INCENTIVES FOR POLLUTION CONTROL: REGULATION AND(?) OR(?) INFORMATION

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Executive Summary

An increasing number of regulators have adopted public disclosure programs to create incentives for pollution control. Previous empirical analyses on monitoring and enforcement issues have focused their attention strictly on studying the impact of the traditional monitoring (inspections) and enforcement (fines and penalties) practices on the environmental performance of polluters. Other analyses have focused their attention on studying the impact of public disclosure programs. An important empirical issue at hand is whether or not these programs can create incentives *in addition to* the incentives normally set in place through traditional means of enforcement such as fines and penalties. In this paper, we perform an empirical analysis of the impact of both traditional enforcement *and* information strategies within the context of a single program. We can thus provide insights on the *relative* impact of the traditional (fines and penalties) and emerging (public disclosure) enforcement strategies.

Our results suggest that the public disclosure strategy adopted by the province of British Columbia (Canada) has a larger impact on both emissions levels and compliance status than orders, fines and penalties traditionally imposed by the Ministry of the Environment and courts. Our results however also demonstrate that the adoption of stricter standards and higher penalties had a significant impact on emissions levels.

From a policy-making perspective, our analysis thus offers two important results. First, the presence of clear and strong standards accompanied with a significant and credible penalty system does send appropriate signals to the regulated community which then responds with a lowering of pollution emissions. Secondly, the public disclosure of environmental performance does create *additional* and *strong* incentives for pollution control. These results do suggest that both regulation *and* information belongs to the regulator's arsenal.

1. INTRODUCTION

It has long been recognised that the implementation of environmental laws, regulations, and standards has suffered from a lack of resources to undertake appropriate monitoring activities, and reluctance to use stringent enforcement actions toward those recalcitrant polluters.[1] In view of those difficulties, an increasing number of environmental regulators around the world have seeked to complement or supplement traditional enforcement actions (fines and penalties) with the adoption of *structured* information programs (or public disclosure programs) by which the environmental performance of polluters is revealed.[2]

Issues pertaining to the monitoring and enforcement of environmental regulations have been the object of only recent and still limited analyses. On the empirical front, two broad issues have partially been addressed. [3] First, an essential issue of interest is the impact of the various monitoring and enforcement actions on the environmental performance of polluters. Magat and Viscusi (1990) and Laplante and Rilstone (1996) have shown that inspections (and the threat of inspections) significantly reduce absolute levels of water pollution emitted by pulp and paper plants in the United States and Canada respectively. They have also shown that inspections increase the likelihood that plants self-report their level of emissions. Gray and Deily (1996) have shown that increased enforcement actions in the U.S. steel industry have significantly reduced non-compliance with air emissions standards. Nadeau (1997) has shown

[1] We define monitoring as the process of verifying the firm's status of environmental performance (e.g. compliance with standards), and enforcement as the undertaking of actions (e.g. fines and penalties) to bring the firm to improve its environmental performance.

that both inspections and enforcement impact the duration of firms' violation of air pollution standards in the pulp and paper industry. More recently, Dasgupta et al. (1999) have shown that inspections significantly reduce industrial air and water pollution in China. [4]

A second issue is the impact of public disclosure programs.[5] Two types of impact have typically been analysed. Analysts have examined the reaction of capital markets to the release of information pertaining to the environmental performance of the plants. Hamilton (1995), Konar and Cohen (1997), Lanoie et al. (1998) have shown that capital markets react significantly to the release of information: upward when the information reveals a superior performance, and downward when a poor performance is revealed.[6] Other analysts have analysed and shown that public disclosure does improve the environmental performance of polluters (see Konar and Cohen (1997) and Afsah et al. (1997)).

From a policy perspective, a potential weakness of the current body of empirical analyses is their focus on studying either the impact of the traditional monitoring and enforcement practices or the impact of information programs. It is to be noted that none of the

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[2] Examples of such programs now abound in both developed (e.g. the Toxics Release Inventory in the United States) and developing countries (e.g. the ECOWATCH program in the Philippines).

[3] For a comprehensive survey of the (limited) empirical literature, see Cohen (1998).

[4] If traditional monitoring and enforcement strategies appear to impact the environmental performance of the plants, it then becomes of further interest to understand the determinants of the regulator's allocation of resources devoted to implementation. Empirical analyses on this issue include Deily and Gray (1991), Dion et al. (1998), Helland (1998) and Nadeau (1997).

[5] It may be useful to distinguish between *structured* information programs whereby the information release is part of a clearly articulated strategy undertaken by the regulator to reveal the environmental performance of plants from *unstructured* information of the type one finds in newspapers, on a more ad hoc basis.

above papers combine an empirical analysis of the impact of both traditional enforcement *and* information strategies within the context of a single research effort. In this paper, we address this weakness and thus hope to provide insights on the *relative* impact of the traditional (fines and penalties) and emerging (information) enforcement strategies.

Since July 1990, the Ministry of Environment, Lands and Parks of British Columbia, Canada (henceforth MOE) publishes twice a year a list of firms that either do not comply with the existing regulation or whose environmental performance is of concern to the MOE. Simultaneously however, the Ministry continues to undertake legal action for those violating the regulation. These unique features allow us to analyse the relative contribution of both types of enforcement actions on the performance of polluters. To do so, we focus on the environmental performance of the pulp and paper plants appearing on the list. Our results suggest that the public disclosure strategy adopted by the province of British Columbia has a larger impact on both emissions levels and compliance status than orders, fines, and penalties traditionally imposed by the MOE and courts. Our results however also demonstrate that the adoption of stricter standards and higher penalties had a significant impact on emissions levels.

In the next section, we briefly describe the institutional and regulatory context currently in place in British Columbia, and the model we purport to test. In Section 3, both the

[6] Analysis of capital market reactions to *unstructured* information release includes Badrinath and Bolster (1996), Dasgupta et al. (1998), Klassen and McLaughlin (1996), Lanoie and Laplante (1994), and Muoghalu et al. (1990).

estimation strategy and dataset are described. Results are presented in Section 4. We briefly conclude in Section 5.

