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Monitoring of Pollution Regulation: Do Local Conditions Matter?¹

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Abstract

Economists have greatly criticized regulations that impose uniform environmental standards. Such a critic ignores that the *implementation* of the standards may vary significantly across plants, thus giving rise in fact to non-uniform standards. The purpose of this paper is to analyze the determinants of the regulator's monitoring activities. We show that greater inspection effort, *ceteris paribus*, is allocated towards those plants whose emissions are likely to generate a higher level of damages. On the other hand, we show that the behavior of the regulator is also a function of variables that may not be directly related to abatement cost and damages. In particular, we show that variables pertaining to local labor market conditions have an impact on the monitoring strategy adopted by the regulator.

1. Introduction

Economists have greatly criticized environmental regulations that impose on polluters *uniform* environmental standards since such standards ignore that plants face non-uniform marginal abatement cost, as well as non-uniform marginal damage functions. However, the presence of uniform standards does not necessarily imply uniform compliance with the

¹ Our thanks to Louis Trottier for his technical assistance, Pierre-Yves Cremieux and David Wheeler for helpful advice and comments. The financial assistance of the Canadian Employment Research Forum, the Canadian Sustainable Forest Management Network of Centres of Excellence, and SSHRC is gratefully acknowledged. Usual disclaimers apply.

standards. The nature of the monitoring and enforcement activities performed by the regulator ultimately determines the extent of pollution control undertaken by the plants and their level of compliance with the regulation.² If compliance with the terms of the regulation imposes any net cost on a plant, its behavior is likely to diverge from the desired one unless the cost of compliance is smaller than the expected cost of non-compliance.³

It has been increasingly recognized that resources devoted to the monitoring of the regulated community and the enforcement of environmental standards are insufficient, and that these activities are seriously lacking.⁴ The regulator, therefore, has to allocate its limited resources to perform a small number of compliance activities. Silverman (1990) writes: "Because of limited resources and the resulting need to establish priorities, each EPA program at agency headquarters in Washington D.C. has developed compliance monitoring plans and enforcement response policies. These strategies *generally* direct the most intensive efforts to those segments of the regulated community most likely to be in non-compliance" (p. 95; italics ours). In the context, the use of the word "generally" takes a special importance since it represents an implicit recognition that universal compliance may not be the objective of the regulator. Similarly in Canada, "upon evaluating the results of the National Inspection Plan, Environment Canada found that all regulations did not require the same level of compliance verification, and decided on a target-oriented approach" (Canada 1992, 38).

Surprisingly, issues pertaining to the monitoring and enforcement of environmental standards have been the object of very few empirical analysis.⁵ Magat and Viscusi (1990) have estimated the impact of inspections on the self-reported discharges of biological oxygen demand (BOD) of pulp and paper plants in the United States, and found that each inspection reduces permanently reported discharges by approximately 20%. More recently, Laplante and Rilstone (1996) have found that not only inspections but also the *threat* of an inspection has a strong negative impact on reported emissions. Both analyses also found that inspections induce more frequent reporting from the plants.⁶

Given that inspections may induce plants to improve their environmental performance, it is of interest to understand the process leading the regulator to undertake monitoring activities. The purpose of this paper is to analyze the determinants of the regulator's decision to monitor (or not to monitor) a plant's environmental performance. In particular, we have

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- 2 Russell (1990) defines *monitoring* as "checking up on whether those covered by the law and regulations are doing (or not doing) what is required of (or forbidden to) them." (p. 243) *Enforcement* is defined as "taking actions that force violators to mend their ways and that provide visible examples to encourage others in the regulated population to maintain desired behavior to avoid a similar fate." (p. 243)
 - 3 Penalties for non-compliance may take various forms, including legal costs, fines, loss of reputation, etc. For more details, see Dewees (1990), Hamilton (1995), Lanoie and Laplante (1994), and Muoghalu et al. (1990).
 - 4 Russell (1990) writes: "What is missing is a commitment of resources to checking up on whether those covered by the law and regulations are doing (or not doing) what is required of (or forbidden) them" (p. 243). See also General Accounting Office (1993), and O'Connor (1994).
 - 5 We note, along with Cropper and Oates (1992), that most of the literature in environmental economics simply makes the (implicit or explicit) assumption that polluters comply with the regulation. Research effort on monitoring and enforcement issues has been for the most part theoretical (see for example, Beavis and Dobbs (1987), Linder and McBride (1984), and Russell et al. (1986)). Fisheries have attracted a certain number of empirical analysis (among others, see Furlong (1991), and Sutinen and Andersen (1985)).
 - 6 See also Fearnley et al. (1995).

built a measure of environmental damages *ceteris paribus*, is allocated towards those higher level of damages. On the other hand, the regulator is a function of variables that affect the level of damages. We are particularly interested in the impact of labor market conditions (e.g., regional unemployment rate) on the strategy adopted by the regulator.

The paper most closely related to our work is Deily and Gray (1991). Using an economic (or positive) theory of regulation (Deily and Gray 1976), they analyze whether or not local environmental standards.⁸ In particular, they show that actions are a function of the probability of complying with the regulation. In a more recent economic theory of regulation to model the impact of monitoring, shown in Section 3, we obtain results similar to Deily and Gray. Moreover, unlike Deily and Gray (1991), we show that greater inspection efforts are directed towards higher levels of damages. This result lends support to the theory of regulation (Posner 1974).

Given the limited number of empirical studies, our analysis as broadening further our understanding of the monitoring and enforcement of environmental standards, the *implementation* of those standards. The expected damages lead to a greater probability of compliance to optimality than would suggest the regulatory model, the current paper extends Deily and Gray (1991) and the validity of the competing theories of regulation.

Our paper proceeds as follows. In the next section, we describe the estimation strategy, and the nature of our data. We conclude in Section 4.

2. Model, Estimation, and Dataset

2.1. Model

Our purpose is to analyse the factors that affect a plant's environmental performance. Assume that the amount of discharges of a given subset of industrial plants (industry specific). Assume moreover that the regulator's compliance with the regulation. How is the regulator's resources? As suggested by Silverman (1990),

- 7 Interestingly, Deily and Gray assert that their theory of regulation is activity at the plant level" (p. 260).
- 8 This theory stipulates that there is a supply and demand for amount of regulation so as to maximize its profit.
- 9 To our knowledge, such a test has only been used in the literature.

enforcement activities performed by the pollution control undertaken by the plants and compliance with the terms of the regulation likely to diverge from the desired one unless the cost of non-compliance.³

Resources devoted to the monitoring of the environmental standards are insufficient, and the regulator, therefore, has to allocate its limited compliance activities. Silverman (1990) writes: "The need to establish priorities, each EPA Region has developed compliance monitoring strategies generally direct the most intensive activity most likely to be in non-compliance" The word "generally" takes a special importance because universal compliance may not be the objective. Evaluating the results of the National Inspection Stations did not require the same level of a cost-oriented approach" (Canada 1992, 38).

