

## AN EMPIRICAL STUDY OF ENVIRONMENTAL STANDARD-SETTING IN KOREA

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*The study focuses on the behavior of the Ministry of Environment in Korea, a standard-setting and budget-constrained agency. It is shown that with standards and fines remaining largely constant during the period of analysis, substitution took place in terms of inspection frequency vis-à-vis stringency of punishment methods. The agency's budget is found to be positively related to inspection frequency, though the relationship is not statistically significant. One important policy implication of the analysis is that an increase in enforcement budget does not guarantee strengthening of enforcement.*

JEL Classification: K42, L51, Q28

Keywords: Environmental Standard, Enforcement, Inspection

### 1. INTRODUCTION

It is usually assumed that environmental standards are set so as to maximize social welfare through the balancing of costs and benefits. Firms subject to regulation incur compliance costs, while the environment is protected and damage to citizens is minimized. Many authors have suggested that environmental standards are in fact set with costs and benefits in mind, even if social welfare maximization itself may not be accomplished (Magat et. al, 1986; Cropper et. al, 1992; Van Houtven and Cropper, 1996). This is not the whole story, though. Some firms violate the standards. Firms violate the standards if the compliance costs exceed the expected fine in the event that violations are detected. Too

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*Received for publication: Feb. 25, 2002. Revision accepted: Sep. 18, 2002.*

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tight a standard can bring about many violations, resulting in damage to the environment. So, optimal standards should take firms' violations into account as well as compliance costs and environmental benefits.

To our knowledge, Viscusi and Zeckhauser (1979) were the first in recognizing that tightening environmental standards is a cost-less way of increasing enforcement. In other words, a tighter standard covers more potential violators and increases expected punishment without any loss in the regulatory agency's budget. In fact, analysis of law enforcement in the framework of economics dates back to Becker (1968). He viewed potential criminals as rational in the sense that they make decisions concerning criminal activity while balancing benefits and costs. The cost is the expected punishment, which is the stringency of punishment itself multiplied by the probability of the offense being detected. Becker (1968) argued that maximum punishment should be set because increasing the detection probability consumes scarce budgetary resources, while setting the punishment itself does not.

Recognizing this function of standard-setting as an enforcement device, Lee (1983) analyzed an environmental regulatory agency as it determined its policy variables for the sake of its own benefit. He argued that, for its private benefit, the regulatory agency sets the standard as tight as possible. Also, Neilson and Kim (2001), recognizing this, analyze how the environmental standard is set by a budget-constrained, standard-setting agency which is trying to set the standard so as to maximize social welfare. They make the assumption that the regulatory agency spends its entire budget within each fiscal year, fearing the next year's budget would be otherwise reduced, and they argue that the tightest standard is set by an agency with a binding budget.

Olson (1999) also indicates the possibility of the stringency of standards being influenced by a change in the agency's budget. Helland (1998) partially confirms this view. Though he does not consider changes in the stringency of standards, he shows that substitution between frequency and stringency of inspections has happened in the case of regulation under the US Clean Water Act. Moreover, Helland (1998) argues that when an agency cannot but have fewer inspections due to increased budgetary constraints, the agency alters its methods of inspection to increase the actual stringency of inspections.

This paper concerns substitution between standards, inspections and fines in the case of Korea's Water Quality Preservation Act. However, as environmental standards and fines under the Act have remained largely constant during the period of analysis (the 1990s) we focus primarily on inspection. Specifically, we examine whether substitution between inspection frequency and punishment stringency has taken place. In the next section we propose several hypotheses to be statistically tested. Section 3 describes the data used and specifies an estimation equation. Section 4 discusses the empirical results and policy implications. Lastly, some concluding remarks are provided in Section 5.

## II. HYPOTHESES

There are two kinds of environmental standards, with one being ambient standards. These represent environmental policy targets and sometimes are referred to as environmental standards. The other kind is emission standards. An emissions standard is imposed on regulated firms and the firms are required to comply with it. This paper concerns emissions standards.