2. CONTEXT AND MODEL

2.1 Context

Industry and regulatory context

Canada is the largest producer of pulp and paper in the world with approximately 33% of world production. Within Canada, the 23 pulp and paper plants located in British Columbia account for approximately 30% of the Canadian production, with 6.5 million tonnes of pulp and 1.5 million tonnes of paper produced in 1992. These amounted to a total production value of approximately 4 billion dollars (CAN),[7] and 8.5% of British Columbia's GDP.[8]

Pulp is produced essentially with mechanical and/or chemical processes. Mechanical processes are usually more efficient in terms of the required amount of wood input to produce a metric ton of pulp. However, the process produces a fibre of lesser quality than chemical processes. These latter ones are therefore usually preferred. Both sulfite and kraft are chemical pulp production processes. Sulfite processes produce pulp of high quality which needs to be washed, but does not require a bleaching of the pulp. However, sulfite processes involve high production costs mainly because of the difficulty (or impossibility) to recover the chemicals used in the production process. Kraft processes produce pulp of very high quality. Moreover,

[7] In 1992, 1 $ CAN was approximately worth 0.75 $ US.
[8] Province of British Columbia (1993).

kraft offers the possibility of chemical recovery thus making it less expensive to use than sulfite processes. However, kraft processes produce a pulp of a darker color; this makes it necessary for the pulp to be bleached before being sent to paper machine. The washing and bleaching steps of the production process are important sources of pollution: washing produces large amount of biological oxygen demand (BOD) and total suspended solids (TSS), while bleaching further produces dioxins and furans.[9] If the industry is a major contributor to British Columbia's economic activity, it is also one of its most important sources of pollution.

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.[10] Insofar as water pollution is concerned, the Federal government has played an important role through its *Fisheries Act* [11] under which *Pulp and Paper Effluent Regulations* [12] were first introduced in 1971. However, these Federal regulations were devised in a way that resulted in the bulk of the pulp and paper plants in British Columbia being outside the realm of the regulation, and therefore not having to comply with any of the regulatory standards defined in the *Federal* regulations.

[9] See Environment Canada (1993) for more details.
[10] The involvement of the federal government in matters of environmental protection is made possible through its jurisdiction over fisheries, harbours, criminal law, and its residual power to legislate for the peace, order and good government of Canada. The appropriate roles and responsibilities of federal and provincial governments are the subject of an everlasting debate (Kenneth, 1990).
[11] Revised Statutes of Canada, 1970, c. F-14.
[12] C.R.C. 1978, c. 830.

On December 13, 1990 the Government of British Columbia introduced the long-awaited revisions to its own pulp and paper effluent regulations. Since then, each plant must obtain a discharge permit in order to operate, and the obtention of the permit is conditional on the plant using a secondary wastewater treatment process. Moreover, as shown in Table 1, the revised regulation considerably tightens up the BOD and TSS standards for those plants located on the coast of the province (with the Pacific Ocean).[13]

Table 1
British Columbia Pulp and Paper Effluent Standards
Pre and Post December 13 1990
(Kg / tonne)

		BOD		**TSS**	
		Kraft process	Mechanical process	Kraft process	Mechanical process
Before December 13 1990	Coastal plants	30	20	17.5	17.5
	Other plants	7.5	7.5	10	10
After December 13 1990	All plants	7.5	7.5	11.25	11.25
	Port Alberni	4.2	4.2	3.9	3.9

While the effluent standards were location specific (coastal vs non-coastal) and process specific (kraft vs mechanical), homogeneous standards were introduced in 1990, with all plants but one having to comply with the same effluent standards, irrespective of their location and production process. Note that the standards were considerably tighter for those

[13] In 1988, the Federal Ministry of Ocean and Fisheries had to put an end to shrimps and crabs fisheries on British Columbia's coastal waters where 3 pulp and paper plants were located. In 1989, oysters fisheries had to be stopped in the vicinity of 6 pulp and paper plants. These events partly explain the introduction of tighter standards in 1990.

plants located on the coastal zone. Standards became effective over a period of 3 years, and all plants had to comply with the new standards by 1994.

Simultaneously with the adoption of the revised regulation, the MOE seeked to increase incentives for abatement and compliance with the new set of standards. As a result, fines under the Waste Management Act increased from a maximum of 50 000 $ (CAN) to a maximum of 3 million $. At the same time, the MOE declared its commitment to pursue its recently devised strategy to publicize, twice a year, the name of plants falling short of an adequate environmental performance.

Bristish Columbia's list of polluters

On July 13 1990, the MOE released for the first time (in British Columbia and in Canada) a list of industrial operations (and municipalities) which were either not complying with their waste management permits (Part I) or which were deemed by the Ministry to be a potential pollution concern (Part II). The Minister then declared that

> the release of this material is a clear indication of our government's intention to deal forthrightly and decisively with pollution concerns. (MOE, Press Release, July 13, 1990)

For each entry contained in the list, the following information is provided: Name of the firm, location, nature of concern (e.g. mining operation effluent, pulp mill effluent, sawmill emissions), the reason(s) for which the firm is on the list, and the number of times the firm has been on the list (e.g. second time on noncompliance report; fourth time on the list).

In order to be listed in the *non-compliance* section of the list, a firm needs to be *significantly* out of compliance with its permit requirements and standards. Typical entries (reasons) in this section of the list are of the following nature:

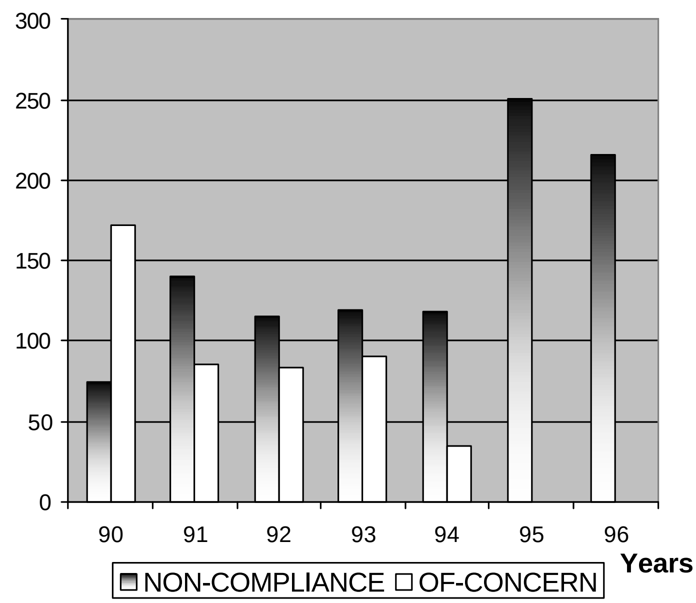
- Exceeded permit limits for total suspended solids in July, August, and September;
- Exceeded permit limits for maximum and average total suspended solids in October, for biological oxygen demand 3 of 13 days in November and for pH two days in December;
- Exceeded permit limit for opacity for 4 of 6 months;
- Incomplete submission of monitoring data.

