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THE OBJECTIVE OF AN ENVIRONMENTAL REGULATORY AGENCY

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The objective of an environmental regulatory agency in charge of enforcing an environmental standard is studied. It is assumed that the standard and the agency's budget are set by an overseeing authority. It is found that depending on the standard and the budget given to the agency, the agency may or may not behave as if it minimizes noncompliance, even though its true objective is to maximize total profit minus damages. It is also shown that when the higher level agency sets the standard and enforcement budget to maximize social welfare, the agency acts as if it minimizes noncompliance.

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I. INTRODUCTION

One task of environmental regulatory agencies is to enforce environmental standards. Some authors have studied this enforcement problem. For example, Garvie and Keeler (1994) assume that the agency chooses the enforcement parameters to minimize the noncompliance with an externally-given standard.[1] It is not clear, though, that this provides an accurate depiction of the agency's behavior. Cropper et. al (1992) and Houtven and Cropper (1996) show that the EPA responds to the regulated firms as well as the environmental lobby, taking both interests into account when it makes its policy decisions. In other words, they view the agency as maximizing the regulated firms' profits net of environ-

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[1] In contrast, Viscusi and Zeckhauser (1979) assume that the enforcement parameters are exogenous and the agency sets the standard.

mental damages. The purpose of this paper is to determine whether or not the two assumptions on preferences -- minimizing noncompliance and maximizing total profit minus damages -- are compatible. Specifically, if the agency's true objective is to maximize total profit minus damages, does the agency behave as if it minimizes noncompliance with the standard?

To address this question, it is assumed that the environmental standard and the agency's budget are set by one governmental body, and that the agency is charged with enforcing the standard. To enforce the standard, the agency chooses the probability with which a firm is monitored and the amount spent on legal expenses. The regulated firms take these parameters as given, and then choose their levels of output and emissions. It is found that whether or not the assumptions on the agency's objective are compatible depends on the standard and the budget given to the agency. If the standard is sufficiently loose, or if the budget is sufficiently small, the agency acts as if it minimizes noncompliance when it maximizes its true objective function. It is also shown that if the governmental body that sets the standard and the budget chooses these parameters to maximize social welfare, taking the responses of the agency and firms into account, the standard and budget will be set in a manner which makes the agency behave as if it minimizes noncompliance.

Section 2 presents the model. Section 3 demonstrates the main results, identifying combinations of environmental standards and enforcement budgets under which the agency does and does not act as if it minimizes noncompliance, and discussing the role of the governmental body setting the standard and the budget to attain the social optimum. Concluding remarks are provided in Section 4.

Ⅱ. THE MODEL

There are n identical polluting firms, a regulatory agency, and an authority overseeing the agency.[2] The overseeing authority provides an institutional environment which the firms and the agency take for granted in pursuing their objectives. More specifically, it selects an environmental standard s that the agency must enforce, and sets the agency's enforcement budget B. The agency implements the given standard by setting enforcement parameters, in particular the detection probability p and the legal enforcement budget E. Then, the firms take the standard and enforcement parameters as given and maximize profits by making proper decisions on the amount of an input, x and the amount of a pollutant discharged, e. As is standard in dynamic games, the analysis begins with the last mover, in this case the firms. With probability p the agency monitors and detects a firm's violation.[3] Once a firm's violation is detected, the

[2] Neilson and Kim (2001) analyze a similar problem but without the overseeing authority. In that paper, the agency sets its own standard.

agency brings it to the courts and uses legal expenditures to influence the fine, and the total amount available for such expenditures is E. So, the fines resulting from a violation of $v=e-s$ is given by $F(v, E)$.[4]

Firms do not comply with the standard if the benefits from noncompliance exceed the expected fines. The firms are identical in the sense that they participate in a constant cost industry with the same production technology. A typical firm's problem can be written as the following:

$$\max_{x,e} \; R(x, e)-rx-pF(e-s, E)$$

where r represents the unit cost of the ordinary input, and $R(x, e)$ is the revenue generated by selling the output produced from the inputs x and e.[5] The first order conditions give us x^*, e^*.

