The Impact of Sanctions and Inspections on Firms' Environmental Compliance Decisions

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Abstract

Firms' compliance decisions are expected to be strongly influenced by the expected fine for non-compliance with environmental regulations. Therefore we simultaneously analyze the agency's inspection decisions and the firms' compliance decisions. We measure the effect of the inspection strategy and the size of the fine on the compliance decisions made by textile firms in Flanders. The results confirm the deterrence effect of increasing inspections, but they do not support a similar finding for monetary sanctions. The low levels of the sanctions that courts levy and the rapidly increasing abatement costs imply that firms' compliance decisions are not positively affected by the imposed penalties. However, the environmental inspection agency does not seem to target firms based on previously imposed monetary sanctions.

JEL-codes: K42 Illegal Behaviour and the Enforcement of Law; Q58 Environmental Policy

Keywords: Monitoring and enforcement; environmental regulations; textile sector

I. INTRODUCTION

In the context of environmental regulation as well as other policy areas, it is important to strategically choose the monitoring and enforcement policy in order to put the legislation in effect. Environmental rules will have little or no impact on environmental quality without an adequate inspection and sanctioning strategy in place and the compliance decisions made by firms are often thought to be strongly influenced by the expected fine for non-compliance (Becker, 1968)[1]. This expected sanction is, in essence, determined by the probability of inspection and by the size of the fine. In this paper we measure the effect of these two variables – jointly and separately – on the compliance decisions made by textile firms in Flanders. These estimations allow us to approximate the benefits of increasing each parameter and compare them with the associated costs.

The design and composition of the monitoring and enforcement policy is of great importance to policy makers, not only because it determines the impact of the environmental legislation, but also because substantial expenditures are associated with it. As a case in point, Cohen (1987) showed the marginal cost of the prevention of oil spills in the US consists for more than 25 % of enforcement costs. Theoretically the optimal monitoring and enforcement strategy, i.e. the probability of detection and the fine structure, has already been studied and determined in, among others, Polinsky and Shavell (1979, 1992), Cohen (1987), Rasmusen (1995) and Garoupa (2001). These authors have found that the optimal fine depends typically on the harm caused, the probability of detection and the cost of levying the fine. Determining the optimal detection probability, however, is less straightforward. It depends, among other things, on the fixed and variable inspection costs, the harm caused, the firms' reactions and the legally allowed penalties.

[1] For an extensive overview of the research following and extending Becker's work, we refer to Cohen (2000) and Polinksy and Shavell (2000).

Previous empirical research which estimates both compliance and inspection decisions include, among others, the work by Gray and Deily (1996). The authors use data on individual steel plants to study the relationship between regulator's enforcement of air pollution regulations and firms' compliance decisions in the United States. They find the expected interactions between the decisions: at the plant level, greater enforcement leads to greater compliance, while greater compliance leads to less enforcement. The analysis did not include information on fines but it did include data on inspections, letters, phone calls, and enforcement orders. The enforcement pressure variable used depended on the total number of these actions.

Nadeau (1997) used survival analysis to model the EPA's effectiveness at reducing the duration of plant-level non-compliance. Nadeau considered the separate effects of monitoring actions (inspections) and enforcement actions (orders and penalties) on the length of the non-compliance period of pulp and paper plants. He found that both instruments reduce the time in violation, though the enforcement actions seem to have a stronger effect.

Finally, Earnhart (2004; 2007) analyze the regulatory factors (i.e. inspections and enforcement actions) that shape the level of performance at individual polluting facilities. The enforcement actions[2] imposed by the US EPA and the Kansas Department of Health and Environment are aggregated into one count variable. No monetary measure of enforcement was included in the analysis because the scarcity of fines imposed in the sample. The evidence provided by the estimations about the amount of deterrence generated by actual interventions is mixed. While federal and state enforcement actions against large municipal wastewater treatment plants in Kansas significantly improve

[2] The enforcement actions include the following types: (1) consent order or agreement, (2) corrective action, (3) remediation requirement, and (4) administrative, civil, or criminal fine. The data were collected using the EPA's Docket database (now called ECHO database).

environmental performance, federal and state inspections at specific facilities are similarly ineffective at improving performance.