Operations *of concern* to the Ministry were defined as "operations some of which are technically in compliance and others were permits do not exist or are not required but which by their nature cause concern to the Ministry" (MOE, Press Release, July 13, 1990). Typical entries in this section were of the following nature:

- Concern with possible impact of effluent on Kitimat River, especially at low river flows;
- Close proximity of landfill leachate to fish bearing streams;
- Odor problem related to the emission of sulphur gases from the effluent treatment system;
- Numerous spills and bypasses;
- Grizzly bears attracted by the disposal of waste at the local landfill.

In 1993, a number of industrial facilities started to express dissatisfaction with appearing on the "pollution concern" section of the list, yet their operations being in compliance with their permit requirements. Moreover, the criteria for being classified as "of concern" were seen as being subjective and inconsistent across regional offices. As a result, this section of the list was dropped in 1994 and as of 1995, British Columbia's list of polluters covers only plants significantly out of compliance with their permit requirements (Figure 1).[14]

Figure 1
Number of citations "Of concern" vs "Out of compliance"
1990 - 1996



2.2 <u>Model</u>

Following the traditional paradigm for analyzing pollution control issues, the regulator is expected to set and enforce rules of environmental behavior. In keeping with this understanding of the problem, the policy analysis literature has focused on appropriate roles for 'ex ante'

[14] Province of British Columbia (1993).

regulation (standards vs. market-based instruments) and ‘ex post’ liability claims by injured parties. This conventional policy discussion has focused almost exclusively on interactions between the regulator and the plant. However, recent research has suggested powerful roles for two additional agents: the community and the market. Indeed, recent evidence throughout the world suggests that neighboring communities can have a powerful influence on plants’ environmental performance (Blackman and Bannister, 1998; Pargal and Wheeler, 1996). Communities which are richer, better educated, and more organized find many ways of enforcing environmental norms. Where formal regulators are present, communities use the political process to influence the tightness of enforcement. Where formal regulators are absent or ineffective, ‘informal regulation’ may be implemented through community groups or NGOs.

Moreover, recent research has indicated that investors are increasingly scrutinizing environmental performance in their investment decision. Among other factors, they have to weigh the potential for financial losses from regulatory penalties and liability settlements. In recent years, the importance of investor interest has been increased by the growth of new stock markets and the internationalization of investment. For similar reasons, international and local suppliers of financing, industrial equipment, and engineering services are increasingly reluctant to do business with firms known as large polluters or experiencing problems with environmental regulations. Recent evidence from both the OECD and developing countries suggests that environmental reputation matters for firms whose expected costs or revenues are affected by judgments of environmental performance by customers, suppliers, and stockholders.[15]

Once we introduce a world of multiple agents (and consequently multiple incentives)**,** there may be a need to rethink the regulator's appropriate role in pollution management. It may be that this role is no longer confined to designing, monitoring and enforcing rules and standards. Instead, the regulator can gain leverage through non-traditional programs which harness the power of communities and markets. In this context, there may be ample room for information-oriented approaches such as the public disclosure of plants' environmental performance.[16]

The notion that such a role exists has certainly gained support among environmental policy-makers. Despite this widespread acceptance of a role for the regulator to provide environmental information, the *normative* foundations for a public intervention of that nature have not been formally studied. In particular, the question of whether and under what circumstances environmental information should be publicly provided has not been adequately addressed.[17]

From an *empirical* perspective, the impact of existing public disclosure programs on the environmental performance of the plants largely remains to be tested. To our knowledge,

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[15] See Cohen (1998) for a thorough review of these studies.
[16] World Bank (1999) elaborates considerably on these concepts.

only Hamilton (1995) and Konar and Cohen (1997) have proceeded to a formal econometric analysis of this impact; both of their studies however are based on the U.S. EPA's *Toxics Release Inventory* (TRI). We do not know of any other formal analysis of other public disclosure programs.[18] Moreover, given the characteristics of the TRI program, these authors were unable to account for the impact of the public disclosure strategy *relative* to traditional form of prosecutions, fines, and penalties. In this context, it becomes difficult to determine whether or not information can be an effective regulatory mechanism *relative* to traditional forms of enforcement actions. As pointed out by Konar and Cohen (1997), "before information remedies are used more frequently as regulatory mechanisms, we need to understand how they work and what effect they have on firm behavior".

Hence, while recent literature appears to indicate a role for public disclosure programs, it is not yet clear whether or not these programs should complement or supplement traditional forms of enforcement. In particular, once the regulator can pursue court actions, fines, and penalties, is there still a role for public disclosure? Can public disclosure create further incentives for pollution control? Given recent research, the model we therefore proceed to test in this paper is of the following nature :

Pollution = f (Regulation, Traditional Enforcement, Public disclosure, **X**)

[17] An exception is Kennedy et al. (1994).

[18] Afsah et al. (1997) provide statistical evidence of the impact of Indonesia's public disclosure program known as PROPER. However, the available information limited them to conduct an *ex ante – ex post* analysis. They show that the plants object to the first public disclosure in 1995 reduced their emissions of BOD by approximately 45% within a period of 18 months.

where **X** is a vector of control variables. In the next section, we proceed to detail our estimation strategy and dataset.

3. ESTIMATION STRATEGY AND DATASET

For the purpose of our empirical analysis, we use plant-level annual data from the pulp and paper industry since this industry has a long history of environmental regulation and generally offers the best availability of emissions data.[19]

Over the period 1987-1996, 24 pulp and paper plants were in operation in British Columbia. After discussion with the MOE, 4 plants were excluded since their manufacturing processes were hardly comparable with those of the other plants. Five other plants were dropped since MOE's files were incomplete, especially over the period 1987 - 1990.