Monitoring and enforcement of environmental standards: an empirical analysis.⁵ Magat and Viscusi (1990) analyzed self-reported discharges of biological oxygen demand in the United States, and found that each inspection station detected approximately 20%. More recently, Laplante and Lanoie (1994) found that inspections are not only a threat but also the threat of an inspection station. Both analyses also found that inspections

improve their environmental performance, it is important for the regulator to undertake monitoring and enforcement. The determinants of the regulator's decision on environmental performance. In particular, we have

whether those covered by the law and regulations (Lanoie and Laplante 1994). Enforcement is defined as "the threat of a penalty (p. 243) and that provide visible examples to encourage behavior to avoid a similar fate." (p. 243) including legal costs, fines, loss of reputation, etc. (Lanoie and Laplante (1994), and Muoghalu et al. (1994)).

of resources to checking up on whether those polluters comply with the regulation. Research for the most part theoretical (see for example, O'Connor (1994)). Fisheries have attracted attention (see Furlong (1991), and Sutinen and Andersen

built a measure of environmental damages to test whether or not greater inspection effort, ceteris paribus, is allocated towards those plants whose emissions are likely to generate a higher level of damages. On the other hand, we also test whether or not the behavior of the regulator is a function of variables that may not be directly related to abatement cost and damages. We are particularly interested in testing whether or not variables pertaining to local labor market conditions (e.g., regional unemployment) have an impact on the monitoring strategy adopted by the regulator.

The paper most closely related to ours is Deily and Gray (1991).⁷ Using solely the economic (or positive) theory of regulation as a reference model (Stigler 1971; Peltzman 1976), they analyze whether or not local labor market conditions affect the enforcement of environmental standards.⁸ In particular, they analyze whether or not EPA's enforcement actions are a function of the probability that a plant closes as a result of these actions instead of complying with the regulation. In a recent paper, Deily and Gray (1996) also use the economic theory of regulation to model the regulator's enforcement decision. As will be shown in Section 3, we obtain results converse to those obtained by Deily and Gray. Moreover, unlike Deily and Gray (1991; 1996) who did not perform such a test, we show that greater inspection efforts are directed towards those plants most likely to cause higher levels of damages. This result lends support to the public interest (or normative) theory of regulation (Posner 1974).

Given the limited number of empirical analysis in this area of research, we view our analysis as broadening further our understanding of the regulator's behavior with respect to the monitoring and enforcement of environmental standards. Our results indicate that unlike standards, the implementation of those standards is not uniform. To the extent that higher expected damages lead to a greater probability of inspections, actual standards may be closer to optimality than would suggest the regulation. Moreover, given the specificities of our model, the current paper extends Deily and Gray's analysis (1991; 1996) to a test of the validity of the competing theories of regulation when applied to environmental issues.⁹

Our paper proceeds as follows. In the next section, we discuss in more details our model, estimation strategy, and the nature of our dataset. We present our results in Section 3 and conclude in Section 4.

2. Model, Estimation, and Dataset

2.1. Model

Our purpose is to analyse the factors that explain the regulator's decision to monitor a plant's environmental performance. Assume that a regulation is in place which restricts discharges of a given subset of industrial polluters (as most environmental standards are industry specific). Assume moreover that limited resources are devoted to monitoring compliance with the regulation. How is the regulator going to allocate its monitoring resources? As suggested by Silverman (1990), the regulator may wish to allocate its resources

7 Interestingly, Deily and Gray assert that their paper is "the first empirical study of the EPA's enforcement activity at the plant level" (p. 260).

8 This theory stipulates that there is a supply and demand of regulation, and that the government chooses the amount of regulation so as to maximize its political support.

9 To our knowledge, such a test has only been performed by Kaserman et al. (1993).

to maximise the rate of compliance with the regulation. If such is an objective, monitoring activities would obviously be a function of a plant's compliance history. In particular, a high frequency of non-compliance may trigger an inspection by the regulator. However, such a strategy would presume that compliance is equally desirable regardless of the impact of a plant's emissions on the environment. It would ignore that the impact of a plant's emissions is a function of the specificities of the environment in which they are discharged.

With respect to effluent discharges, for any given concentration of conventional pollutants (such as BOD and total suspended solids (TSS)), the environmental impact is a function of the flow of the effluents relative to the flow of the river in which the effluent is discharged: *ceteris paribus*, the greater the river flow, the smaller the environmental impact. Hence, given that the impact of a unit of pollution may vary considerably across locations, the regulator may wish to allocate its resources not so much as to increase compliance with the regulation but instead to minimize environmental damages. This behavior would support the public interest (or normative) theory of regulation which, applied to this particular instance, would explain environmental regulation as an instrument that corrects market failure and increases social welfare (Posner 1974).¹⁰ Given this interpretation of the regulation, the regulator's monitoring strategy would, *ceteris paribus*, be explicitly affected by the fact that damages are heterogeneous across locations, and at least implicitly would allow higher discharges (through lower probabilities of inspections) in locations where damages are smaller. Following the same public interest theory model, we also hypothesize that monitoring activities would account for heterogeneity of abatement costs across plants. However, the sign of that relationship is an empirical issue: while the regulator may wish low abatement cost plant to engage into greater levels of abatement, it may direct its monitoring resources towards high cost plants which may have greater incentives to avoid compliance.

Moreover, other variables may also affect the regulator's behavior. If one espouses the economic (or positive) theory of regulation, the regulator would allocate monitoring resources so as to maximize net political support. On this basis, Deily and Gray (1991; 1996) predict that local employment conditions would particularly influence enforcement actions. Enforcement actions in Deily and Gray include letters, phone calls, penalties, enforcement orders, inspections, etc. Monitoring activities (e.g., inspections) are not differentiated from enforcement activities (e.g., orders and fines). In particular, they predict that plants in high unemployment areas would be the target of a smaller number of enforcement actions than plants in lower unemployment areas. However, somewhat surprisingly, they find that "plants in high-unemployment counties are facing more enforcement actions than fewer." (1991, 269).

Deily and Gray (1991; 1996) also predict that large plants (relative to the community labor force) would face a smaller number of enforcement actions, since it may prove too costly for the regulator to disrupt a large proportion of the labor force (where the cost is measured in terms of political support). An alternative view however is that in order to maximize political support, the regulator may trade-off the support of those concerned with environmental quality with those whose income is an important function of the economic activity generated by the presence of a large (polluting) plant. Support from an environmentally aware

10 This does not preclude that environmental interests could be a strong force in an economic interest group model. See for example Afsah, Laplante, and Wheeler (1996) and Pargal and Wheeler (1996).

community may be obtained by the under inspections (irrespective of whether or actions), while support from the group w may be obtained by engaging into less en we therefore predict that the "visibility" o monitored: the greater the visibility (mea labor market), the larger the probability plants in the local labor market face a sma remains an empirical issue.