According to the Basic Act of Environmental Policy, ambient standards as policy targets are set in a General Meeting of Ministers presided over by the President. In light of these targets, the Ministry of Environment sets emission standards. Naturally, the government sets the rule and some firms violate. So, the Ministry of the Environment can adjust enforcement policy variables to ensure that the policy objectives are attained. That is, it needs to determine how often it will monitor regulated firms and how hard it will punish detected firms.<sup>1</sup>

To summarize the basic function of the Korean Ministry of Environment, the agency both sets emissions standards and enforces them. Its choices are constrained by its budget. To derive testable hypotheses, we need a model of an environmental regulatory agency like the Ministry of the Environment in Korea. Neilson and Kim (2001) provide a model that fits the situation. They show that if the agency's budget is sufficiently small, it sets the standard as tight as possible, and if the budget is sufficiently large, the agency can obtain its unconstrained optimum with many different combinations of standards and enforcement parameters, where this optimum maximizes social net benefits. Moreover, they provide an example where standards can ensure optimal use of a scarce budget. However, the emissions standards and fines<sup>2</sup> in Korea have been almost the same since the legislation of Water Quality Preservation Act in 1991. The emission standards have been tightened twice, in 1994 and 1996 (with the latter representing a relatively stricter tightening), as is further discussed in the next section. On the other hand, the fine structure did not really change at all, though the effluent charge calculation coefficient has been adjusted according to the inflation rate.

Other things being equal, as the agency's budget decreases, the money available for enforcement is likely to be reduced. The agency can make up for this shortage using the cheapest way of enforcement, i.e. making standards stricter or increasing fines. However, if standards and fines are not changed for

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<sup>1</sup> Of course, with a sufficiently large budget, the agency need not be thus constrained. However, in the more realistic case of facing budgetary constraints, the agency needs to economize.

<sup>2</sup> Here "fines" means the excess effluent charges specified in the Water Quality Preservation Act. The effluent charges are of two kinds. One is called a basic charge and the other is called an excess charge. The excess effluent charge is paid when a firm's emissions exceed the emissions standards. The excess charge is thus of the nature of a fine.

some reason, the agency is likely to reduce its enforcement budget.<sup>3</sup> Likewise, when the budget is increased, we can predict that more resources can be devoted to enforcement, again assuming standards and fines remain the same. Thus, we propose the following hypothesis:

***Hypothesis 1 :The enforcement activity, or frequency of inspection, is positively related to the size of the agency's budget.***

Regulated firms balance compliance costs and expected fines, and the agency can attain its objective by imposing proper expected fines on the firms. Since expected fine is simply the product of the fine amount times the probability of being fined, there can be substitution between them. In other words, a large fine with a small probability of detection can have the same effect as a small fine with a high probability of detection.<sup>4</sup> However, as noted in the case of Korea's Water Quality Preservation Act, fines did not change. We can think of several other ways of changing fines. One is to change standards within an appropriately structured fine schedule.<sup>5</sup> However, standards have changed very little. Another possibility involves changing the method of inspection. As in Helland (1998), the agency can do either cursory inspections or more comprehensive sampling inspections. A comprehensive inspection can detect firms violations better than a superficial one.

The last alternative we focus on is changing the kind of punishment. The Korean Ministry of the Environment employs four kinds of punishment. In order of stringency of punishment they are 1) Warning, 2) Mandate to Make Improvements, 3) Order to Cease Operations, and 4) Prosecution. Now, suppose that the agency's budget is decreased and the funds available for enforcement are thus reduced. In order to attain the environmental policy objective, the agency needs to maintain the optimal expected fine by changing either standards or fines. However, if standards and fines do not change for whatever reason, then the agency is likely to choose a stronger method of inspection and/or punishment.

On the other hand, if the budget is increased, the agency can afford more frequent inspections. Without changing the stringency of punishment, this would impose a greater burden on regulated firms. So, the agency could relax the stringency of punishment to return to the same amount of burden as before.<sup>6</sup>

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<sup>3</sup> Of course, a decrease in budget does not automatically mean a reduction in enforcement. The agency might reduce other parts of the budget instead, for example, reducing R&D spending on water quality improvement.

