-mechanism design and start constructing multidimensional incentives to efficiently allocate effort toward environmental and economic goals.

Key words: Command and control, environmental education, environmental policy, voluntary agreements

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Legitimate concerns about the effectiveness of mandatory command and control regulations for environmental abatement have shifted mechanisms toward voluntary agreements such as the contract-based regulation evaluated by Bontems and Thomas. Their article is an excellent illustration of the power and complexity of potential contractual agreements addressing nonpoint-source pollution. Complexity is most apparent with information asymmetries, making designing efficient mechanisms particularly challenging. As addressed by Bénabou and Tirole, providing incentives for voluntary actions can have a perverse effect, when considering social reputation, of reducing the level of voluntaryism. Paying for blood donors could actually reduce supply (Titmuss), and imposing stiffer penalties could undermine agents' justification for obeying the law (Akerlof and Dickens). Consideration of optimal agent incentives when faced with information asymmetries and social reputation may require a new environmental paradigm. As developed theoretically in this paper, a new regulatory capitalism paradigm mating voluntary agreements with environmental education offers a mechanism which accounts for information asymmetry and reputation. Such a design exploits a key difference between voluntary versus educational incentives in terms of their impact on agents' incentive compatibilities. Specifically, in a principal-agent model, voluntary agreements are associated with an incentive-compatibility constraint, whereas educational programs are not. As demonstrated in the theoretical development, this key difference can tilt the optimal allocation of voluntary agreements and educational programs toward the latter.

The new environmental paradigm, with voluntary agreements and education as linchpins, has not received an adequate theoretical development, especially in the presence of information asymmetries. Previous literature addresses voluntary agreements as a dichotomist zero-one tradeoff. In terms of addressing differences in the old versus the new paradigm, either mandatory controls or voluntary agreements are implemented or voluntary agreements are addressed in isolation from other mechanisms. For economic and policy analysis the question should not be framed in zero-one totals, but instead in terms of marginal contributions and costs. This yields an optimal combination of voluntary and educational mechanisms for policy.

The aim of this paper is to outline theoretically how voluntary agreements are not established in isolation of other mechanisms such as education. Instead mechanisms are designed to support and enhance one another. For example, in 2003 the EPA sponsored the third national conference on nonpoint-source pollution information and education programs (Kiefer and Kirschner). This conference highlights the importance of environmental education in the new environmental paradigm. Policy is being framed and programs initiated for educating agents on the environmental consequences of their productive actions.

New Order of Regulatory Capitalism

In almost every sector of the economy, a new order of regulatory capitalism has existed since the 1980s (Levi-Faur). This new order differs from older forms of capitalist governance which relied on mandatory command and control policies. In terms of environmental quality, the new order is characterized by a proliferation of new technologies for regulation, with self-regulation in the shadow of the state, and the growth of international networks of environmental experts. This new order goes beyond privatization by including increased delegation to autonomous agents and the formalization of principal and agent relationships.

As addressed by Khanna, for environmental quality, the new order is the result of growing doubts in the effectiveness of command and control regulations for environmental abatement. Alternative flexible instruments based on price signals with economic incentives are the tools for the new order. These new environmental instruments are to a large part explained by the international diffusion of a new regulatory paradigm (Busch, Jörgens, and Tews; Wheeler and Afsah). This regulatory capitalism is more open to collective actions than is usually portrayed by both advocates and opponents of freer markets. The foundation of the new paradigm is voluntary agreements supported with environmental education (Dietz and Stern).

However, asymmetric information associated with agents' efforts toward environmental abatement makes designing efficient mechanisms based on the new paradigm challenging. Information asymmetry is particularly a problem in markets with numerous nonpoint-source polluting agents, where hidden actions are constraints to efficient environmental mechanism design. Glachant indicates a voluntary agreement has higher costs relative to mandatory control in the presence of information asymmetries with a large number of agents. This suggests voluntary agreements alone might not yield a Pareto-efficient or even a second-best Pareto-efficient mechanism design given information asymmetries. A case study by Murphy and Jaccard of BC Hydro, a publicly-owned British Columbia electric utility, supports this implication. Their analysis suggests a voluntary program had little effect on the utility's environmental effort. As indicated in Poe *et al.*, a large gap exists between actual and socially desirable levels of agents' environmental efforts. The Bontems and Thomas investigation is a case in point.