Following the preceding discussion, w toring activities by using a model specific both the normative and positive theory of

$$\text{Monitoring} = f(\text{LOCAL EMPLOYMENT COMPLIANCE, C})$$

2.2. Estimation Strategy and Data

For the purpose of our econometric an pulp and paper industry in Quebec. The ind activity and is also its most important sou late 1980s approximately 60% of the total I in Quebec. In Canada, jurisdiction over w provincial governments. The basis of the Insofar as water pollution is concerned, the through its "Fisheries Act" under which Regulations" in 1971. Similarly, the gover Quality Act," has introduced the "Règlem As of May 1992, new federal and provin paper industry whereby new emission stan have been defined. However, for the pe inclusively), only the Quebec regulation co toxicity). The standards are set in kilogram are *uniform* and apply equally to every pla regulation is assessed by comparing the al the plant.¹¹ Though 60 plants were in pr dataset was available for only 46 of those been performed by the regulator over the p

11 For more details, see Laplante and Rilstone (1990).

12 Observations were missing from the monthly r to report seemed to be unsystematic. These ob replaced by forecasts from 12th-order univaria for the plants not included in our dataset, Lapl report does not appear to be the result of a stra

13 A sampling inspection is an inspection where t content of the samples. Other types of monito (1990, 338) for more details.) We have tried t

regulation. If such is an objective, monitoring a plant's compliance history. In particular, a high frequency of inspection by the regulator. However, such a policy is socially desirable regardless of the impact of a plant's emissions on the environment in which they are discharged.

Given a concentration of conventional pollutants in a river, the environmental impact is a function of the river in which the effluent is discharged: the further from the river, the smaller the environmental impact. Hence, given a fixed budget, the regulator will allocate resources considerably across locations, the regulator will inspect plants to increase compliance with the regulation more frequently. This behavior would support the public interest. Such a policy, applied to this particular instance, would be a policy that corrects market failure and increases environmental quality. In other words, the regulator's behavior is explicitly affected by the fact that damages are smaller at locations where damages are smaller. Following this logic, we also hypothesize that monitoring activities will be more costly across plants. However, the sign of that effect is ambiguous. The regulator may wish to direct its monitoring resources towards high cost plants to avoid compliance.

The regulator's behavior. If one espouses the view that the regulator would allocate monitoring resources based on the cost of non-compliance, then on this basis, Deily and Gray (1991; 1996) find that monitoring activities particularly influence enforcement actions. Such actions (e.g., letters, phone calls, penalties, enforcement actions, etc., inspections) are not differentiated from other actions. In particular, they predict that plants in high cost areas will receive a smaller number of enforcement actions than plants in low cost areas. Somewhat surprisingly, they find that "plants in high cost areas receive more enforcement actions than fewer." (1991,

large plants (relative to the community labor force) receive more enforcement actions, since it may prove too costly for the regulator to monitor a large labor force (where the cost is measured in terms of the number of workers). However, it is also possible that in order to maximize political support from those concerned with environmental quality, the regulator will direct a larger fraction of the economic activity generated in the area to support from an environmentally aware

could be a strong force in an economic interest group (1996) and Pargal and Wheeler (1996).

community may be obtained by the undertaking of "visible" monitoring activities such as inspections (irrespective of whether or not these inspections give rise to enforcement actions), while support from the group who benefits largely from the presence of the plant may be obtained by engaging into less enforcement actions. Hence, unlike Deily and Gray, we therefore predict that the "visibility" of the plants may affect the probability that it being monitored: the greater the visibility (measured as the importance of the plant in the local labor market), the larger the probability of inspections. Altogether, whether or not large plants in the local labor market face a smaller or a larger number of monitoring actions thus remains an empirical issue.

Following the preceding discussion, we therefore seek to explain the regulator's monitoring activities by using a model specification which includes variables that could support both the normative and positive theory of regulation:

$$\text{Monitoring} = f(\text{LOCAL EMPLOYMENT CONDITIONS, DAMAGE OF POLLUTION, COMPLIANCE, CONTROL VARIABLES}).$$

2.2. Estimation Strategy and Data

For the purpose of our econometric analysis, we use plant-level monthly data from the pulp and paper industry in Quebec. The industry is a major contributor to Quebec's economic activity and is also its most important source of conventional pollutants, producing in the late 1980s approximately 60% of the total BOD load produced by the manufacturing industry in Quebec. In Canada, jurisdiction over water pollution control is shared by the federal and provincial governments. The basis of the overlap relies on the Constitution Act of 1867. Insofar as water pollution is concerned, the federal government has played an important role through its "Fisheries Act" under which it has introduced the "Pulp and Paper Effluent Regulations" in 1971. Similarly, the government of Quebec, pursuant to its "Environmental Quality Act," has introduced the "Règlement sur les fabriques de pâtes à papiers" in 1981. As of May 1992, new federal and provincial regulations were introduced for the pulp and paper industry whereby new emission standards for TSS, BOD, toxicity, dioxins, and furans have been defined. However, for the period covered by our sample of data (1985-1991 inclusively), only the Quebec regulation contained standards for BOD and TSS (and not for toxicity). The standards are set in kilograms (of BOD and TSS) per ton of production. They are uniform and apply equally to every plant in the industry. A plant's compliance with the regulation is assessed by comparing the allowable discharge with the total load reported by the plant.¹¹ Though 60 plants were in production over the period of analysis, a complete dataset was available for only 46 of those plants.¹² A total of 63 sampling inspections have been performed by the regulator over the period of analysis.¹³ However, due to the exclusion

11 For more details, see Laplante and Rilstone (1996).

12 Observations were missing from the monthly reports filed by the plants. In a number of cases, the neglect to report seemed to be unsystematic. These observations were treated as randomly missing and were replaced by forecasts from 12th-order univariate autoregressions. This left us with 46 of the 60 plants. As for the plants not included in our dataset, Laplante and Rilstone (1996) have shown that the failure to report does not appear to be the result of a strategic behavior from the plants.

13 A sampling inspection is an inspection where the regulator samples the plant's effluents and measures the content of the samples. Other types of monitoring activities are also performed. (See Magat and Viscusi (1990, 338) for more details.) We have tried to document monitoring activities other than sampling