<sup>4</sup> Implicitly, a neutral attitude toward risk is assumed here, though it is possible to make varying assumptions regarding attitudes towards risk.

<sup>5</sup> The appropriate structure involves increasing (as opposed to constant) marginal fines. Otherwise, fines would not become bigger though standards become stricter.

<sup>6</sup> Because of bureaucratic self-interest, the agency might maintain the stringency of punishment in order to appropriate sufficient budget.

This leads us to the second hypothesis:

**Hypothesis 2 :** The frequency of inspection is inversely related to the stringency of punishment methods.

Finally, we propose a hypothesis regarding some macro-variables. If the economy grows and per capita income increases, then it is believed that the demand for environmental quality also increases.<sup>7</sup> This means that people become more sensitive to environmental quality. So, other things being equal, an increase in income may lead to either stronger enforcement or more stringent standards. On the other hand, when the economy slows and unemployment increases, the burden on regulated firms may come in for reconsideration. This might lead to deregulation and loosening of either standards or enforcement. Having standards and fines remain constant, we can propose the following hypothesis.

**Hypothesis 3:** The frequency of inspection is positively related to GDP and negatively related to unemployment rate.

### III. EMPIRICAL ANALYSIS

#### 1. Estimation Equation and Data

For this empirical study, we need to have a data series including emissions standards, inspection frequency, fines, stringency of punishment, the ministry's budget and some macro variables (i.e. GDP, deflator). The most challenging task concerns the development of a kind of indicator or summary of standards, fines, and various enforcement parameters. We use annual data and the sample period is 1991-2000.

To test the proposed hypotheses, we specify the estimation equation as in the following:

$$INSF_t = \alpha_0 + \beta_1 + PUNS_t + \beta_2 \cdot BUD_t + \beta_3 \cdot STAN_t + \beta_4 \cdot GDP_t + \varepsilon_t$$

In the equation,  $\varepsilon_t$  represents the error term, and a normal distribution with zero mean and constant variance is assumed.

Emission standards are found in the appendix of the Rules for Implementing the Water Quality Preservation Act. As for emission standards, there are two kinds: one for concentration of organic and suspended materials like BOD and COD, and the other kind for various toxic pollutants. Notably, few changes have

<sup>7</sup> According to Grossman and Krueger (1995), environmental quality tends to deteriorate as the economy grows, but it improves as the economy grows beyond a per capita income level of approximately \$5,000.

been made to emission standards. There have been two changes (in 1994 and 1996) since the promulgation of Water Quality Preservation Act in 1991. In 1994, the BOD standard applied to firms emitting more than 2,000m<sup>3</sup> of wastewater daily was tightened. In 1996, the BOD standard was again tightened, as was the standard concerning phenol. Of the standards regarding toxic pollutants, only the one for phenol has been tightened and only once in 1996.

Different standards apply to four types of areas: "Clean" Area, Area "Ga", Area "Na", and "Special" Area.<sup>8</sup> For simplicity, we have created a summary standard that represents a weighted average of the different standards.<sup>9</sup> We use in the estimation the standards for BOD and phenol, which are represented by *STAN1* and *STAN2*, respectively.

*INSF* represents the number of firms whose compliance was inspected by the agency. In fact, firms are primarily subject to inspection by either of two different types of enforcement agencies: one under the central government and the other under local governments. The central government monitors firms in government-established industrial complexes, while local governments inspect the remaining firms. In addition, a special agency called the 'central enforcement team' directly under the central government serves as a back-up monitoring mechanism and in principle covers all emitting firms in the country. Also, in 1997, a special task force responsible for monitoring water quality in Korea's four main rivers was established. *INSF1* stands for the number of firms that the first two agencies have monitored. *INSF2* represents the total number of firms that the four different enforcement agencies have inspected. *INSF* is reported in annual editions of the White Paper issued by the Ministry of the Environment.