The agency is assumed to spend its entire budget[6] and maximize a utility function consisting of the firms' profit minus social damages subject to the firms' incentives and an exogenously-given budget and standard. The agency's choice variables are the detection probability and the legal expenditures, which in turn affect the magnitude of fines. So, the agency tries to maximize its objective by allocating its budget on monitoring and litigation. The agency's problem can be written as the following:

$$\begin{aligned} \max_{p,E} \; & n(R(x, e)-rx)-D(ne) \\ s.t. \; & M(p, E)=B \\ & e=e^*(p, E, s) \\ & x=x^*(p, E, s) \end{aligned} \tag{1}$$

where D and M stand for the environmental damages and enforcement expenditure functions, respectively. It is assumed that marginal damages increase at an increasing rate and that higher enforcement parameters increase enforcement costs. The first order conditions are the following:

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[3] The reason that the agency does not employ perfect monitoring is twofold. First, with a limited budget perfect monitoring may not be feasible. Second, perfect monitoring is inconsistent with Nash equilibrium, since if monitoring is perfect, all firms comply with the standard, in which case the agency prefers to monitor less.

[4] The agency's attempts to influence the fines through E reflects the firms' avoidance efforts. A model incorporating regulated firms' avoidance efforts, as in Malik (1990) would be more general, but such considerations are omitted here for simplicity. It is also possible to analyze the structure of fines and violations only, as in Harford (1978) and Roberts and Spence (1976).

[5] Intuitively, revenue can be expanded in two ways. One is to use more of the internalized input x, and the other is to use more of the external input e.

[6] The bureaucracy tends to use up its budget in the fear that otherwise the next account year's budget would be reduced. The above assumption captures this kind of bureaucracy.

$$n(R_e - D_e)e_p^* - \lambda M_p = 0 \tag{2}$$

$$n(R_e - D_e)e_E^* - \lambda M_E = 0 \tag{3}$$

$$B - M(p, E) = 0 \tag{4}$$

$$\lambda \geq 0 \tag{5}$$

Notice that the Lagrange multiplier λ could be either positive or zero. So, we have two different sets of first order conditions. First, look at the case where $\lambda > 0$. The first order conditions reduce to the following and (4):

$$\frac{e_p^*}{e_E^*} = \frac{M_p}{M_E}$$

Notice that these are the same as the first order conditions for the following problem:

$$\min_{p,E} \; n(e - s)$$

$$s.t.\; M(p, E) = B$$

In other words, in this case the agency maximizes its objective by minimizing violations of the standard. So, in this case the objectives of maximizing the agency's utility and minimizing noncompliance yield identical outcomes.[7]

Now, consider the case where $\lambda = 0$. The first order conditions reduce to the following and (4).

$$R_e - D_e = 0 \tag{6}$$

These are the same as the first order conditions for the agency's problem (7) when the Lagrange multiplier is zero. Notice that in (7) the agency chooses the standard as well as the enforcement parameters:[8]

$$\max_{p,E,s} \; n(R(x, e) - rx) - D(ne) \tag{7}$$

$$s.t.\; M(p, E) \leq B$$

[7] Garvie and Keeler (1994) studies the agency's endogenous choice of p and E under a sufficiently small budget relative to the given standard like in the above.

[8] In fact, this is true only on the condition that the agency chooses in (7) the same standard as the overseeing authority-given standard s in the problem (1). However, there are infinitely many cases of s where the Lagrange multiplier for (7) is zero, which will be explained in the next section.

$$e = e^*(p, E, s)$$
$$x = x^*(p, E, s)$$
$$0 \leq p \leq 1, 0 \leq E \leq B, s \geq 0.$$

So, when $\lambda = 0$, the agency behaves as if the choice of a standard is not limited. However, in this case, it might be the case that p and E are not efficiently allocated from the social point of view. Since $\lambda = 0$, the budget is so large that further increases contribute nothing to social welfare at the margin. With the assumption that the agency uses its entire budget, this implies that some of the budget might be wasted for the sake of the agency's own interests.

Ⅲ. MAXIMIZING UTILITY AND MINIMIZING NONCOMPLIANCE

It has been assumed that the agency maximizes a utility function consisting of total profit less social damages. We have shown that an agency maximizing this utility function behaves as if it minimizes noncompliance if the multiplier on the budget constraint is strictly positive, that is, if the constraint is binding. Our next concern is when the budget constraint is binding.