Due to the interactions between the agency's inspection strategy and the firms' compliance decisions, these two decision variables need to be estimated simultaneously (see, for instance, Gray and Deily, 1996, Nadeau, 1997, and Helland, 1998). The focus of this contribution is different from much of the earlier empirical work since the impact of monitoring and enforcement on firms' compliance decisions is investigated in more detail. More specifically, the estimation takes the monetary consequences (fines and settlements) for violating firms into account. The results confirm the deterrence effect of increasing inspections, but they do not support a similar finding for monetary sanctions. The low levels of the sanctions that courts levy and the rapidly increasing abatement costs imply that textile firms' compliance decisions are not positively affected by the imposed penalties. Also, the analysis of the agency's inspection decision shows that the regulator targets firms that are more likely to be in violation and thus confirms previous empirical studies such as Gray and Deily (1996), Laplante and Rilstone (1996) and Stafford (2002).

Section II describes the model that will be estimated. The dataset and the variables used are presented in sections III and IV. Section V gives the estimation results for three different specifications of the model and in section VI we discuss these results.

II. Econometric Model

This section presents the model to be estimated as well as the econometric method that is used. The goal of the estimation is to examine the effect of monitoring and enforcement on firms' compliance decisions while taking into account the inspection agency's audit decisions.

It is commonly known that data on noncompliance with laws and regulations are systematically biased. Typically, the data only include detected violations, which are not representative of all violations. This problem of incomplete detection can seriously complicate statistical analysis. In order to analyze the compliance decision of Flemish textile firms, we use a bivariate probit model with partial observability. This model is an extension of the bivariate probit model with full observability developed by Zellner and Lee (1965). Poirier (1980) has discussed the estimation and identification issues of this model when the observed binary outcome of the model does not reflect the binary choice of a single decision-maker, but rather the joint unobserved binary choices of two decision-makers (i.e. firm and inspection agency). Meng and Schmidt (1985) extended the model and discussed five cases which range from full observability to partial observability in the sense of Poirier (1980). Feinstein (1990) has renamed this method 'detection controlled estimation' and has presented a case study of the US Occupational Safety and Health Administration's safety regulation. Helland (1998) has applied this method to the enforcement of pollution control laws and has investigated the compliance and self-reporting decisions of pulp and paper firms with respect to US water pollution regulation.

In our case, we observe more than in Poirier's model, but less than in the full observability case. Meng and Schmidt (1985) refer to this case as 'censored probit' or 'partial partial observability'. Essentially, we observe the compliance status of firm *i* in quarter *t* $\left(y_{2it}\right)$ if and only if firm *i* was inspected in quarter *t* $\left(y_{1it}=1\right)$. However, if $y_{1it}=0$ we have no information about y_{2it}. Thus we have two binary dependent variables y_{jit}, j = 1, 2. Each is generated by a probit equation, and the two equations' errors are correlated. The model is then:

$$\begin{aligned} V_{1it} &= x_{1it}\beta_1 + \varepsilon_{1it} \\ V_{2it} &= x_{2it}\beta_2 + \varepsilon_{2it} \end{aligned} \qquad (1)$$

where β_j is a vector of the coefficients to be estimated and x_{jit} is a vector including several monitoring and enforcement variables and plant characteristics, which are discussed in section IV. The errors $\left(\varepsilon_{1it}, \varepsilon_{2it}\right)$ are assumed to be independent and identically distributed as standard bivariate normal with correlation ρ. The latent variables V_{jit} are unobservable and are related to the binary dependent variables y_{jit} by the rule:

$$y_{jit} = \begin{cases} 1 & if\ V_{jit} \geq 0 \\ 0 & if\ V_{jit} < 0 \end{cases} \quad (2)$$

Each period firm *i* decides whether to comply with environmental regulations $\left(y_{2it} = 1\right)$ or not $\left(y_{2it} = 0\right)$. A site will comply if the benefits of compliance exceed the costs of complying $\left(V_{2it} \geq 0\right)$. In each period the environmental inspection agency also decides to inspect a number of sites $\left(y_{1it}\right)$. For the noncompliance data, the first probit equation (i.e. the inspection decision) is completely observed, but for the second (i.e. the compliance decision) we have a censored (or selected) sample. When a firm is not inspected in a particular period, we have no information about its compliance status and thus two out of four possible outcomes ($y_{1it} = 0, y_{2it} = 1$ and $y_{1it} = 0, y_{2it} = 0$) are indistinguishable. In this instance, the methodology developed by Poirier (1980) and Meng and Schmidt (1985) allows a consistent estimation of the factors influencing inspections and violations (see also Greene, 2002).