The variables used to estimate our model are discussed below; definitions, means, and standard deviations are provided in Table 2. The dataset was entirely provided by the MOE. Most of the data came from public reports. However, data on emissions and limits was provided to us upon special request, and involved a manual investigation of a large number of files.

The analysis is performed for both BOD and TSS. For each of them, we use two different ways of defining the dependent variable: the absolute level of pollution (ABSBOD,

[19] Magat and Viscusi (1990), Laplante and Rilstone (1996), Nadeau (1997), Dion et al. (1998), Lanoie et al. (1998) also use the pulp and paper industry for a similar reason.

ABSTSS), and a measure of the level of compliance with the emissions standards (COMPBOD, COMPTSS), defined as:

(actual emissions – allowable emissions) / allowable emissions.[20]

TABLE 2
Definition, mean and standard deviation of variables
(plant-level yearly data covering 15 plants for the period 1987-1996)

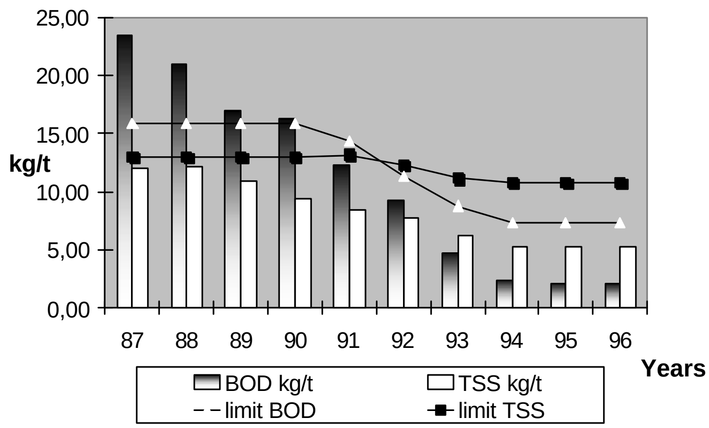
VARIABLES	DEFINITION	MEAN	STANDARD DEVIATION
Dependent Variables			
COMPBOD	Compliance rate for BOD	-0.08548	0.3075
COMPTSS	Compliance rate for TSS	-0.32015	0.37810
ABSBOD	Absolute level of BOD emissions (kg/day)	10479	13187
ABSTSS	Absolute level of TSS emissions (kg/day)	8687.4	6373.6
Independent variables			
OUT OF COMPLIANCE	Number of appearances (in a given year) on the polluters list under the heading "out of compliance"	0.26667	0.53532
OF CONCERN	Number of appearances (in a given year) on the polluters list under the heading "of concern"	0.08889	0.35548
REGUL90	Dummy equal to one when a plant is subject to the new B.C. regulation, 0 otherwise	0.57037	0.49887
PROSECUTION	Number of prosecutions faced by a plant in a given year	0.93333	2.4834
FINE	Total amount of fines imposed on a plant in a given year	4314.1	16529
Control Variables			
PRODUCTION	Production in tons/day	1132.5	510.54
BASSIN	Dummy variables capturing the river in which the plant rejects its effluents		
	Fraser River (omitted)	0.33333	0.47316
	1. Vancouver Bassin	0.26667	0.44386
	2. Howe Sound River	0.13333	0.47316
	3. Columbia Lake	0.06667	0.06268
	4. Skeena River	0.06667	0.06268
	5. Peace River	0.13333	0.11642
REGION	Dummy variable capturing the B.C. administrative region where the plant is located		
	Vancouver Island Region (omitted)	0.26667	0.40386
	1. Lower Mainland Region	0.20000	0.40149

[20] Allowable emissions (kg / day) are calculated as : emissions standards (kg / tonne) times daily production (tonnes / day).

	2. Southern Interior Region	0.06667	0.25037
	3. Cariboo Region	0.06667	0.25037
	4. Skeena Region	0.06667	0.25037
	5. Northern Interior Region	0.26667	0.44386
	6. Kootenay Region	0.06667	0.25037
PROCESS	Dummy equal to 1 if the plant has a mechanical process, 0 otherwise	0.80000	0.40149

Observe in Figure 2 that emissions levels fell considerably over the period of analysis and that compliance rate significantly improved.

Figure 2
Actual emissions and limits



Our independent variables capture the appearance of the plants on the list of polluters, the tightening of the standards in 1990, and the prosecutions and fines imposed on the plants over the period of analysis. As explained previously, until 1994, the lists published by the MOE were divided into two categories: of concern and out of compliance. Accordingly, we have two variables to capture the appearance of the plants on these lists. Since two lists are published every year, and since we are using yearly data, we define the variable OF CONCERN as the number of times a plant has appeared on the lists under this heading in a given year (OUT OF COMPLIANCE is defined the same way). We also lag these variables to allow the plants some time to react to their appearance on the lists[21]. In our sample, only one plant never appeared on any list, while another has appeared only once under the OF CONCERN category. On the other hand, two plants have appeared seven times each on the thirteen lists that were available (six times under the OUT OF COMPLIANCE category).

The variable PROSECUTION is defined as the number of prosecutions against a plant in a given year, while FINE is the total amount of fines imposed on a plant in a given year. These variables are lagged to allow for some time of reaction. From 1987 to 1996, there were 126 prosecutions against the plants in our sample; however, only 17 of these resulted in a fine being imposed. These fines totaled 582 400 $. The sequence of fines and appearances on the list of polluters is presented in Table 3.

A dummy variable, REGUL90, captures the introduction of the more stringent regulation in 1990. As mentioned earlier, the regulation became effective over the period 1991 – 1994. Hence, the variable REGUL90 takes the value 1 starting only during the exact year each plant had to operate under the new regulation.

We also include a number of CONTROL VARIABLES. As in Magat and Viscusi (1990) and Laplante and Rilstone (1996), a LAGGED DEPENDENT VARIABLE is introduced to serve as a proxy for the firm's stock of capital related to pollution control and for

[21] As in Magat and Viscusi (1990) and Lanoie (1992), the use of a lagged policy variable may be justified to avoid any simultaneity problem.

the general character of its abatement technology. Firms with high levels of pollution in the past are likely to continue to have high levels in the future because the nature of their technology makes it costly to achieve pollution reductions.