Table 1. Variable Definitions, Means, and Standard Deviations

Variable	Definition	Mean	Standard Deviation
<i>INSP</i>	Number of inspections per month at plant <i>i</i> .	0.02	0.12
<i>AGE</i>	Number of years of production by plant <i>i</i> .	63.74	32.49
<i>UNEMPL</i>	Unemployment rate in the economic region where the plant is located.	11.43	3.20
<i>EMPL</i>	Number of employees hired by the plant divided by total employment within a circumference of 100 km of the plant (in thousands) x 100.	5.72	8.54
<i>COMPTSS</i>	Number of months within the previous 12 months in which the plant complied with TSS standards.	6.79	5.00
<i>COMPBOD</i>	Number of months within the previous 12 months in which the plants complied with BOD standards.	6.74	5.05
<i>INSPREG</i>	Total number of inspections per year made in the administrative region where the plant is located, <i>excluding</i> inspections at the plant.	0.98	1.14
<i>REGIONAL DUMMIES</i>	Dummy variable equals to 1 if located in the region, 0 otherwise (Region 9 is omitted from estimation):		
	Region 1	0.11	0.31
	Region 2	0.13	0.34
	Region 3	0.15	0.36
	Region 4	0.20	0.40
	Region 5	0.07	0.25
	Region 6	0.13	0.34
	Region 7	0.11	0.31
	Region 8	0.07	0.25
	Region 9	0.04	0.20
<i>TREND</i>	<i>TREND</i> = 1 for 01/1985, =2 for 02/1985, and so forth.	42.50	24.25
<i>ANNUAL DUMMIES</i>	1988 is omitted for estimation.	0.14	0.35
<i>INCOME</i>	Average annual household income within 100 km circumference of the plant.	34 185	4 715
<i>ORGANO</i>	Dummy variable to capture the presence of organochlorides in the effluent. Variable = 1 if contains; 0 otherwise.	0.02	0.35
<i>POPUL</i>	Population of the city if the plant's discharges are upstream the city. It takes a value of 0 if discharges are downstream the city.	14 551.76	21 798.72
<i>FLOW</i>	Ratio of firm's effluent over flow of river (m^3/sec).	0.009	0.032
<i>ZONE</i>	Polytomic variable taking a value between 1 and 5. 1 represents a zone where total environmental pressure on a river is low, and 5 where it is very high.	1.5681	1.053

of 14 plants, we retain 56 of the 63 inspe

Let us turn to the variables used to esti standard deviation of the variables are p *TORING*, is captured by a sampling inspe takes a value of 1 when there is an inspe

The LOCAL EMPLOYMENT COND similar to those used by Deily and Gray. at the plant to employment in the local la we expect a positive effect of this variabl plant in the regional labor market, the mo the community. Political support may thu environmental protection is an important view of Deily and Gray (1991) analysis in activities, the impact of this variable re regional unemployment rate as defined represents the age of the plant. It reflects face if non-compliance was detected, and large plant is requested to reduce its emissi will have a negative impact on the probab

As a measure of the DAMAGE OF PO *ORGANO*, *POP*, and *ZONE*. The variable relative to the river flow. Conversation Environment assured us that such a varia potential of a plant's effluent to cause en have a positive impact on the probability relative to the flow of the river, the great probability of an inspection. While this va pollutants to cause damages, it ignores that and furans to cause damages may not be have thus introduced the variable *ORGAN* contains such pollutants.

While emissions of pollutants likely rec from such reduction are a function of the v we would have liked to estimate the econo the plant's discharges and predict that the inspection. Given the large number of river ing, such an exercise would not have been of the Environment, we have decided to co the city in which the plant is located, only upstream the location of the population (*P*

inspections. However, in Quebec, during the pe regional basis and it proved impossible to obtai the case that sampling inspections are the regul standard and give credibility to the self-reportin

14 The size of the local labor market is defined as

Standard Deviations		
	Mean	Standard Deviation
at plant i.	0.02	0.12
plant i.	63.74	32.49
ic region	11.43	3.20
plant	5.72	8.54
a		
nt (in		
ous 12	6.79	5.00
d with TSS		
ous 12	6.74	5.05
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ear made in	0.98	1.14
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	0.11	0.31
	0.13	0.34
	0.15	0.36
	0.20	0.40
	0.07	0.25
	0.13	0.34
	0.11	0.31
	0.07	0.25
	0.04	0.20
/1985, and	42.50	24.25
	0.14	0.35
e within 100	34 185	4 715
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river	0.009	0.032
etween 1	1.5681	1.053
total		
is low, and		

of 14 plants, we retain 56 of the 63 inspections.

Let us turn to the variables used to estimate the above equation. The definition, mean, and standard deviation of the variables are provided in table 1. The dependent variable, *MONITORING*, is captured by a sampling inspection by the environmental authorities (INSP); it takes a value of 1 when there is an inspection and 0 otherwise.

The *LOCAL EMPLOYMENT CONDITIONS* are captured by a vector of three variables similar to those used by Deily and Gray. First, *EMPL* is defined as the ratio of employment at the plant to employment in the local labor market.¹⁴ Following our previous discussion, we expect a positive effect of this variable on the probability of an inspection: the larger the plant in the regional labor market, the more visible is the regulator's monitoring activities in the community. Political support may thus be more favorable from the constituents for whom environmental protection is an important determinant of their political support. However, in view of Deily and Gray (1991) analysis in which *EMPL* has a negative impact on enforcement activities, the impact of this variable remains an empirical issue. Second, *UNEMPL* is the regional unemployment rate as defined and measured by Statistic Canada. Third, *AGE* represents the age of the plant. It reflects (admittedly crudely) the costs that a plant could face if non-compliance was detected, and therefore the potential impact on employment if a large plant is requested to reduce its emissions. We expect that each of these last two variables will have a negative impact on the probability of an inspection.

As a measure of the *DAMAGE OF POLLUTION*, we use 4 different variables: *FLOW*, *ORGANO*, *POP*, and *ZONE*. The variable *FLOW* represents the flow of the plant's effluent relative to the river flow. Conversations with experts in the Quebec Ministry of the Environment assured us that such a variable captures in a simple and reasonable way the potential of a plant's effluent to cause environmental damages. We expect this variable to have a positive impact on the probability of inspection: the larger the effluent of the firm relative to the flow of the river, the greater the potential for damages, and the higher the probability of an inspection. While this variable may capture the potential for conventional pollutants to cause damages, it ignores that the potential for organochlorides such as dioxins and furans to cause damages may not be affected in a same manner by the river flow. We have thus introduced the variable *ORGANO* which takes the value 1 if a plant's effluents contains such pollutants.

While emissions of pollutants likely reduce water ambient quality, the damages suffered from such reduction are a function of the various uses that can be made of the water. Ideally, we would have liked to estimate the economic value of the portion of the river affected by the plant's discharges and predict that the higher this value, the larger the probability of an inspection. Given the large number of rivers in which the plants in our sample are discharging, such an exercise would not have been feasible. Following discussions with the Ministry of the Environment, we have decided to consider as a proxy for damages, the population of the city in which the plant is located, only to the extent that the plant discharges its effluent upstream the location of the population (*POPUL*). If the plant's outlet(s) is located down-

inspections. However, in Quebec, during the period considered, monitoring activities were performed on a regional basis and it proved impossible to obtain comparable information across regions. It does remain the case that sampling inspections are the regulator's ultimate device to assess compliance with the standard and give credibility to the self-reporting procedure.