As Meng and Schmidt (1985) state, the first probit equation can always be estimated separately since it is fully observed. However, this will be inefficient, unless $\rho = 0$. Furthermore, there will be a selectivity bias in the separate estimation of the second equation, unless $\rho = 0$. Therefore, we only consider the joint estimation of both equations by maximum likelihood, for which the likelihood function is:

$$\ln L(\beta_1, \beta_2, \rho) = \sum_i^N \sum_t^T \begin{bmatrix} y_{1it} y_{2it} \ln F(x_{1it}\beta_1, x_{2it}\beta_2; \rho) \\ + y_{1it}(1 - y_{2it}) \ln\left[\Phi(x_{1it}\beta_1) - F(x_{1it}\beta_1, x_{2it}\beta_2; \rho)\right] \\ + (1 - y_{1it}) \ln \Phi(x_{1it}\beta_1) \end{bmatrix} \quad (3)$$

Here $F(\cdot, \cdot; \rho)$ denotes the bivariate standard normal distribution function with correlation coefficient ρ, while $\Phi(\cdot)$ is the univariate standard normal distribution function; $i = 1, 2, \ldots N$ indexes the observed firms and $t = 1, 2, \ldots T$ the observed periods.

III. DESCRIPTION OF THE DATA

This section describes the dataset that is used. We investigate the inspection and sanctioning strategy used by the Flemish authorities when dealing with environmental violations in the textile industry. As a large industrial sector, the textile industry contributes significantly to water pollution in the Flemish region (and thus in Belgium): it is the fourth largest industrial contributor to COD, total nitrogen and heavy metal pollution (VMM 2007). As environmental permit regulation is a regional matter (and not a federal one), it makes sense to focus on the regional environmental policy. Moreover, the goals of the Flemish environmental policy are consistent with European directives: a notable example is the water quality objectives formulated in the European Water Directive. This implies that the results of the analysis are relevant for more sectors and regions than only the textile industry in Flanders.

3.1 Data

In 2002 the Flemish environmental inspection agency (AMI) performed a complete environmental audit of forty-one textile improvement and carpet production companies (NACE-codes 17.3 and 17.51) within the framework of the internal project P216. The database collected by AMI contains information about 1800 inspections completed between 1991 and 2003. Per inspection we have information on its characteristics (type, cause, and timing) and on its results (violations and enforcement actions). Using the same dataset, Rousseau (2007) and Billiet and Rousseau (2005) distinguish three types of inspections – routine, reactive, and project-related – and the targeting approach of the inspection agency is determined for each category using survival analysis. However, these two studies ignored the compliance decision of the firms and its interaction with the agency's inspection strategy. In order to investigate the firms' compliance decisions as well as the inspection decision, we now add data on the water related emissions by each firm, which were collected by the Flemish Environmental Agency (VMM). The dataset contains yearly (1994 – 2003) information on several key indicators such as daily BOD[3] load and the daily effluent load at the sites. We merge these two datasets and look at quarterly[4] data rather than individual inspection data. Thus we observe compliance and inspection decisions for 39 quarters (from January 1994 till September 2003) for 41 firms[5], or a total of 1599 observations. Since some data for some explanatory variables are missing, the econometric analysis is based on approximately 1000 observations.

Table 1 shows the number of inspections performed per year and the compliance status of the firms during these audits. The peak in 2002 is due to the project P216. On average 165 site visits took place per year, or each firm was inspected four times per year. Looking at the compliance status of the firms during these inspections, we find that over the years at least 42 % (1994) and at most 77 % (1999) of the firms were compliant (excluding missing values). Over the complete database in 55 % of the inspection visits the firm

[3] BOD or Biological Oxygen Demand represents the amount of oxygen (mg/l waste water) that certain bacteria use, during five days at 20°C, in order to oxidise organic carbon to carbonic acid.

[4] In order to estimate the bivariate probit model with partial observability it is necessary to use quarterly data, since each dependent variable needs to have both zero and one values.