Other mechanisms yielding voluntary efforts toward a cleaner environment complementing agreements among the principal and agents are possible. The literature is rich in enumerating cases where educating agents to the environmental consequences of their actions can elicit voluntary environmental effort from agents (Alrusheidat; Dasgupta; Edmonds; Norton, Phipps, and Fletcher; Polunin; Price). Glachant alludes to the possible advantage of education by indicating that collective learning may have significant cost advantages in the presence of homogeneous agents. To the degree educational programs are nonrival, they are still effective even with a relatively large number of agents. Furthermore, they do not suffer from possible free-riding strategic behavior characterized by voluntary agreements. This is particularly important in the presence of nonpoint-source pollution where it may be difficult to determine even the number of polluting agents, yet alone their contributions to the externality. By its definition, nonpoint-source pollution is a case of asymmetric information. Regulatory efforts should focus on mechanisms which mitigate the inefficiencies associated with the presence of moral hazard.

Old Versus New Paradigm Comparisons

The shift in environmental paradigms has not gone unnoticed in the economics literature. As outlined in literature reviews, both Alberini and Segerson, followed by Khanna, acknowledge a number of studies empirically analyzing the decisions of agents to participate in voluntary EPA programs such as the 33/50, Green Lights, and WasteWise programs. Specifically, Stranlund provided one of the first investigations of the relative efficiency between mandatory and voluntary mechanisms in achieving environmental objectives. He models agent compliance to an environmental norm and develops the necessary and sufficient conditions for a voluntary compliance regime to be a welfare improvement. These conditions depend on the degree of rivalness and excludability of public effort, and the relative costs of private to public effort. Wu and Babcock (1999) extend and generalize Stranlund's model to examine if voluntary programs can be constructed which dominate mandatory programs for controlling nonpoint-source pollution. In a game-theoretic framework, Segerson and Miceli examine if a voluntary versus a mandatory mechanism is the likely outcome of interaction, and if so, whether the resulting voluntary mechanism results in an environmentally efficient level of protection.

In the new paradigm framework, by publicly providing environmental education, agents are able to make informed decisions on the environmental effects of their actions. Once informed of the production advantages and marketing benefits associated with environmental effort, agents will pursue this effort on their own accord. This has lead to popular new catchphrases, such as "the natural step, eco-efficiency, and triple bottom line" (Murphy and Jaccard). Agents' incentives for modifying their effort toward environmental abatement in response to environmental education may trump any voluntary agreements, lowering their costs of abatement, and enhancing their relations with a regulatory authority.

As addressed by Feather and Amacher, a lack of agent information regarding both the profitability and the environmental benefits of expending environmental effort may account for limited adoption. When environmental effort depends primarily upon producer perceptions, financial incentives, including cost sharing or tax exemptions, can be relatively costly. An alternative is to implement programs that educate agents. Especially given any nonrival characteristics of education programs, it is hypothesized they could dominate any financial incentive. Feather and Amacher support this hypothesis by indicating producer perceptions do play a major role in explaining environmental effort. However, findings by Tucker and Napier suggest the variability of agents' information-use patterns and perceptions indicate significant information rivalness, reducing any cost advantages of broad-based approaches for delivering educational information. Thus, educational programs are likely to have a greater impact if targeted to the interests and characteristics of specific agents with similar educational deficiencies. This result is supported in the empirical work of Wang, Young, and Camara. In their investigation of agricultural wind erosion control, they found, in contrast to general environmental education, targeted educational programs, which highlight the environmental threat of wind erosion and potentially profitable abatement practices, had significant positive impacts on agents' environmental efforts.

One such targeted program developed by the USDA cooperative extension service is "best management practices" (BMPs), aimed at reducing movement of nutrients, pesticides, and sediments into surface water resources. In terms of net returns, Valentin, Bernardo, and Kastens indicate the effects on net returns from the adoption of BMPs is mixed. For wheat and corn production, nutrient BMPs positively impact net returns. In contrast, a small but negative relation with net returns exists for herbicides on corn. They suggested this negative relation may be explained by agents not educated in the correct application of herbicides, so educational programs addressing producer application of practices, as opposed to simply encouraging adoption, may be warranted. In this regard, various computer programs have been developed to aid agents in acquiring information. For example, computer decision-support programs for agents' environmental effort have been developed (Collentine, Larsson, and Hannerz)

A positive link between environmental education and agent effort is extensively supported in the literature. Other studies all indicate that more experienced and educated agents will expend more environmental effort (Baidu-Forson; Lichtenberg and Zimmerman; Lohr and Park; Lohr, Park, and Higley; and McCann and Easter).