Fines here means excess effluent charges as specified under the Orders for Implementing the Water Quality Preservation Act. The excess charge is just the product of a starting fine<sup>10</sup>, violation size coefficient, regional coefficient and daily emissions volume coefficient. Again, fines did not change since the initial promulgation of the Act, save for annual adjustments for inflation.

In addition to imposing fines, the agency can punish violating firms in various

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<sup>8</sup> Standards are set such that the Ministry of Environment can attempt to meet its objectives with regards to the five grades of water quality it has defined, with Grade 1 representing the highest water quality. Standards are set for the Clean Area that are consistent with Grade 1 water quality. Standards are set for Area Ga that are consistent with Grade 2 water quality. Standards are set for Area Na that are consistent with Grades 3-5. Typically, the areas designated as a Special Area must meet the most stringent water quality standards.

<sup>9</sup> For our dependent variable, *INSF*, discussed below, data were not available concerning the type of area within which inspected firms were located. In other words, information was not available concerning whether inspected firms were in a "Clean" Area, an Area "Ga", etc. However, information was available concerning the total number of firms in the four types of designated areas; these proportions were used as weights in constructing the summary standards.

<sup>10</sup> This is different from the basic charge noted in footnote 2. This is a base figure that the actual fine is calculated with through various coefficients.

different ways, information on which is also included in the annual White Paper. As previously mentioned, the agency can just give a warning, mandate improvements, order a firm to shut down operations, or it can recommend the case for prosecution. Annually, the type of punishment has varied, with differing percentages accorded to each component. *PUNS* captures this variation; it is a weighted sum of component percentages, with stronger punishments given greater weight.<sup>11</sup> *PUNS* is a proxy for the stringency of punishment. As noted in the previous section, in view of the fine structure remaining effectively constant, *PUNS* reflects the extent of expected punishment. *PUNS* here summarizes only the punishments made by the first two enforcement agencies. In other words, it does not include the data from the 'central enforcement team' and '4 main rivers special monitoring task force.'

*BUD1* represents the appropriation for water quality improvement, while the alternative measure *BUD2* represents the entire budget of the Ministry of the Environment. We have used data excerpted from the ministry's report to the National Assembly in the national audit. Finally, *GDP* is gross domestic product in billions of (1995 constant) won as reported by the Bank of Korea. Table 1 summarizes the data used.

[Table 1] Data and Descriptive Summary Statistics

	INSF1	INSF2	PUNS	BUD1	BUD2	STAN1	STAN2	GDP
1991	75,054	73,895	207.4	1,848	2,718	127.1	4.7	287738
1992	68,723	67,402	203.6	125	1,396	127.1	4.7	303384
1993	73,778	72,239	199.2	183	1,887	127.1	4.7	320044
1994	130,338	127,772	183.1	572	4,716	88.8	4.7	346448
1995	110,691	108,371	190.5	1,726	6,729	88.8	4.7	377350
1996	94,635	93,014	197.2	2,438	8,851	69.7	3.0	402821
1997	76,894	73,988	203.9	2,957	10,802	69.7	3.0	423007
1998	92,793	76,746	204.8	3,520	11,131	69.7	3.0	394710
1999	98,444	77,144	208.7	3,552	11,536	69.7	3.0	437709
2000	95,245	76,988	199.1	4,092	13,023	69.7	3.0	476269
Descriptive Summary Statistics								
Mean	91659.50	84755.90	199.75	2101.30	7278.90	90.74	3.85	376948.1
Std. Dev.	19052.10	19294.30	7.9315	1455.07	4374.09	26.22	0.90	61645.55
Skewness	0.6700	1.3402	-0.9394	-0.1506	-0.1410	0.6344	0.0000	0.0020
Kurtosis	2.6932	3.4683	2.9705	1.6256	1.4557	1.6257	1.0000	1.8804

Note: *BUD1*, *BUD2*, and *GDP* are in hundred millions won. *STAN1* and *STAN2* are in milligrams per liter.

<sup>11</sup> Arbitrary weights are given to components. Warning is assigned one point, while Improvement Mandate, Order to Cease Operations, and Prosecution are assigned two, three, and four points, respectively. The absolute size of points reflects the stringency of punishment methods. However, the size itself does not have any meaning. Only the order of size matters like in an ordinal utility measure.