We can think of two different scenarios. One is that the standard given to the agency is too loose. Suppose the given standard exceeds the agency's unconstrained optimal emission level. Denoted by e^m, it is the solution to the following problem:

$$\max_{x, e} \; n(R(x, e) - rx) - D(ne)$$

In other words, e^m is the discharge level that the agency attain when the agency sets the firms' input usage and the discharge level directly. In this case, the agency cannot get firms to discharge the level of emissions the agency thinks is optimal, regardless of the size of the budget, because even if the firms comply perfectly with the standards, they pollute too much from the agency's perspective. The best the agency can do is to minimize the firms' noncompliance with the standard. The other case where the agency's budget constraint is binding is that, given the standard, the budget is too small for the agency to achieve its optimal level of emissions. This may occur either because the agency cannot afford to monitor enough, or because the system of fines is too weak. In summary, either "too loose" a standard or "too small" a budget makes the agency behave as if it minimizes noncompliance.

It remains to show that there are conditions under which the agency does not act as if it minimizes noncompliance. In the previous section we demonstrated that if the budget constraint is not binding, the agency act as if it chooses the given standard along with the enforcement parameters to maximize profits less damages. In this case the first order conditions for the agency's maximization

problem (1) reduce to two equations: (6) and (4). If the agency actually chooses the standard as well as the enforcement parameters under a sufficient budget, in other words, if it solves the problem (7) given a sufficient budget, it would get the same type of first order conditions as (6) and (4) but with three unknowns.[9] There are multiple solutions for two equations with three unknowns. Let $\Sigma(B)$ be the set of values of s which are consistent with this system of equations. Specifically, for any $s \in \Sigma(B)$ there exist values of p and E such that (p, E, s) solves the problem (7). As long as the overseeing authority chooses a value of s which is in $\Sigma(B)$, $\lambda = 0$ and the agency behaves as if it faces no budget constraint.

The last issue we wish to explore is social welfare. Social welfare consists of consumer surplus (CS) and the enforcement budget (B) as well as the firms' profits and the environmental damages. It is assumed that the overseeing authority is concerned with social welfare, while the regulatory agency tries to maximize only the firms' profits net of environmental damages. Put it in a mathematical form, the overseeing authority tries to solve the following problem:

$$\max_{B,s} \; W = W^* + CS(x, e) - B$$

where W^* stands for the agency's maximum utility given B and s. The first order conditions are:

$$\frac{\partial W^*}{\partial B} + \frac{\partial CS}{\partial B} - 1 = 0$$
$$\frac{\partial W^*}{\partial s} + \frac{\partial CS}{\partial s} = 0$$

Note that since the agency's multiplier λ is the marginal value of relaxing the budget constraint, we have $\lambda = \partial W^*/\partial B$. We claim that the λ get positive in the overseeing authority's optimization problem. An increase in the agency's budget, holding the standard fixed, leads to an increase in enforcement activity, which in turn leads to a decrease in output of the good. So, when the budget increases, consumer surplus falls, and $\partial CS/\partial B < 0$. For $\partial W^*/\partial B + \partial CS/\partial B = 1$ to hold, it must be the case that $\partial W^*/\partial B > 0$, which means that the agency's budget constraint must be binding. In conclusion, the overseeing authority, who is concerned with the true social welfare, causes $\lambda > 0$, i.e., the agency behaves as if it minimizes noncompliance. This validates the approach by Garvie and Keeler (1994), who directly assumes that the agency simply minimizes noncompliance.

[9] While the s in the one is given, the s in the latter is a variable. So, the two sets of first order conditions are different actually.

Ⅳ. CONCLUSION

This paper describes a setting in which polluting firms face two levels of regulation. The higher level sets the environmental standard and enforcement budget for the lower level agency, which then enforces the standard. If the lower level agency's true objective is to maximize total firms' profits minus environmental damages, the agency may or may not behave as if it minimizes noncompliance with the standard. If, however, the higher level agency sets the environmental standard and enforcement budget to maximize social welfare, then the lower level agency is in a situation in which it does act as if it minimizes noncompliance with the standard. Thus, the assumption made by other authors may well be a valid shortcut in analyzing the enforcement of environmental policy.

We implicitly assumed that the overseeing authority always makes independent and homogeneous decisions. In other words, the authority sets the standard and enforcement budget independent of any other entity's control and has no difficulty deriving policy conclusions within its authority. This, however, is not always the case in reality. For example, a Congressional committee oversees the Environmental Protection Agency, and that committee is necessarily comprised of representatives with conflicting interests (Weingast and Moran, 1983). Consequently, finding the determinants of the committee's final decisions is an interesting and open question, but it is left to future research.

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