14 The size of the local labor market is defined as the labor force within 100 km from the plant.

stream the city, the variable takes the value 0.¹⁵ Finally, we have constructed a general index of environmental pressure for *each river* in which pulp and paper plants are discharging their effluents. We expect that the higher the environmental pressure, the more damaging could be a plant's effluents, and therefore the greater the probability of an inspection. We first calculated the following ratio: ((industrial wastewater discharges + domestic wastewater discharges) / flow of the river). We then have constructed an index *ZONE* which gives a value between 1 and 5 to the ratio calculated above with 1 representing an area of low pressure, and 5 an area of very high pressure.¹⁶

We have also included a variable *INCOME*, which measures the average household income within 100 km of the plant. We expect that the higher the level of income, the greater the demand for a cleaner environment, and the larger the probability of monitoring of the plant's environmental performance. It is interesting to note that this variable may give support to both theories of regulation. Following the public interest theory of regulation, ceteris paribus higher levels of income give rise to a higher valuation of the environmental damages and therefore to a smaller level of optimal pollution for any given levels of abatement cost. On the other hand, following the economic theory of regulation, communities with higher level of income may be more adept at exercising pressure on the regulator to reduce pollution emissions (higher demand for regulation).

COMPLIANCE is captured by the number of months that the plant was in compliance with BOD and TSS standards during the last twelve months. We therefore have two variables labeled *COMPBOD* and *COMPTSS*; they should have a negative influence on the probability of an inspection.

As discussed previously, if the *LOCAL EMPLOYMENT CONDITIONS* variables have a strong explanatory power, this would lend some support to the economic theory of regulation, while if the *DAMAGE OF POLLUTION* and the *COMPLIANCE* variables have more explanatory power, this would support the public interest theory of regulation.

Finally, we consider two sets of *CONTROL VARIABLES*. The first one is included to capture the differences in monitoring effort across administrative regions. For this purpose, we use either *REGIONAL DUMMIES* or, as in Deily and Gray, a variable labeled *INSPREG* which measures the total number of inspections within a region in a given year. The second set of control variables is included to capture omitted influences that may vary across time, but not across regions. For instance, greater public awareness of environmental issues through the period may have led to an increase in monitoring effort. These influences are captured either by *YEARLY DUMMIES* or a *TIME TREND*.

Given the dichotomous nature of our dependent variable,¹⁷ we use the probit model for our estimations.¹⁸ Different specifications are presented with various control variables.

15 Short of measuring the economic value of the river, we wished to estimate the number of people living within a given distance (e.g., 15 km) downstream the plant's discharge point(s). However, the required distance would itself have been a function of the river flow. A dispersion model for each river would then have been necessary to estimate the correct distance to include in the calculation for each plant. These models are lacking.

16 Constructing in this way the *ZONE* variable avoids a potential problem of multicollinearity with the *FLOW* variable.

17 There is no plant in our sample that had more than one inspection in a given month.

18 We have tested a probit model with fixed effects (unconstrained model) by adding 45 dummies for plants, 11 dummies for months, and 6 dummies for years. None of these variables were statistically significant.

Furthermore, experimentations were conducted to (t-6). The justification for this lies on the higher level of damages and the timing of the monthly data, with plants having to self-monitor on a monthly basis.

3. Empirical Results

We have first estimated different combinations of effects (*REGIONAL DUMMIES* and *INSPREG* and *INSPREG TREND*). With respect to regional effects, *REGIONAL DUMMIES* were significant, while *INSPREG* was always not significant. With respect to time, both *INSPREG* and *INSPREG TREND* were not significant. However, models with *YEARLY DUMMIES* and we therefore keep this specification (see Appendix 1).

Results are presented in table 2. The first specification (Gray (1991) omitting the variables that control for regional effects) includes various lags of the *FLOW* variable (*FLOW_{t-3}* (4); *FLOW_{t-4}* (5); *FLOW_{t-4}* (6)). Results show a relatively high percentage of correct predictions. In this discussion, we will focus on the last four specifications of correct predictions.¹⁹

First note that the *AGE* variable is never significant to the extent that this variable may be used as a proxy to indicate that the regulator does not consider the costs of resources across plants.²⁰ It is interesting to note that the coefficient of a similar nature. They write: "the coefficient of *AGE* is significant but insignificant, perhaps indicating that there is a difference in abatement costs across plants" (p. 270).

With respect to the variables pertaining to the plant, we observe that the coefficient of the *EMPL* variable is significant thus indicating that the more employment there is in other words the more "visible" is the plant. An increase of 1% in the variable *EMPL* increases the probability of an inspection. As pointed out earlier, Deily and Gray (1991) control for this difference by noting that Deily and Gray include variables for *monitoring and enforcement activities*, which

We have also conducted a test of maximum likelihood estimation. This was not preferable to the constrained version presented in the paper.

19 For these specifications, we have also tested a logit model and the percentage of correct predictions almost always exceeded 80%.

20 In response to a reviewer's suggestion, we have included a variable for plant capacity. It is indeed well known that there are many plants with a variable also turned out to be statistically insignificant.

Finally, we have constructed a general index which pulp and paper plants are discharging their environmental pressure, the more damaging could be the probability of an inspection. We first constructed an index *ZONE* which gives a value above with 1 representing an area of low

ZONE, which measures the average household income. The higher the level of income, the greater the probability of monitoring of the plant. It is interesting to note that this variable may give support to the public interest theory of regulation, which predicts a higher valuation of the environmental quality. The optimal pollution for any given levels of income. The economic theory of regulation, community pressure (adept at exercising pressure on the regulator for regulation).

of months that the plant was in compliance with the discharge point(s). We therefore have two variables which have a negative influence on the probability

EMPLOYMENT CONDITIONS variables have provided some support to the economic theory of regulation and the COMPLIANCE variables have provided support to the public interest theory of regulation.

CONTROL VARIABLES. The first one is included to control for cross administrative regions. For this purpose, we use the variable *INSPREG* as in Deily and Gray, a variable labeled *INSPREG* which measures the number of inspections within a region in a given year. The second variable measures the unexplained influences that may vary across time, such as public awareness of environmental issues and changes in monitoring effort. These influences are captured by the variable *TIME TREND*.

As an independent variable,¹⁷ we use the probit model for which we presented with various control variables.

We wished to estimate the number of people living near the plant's discharge point(s). However, the required data on population and river flow. A dispersion model for each river would then be required to include in the calculation for each plant. These

are a potential problem of multicollinearity with the

number of inspections in a given month.

We estimated the unconstrained model by adding 45 dummies for plants, but none of these variables were statistically significant.

Furthermore, experimentations were conducted with different lags of the *FLOW* variable up to (t-6). The justification for this lies on the rationale that there may be a time lag between a higher level of damages and the timing of an inspection. This is particularly true when using monthly data, with plants having to self-report their production and discharges data on a monthly basis.

3. Empirical Results

We have first estimated different combinations of the control variables to account for regional effects (*REGIONAL DUMMIES* and *INSPREG*) and time (*YEARLY DUMMIES* and *TIME TREND*). With respect to regional effects, *REGIONAL DUMMIES* appeared to be never significant, while *INSPREG* was always statistically significant. We thus present results using *INSPREG*. With respect to time, both *YEARLY DUMMIES* and *TIME TREND* were not significant. However, models with *YEARLY DUMMIES* were always performing better and we therefore keep this specification (results from various specifications are presented in Appendix 1).