## 2. Results and Discussion

For the variables *INSF*, *BUD* and *STAN*, two alternatives exist for each variable. So, we have eight possible combinations of variables. We have done regression analysis on all the possible combinations. Our observation is that the results are almost the same in all cases. We present two representative cases in the following tables, where *INSF2* is the independent variable.<sup>12</sup> Logarithmic values are used in the estimation and all values are in real terms.

[Table 2] Estimation Result (1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	653378.0	84651.80	7.718418	0.0006
PUNS	-2269.926	418.0312	-5.430040	0.0029
BUD1	383.0212	375.4387	1.020196	0.3544
STAN1	-450.0502	239.3322	-1.880441	0.1188
RGDP	-0.217997	0.097031	-2.246671	0.0746
R-squared=0.926341, Adjusted R-squared=0.867413				

[Table 3] Estimation Result (2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	675571.7	171616.5	3.936519	0.0110
PUNS	-2738.511	570.2159	-4.802587	0.0049
BUD1	631.3343	451.9076	1.397043	0.2212
STAN2	-3062.189	8775.410	-0.348951	0.7413
RGDP	-0.119054	0.129944	-0.916188	0.4016
R-squared=0.877238, Adjusted R-squared=0.779028				

The coefficient for *PUNS* has the expected sign and it is significant at the 1% level. So, hypothesis 2 is empirically supported. This suggests that there has been substitution between inspection frequency and the stringency of punishment methods. Helland (1998) obtained a similar finding, though the substitution he found was between inspection frequency and the stringency of inspection methods.

The coefficients for *BUD* and *STAN* have signs consistent with the relevant hypotheses, but they are not statistically significant. One possible reason for the insignificance of *BUD* is that the data used for *INSF* is mixed. In other words, the data includes the number of firms inspected by local governments as well as the central government. If a decomposed data set is available, the regression is

<sup>12</sup> The two cases shown use the variable, *BUD1*, which is the budget figure that is specific to water quality improvement, and make use of the two differing standards for phenol and BOD, *STAN1* and *STAN2*, respectively.



more proper and we could check the relationship between the central government's and local government's enforcement activities.

#### IV. CONCLUDING REMARKS

The Ministry of Environment in Korea both sets emissions standards and enforces them. The Ministry faces budgetary constraints effectively set by the National Assembly. With this discretion on the one hand, and constraint on the other in mind, we proposed several hypotheses. Of particular interest was substitution between emissions standards, fines and enforcement parameters. However, there has been very little change in standards and fines (perhaps reflecting the not inconsiderable political obstacles entailed in making such changes). So, we have focused on possible substitution between inspection frequency and the stringency of punishment methods. It was found that such substitution was statistically significant. This may mean that the enforcement agency varies its punishment methods in accordance with budgetary constraints. For example, faced with a tight budget, the agency might opt for stronger methods of punishment. Helland (1998) advanced a similar idea, but focused on substitution between inspection frequency and stringency of inspection methods.

One drawback in this study is that the data available are limited. Though the Environment Preservation Act (1977) has provided a basis for active protection of the environment, it was not until 1990 that the Act was developed into several specialized acts including the Water Quality Preservation Act. Thus, only since this time is data available that is suitable for this empirical study. Moreover, we have not considered one potentially important variable that might influence the agency's choice. The agency can provide the public good of environmental quality in a more direct manner as opposed to inducing firms to preserve environmental quality. The government can treat pollution directly at government-established treatment facilities. Investments in basic environmental treatment facilities are independent of the budget of the Ministry of the Environment. Such investments are made through special grants to local governments that are then matched by local government funding. Such government-established treatment facilities effectively deal directly with firms emissions, and do so with certainty. Reduced environmental damage through direct provision of this public good allows for the possibility of looser standards or possibly less enforcement activity. On the other hand, regulated firms might respond strategically to this. In other words, firms, in response to the government's direct provision of the public good, may exert less effort in abating emissions.

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