TABLE 3
APPEARANCES ON LISTS AND FINES[1]

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Alberni Pulp and Paper Division				2*OC	OC	OC	NC			
					50 000$	10 000$				
Prince Georges Pulp and Paper									NC	
		65 000$		50 000$						
Celgar Pulp and Paper					NC		2*NC	OC,2*NC	NC	
										500$
Crofton Pulp and Paper					2*NC	NC			NC	NC
					20 000$			10 000$		
Elk Falls Pulpmill Division				2*NC						
Finlay Pulp and Paper										
									200 $	
Harmac Pulp Division				2*OC	OC					
Mackenzie Pulp Division							NC	NC	NC	NC
			25 000$							
Northwood Pulp				OC,2*NC		NC				NC
Port Mellon Pulp				NC						
			125 000$	50 000$			75 000$			
Powell River Pulp Division				2*OC	NC	NC	NC			
									200$	
Quesnel Pulp						NC	NC			
Skeena Pulp Operations				NC	OC	NC		2*NC	NC	NC
					65 000$					
Squamish Pulp Operations				2*NC	NC	NC				
					25 000$					
Weyerhaeuser Pulp Mill							NC			
				7 500$		4 000$				

[1] NC: Non-compliance; OC: Of concern; $: Fine

We were able to account for the actual level of plants' PRODUCTION through a calculation performed using two sets of pollution limits. Indeed, the MOE produces two series of limits : one expressed in terms of kilograms/tons and another one expressed in terms of kilograms/day. Given that we were provided with both series, we were able to calculate a measure of production expressed in terms of tons/day. To our knowledge, this is the first time a measure of the real production is used in a study on pollution levels. Previous authors, such as Magat and Viscusi (1990) and Laplante and Rilstone (1996), used a measure based on plants' production capacity. During the period under study, the average production followed a somewhat erratic path : a sharp increase was observed in the first three years (1987-1990), followed by an important reduction in the 1990-91 recession, then followed by a steady increase until 1996.

Two sets of variables are introduced to caputre the localisation of the plants : BASSIN and REGION. BASSIN refers to the river in which each plant rejects its pollutants, while REGION refers to the administrative region where the plant is situated. Localisation variables are useful to account for aspects such as varying importance of environmental awareness or lobbying across regions, or potentially different levels of monitoring across regions. These differences may be due, among other things, to the level of deterioration of the local ecosystems, or the potential for local environmental damages (Pargal and Wheeler (1996), Dion et al. (1998)).

Finally, a dummy variable is included to account for the pulp PRODUCTION PROCESS of the mill. The PROCESS variable is equal to one when the mechanical process is used. Its coefficient is expected to be negative.

4. EMPIRICAL RESULTS

The estimations are performed using a generalized least-squares (GLS) procedure based on the cross-sectionnally and time-wise autoregressive model presented in Kmenta (1986, pp.616-625)[22]. Table 4 and 5 present the results pertaining to BOD and TSS respectively. Each table includes eight specifications, four using the compliance rate as the dependent variable and four using the absolute level of pollutant. For each dependent variable, the various specifications allow for different sets of localisation variables, and for lagged or contemporaneous environmental policy variables[23]. Overall, the explanatory power of the different specifications is satisfactory, and the results are fairly stable across specifications.

The appearance of a plant on the list under the heading OUT OF COMPLIANCE has a contemporaneous impact on both pollutants. Indeed, all coefficients of the variable OUT OF

[22] Initial tests showed the presence of first-order serial correlation and of heteroskedasticity.
[23] Other attemps were made using a time trend, fixed effects or the plants'age as additional independent variables. Their inclusion did not improve significantly the explanatory power of our regressions as confirmed by log-likelihood ratio tests.

COMPLIANCE, except one, are negative and significant. For BOD, the appearance on the list leads to an improvement of 0.063 in the compliance rate, and to a reduction in the absolute level of emissions in the range of 1111 - 1164 kg/day. For TSS, the appearance on the list leads to an improvement of the compliance rate of 0.094, and to a reduction in the absolute level of emissions in the range of 1225 – 1261 kg/day.

The significance of the contemporaneous OUT OF COMPLIANCE variable and not of the lagged variable is not necessarily surprising given that two lists are published each year (in some years, the first list was published in January). The appearance on the list under the heading OF CONCERN seems to have no impact on pollution, which may suggest that the MOE was correct to eliminate this category in 1994.

The variable capturing the major change in regulation REGUL90 is almost everywhere negative and significant. The impact of this new regulation is strong: improvement in the compliance rate of 0.158 for BOD and of 0.07 for TSS, and reduction of the level of emissions in the range of 3800 - 4511 kg/day for BOD and in the range of 1291 – 1909 kg/day for TSS.

TABLE 4
REGRESSION RESULTS – BOD
Coefficients (t-statistics)