Results are presented in table 2. The first specification is a version analogous to Deily and Gray (1991) omitting the variables that capture the damage of pollution. The following specifications include various lags of the *FLOW* variable: *FLOW_t* (2); *FLOW_{t-1}* (3); *FLOW_{t-2}* (4); *FLOW_{t-3}* (5); *FLOW_{t-4}* (6). Results show that the explanatory power of the model is relatively high with a percentage of correct predictions above 80%. For the purpose of our discussion, we will focus on the last four specifications which offer the largest percentage of correct predictions.¹⁹

First note that the *AGE* variable is never significant and that its sign is unstable. To the extent that this variable may be used as a proxy for the cost of compliance, this result would indicate that the regulator does not consider compliance costs when allocating its monitoring resources across plants.²⁰ It is interesting to note that Deily and Gray (1991) obtain a result of a similar nature. They write: "the coefficient on [the compliance cost variable] is negative but insignificant, perhaps indicating that regulators do not pay much attention to variation in abatement costs across plants" (p. 270).

With respect to the variables pertaining to LOCAL EMPLOYMENT CONDITIONS, we observe that the coefficient of the *EMPL* variable is always positive and statistically significant thus indicating that the more important the plant is in the local labor market, or in other words the more "visible" is the plant, the greater the probability of inspections: an increase of 1% in the variable *EMPL* increases the probability of inspection by 0.1135%. As pointed out earlier, Deily and Gray (1991) obtained a contrary result. We explain this difference by noting that Deily and Gray included in their analysis (added together) both *monitoring* and *enforcement* activities, while we consider solely the impact of monitoring

We have also conducted a test of maximum likelihood. Results have shown that the unconstrained model was not preferable to the constrained version presented here.

19 For these specifications, we have also tested a logit version of the model. Results were of a similar nature and the percentage of correct predictions almost identical.

20 In response to a reviewer's suggestion, we have replaced the variable *AGE* with the plant's production capacity. It is indeed well known that there are important economies of scale in abatement. This capacity variable also turned out to be statistically insignificant.

Table 2. Empirical Results—Probability of an Inspection

VARIABLE	(Pr > Chi-squared)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
INTERCEPT	-1.7070 (0.0173)	-1.5951 (0.0437)	-1.9481 (0.0119)	-1.9375 (0.0118)	-2.2590 (0.0036)	-2.4927 (0.0020)	-2.4975 (0.0022)	-2.8672 (0.0007)	-2.2477 (0.0094)
AGE	0.00186 (0.3473)	-0.0023 (0.2911)	-0.00107 (0.6209)	-0.00139 (0.5202)	0.00002 (0.9915)	0.00025 (0.9118)	0.00063 (0.7940)	0.00062 (0.7969)	-0.00048 (0.8528)
UNEMPL	-0.0670 (0.0056)	-0.0603 (0.0363)	-0.0561 (0.0481)	-0.0597 (0.0346)	-0.0536 (0.0624)	-0.0456 (0.1214)	-0.0480 (0.1085)	-0.0448 (0.1350)	-0.0676 (0.0230)
EMPL	0.0225 (0.0001)	0.0242 (0.0001)	0.0239 (0.0001)	0.0219 (0.0005)	0.0230 (0.0004)	0.0218 (0.0011)	0.0213 (0.0019)	0.0224 (0.0012)	0.0233 (0.0004)
COMPTSS	0.0154 (0.3342)	0.0196 (0.2738)	0.0233 (0.1974)	0.0221 (0.2174)	0.0271 (0.1439)	0.0214 (0.2509)	0.0234 (0.2167)	0.0217 (0.2479)	0.0245 (0.0275)
COMPBOD	-0.0154 (0.3342)	-0.00691 (0.6727)	-0.0094 (0.5733)	-0.0102 (0.5337)	-0.0135 (0.4284)	-0.0198 (0.0255)	-0.0217 (0.2257)	-0.0246 (0.1804)	-0.0228 (0.2067)
INSPREG	0.3581 (0.0001)	0.3520 (0.0001)	0.3397 (0.0001)	0.3369 (0.0001)	0.3392 (0.0001)	0.3520 (0.0001)	0.3649 (0.0001)	0.3760 (0.0001)	0.3653 (0.0001)
INCOME	-9.4E-6 (0.5968)	-0.00001 (0.4511)	-9.17E-6 (0.6326)	-6.7E-6 (0.7262)	-3.9E-6 (0.8378)	6.42E-7 (0.9742)	-8.16E-9 (0.9997)	0.000013 (0.5507)	6.75E-6 (0.7584)
YEAR85	0.1629 (0.5346)	0.1789 (0.5146)	0.2281 (0.4072)	0.2018 (0.4645)	0.3344 (0.2323)	0.3130 (0.2734)	0.2941 (0.3107)	0.3005 (0.2998)	0.2308 (0.4235)
YEAR86	-0.0768 (0.7481)	-0.1290 (0.6019)	-0.1062 (0.6653)	-0.0875 (0.7201)	-0.1042 (0.6732)	-0.0500 (0.8431)	-0.0574 (0.8216)	-0.00971 (0.9698)	-0.0625 (0.9807)
YEAR87	0.0737 (0.7705)	0.0943 (0.7144)	0.0769 (0.7642)	0.0808 (0.7517)	0.0694 (0.7873)	0.1376 (0.6010)	0.1465 (0.5792)	0.1561 (0.5592)	0.1869 (0.4817)
YEAR89	-0.1254 (0.6642)	-0.2421 (0.4364)	-0.2721 (0.3782)	-0.2765 (0.3684)	-0.3208 (0.3098)	-0.2521 (0.4316)	-0.2529 (0.4343)	-0.2523 (0.4362)	-0.2591 (0.4241)
YEAR90	-0.2076 (0.3848)	-0.1985 (0.4159)	-0.2114 (0.3864)	-0.2134 (0.3817)	-0.2645 (0.2857)	-0.2547 (0.3240)	-0.2960 (0.2620)	-0.3261 (0.2209)	-0.3150 (0.2402)
YEAR91	0.0750 (0.7740)	0.0553 (0.8425)	0.00926 (0.9732)	0.00369 (0.9893)	-0.0202 (0.9414)	-0.0711 (0.8076)	-0.0729 (0.8053)	-0.1483 (0.6252)	-0.0737 (0.8068)
FLOW	—	-9.1933 (0.1770)	2.0440 (0.6173)	1.7193 (0.6823)	8.8449 (0.0081)	9.2607 (0.0050)	11.1915 (0.0015)	11.2020 (0.0005)	14.5539 (0.0004)
ORGANO	—	—	—	—	—	—	-0.0239 (0.8925)	-0.1123 (0.5496)	-0.1075 (0.5653)
POPUL	—	—	—	—	—	—	—	-6.7E-6 (0.0716)	-4.6E-6 (0.1651)
ZONE	—	—	—	—	—	—	—	—	-0.1088 (0.1789)
% correct predictions	81.2%	80.6%	80.5%	80.0%	83.1%	83.6%	83.9%	85.2%	84.0%

activities. If enforcement activities mainly explain the result obtained by Deily and Gray, the combination of our results with theirs would indicate that the regulator undertakes monitoring activities where its actions may be most visible (thus indicating an inclination to protect environmental quality), but remains reluctant to impose enforcement actions on those plants which may be more adept at challenging the regulator or, as suggested by Deily and Gray, whose closure would be most disrupting to the local labor market.