With the literature indicating both voluntary agreements and educational programs exerting a positive influence on agents' environmental effort, the objective underlying the new paradigm is determining the relative combination of these mechanisms. Identifying and packaging voluntary agreements with educational programs can increase adoption of the efficient level of effort and provide a least-cost combination of efforts for obtaining this efficient level (Cooper). In terms of concentrated animal feeding operations outside the Clean Water Act's regulatory lens, Poe, *et al.* conclude a package of voluntary and educational programs can be expected to generate the desirable level of environmental effort if adequate cost sharing is provided. However, in the presence of information asymmetries, determining the optimal combination of these mechanisms is challenging.

Theoretical Model

As an initial attempt toward a theoretical development of this new environmental order, Bénabou and Tirole's model of prosocial behavior is adapted to a set of n agents generating nonpoint-source pollution such as nitrogen leaching. Suppose each agent selects a binary environmental activity (e.g. a BMP), a, from a choice set $A = \{0, 1\}$ with 1 representing participation and 0 nonparticipation, where the visibility of this activity varies across other producers, employees, and consumers. Choosing a entails a utility cost $C(a)$ which is mitigated by an educational, e, or a monetary, y, incentive rate or both per unit of a. Educational incentives could be extension sponsored programs or access to literature, and monetary incentives may consist of direct subsides or taxes and/or qualifying for governmental programs (swampbuster provisions). These incentive rates are set by a principal (government bureau) and the individual agent takes them as given.

Denoting *v* and *m* as agent's intrinsic valuation for contributing to environmental activities and the monetary valuation of education, respectively, along with normalizing an agent's valuation for money, participation at level *a* then yields a direct net benefit

$$a(v + me + y) - C(a).$$

Each agent's preference type *v* is drawn independently from a continuous distribution density $g(v)$ with mean $\bar{v}$. Its realization is private information, known to an agent with participation level *a* but not observable by others. This intrinsic motivation to behave proenvironmentally, *v*, can stem from two sources: impact of an agent's actions on the environment and pleasure of being an environmentalist. An agent may care about the overall level of environmental quality to which his/her actions contribute. Let this component of utility be $w(n\bar{a}/n^{\kappa})$, where $\bar{a}$ represents the average participation level for the activity; $\kappa \geq 0$ is the degree of congestion; and *w* measures the intensity of the agent's proenvironmentalism. In addition, an agent may experience the pure pleasure in being a proenvironmentalist, *u*, independent of social concerns. This would make the agent value his/her own contribution to $n\bar{a}$ more than other agents. Combining these pure, *u*, and impure, $w(n/n^{\kappa})$, forms of proenvironmentalism yields $v = u + w(n/n^{\kappa})$.

As addressed by Bénabou and Tirole, in addition to this direct net benefit, decisions carry reputational costs and benefits, reflecting the judgements and reactions of other producers, employees, consumers, and the community as a whole. Assume reputation depends linearly on observers' posterior expectations of the agent's type v. Thus, the reputational payoff from choosing a, given incentive rates e and y is

$$R(a, e, y) = x\gamma(e)E(v|a, e, y),$$

where γ reflects an agent's proenvironmental status, and x measures the visibility or salience of their actions (probability it will be observed by others). As the visibility of actions cloud, x declines, information asymmetries, along with their inefficiencies, develop. The major difference in monetary and educational incentive rates is reflected in their influence on agents' reputational payoffs. Education has the potential of altering agents' appearance of being environmentally concerned, $\gamma(e)$, which creates a self-incentive on the part of agents toward adoption of environmental activities. This educational self-incentive supplants an incentive-compatibility constraint with hidden actions given information asymmetries. Education offers a signal of the proenvironmental status of an agent. In contrast, monetary incentives do not influence an agent's level of proenvirnomental status, γ.

The social self esteem benefit, $x\gamma(e)E(v|a, e, y)$, is then combined with proenvironmental motivation, $v = u + w(n/n^{\kappa})$, where an agent solves

$$\max_{a} a(v + me + y) - C(a) + x\gamma(e)E(v|a, e, y).$$

F.O.C.s

$$c = v + me + y + r(e, y),$$

where c represents a cost shift from the binary choice represented by a, $c = C(1) - C(0)$. The last term denotes a change in reputational return from a, $r = R(1, e, y) - R(0, e, y)$. An agent's choice of a reveals the sum of three motivations: intrinsic, v, extrinsic, e and y, and reputational, r. As noted by Bénabou and Tirole, all three vary across agents, so learning about v and agents' valuation of money, corresponds to a signal-extraction problem. Higher incentive rates *e* and *y* reduce the informativeness of actions about *v* while increasing it about money. The heterogeneity in agents' image concerns γ represents an additional source of noise which makes inferences about both *v* and money less reliable and which is amplified when actions become more visible (higher *x*).