	1	2	3	4	5	6	7	8
Dependent variables	COMPBOD	COMPBOD	COMPBOD	COMPBOD	ABSBOD	ABSBOD	ABSBOD	ABSBOD
R SQUARE	**0.8947**	**0.8896**	**0.9030**	**0.9002**	**0.8852**	**0.8824**	**0.8841**	**0.8823**
COMPBOD(1) [b]	0.60685 (13.71)*	0.57159 (12.94)*	0.64456 (14.62)*	0.60413 (13.53)*				
ABSBOD(1)					0.65556 (12.97)*	0.64247 (13.17)*	0.66219 (13.04)*	0.64804 (13.27)*
PRODUCTION	-0.67E-04 (-1.179)	-0.89E-04 (-1.59)	-0.79E-04 (-1.477)	-0.11E-03 (-2.094)*	1.1544 (0.292)	1.5326 (1.279)	1.2197 (0.234)	1.6450 (1.434)
PROSECUTION	0.26E-02 (0.2972)	0.35E-02 (0.4021)			63.552 (0.5223	80.709 (0.6493)		
PROSECUTION(1)			-0.16E-02 (-0.1637)	-0.30E-03 (-0.033)			-68.518 (-0.5573)	-66.051 (-0.5244)
FINE	0.66E-06 (0.4134)	0.78E-06 (0.4725)			-0.31E-01 (-1.78)**	-0.32E-01 (-1.80)**		
FINE(1)			-0.29E-05 (-1.938)*	-0.33E-05 (-2.033)*			-0.25E-01 (-1.560)	-0.25E-01 (-1.494)
REGUL90	-0.17193 (-3.882)*	-0.17191 (-3.774)*	-0.15814 (-3.828)*	-0.16664 (-3.981)	-4310 (-5.045)*	-4511.1 (-5.194)*	-3799.6 (-4.484)*	-4046 (-4.708)*
OF CONCERN	0.53E-02 0.1215)	0.14E-01 (0.3187)			-1098 (-1.231)	-1059.6 (-1.19)		
OF CONCERN(1)			-0.12E-01 (-0.2727)	-0.39E-01 (-0.8782)			-329.93 (-0.3823)	-250.39 (-0.2893)
OUT OF COMPLIANCE	-0.63E-01 (-1.85)**	-0.48E-01 (-1.318)			-1164.4 (-2.032)*	-1111.4 (-1.91)**		
OUT OF COMPLIANCE(1)			-0.26E-01 (-0.6968)	-0.31E-01 (-0.8509)			-262.08 (-0.3993)	-175.90 (-2684)
PROCESS	-0.14426 (-2.183)*	-0.16612 (-2.229)*	-0.12587 (-1.850)*	-0.14222 (-1.87)**	-1490 (-1.056)	-2389.1 (-1.72)**	-1331.5 (-0.9626)	-2295.7 (-1.69)**
REGION 1	-0.48E-01 (-0.7489)		-0.39E-01 (-0.5940)		-1044 (-0.6878)		-645.30 (-0.4414)	
REGION 2	-0.30E-01 (-0.3371)		-0.36E-01 (-0.4686)		-1657.1 (-0.9010)		-1261.3 (-0.7071)	
REGION 3	-0.28424 (-1.11)		-0.37233 (-1.34)		-2323.7 (-1.141)		-2126.2 (-1.079)	
REGION 4	0.84E-02 (0.60E-01)		-0.97E-02 (-0.1005)		927.22 (0.4213)		679.14 (0.2820)	
REGION 5	0.48E-01 (0.9108)		0.16E-01 (0.2944)		-683.79 (-0.5187)		-482.87 (-0.3810)	
REGION 6	0.65635 (1.410)		0.47485 (0.9113)		473.26 (0.2119)		331.74 (0.1429)	
BASSIN 1		0.27E-01 (0.5328)		0.38E-01 (0.8045)		1799.4 (1.336)		1623.4 (1.238)
BASSIN 2		0.16573 (0.9922)		0.16561 (1.121)		212.56 (0.1913)		384.44 (0.3604)
BASSIN 3		0.78573 (1.659)**		0.63661 (1.193)		1907.4 (0.9609)		1548 (0.7398)
BASSIN 4		0.24E-01 (0.1727)		0.24E-01 (0.2563)		2278.8 (1.134)		1803.8 (0.8050)
BASSIN 5		0.40E-01 (0.4148)		-0.92E-02 (-0.0985)		1852.5 (1.051)		1906.8 (1.143)
CONSTANT	-0.32E-02	-0.15E-01	0.34E-01	0.34E-01	4481.3	3089.8	3587.8	2438.6

	(-0.3E-01)	(-0.1582)	(0.3339)	(0.3939)	**(1.859)****	**(1.667)****	(1.515)	(1.345)
Fischer test	**24.41***	**24.41***	**24.81***	**25.71***	**23.00***	**24.36***	**23.29***	**24.79***
LIKELIHOOD RATIO TEST	**190.93***	**188.86***	**197.88***	**196.03***	**93.57***	**91.61***	**89.98***	**87.88***

* significant at 5%, ** significant at 10 % ; b (1) means that the variable has been lagged one year

TABLE 5
REGRESSION RESULTS – TSS
Coefficients (t-statistics)

	9	10	11	12	13	14	15	16
Dependent variables	COMPTSS	COMPTSS	COMPTSS	COMPTSS	ABSTSS	ABSTSS	ABSTSS	ABSTSS
R SQUARE	**0.9679**	**0.9194**	**0.9328**	**0.9053**	**0.9477**	**0.9380**	**0.9439**	**0.9358**
COMPTSS(1) [b]	**0.60324 (11.43)***	**0.75797 (14.63)***	**0.61274 (9.397)***	**0.72925 (11.82)***				
ABSTSS(1)					**0.62004 (12.33)***	**0.63228 (11.10)***	**0.58671 (11.38)***	**0.60083 (10.38)***
PRODUCTION	**-0.56E-04 (-1.924)****	**-0.62E-04 (-1.729)***	-0.50E-04 (-1.473)	-0.57E-04 (-1.499)	**2.4796 (3.908)***	**1.6780 (2.431)***	**2.7832 (4.357)***	**2.1067 (3.058)***
PROSECUTION	-0.18E-02 (-0.4848)	-0.26E-02 (-0.4436)			1.2534 (0.0155)	-23.552 (-0.2872)		
PROSECUTION(1)			-0.45E-02 (-0.9946)	-0.37E-02 (-0.6278)			-35.591 (-0.4583)	-62.611 (-0.7571)
FINE	0.16E-05 (1.553)	**0.21E-05 (1.877)****			0.52E-02 (0.4768)	0.24E-02 (0.2018)		
FINE(1)			-0.93E-06 (-1.393)	-0.84E-06 (-0.9770)			-0.14E-03 (-0.014)	0.58E-03 (0.0508)
REGUL90	**-0.70E-01 (-2.503)***	-0.23E-01 (-0.8591)	**-0.69E-01 (-2.392)***	-0.41E-01 (-1.263)	**-1492.1 (-3.699)***	**-1291.4 (-3.139)***	**-1909.6 (-4.628)***	**-1745.2 (-4.165)***
OF CONCERN	**-0.48E-01 (-2.296)***	**-0.69E-01 (-1.95)****			-33.697 (-0.087)	43.531 (0.1020)		
OF CONCERN(1)			-0.26E-01 (-0.7079)	-0.32E-01 (-0.7600)			-346.53 (-0.9288)	-325.81 (-0.8024)
OUT OF COMPLIANCE	**-0.93E-01 (-3.914)***	**-0.95E-01 (-3.123)***			**-1261.2 (-3.588)***	**-1225.1 (3.413)***		
OUT OF COMPLIANCE(1)			-0.38E-01 (-1.367)	-0.45E-01 (-1.381)			-495.98 (-1.203)	-482.26 (-1.139)
PROCESS	**-0.11142 (-2.046)***	-0.95E-02 (-0.1842)	**-0.10756 (-1.91)****	-0.24E-01 (-0.4512)	-750.81 (-1.458)	-105.85 (-0.1912)	-654.28 (-1.298)	-118.17 (-0.2224)
REGION 1	-0.44E-01 (-1.556)		-0.56E-01 (-1.49)		**-1235.5 (-2.010)***		**-1245.9 (-2.007)***	
REGION 2	0.27E-01 (0.3049)		0.24E-01 (0.2663)		213.19 (0.1541)		221.20 (0.1564)	
REGION 3	**0.27979 (3.113)***		**0.26113 (2.810)***		**2149 (2.576)***		**1939.8 (2.279)***	
REGION 4	**0.18074 (2.26)***		**0.16197 (1.722)****		**2358.7 (2.555)***		**2179.9 (2.116)***	
REGION 5	**0.10851 (2.502)***		**0.11354 (3.072)***		**1162.5 (2.286)***		**1005.7 (1.978)***	
REGION 6	0.10432 (1.142)		0.67E-01 (0.6274)		964.13 (1.133)		649.89 (0.7328)	
BASSIN 1		-0.16E-01 (-0.4686)		**-0.66E-01 (-1.84)****		**-1131 (-1.947)***		**-1036.2 (-1.771)***
BASSIN 2		**-0.11893 (-1.69)****		-0.95E-01 (-1.28)		**-1609.6 (-1.94)****		**-1616.3 (-1.987)***
BASSIN 3		0.43E-02 (0.052)		-0.56E-01 (-0.5679)		-240.43 (-0.2720)		-382.15 (-0.4152)
BASSIN 4		0.94E-01 (1.252)		0.50E-01 (0.5698)		1417.6 (1.557)		1323.9 (1.281)
BASSIN 5		-0.23E-01		-0.53E-01		-890.29		-762.13