[5] The missing data, the merger between two of the firms and the bancrupcy of another imply that we cannot take advantage of the panel nature of our dataset.

under scrutiny was found to comply with environmental regulations, again excluding missing values.

Table 1 : Number of inspections per year and compliance status

	Compliant	*Violation*	*Missing*	***Total number of inspections***
2003	69	84	29	182
2002	137	145	17	299
2001	81	60	19	160
2000	87	54	17	158
1999	106	31	24	161
1998	84	55	17	156
1997	70	50	19	139
1996	69	73	23	165
1995	60	51	18	129
1994	31	42	30	103
Total	794	645	213	1652

The inspection visits performed as a result of the enforcement project P216 are more comprehensive and are therefore more likely to detect an infraction of one or more aspects of the environmental regulation in place. Indeed, we find that significantly more violations were reported in 2002 and 2003. The number of administrative violations increased by more than 200 percent compared to the average in the previous years. Thus administrative violations seem to be pervasive. Examples of these are missing fire and maintenance reports, incomplete registers of toxic substances, belated submission of yearly emission reports, or incorrect environmental licenses. Moreover the more profound inspections, however, also uncovered several emissions related violations: detections increased with almost 50 percent. Examples of this type of violations are breaches of emission standards for one or more water pollutants, air pollution, smoke or bad smell, and oil spills. Hence we conclude that the apparent state of compliance of firms can be deceptive since more thorough audits can lead to substantial increases in observed violations.

We also investigate the enforcement actions taken after or during an inspection which found a firm in violation. The environmental agency can issue advices, warnings or notices of violations.[6] An advice is given to recommend the firm to make sure that the present situation of compliance with regulations continues in the future.[7] A warning, on the other hand, is provided to instruct the firm to end the present situation of non-compliance and abide with all appropriate laws, decrees, and permits. A notice of violation (NOV)[8] formally documents a violation. This document can be used as evidence in a court of law and a copy is send to the Public Prosecutor. Moreover, the agency can also use administrative sanctions, such as making a motivated proposal to the administration in power to suspend or withdraw the firm's environmental permit. The latter sanctioning instrument does not occur in our sample.

After detecting a violation, the inspection agency took some type of enforcement action in 20 to 30 % of the cases. This does not mean that the agency only reacts to 20 or 30 % of total violations. After all, it might take several visits – during which the firm is in violation – to formally prove the violations. It is also plausible that after the notice of violation accompanied by a warning has been issued, the environmental offense will continue for quite some time. After all, it often takes time to comply. Requesting a new or extended license can take months. Building a new water purification station can even take years.

[6] The use and definitions of these enforcement instruments can be found in art. 30 of the Environmental Permit Decree and art. 64 of Vlarem I.

[7] In practise this instrument is also used for minor administrative violations (such as the presence of a fire safety report) and to enforce previously issued warnings. In our sample, 19 of 20 advices follow a violation.

[8] Internal regulations of AMI state that the civil servants do not always have to issue a notice of violation when violations are discovered. They can evaluate the situation and use their professional competences to decide on the firm's level of precaution. However, a warning will always be sent to a violating firm.

Throughout this period, the agency is likely to pay some follow-up visits. During these visits they find the firm in violation (which they already knew) and take no further action (because they already did).

Table 2: Enforcement actions (Rousseau, 2007)

<table>
<tr><th>Noncompliant during inspection</th><th colspan="2">Enforcement action taken</th><th colspan="2">Information on follow-up[9]</th><th colspan="2">Legal consequence</th><th>Average monetary penalty</th></tr>
<tr><td rowspan="8">709</td><td rowspan="5">NOV</td><td rowspan="5">140</td><td rowspan="4">Info</td><td rowspan="4">69</td><td>Court of Appeal</td><td>2</td><td>7165 Euro</td></tr>
<tr><td>First instance</td><td>15</td><td>2869 Euro</td></tr>
<tr><td>Settlement</td><td>16</td><td>260 Euro</td></tr>
<tr><td>Dismissal</td><td>36</td><td>0</td></tr>
<tr><td>No info</td><td>71</td><td colspan="3"></td></tr>
<tr><td>Warning</td><td>38</td><td colspan="5">0</td></tr>
<tr><td>Advice</td><td>21</td><td colspan="5">0</td></tr>
<tr><td>No action</td><td>510</td><td colspan="5">0</td></tr>
</table>