An agent will now select environmental choices if $v \geq c - me - y - r(e, y) = v^*(e, y)$. This result is consistent with the theoretical implication derived by Lohr, Park, and Higley. They determined proenvironmental activities increase with intensity of environmental attitudes. The stronger agents' beliefs regarding the importance of mitigating environmental risk, the greater their level of action.

Recall an agent's intrinsic participation $v = u + w(n\bar{a}/n^{\kappa})$, where *u* is a pure pleasure of being a proenvironmentalist and *w* is the marginal utility of the public good $w(n\bar{a}/n^{\kappa})$. As with Bénabou and Tirole, take *u* and *w* to be independently distributed and denote the mean of *w* as $\bar{w}$. Given incentive rates *e* and *y* an equilibrium is determined by a threshold v^*. Agents' expected per capita welfare is then

$$\bar{U}(v^*, e, y) = E[w(n\bar{a}/n^{\kappa}) + a(u - \mathbf{c} + me + y) + x\gamma(e)v],$$

$$= \int_{v^*}^{v^+} [(n - 1)(\bar{w}/n^{\kappa}) + v - c + me + y]g(v)dv + x\gamma(e)\bar{v},$$

where v^+ denotes the highest utility, *v*, among the *n* agents. Each agent generates for the other $(n - 1)$ agents positive spillovers for each activity choice along with direct utility, $v - c + me + y$ and average reputation, $x\gamma(e)\bar{v}$. The welfare impact of a marginal increase in agents' participation is

(1) $-\partial\bar{U}(v^*, e, y)/\partial v^* = [(n - 1)(\bar{w}/n^\kappa) + v^* - c + me + y]g(v^*),$

$$= [(n - 1)(\bar{w}/n^\kappa) - \Delta(v^*)]g(v^*).$$

The first term on the right-hand side is the public-goods externality which may be denoted as $\bar{z} = (n - 1)(\bar{w}/n^\kappa)$. The second term reflects the condition that each marginal participant brings down the reputation of proenvironmentist as well as that of antienvironmentists. As noted by Bénabou and Tirole, the reputational losses of inframarginal agents on both sides must add up to the gains of the marginal participant, $\Delta(v^*) = r(e, y)$. Thus, condition (1) is the difference between a free-riding effect and a reputation-stealing effect.

A government environmental bureau's choice of incentive rates, *e* and *y*, leading to a social optimum may be determined by assuming the bureau internalizes some fraction $\alpha \in [0, 1]$ of agents' welfare and also derives from each agent's participation a benefit, *B*. Bureau's expected per agent payoff is then

$$\bar{W}(e, y) = \alpha\bar{U}[v^*(e, y); e, y] + [B - d(n)e - y]\bar{a}(e, y),$$

where $d(n)$ is per unit bureau cost of providing *e*, and assuming some scale efficiency, $d_n \equiv \partial d/\partial n < 0$. Following Bénabou and Tirole, the bureau discounts agents' welfare, $\alpha < 1$, given some cost of public funds and $B > 0$ could reflect a different discounting between public and private funds. Using (1) the bureau's F.O.C.s for maximizing its expected payoff are

(2a) $\partial\bar{W}(e, y)\partial y = (\alpha MSB - de - y)\bar{a}_y - (1 - \alpha)\bar{a}(e, y) = 0,$

(2b) $\partial\bar{W}(e, y)\partial e = (\alpha MSB - de - y)\bar{a}_e + \alpha MRB - (d - \alpha m)\bar{a}(e, y) = 0,$

where $MSB \equiv \bar{z} - \Delta(v^*) + (B/\alpha)$ denotes the marginal social benefits of agent actions and $MRB \equiv x\gamma'(e)\bar{v}$ represents the marginal reputational payoff from education. Given

v^+

$\bar{a}(e, y) = \int_{v^*(e, y)} a(e, y)g(v)dy$, then $\bar{a}_y \equiv \partial(\bar{a}, y)/\partial y = -\partial v^*(e, y)/\partial y[g(v^*)]$ with similar evaluations for e. Note that MRB in (2b) reflects the ability of education to positively influence an agent's proenvironmental status.