The coefficient of our variable *UNEMPL* is as expected of a negative sign and statistically significant for most specifications: the larger the level of unemployment in a region, the smaller the probability of inspections. Deily and Gray (1991) somewhat surprisingly obtained the converse result. They explain their result by suggesting that "to the extent that high-unemployment areas tend to be more populous or more polluted, the benefits from reducing emissions in such areas may be greater" (p. 270). Our results support the hypothesis

formulated earlier in this paper as well as Gray.

With respect to the variables capturing the effect of regional characteristics, the coefficient of the variable *FLOW* is positive, indicating that an increase in the level of regulation, and is statistically significant. Doubling of a plant's effluent flow (relative to the regional average) results in an increase in inspections by 8.9%. The maximization of regional environmental quality, whose discharges may create higher environmental damages, may create higher environmental damages. We cannot clearly explain why this variable is not statistically significant. We note however that there is a time lag between the time when plants submit their discharge reports and the time when inspections are available to local enforcers for actions.

Coefficients of the variables *INCOME* and *POPUL* are not statistically significant. This indicates to us that a marginal increase in income by a plant's effluent would need to be determined to justify the cost of damages on monitoring activities. In terms of the portion of each river along which pollution is occurring, the results are precisely documented and analysed.

The variable capturing the number of environmental standards in the previous year is also statistically significant with the expected negative sign: a greater number of standards increases the probability of inspections. However, the variable *YEAR90* has a positive sign but is never significant. This result with respect to BOD is more likely to influence the probability of inspections with respect to TSS (a similar result is found in the case of TSS) and compliance (with BOD standards) is more important.

This evidence suggests that both the pollution theory and the resource theory of regulation contribute to explain the environmental performance of regulated plants. It is empirically that both theories may be complementary rather than black or totally white. This contrasts with the results of whose empirical test strongly supports the

4. Conclusion

Though environmental regulations imposed on heterogeneous local conditions (such as the presence of environmental hotspots), results in this paper suggest that the presence of this heterogeneity. *Ceteris paribus*, plants facing environmental damages are facing a higher probability of an inspection appears to be a decreasing function of the regional unemployment rate and a decreasing function of the regional unemployment rate offer important insights into the regulatory process. Plants, facing limited resources, do not blindly resist environmental regulation: *ceteris paribus*

Inspection (unadjusted)	(5)	(6)	(7)	(8)	(9)
2.2590	-2.4927	-2.4975	-2.8672	-2.2477	
(0.0036)	(0.0020)	(0.0022)	(0.0007)	(0.0094)	
0.00002	0.00025	0.00063	0.00062	-0.00048	
(0.9915)	(0.9118)	(0.7940)	(0.7969)	(0.8528)	
0.0536	-0.0456	-0.0480	-0.0448	-0.0676	
(0.0624)	(0.1214)	(0.1085)	(0.1350)	(0.0230)	
0.0230	0.0218	0.0213	0.0224	0.0233	
(0.0004)	(0.0011)	(0.0019)	(0.0012)	(0.0004)	
0.0271	0.0214	0.0234	0.0217	0.0245	
(0.1439)	(0.2509)	(0.2167)	(0.2479)	(0.1975)	
0.0135	-0.0198	-0.0217	-0.0246	-0.0228	
(0.4284)	(0.0255)	(0.2257)	(0.1804)	(0.2067)	
0.3392	0.3520	0.3649	0.3760	0.3653	
(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	
3.9E-6	6.42E-7	-8.16E-9	0.000013	6.75E-6	
(0.8378)	(0.9742)	(0.9997)	(0.5507)	(0.7584)	
0.3344	0.3130	0.2941	0.3005	0.2308	
(0.2323)	(0.2734)	(0.3107)	(0.2998)	(0.4235)	
0.1042	-0.0500	-0.0574	-0.00971	-0.0625	
(0.6732)	(0.8431)	(0.8216)	(0.9698)	(0.9807)	
0.0694	0.1376	0.1465	0.1561	0.1869	
(0.7873)	(0.6010)	(0.5792)	(0.5592)	(0.4817)	
0.3208	-0.2521	-0.2529	-0.2523	-0.2591	
(0.3098)	(0.4316)	(0.4343)	(0.4362)	(0.4241)	
0.2645	-0.2547	-0.2960	-0.3261	-0.3150	
(0.2857)	(0.3240)	(0.2620)	(0.2209)	(0.2402)	
0.0202	-0.0711	-0.0729	-0.1483	-0.0737	
(0.9414)	(0.8076)	(0.8053)	(0.6252)	(0.8068)	
8.8449	9.2607	11.1915	11.2020	14.5539	
(0.0081)	(0.0050)	(0.0005)	(0.0005)	(0.0004)	
—	—	-0.0239	-0.1123	-0.1075	
—	—	(0.8925)	(0.5496)	(0.5653)	
—	—	—	-6.7E-6	-4.6E-6	
—	—	—	(0.0716)	(0.1651)	
—	—	—	—	-0.1088	
—	—	—	—	(0.1789)	
3.1%	83.6%	83.9%	85.2%	84.0%	

formulated earlier in this paper as well as the hypothesis initially formulated by Deily and Gray.

With respect to the variables capturing the impact of DAMAGE OF POLLUTION, the coefficient of the variable *FLOW* is positive as we predicted using the public interest theory of regulation, and is statistically significant when the variable is lagged 3 or 4 periods: a doubling of a plant's effluent flow (relative to river flow) increases the probability of inspections by 8.9%. The maximization of social welfare would indeed indicate that plants whose discharges may create higher environmental damages face a higher probability of inspections. We cannot clearly explain why only the lagged value of the *FLOW* variable is significant. We note however that there is typically a period of a few months between the time when plants submit their discharge reports and the time when this information becomes available to local enforcers for actions.

Coefficients of the variables *INCOME* and *ORGANO* are never significant. The coefficient on the variable *POPAVAL* is unexpectedly negative and in most circumstances not significant. This indicates to us that a more precise proxy for the potential damages caused by a plant's effluent would need to be developed in order to test more precisely the impact of damages on monitoring activities. In this particular instance, we suggest that the use of the portion of each river along which pulp and paper plants are discharging should be precisely documented and analysed.