In table 2 we analyze what happens after an inspection that found a firm in violation and focus, more specifically, on the monetary penalties imposed. As mentioned above, in the majority (72 %) of the cases no enforcement action was taken. We concentrate on the notices of violations that are issued, since a copy of those is always sent to the Public Prosecutor in order to start criminal prosecution. These violations can potentially lead to monetary penalties. In our sample, only 25 percent of the cases (17 out of 69) are actually brought to trial. In 23 percent of the cases (16 out of 69) a settlement is negotiated and the remaining cases (52%) are dismissed without further consequences. Looking at the average monetary penalty, we see that the average settlement amount is 260 Euro, the

[9] We process here the information received by AMI on the follow-up on NOVs by the Prosecutor's Office.

average fine at the first instance is 2869 Euro and the average fine at the Court of Appeal is 7165 Euro.

The monetary penalty for violating environmental regulations in Flanders is apparently limited. The expected monetary sanction, combining fines and settlements, after a violation is detected equals only 176 Euro. There must therefore be other motivations for firms to comply with environmental policies. Typically, the environmental agency starts with more lax instruments only to move up to harsher ones and thus it proceeds through the different stages of an enforcement pyramid (Ayres and Braithwaite, 1995) until it has secured an offender's compliance (see figure 1). This threat of harsher punishment (e.g. firm closure) can be sufficient to make firms comply. For Flanders (AMI 2003), the agency reports that in 2003 45 compulsory measures (i.e. orders to terminate (part of) the firm's activity) and 26 proposals to the qualified authority to withdraw or suspend a firm's license (including one textile firm) were used. These administrative sanctions, combined with the occurrence of criminal sanctions which can also include mandatory measures, make the threat of harsher punishment credible for Flanders. Nyborg and Telle (2006) provide similar evidence for the Norwegian environmental inspection policy: violators failing to respond adequately to warnings are met by more formal and direct sanctions. Other possible reasons for firms' compliance include, among other things, risk aversion, the presence of social norms, the presence of other environmental regulations and dynamic interactions between firms and inspection agency.

INSERT FIGURE 1 ABOUT HERE

IV. Explanatory variables

In this section we define the explanatory variables. We now discuss the different factors that determine firms' compliance and the environmental agency's inspection decisions. We use quarterly data and summarize the different variables in table 3 at the end of this section.

4.1 Probability of compliance

The probability of compliance will depend on variables determining the expected costs and benefits of a violation and other firm characteristics. The specification of the compliance equation is given by

$$Compliance_{it} = f\begin{pmatrix} INSPQ, COMP, NOV, COMPLAINT, MONSAN / SANCTION, EXPSAN \\ IMPROVE, CAPACITY, SURFACE, BOD, RETURN, AGE, Y2002 \end{pmatrix}$$

Firstly firms' compliance decisions depend on several monitoring and enforcement variables such as the predicted number of inspections and their history of past violations. The probability of future inspections is approximated by the variables INSPQ1 and INSPQ2, which indicate whether or not a firm was visited by the agency one (two) quarter(s) ago. INPSQ1/2 will probably pick up firm characteristics that are not included in the analysis but that influence the likelihood of being examined by AMI. Examples of these unobservable plant characteristics are the social norms of the managers, the environmental awareness of the plant's neighbors, and the skills of the workers. Also, however, if the plant was inspected often before, this could be because it is known by the agency to be a bad performer. In order to predict a firm's compliance status, we also include the observed compliance status one, two, three and four quarters ago (COMP1, COMP2, COMP3 and COMP4). Note that we assume that firms are 'innocent until proven guilty'; so COMP1/2/3/4 equals one not only if the firm was actually observed to comply during an inspection, but also if the firm was not inspected in the relevant time period. If a firm was compliant in the previous quarter (COMP1=1), we can expect the firm to be still following the rules this period. Therefore we expect a positive coefficient for the variables