These F.O.C.s (2) lead to the following proposition.

PROPOSITION 1: *A Ramsey-subsidy ratio weighted by net marginal costs and adjusted for reputational payoff will yield the optimal level of relative incentives. Specifically*

$$(3) \qquad \frac{y^S}{e^S} = \frac{\epsilon_y}{\epsilon_e}\left[\frac{d - \alpha m}{1 - \alpha} - \frac{\alpha MRB}{(1 - \alpha)\bar{a}}\right],$$

where the elasticities of average participation level with respect to monetary and educational incentives are $\epsilon_y \equiv \bar{a}_y y/\bar{a}$ *and* $\epsilon_e \equiv \bar{a}_e e/\bar{a}$*, respectively. Note that* $\alpha/(1 - \alpha)$ *is the odds ratio or the relative weight given to agent's MRB per unit of participation by the environmental bureau.*

PROOF:

Solving for $\alpha MSB - de - y$ in (2) and equating yields

$$\frac{(1 - \alpha)\bar{a}}{\bar{a}_y} = \frac{(d - \alpha m)\bar{a}}{\bar{a}_e} - \frac{\alpha MRB}{\bar{a}_e}.$$

Dividing through by $(1 - \alpha)$ and representing in terms of elasticities results in

$$\frac{y}{\epsilon_y} = \frac{e(d - \alpha m)}{\epsilon_e(1 - \alpha)} - \frac{\alpha MRBe}{\epsilon_e(1 - \alpha)\bar{a}}.$$

Solving for the incentive ratio, y/e, yields (3).

From (3) the Ramsey-subsidy ratio is the ratio of incentive elasticities weighed by their respective net marginal costs adjusted by the reputational payoff per unit of participation, $MRB/\bar{a}$, weighted by the odds ratio. Note that the net marginal costs are $(d - \alpha m)$ and $(1 - \alpha)$ for education and monetary incentives, respectively, where d and 1 are the bureau's marginal costs and αm and α are the agent's discounted monetary marginal utilities. As the cost of providing education declines, possibly resulting from scale efficiency as n increases, the lower will be the optimal ratio. This would be reinforced with higher *MRBs*, which also lowers the socially optimal incentive ratio, y^S/e^S. If $\alpha = 0$, the government bureau does not internalize any agent welfare including reputational welfare. In this case, the Ramsey-subsidy ratio results, $y^S/e^S = d(\epsilon_y/\epsilon_e)$. The optimal ratio is proportional to the elasticities, where the magnitude of the proportionality is determined by the bureau's per-agent marginal cost of education. The more participation is responsive to the monetary (education) incentive the higher (lower) will be the optimal ratio.

The socially optimal level of incentive rates e^S and y^S may be derived by simultaneously solving (2)

$$\text{(4a)} \qquad y^S = \frac{\alpha MSB - \dfrac{d\alpha}{d - \alpha m} MRB(\epsilon_e/\bar{a}_e)}{1 + d\dfrac{\epsilon_e(1 - \alpha)}{\epsilon_y(d - \alpha m)} + \dfrac{1 - \alpha}{\epsilon_y}}$$

$$\text{(4b)} \qquad e^S = \frac{\alpha MSB + (\alpha MRB/\bar{a}_e)(\dfrac{\epsilon_y}{1 - \alpha} + 1)}{d + \dfrac{\epsilon_y(d - \alpha m)}{\epsilon_e(1 - \alpha)} + \dfrac{d - \alpha m}{\epsilon_e}}.$$

These optimal incentive levels are listed in Table 1 along with their adjustments under alternative elasticity and internalized welfare assumptions.

Given (4), a further investigation of the effect marginal cost of education, d, has on the optimal incentives is revealed in the following proposition

PROPOSITION 2: *(1) The optimal level of education is inversely related to its marginal cost and (2) if the elasticity of education with respect to its marginal cost is elastic, then the monetary* *incentive is a substitute for education. Specifically*

$\partial e/\partial d \equiv e_d < 0$, *and*

$\partial y/\partial d \equiv y_d > 0$ *(substitute), if* $\epsilon_{ed} \equiv (\partial e/\partial d)(d/e) < -1$.

PROOF:

Part 1 follows directly by evaluating the partial derivative of (4b) with respect to *d*. Part 2 results by solving (2a) for *y*

$$y^S = \frac{\alpha MSB - de^S}{1 + \frac{1-\alpha}{\epsilon_y}} .$$

$$y^S_d = \frac{-de_d - e^S}{1 + \frac{1-\alpha}{\epsilon_y}} ,$$

$$y^S_d = \frac{-e^S(\epsilon_{ed} + 1)}{1 + \frac{1-\alpha}{\epsilon_y}} .$$

If $\epsilon_{ed} < -1$, then $y_d > 0$.