The variable capturing the number of months that the plant was in compliance with BOD environmental standards in the previous 12 months, *COMPBOD*, is sometimes significant with the expected negative sign: a greater frequency of non-compliance with BOD standards increases the probability of inspections. However, the variable *COMPTSS* has an unexpected positive sign but is never significant. This may suggest that the performance of a plant with respect to BOD is more likely to influence the regulator's behavior than its performance with respect to TSS (a similar result is found in Laplante and Rilstone (1996)). It also suggests that inspections are not purely random and that they tend to be concentrated where non-compliance (with BOD standards) is more important, as suggested by Silverman (1990).

This evidence suggests that both the public interest theory of regulation and the economic theory of regulation contribute to explain the decision of the regulator to monitor the environmental performance of regulated plants. In a sense, such results indicate pragmatically that both theories may be complementary, or that the "real" world is neither totally black or totally white. This contrasts with the results presented by Kaserman et al. (1993) whose empirical test strongly supports the economic theory of regulation.

4. Conclusion

Though environmental regulations impose uniform standards on plants that are facing heterogeneous local conditions (such as environmental damages and labor market conditions), results in this paper suggest that the monitoring of those standards is responsive to this heterogeneity. *Ceteris paribus*, plants whose emissions are most likely to impose high environmental damages are facing a higher probability of being inspected; similarly, the probability of an inspection appears to be an increasing function of the visibility of the plant and a decreasing function of the regional unemployment rate. We do believe that these results offer important insights into the regulator's behavior. First, it does suggest that regulators, facing limited resources, do not blindly enforce uniform standards as set and required by environmental regulation: *ceteris paribus*, monitoring effort is likely to be higher where

tain the result obtained by Deily and Gray, could indicate that the regulator undertakes most visible (thus indicating an inclination to attempt to impose enforcement actions on those plants that are most visible to the regulator or, as suggested by Deily and Gray, to the local labor market.

As expected of a negative sign and statistically significant, the level of unemployment in a region, the results of Deily and Gray (1991) somewhat surprisingly observed by suggesting that "to the extent that plants are more or less visible or more polluted, the benefits from monitoring are higher" (p. 270). Our results support the hypothesis

environmental damages are higher.

This result would suggest that it may be less costly to set (sub-optimal) uniform standards and let enforcers take care of the specificities of local conditions, instead of setting standards that reflect those specificities and letting no room to the enforcers to deviate from the standards. In other words, in view of the inability and impossibility for the regulator to define environmental standards that would be specific for every possible set of circumstances and contingencies, some of them not being foreseeable at the time standards are defined, the implementation of the standards needs to be flexible and allow for the *effective* standard to account for those changing conditions.²¹ Secondly, we have shown that regulators do respond to both the visibility of the plant in the region as well as local labor market conditions. This result would appear to complement the result obtained by Deily and Gray (1991): regulators appear to *monitor* larger plants for visibility of their actions (and thus satisfy a subset of the electorate), but avoid enforcing the regulation for those larger plants (thus satisfying another subset of the electorate).

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Appendix 1. Further Empirical Results—Probability of an Inspection (Pr > Chi-squared)				
Variables	(1)	(2)	(3)	(4)
INTERCEPT	-2.3301 (0.0018)	-2.2477 (0.0094)	-2.3954 (0.0747)	-1.1634 (0.4382)
AGE	-0.00023 (0.9269)	-0.00048 (0.8528)	0.000533 (0.8476)	-0.00012 (0.9664)
UNEMPL	-0.0601 (0.0328)	-0.0676 (0.0230)	-0.0907 (0.0087)	-0.1359 (0.0008)
EMPL	0.0228 (0.0005)	0.0233 (0.0004)	0.0225 (0.0074)	0.0217 (0.0075)
COMPTSS	0.0179 (0.2721)	0.0245 (0.1975)	0.00199 (0.9008)	0.0213 (0.2830)
COMPBOD	-0.251 (0.1355)	-0.0228 (0.2067)	-0.0268 (0.0957)	-0.0242 (0.1768)
INSPREG	0.3316 (0.0001)	0.3653 (0.0001)	—	—
REG1	—	—	0.3594 (0.4221)	0.2936 (0.5146)
REG2	—	—	0.2248 (0.5267)	0.2176 (0.5500)
REG3	—	—	-0.3488 (0.3642)	-0.5580 (0.1645)
REG4	—	—	-0.0911 (0.7970)	-0.2263 (0.5333)
REG5	—	—	0.2306 (0.6039)	-0.0835 (0.8564)
REG6	—	—	-0.4644 (0.2759)	-0.5188 (0.2363)
REG7	—	—	-0.2704 (0.5751)	-0.1529 (0.7524)
REG8	—	—	-0.3096 (0.4437)	-0.2755 (0.5070)
INCOME	0.000015 (0.4493)	6.755E-6 (0.7584)	0.00005 (-0.0072)	0.000012 (0.7528)
TREND	-0.00555 (0.1580)	—	-0.0072 (0.2393)	—
YEAR85	—	0.2308 (0.4235)	—	0.6834 (0.0254)
YEAR86	—	-0.00625 (0.9807)	—	0.3248 (0.2093)
YEAR87	—	0.1869 (0.4819)	—	0.0290 (0.9132)
YEAR89	—	-0.2591 (0.4241)	—	-0.4796 (0.1331)
YEAR90	—	-0.3150 (0.2402)	—	0.3390 (0.1753)
YEAR91	—	-0.0737 (0.8068)	—	0.2113 (0.5292)
FLOW (t-4)	13.6256 (0.0008)	14.5539 (0.0004)	16.2489 (0.0001)	15.1007 (0.0002)
ORGANO	-0.1045 (0.5698)	-0.1075 (0.5653)	-0.1124 (0.5467)	-0.1598 (0.4097)
POPUL	-4.9E-6 (0.1422)	-4.65E-6 (0.1651)	-3.82E-6 (0.2486)	-3.7E-6 (0.2778)
ZONE	-0.0922 (0.2457)	-0.1088 (0.1789)	-0.1462 (0.0714)	-0.1339 (0.0961)
% correct predictions	83.3%	84%	72.3%	77.6%

Bill Averaging I

Department of E

Abstract

This paper examines consumer behavior in residential electricity markets where monthly payments are

First, we offer a theoretical model and find that (i) participation increases usage peaks and troughs, a result that leads to exaggerated swings in usage over the determinants of voluntary participation and high usage are less important than general energy conservation.

1. Introduction

Bill averaging programs have become popular in many States public utilities offering electricity. Ha et al. 1993, 284-285, "bill averaging," "budget smoothing," "offer residential consumers a computerized bill despite wide variation in usage over time. history is exploited to estimate total amount in twelve (nearly equal) installment low use months, and consumers are charged in months, at the cost of higher charges from predicted levels trigger adjustment level bills, they substantially reduce

This article initiates the formal economic analysis. are three. First, we provide a theoretical model and derive two theorems about the benefits consumers when it is sufficient will affect consumer behavior, ca