		(-0.4112)		(-0.9011)		(-1.16)		(-0.9610)
CONSTANT	-0.87E-01 (-1.423)	-0.53E-02 (-0.053)	-0.92E-01 (-1.358)	0.23E-01 (0.3884)	**-1492.1 (-3.699)***	**2216.7 (2.062)***	867.84 (1.038)	**2157.7 (1.993)***
FISCHER TEST	**48.41***	**30.60***	**32.52***	**24.42***	**37.50***	**35.45***	**31.77***	**31.11***
LIKELIHOOD RATIO TEST	**65.80***	**50.96***	**67.93***	**54.13***	**86.15***	**83.36***	**75.72***	**73.93***

* significant at 5%, ** significant at 10 % ; b (1) means that the variable has been lagged one year

As discussed earlier, the introduction of lower (more stringent) emissions standards leads to an increase in the expected probability of being caught in non-compliance with the negative consequences that may follow for firms. This, with a significant increase in the maximum penalty partly explain the plants' reaction to the new regulation. As shown in Figure 2, plants had a better rate of compliance at the end of the period with stricter limits than at the beginning of the period where limits were less stringent. Discussions with MOE officials led us to believe that, with the new limits, all firms had to be equipped with "state-of-the-art" abatement technologies (secondary treatment).

PROSECUTIONS have no impact on either types of pollutants, while lagged FINES lead to an improvement in the BOD compliance rate (elasticity in the -0.15 / -0.17 range). It is instructive to compare the magnitude of the impact of fines versus the impact of the lists. Strictly speaking, one cannot immediately compare the coefficients of these variables given that the FINE variable is continuous and can be interpreted through the calculation of a conventional elasticity, while the OUT OF COMPLIANCE variable is a non-continuous dummy variable. Nevertheless, three observations can be made.

First, the appearance on the out of compliance list appear to have an impact on both types of pollutants, each one of them expressed either in absolute terms or in terms of compliance rate. On the other hand, fines have an effect only on the BOD compliance rate. Second, our coefficients indicate that doubling the average size of the fines would lead to an improvement in the BOD compliance rate of approximately 15 %, i.e. a reduction of 0.013 in the compliance rate; on the other hand, an additional appearance on the OUT OF COMPLIANCE list leads to a reduction of 0.063 in the BOD compliance rate, which is significantly more important. Third, the fact that lagged FINES variable is significant, while it is the contemporaneous OUT OF COMPLIANCE variable that is significant, may suggest that the lists of polluters can provide a stronger incentive than conventional enforcement measures for a quick response to correct a damageable situation. Altogether, these three observations suggest that MOE's lists could have had a stronger impact than the fines as they were applied.

Among the CONTROL VARIABLES, the lagged dependent variable has everywhere a strong and significant impact. The coefficients are in the 0.57 - 0.75 range, which implies that approximately 65 % of the pollution in a given year (absolute emissions or compliance rate) is explained by the pollution in the preceding year.[24]

The PRODUCTION level has a positive impact on the absolute level of TSS emissions and a negative impact on the TSS compliance rate (elasticity in the range 0.22 / 0.36 for the absolute level of pollution, and in the range –0.21 /-0.26 for the compliance rate). These results suggest that larger firms may be able to comply more easily with the regulation for reasons like the existence of economies of scale in the abatement technology. For BOD, the same pattern is observed in the signs of the coefficients, but only one of them is significant.[25]

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[24] Similar results were observed in Magat and Viscusi (1990) and Laplante and Rilstone (1996).
[25] Similar results were observed in Lanoie et al. (1998).

The LOCALISATION variables are rarely significant for BOD while many of them are significant in the regressions related to TSS. Lastly, the coefficients of our PROCESS variable are everywhere negative, and they tend to be more significant in the BOD regressions than in the TSS. This shows that, as expected, the use of the mechanical process leads to higher compliance rate and lower absolute levels of emissions.