Proposition 2 implies that for the monetary incentive to be an educational substitute, education must be very responsive to its marginal cost. In such a case, an increase in the educational costs yields a relatively large reduction in its level, and the bureau then replaces education with the monetary incentive. Analogous to a profit-maximizing firm only operating in the elastic portion of its demand curve, this case of $e_{ed} < -1$ is associated with a socially-welfare maximizing government bureau.

COROLLARY: *The socially optimal level of educational incentives is in the elastic portion of the government bureau's demand curve. Specifically, at* e^S, $\epsilon_{ed} < -1$.

PROOF:

$$\epsilon_{ed} = \frac{-\left(1 + \dfrac{\epsilon_y}{\epsilon_e(1-\alpha)} + \dfrac{1}{\epsilon_e}\right)d}{d + \dfrac{\epsilon_y(d-\alpha m)}{\epsilon_e(1-\alpha)} + \dfrac{d-\alpha m}{\epsilon_e}}\,.$$

Factoring out d in the denominator and cancelling

$$\epsilon_{ed} = \frac{-\left(1 + \dfrac{\epsilon_y}{\epsilon_e(1-\alpha)} + \dfrac{1}{\epsilon_e}\right)}{1 + \dfrac{\epsilon_y}{\epsilon_e(1-\alpha)} + \dfrac{1}{\epsilon_e} - \dfrac{\alpha m}{d\epsilon_e}\left(\dfrac{\epsilon_y}{1-\alpha} + 1\right)}\,.$$

If participation is positively related to the incentives, ϵ_e and $\epsilon_y > 0$, then the last term in the denominator is positive yielding $\epsilon_{ed} < -1$.

Given the proposition and corollary, at the optimal incentives, monetary incentives will be a substitute for education. This is particularly apparent for $\alpha = 1$. In Table 1, e^S is determined at the point where the net marginal cost of education ($d - m$) equals the MRB. The monetary incentive is then $y^S = MRB - de^S$, which indicates the substitution of y for e. Note that, y^S could be negative, indicating a tax if $de^S > MRB$. In this case an agent would be paying for some share of the education.

As an aid in further interpreting (4), from Table 1, if $e = 0$, then (4a) reduces to Bénabou and Tirole's (34) page 1672 for the social optimal level of monetary incentives

(5) $$y^S = \frac{\alpha MSB}{1 + \dfrac{1-\alpha}{\epsilon_y}}\,.$$

This yields their Proposition 9 for nondistortionary incentive rates, $\alpha = 1$, $y^S = y^P - \Delta(c - y^P)$, where y^P is the Pigouvian subsidy, $y^P = \bar{z} + B$. The socially optimal incentive rate is always less than the Pigouvian subsidy. In contrast to Bénabou and Tirole's (34), (4a) is augmented not only by the Ramsey-subsidy ratio but also by the *MRB*, reflecting the effect reputation enhancement through educational incentives has on monetary incentives. This Ramsey ratio measures how responsive the monetary incentive is to a change in the education incentive. The more responsive it is, the lower will be the social optimal level of monetary incentives. In terms of *MRB*, an agent's change in reputation from an education incentive has an indirect effect on the optimal level of monetary incentives. This effect is represented by the last term in the numerator of (4a). It measures the decrease in y^S from the effects of education on reputation. Both the Ramsey ratio and *MRB* effects result in a more elastic ϵ_e yielding a lower y^S which further drives a wedge between the social optimal monetary incentive, y^S and the Pigouvian subsidy, y^P. In contrast, the more elastic ϵ_y, the higher is y^S and narrowing of the wedge.

The optimal level of educational incentive, e^S, modeled in (4b) is symmetric to (4a) with the exception of the *MRB* term. There is a positive direct marginal reputational payoff from participation, $\alpha MRB/\bar{a}_e$, combined with a positive indirect effect, which together augment the *MSB*. This additional direct *MRB* effect distinguishes education from monetary incentives. In contrast to $e = 0$ yielding Bénabou and Tirole's (34) for monetary incentives (5), when $y = 0$

$$(6) \qquad e^S = \frac{\alpha MSB + \alpha MRB/\bar{a}_e}{1 + \dfrac{d - \alpha m}{\epsilon_e}} .$$

The direct *MRB* influence on e^S implies a qualification to Bénabou and Tirole's Proposition 9 part 1, "that the socially optimal incentive rate is always strictly less than the standard Pigouvian subsidy." Consistent with Bénabou and Tirole's Proposition 9 part 1 assumptions, let $\alpha = d = m = 1$ which results in the following proposition

PROPOSITION 3: *The socially optimal incentive rate will exceed the standard Pigouvian subsidy if the marginal reputational payoff of education is greater than the reputation-stealing effect.*

PROOF:

For $y = 0$ and $\alpha = d = m = 1$

$e^S = MSB + MRB/\bar{a}_e,$

$\quad = y^P - \Delta(v^*) + MRB/\bar{a}_e,$

and

(6) $\quad e + \Delta(v^*) = c - v^*.$

Thus,

$v^* = c - y^P - MRB/\bar{a}_e.$

Substituting into (6)

$e^S = y^P + MRB/\bar{a}_e - \Delta(c - y^P - MRB/\bar{a}_e).$

The proposition results if $MRB/\bar{a}_e > \Delta(c - y^P - MRB/\bar{a}_e)$. The general result follows from this restricted outcome.

An important consequence of Proposition 3 is the reputation-stealing effect, addressed by Bénabou and Tirole resulting in an opprobrium effect, can be mitigated by an educational incentive which increases an agent's reputational payoff. This result is true even in the face of hidden actions where the visibility of actions, x, is impaired by information asymmetry.

As indicated in Table 1, when $\alpha = 0$, the government bureau does not internalize any fraction of agents' welfare and only derives a monetary value of B from each agent's participation. Not considering agents' welfare implies no consideration of each agent's reputation and free-riding effects, so the optimal levels of monetary and education incentives, e^S and y^S, depend solely on their elasticities, ϵ_e and ϵ_y. In the polar case, where these elasticities become perfectly elastic, agents' are perfectly responsive to any incentives. This is analogous to a command and control policy where agents have no choice in participation. In contrast, when the elasticity is zero, there is no responsiveness. The agents' are totally shirking. Considering a government bureau which internalizes a fraction of agents' welfare, $0 < \alpha < 1$, the command and control policy results in a weighted Bénabou and Tirole Pigouvian incentive, $y^S = \alpha MSB$ for $\epsilon_y \rightarrow \infty$ and the reputational adjusted incentive is $e^S = MSB + MRB/\bar{a}_e$ for $\epsilon_e \rightarrow \infty$.

Voluntary programs imply some degree of agent unresponsiveness, so voluntary agreements will not yield the same efficient outcome compared with either command and control or a Pigovian tax mechanism. This is consistent with Glachant's results which suggest, in a Coasen approach under asymmetric information, voluntary agreements are not relatively efficient when compared with either a command and control or a Pigovian approach. The result is also analogous with Peterson and Boisvert who demonstrate any comparative evaluation of command and control programs with voluntary agreements must weigh the additional cost of self-selection against the administrative cost and intrusiveness of command and control.

However, the results listed in Table 1 indicate educational incentives can mitigate this self-selection problem. In terms of the educational incentive rate, the associated marginal reputational benefit of agents' actions is influenced by the visibility of their actions, x. A high visibility of actions will enhance the marginal reputational benefit of actions by revealing agents' proenvironmental choices. Education is then a strong signal of proenvironmentalism. In contrast, low visibility of actions leading to information asymmetry can result in limited responsiveness for educational as well as monetary incentive rates (self-selection problem). With hidden actions, government bureaus must satisfy an incentive-compatibility constraint, where they offer a compensation scheme that provides an agent an incentive to choose the required action level. However, a low level of paraticipation can be enhanced by increasing an agent's proenvironmental status. Increasing an agent's proenviromentalism status can, in contrast to monetary incentives, mitigate hidden action inefficiency.

Thus, participation in voluntary agreements can be enhanced through educational programs designed to reduce costs of learning and integrating environmental activities into an agent's production processes. Government educational programs, aimed at educating agents on their environmental consequences from production, influence the proenvironmental status of an agent. In contrast to monetary incentives, an educational incentive positively impacting an agent's proenvironmental status, enhances the responsiveness of agents' undertaking environmental activities.