5. CONCLUSION

This paper has examined the relative impact of both traditional enforcement practices and information strategies on pollution levels and rates of compliance. The analysis was performed in the context of British Columbia where the MOE publishes, since 1990, a list of firms that either do not comply with the existing regulation or that are of concern to the MOE, and where simultaneously the Ministry continues to undertake legal action for those violating the regulation. The empirical investigation was based on a sample covering 15 plants in the pulp and paper industry over the period 1987 – 1996. Two types of pollutants were considered : BOD and TSS. Our results showed that a tightening up of the standards in 1990 had a very significant impact on plants' environmental performance and that appearances on polluters' list led plants to improve their environmental performance. Furthermore, we provided some evidence that the impact of appearing on the polluters'list was stronger than that of fines.

Our analysis suggests that, although useful, information strategies cannot necessarily replace traditional enforcement practices in the area of environmental protection. In fact, these two approaches can be perhaps better be used as complementary policy instruments in order to achieve improvements in firms' environmental performance. This way of proceeding presents the advantage of putting different types of pressure (reputational, financial, judiciary) on firms, increasing the likelihood that they will undertake actions in line with environmental protection.

From a policy-making perspective, our analysis thus offers two important results. First, the presence of clear and strong standards accompanied with a significant and credible penalty system does send appropriate signals to the regulated community which then responds with a lowering of pollution emissions. Secondly, the public disclosure of environmental performance does create *additional* and *strong* incentives for pollution control. These results do suggest that both regulation *and* information belongs to the regulator's arsenal.

References

Afsah, S., Laplante, B., and D. Wheeler (1997), *Regulation in the Information Age: Indonesian Public Information Program for Environmental Management*, World Bank, Development Research Group, Washington, D.C.

Badrinath, S.G. and P.J. Bolster (1996), "The role of market forces in EPA enforcement activity", *Journal of Regulatory Economics*, 10, 165-81.

Blackman, A. and G.J. Bannister (1998), "Community pressure and clean technology in the informal sector: An econometric analysis of the adoption of propane by traditional Mexican brickmakers", *Journal of Environmental Economics and Management*, 35, 1, 1-21.

Cohen, M. (1998), Monitoring and Enforcement of Environmental Policy. Forthcoming in Tietenberg and Folmer (eds), *International Yearbook of Environmental and Resource Economics*, Volume III, Edward Elgar Publishers.

Dasgupta, S., Laplante, B., and N. Mamingi (1998), *Capital Market Responses to Environmental Performance in Developing Countries*, World Bank, Development Research Group, Washington, D.C.

Dasgupta, S., Laplante, B., Mamingi, N, and Wang, H. (1999), *Inspections, Pollution Prices, and Environmental Performance: Evidence from China*, World Bank, Development Research Group, Washington, D.C.

Deily, M.E. and W.B. Gray (1991), "Enforcement of pollution regulations in a declining industry", *Journal of Environmental Economics and Management*, 21, 260-*74*.

Dion, C., Lanoie, P. and B. Laplante (1998), "Monitoring of pollution regulation: Do local conditions matter?", *Journal of Regulatory Economics*, 13, 5-18.

Environment Canada (1993), *The basic technology of the pulp and paper industry and its environment protection practices*, Ottawa.

Gray, W.B. and M.E. Deily (1996), "Compliance and enforcement: air pollution regulation in the U.S. steel industry", *Journal of Environmental Economics and Management*, 31, 96-111.

Hamilton, J.T. (1995), "Pollution as news: Media and stock market reactions to the Toxics Release Inventory data", *Journal of Environmental Economics and Management*, 28, 98-113.

Helland, E. (1998), "The enforcement of pollution control laws: Inspections, violations, and self-reporting", *Review of Economic and Statistics*, 141-53.

Kennedy, P.W., Laplante, B. and J. Maxwell (1994), "Pollution policy: The role for publicly provided information", *Journal of Environmental Economics and Management*, 26, 31-43.

Kenneth, S.A. (1991), *Monitoring Interjurisdictional Waters in Canada: A Constitutional Analysis*, Canadian Institute of Resources Law, Faculty of Law, University of Calgary, Calgary, Alberta, Canada.

Klassen, R.D. and C.P. McLaughlin (1996), "The impact of environmental management on firm performance", *Management Science*, 42, 1199-1214.

Kmenta, J. (1986), *Elements of econometrics*, 2nd Edition. New York: MacMillan.

Konar, S. and M.A. Cohen (1996), "Information as regulation: The effect of community right to know laws on toxic emission", *Journal of Environmental Economics and Management*, 32, 109-124.

Lanoie, P., "The impact of occupational safety and health regulation on the risk of workplace accidents – Quebec, 1983 –1987", *Journal of Human Resources*, XXVII (1992): 643 –660.

Lanoie, P., and B. Laplante (1994), "The market response to environmental incidents in Canada: A theoretical and empirical analysis", *Southern Economic Journal*, 60, 657-72.

Lanoie, P., Laplante, B., and M. Roy (1998), "Can capital markets create incentives for pollution control?", *Ecological Economics*, 26, 31-41.

Lanoie, P., M. Thomas, and J. Fearnley (1998), "Firms responses to effluent regulations: pulp and paper in Ontario, 1985-1989", *Journal of Regulatory Economics*, 13 (1998): 103 –120.

Laplante, B., and P. Rilstone (1996), "Environmental inspections and emissions of the pulp and paper industry in Quebec", *Journal of Environmental Economics and Management*, 31, 19-36.

Magat, W.A. and W.K. Viscusi (1990), “Effectiveness of the EPA’s regulatory enforcement: The case of industrial effluent standards”, *Journal of Law and Economics*, 33, 331-60.

Muoghalu, M., Robison, H.D., and J.L. Glascock (1990), “Hazardous waste lawsuits, stockholder returns, and deterrence”, *Southern Economic Journal*, 7, 357-70.

Nadeau, L.W. (1997), “EPA effectiveness at reducing the duration of plant-level noncompliance”, *Journal of Environmental Economics and Management*, 34, 54-78.

Pargal, S. and D. Wheeler (1996), “Informal regulation of industrial pollution in developing countries: Evidence from Indonesia”, *Journal of Political Economy* 104, 1314-27.

Province of British Columbia (1993), *B.C.’s Pulp Mills: Effluent Status Report*, Victoria, British Columbia, Canada.

World Bank (1999), *Greening Industry: New Roles for Communities, Markets, and Governments*, World Bank, Washington, D.C.