With education positively influencing proenvironmental status, a bureau has an additional tool for inducting the optimal level of activities. In contrast to monetary incentives, educational incentives can offset reputation-stealing effects and a low level of visibility by increasing the proenvironmental reputation of agents. The problem of hidden actions as visibility declines can be mitigated by environmental education. In terms of information asymmetry terminology, as opposed to monetary incentives, there is no incentive-compatibility constraint for education.

Conclusions

The derived optimal incentive rates are consistent with the new order and an environmental regulatory paradigm encompassing self-regulation in the shadow of the state with collective principal and agent actions. The implication is that joint analysis is required for determining the total environmental activities of simultaneous applications of voluntary and educational incentives on agents' environmental actions. Considering each mechanism in isolation from others may bias the results. As suggested by Wu and Babcock (1998) in the adoption of tillage, rotation, and soil testing practices, through joint analysis, the effects of alternative combinations of management practices can be evaluated. Limited literature exists in jointly considering environmental agreement and program effects on agents' response and environmental enhancement. One exception is Amacher and Feather who consider the impacts of bundling BMP programs. A body of literature does exist on the joint adoption practices of technologies. As a foothold to this literature, see Khanna, Epouhe, and Hornbaker. With the new order of regulatory capitalism, it is time to concentrate on removing barriers yielding inefficient mono-mechanism design and start constructing multidimensional incentives to efficiently allocate effort toward environmental and economic goals.

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Table 1. Social Optimal Monetary and Educational Incentives

Internalized Welfare Coefficient, α	Elasticities[a]	Social Optimal Incentives Monetary, y^S, and Educational, e^S
$0 < \alpha < 1$	ϵ_y and $\epsilon_e > 0$	$y^S = \dfrac{\alpha MSB - \dfrac{d\alpha}{d - \alpha m} MRB(\epsilon_e/\bar{a}_e)}{1 + \dfrac{\epsilon_e(1-\alpha)}{\epsilon_y(d - \epsilon m)} + \dfrac{1-\alpha}{\epsilon_y}}$
		$e^S = \dfrac{\alpha MSB + (\alpha MRB/\bar{a}_e)(\dfrac{\epsilon_y}{1-\alpha} + 1)}{1 + \dfrac{\epsilon_y(d - \alpha m)}{\epsilon_e(1-\alpha)} + \dfrac{d - \alpha m}{\epsilon_e}}$
	$\epsilon_y \rightarrow \infty$	$y^S = \alpha MSB, \quad e^S = 0$
	$\epsilon_e \rightarrow \infty$	$y^S = 0, \quad e^S = \alpha MSB + \alpha MRB/\bar{a}_e$
	$\epsilon_y = 0$	$y^S = 0, \quad e^S = \dfrac{\alpha MSB + \alpha MRB/\bar{a}_e}{1 + \dfrac{d - \alpha m}{\epsilon_e}}$
	$\epsilon_e = 0$	$y^S = \dfrac{\alpha MSB}{1 + \dfrac{1-\alpha}{\epsilon_y}}, \quad e^S = 0$
$\alpha = 0$	ϵ_y and $\epsilon_e > 0$	$y^S = \dfrac{B}{1 + \dfrac{\epsilon_e}{d\epsilon_y} + \dfrac{1}{\epsilon_y}}, \quad e^S = \dfrac{B}{1 + \dfrac{d\epsilon_y}{\epsilon_e} + \dfrac{d}{\epsilon_e}}$
	$\epsilon_y \rightarrow \infty$	$y^S = B, \quad e^S = 0$
	$\epsilon_e \rightarrow \infty$	$y^S = 0, \quad e^S = B$
	$\epsilon_y = 0$	$y^S = 0, \quad e^S = \dfrac{B}{1 + \dfrac{d}{\epsilon_e}}$
	$\epsilon_e = 0$	$y^S = \dfrac{B}{1 + \dfrac{1}{\epsilon_y}}, \quad e^S = 0$

Table 1. Continued

Internalized Welfare Coefficient, α	Elasticities[a]	Social Optimal Incentives Monetary, y^S, and Educational, e^S	
$\alpha = 1$			
	ϵ_y and $\epsilon_e > 0$	$y^S = MSB - de^S$,	$(d - m)\bar{a} = MRB \rightarrow e^S$
	$\epsilon_y = 0$	$y^S = 0$,	$e^S = \dfrac{MSB + MRB/\bar{a}_e}{d + \dfrac{d - m}{\epsilon_e}}$
	$\epsilon_e = 0$	$y^S = MSB$,	$e^S = 0$

[a] ϵ_y and ϵ_e are the elasticities of participation for monetary and educational incentives, respectively.