COMP. Firms that were in violation and received a notice of violation less than four quarters ago (NOV) can either still be in violation or they can have rectified the situation. The expected sign of the variable NOV can thus not be predicted. If a complaint concerning a firm is received by the environmental inspection agency, we can suspect that that firm has a higher probability of being found in violation when inspected. The variable COMPLAINT counts the number of complaints that were received of the firm in the previous four quarters and its coefficient is expected to be negative. Based on the economics of crime (Becker, 1968), we expect firms that had to pay a monetary sanction in the recent past to be more compliant in the present. The 0/1-variable MONSAN equals one if the firm had to pay a monetary sanction less than eight quarters ago. The variable SANCTION is continuous and specifies the level of the monetary sanction that the firm had to pay in the previous eight quarters. Again we expect that firms that were recently subject to a monetary sanction will be more likely to follow the rules. We also define the variable EXPSAN as the product of INSPQ1 and SANCTION. This variable is thus a proxy for the expected monetary sanction for each firm based on its past violations.

Another set of factors determining firm’s compliance are plant characteristics. The firms in our sample belong to two subsectors of the textile industry, textile improvement and carpet production, and we expect to see a difference between the two firm types. The average composition of the wastewater discharged by the two sectors indicates that, overall, carpet production tends to be dirtier than textile improvement (Jacobs et al., 1998). Thus the coefficient of the variable IMPROVE (i.e. a dummy for the cleaner sector) can be expected to be positive. The size of the firm is another important factor and is measured by the variable CAPACITY. CAPACITY measures the amount of fabric or fibers (in tons) that a firm can treat and/or dye in one day.[10] Larger firms potentially produce more pollution. However, they are also better informed and have more resources to spend on abatement. The influence of firm size on its compliance status is, therefore, ambiguous. Further, it will also be important whether the firms discharge in the sewer system or in surface waters[11]. Firms discharging in surface waters might be more careful, in which case we expect a positive sign for the variable SURFACE. Firms that emit higher levels of pollutants might be more likely to exceed environmental regulations. We use the daily load of BOD as a proxy for the size of the pollution caused by the firm and expect its coefficient to be negative[12]. We also look at the influence of the financial situation of the firm through the firm's annual gross rate of return (RETURN). Firms with more financial resources presumably spend more on information gathering and emission abatement. This implies a positive coefficient for RETURN. We also include the age of the plants (AGE) as a determinant of compliance behavior. We can also expect more detected violations during the execution of project P216 in the year 2002, since the project implied a thorough scanning of textile firms. We expect, therefore, a negative sign for the dummy Y2002.

4.2 Probability of inspection

The inspection agency selects the firms it inspects based on several characteristics. The specification of the inspection decision is

$$Inspection_{it} = f\begin{pmatrix} INSPQ, COMP, NOV, COMPLAINT, MONSAN, \\ IMPROVE, SURFACE, BOD, QFLOW, Y2002 \end{pmatrix}$$

[10] This measure is expressed in daily terms in order to correct for differences in production processes (continuous versus non-continuous processes). Moreover, we treat capacity as fixed over the complete time horizon of our dataset since investment decisions typically are long term decisions.

[11] In our sample half of the firms discharge in surface waters while the other half discharge in the sewer system.

[12] The VMM data provide us with an estimate of the daily load of BOD for each calendar year for each firm.

These determinants can be divided into two categories: i) monitoring and enforcement variables and ii) plant characteristics. These are subsequently discussed in more detail.

A first set of monitoring variables (INSPQ1 and INSPQ2) represent whether the firm was inspected one (two) quarters ago. Recently inspected firms might face a lower probability of being inspected in the current quarter. However, INPSQ might also pick up firm characteristics that are not included in the analysis but that influence the likelihood of being examined by AMI. If the plant was inspected often before, this could be because it is known to be a bad performer. The practice of inspecting firms most likely to violate a regulation is often referred to as targeting (Harrington, 1988). A significant and positive coefficient for the variable INSPQ might thus be proof of targeting. Empirical evidence (e.g. Eckert, 2004, Gray and Deily, 1996, Nadeau, 1997, and Rousseau, 2007) has already shown that environmental inspection agency often target firms based on their compliance history. Thus we expect a negative coefficient for the variable COMP and a positive one for the variables NOV, MONSAN and SANCTION. Furthermore we expect that firms with many complaints in the past year (COMPLAINT) will be more frequently inspected. This prediction is based on the agency’s internal regulations, which state that complaints must be followed by a site visit within three months.

Next we discuss the firm characteristics that were included in the analysis. We can expect a negative sign for the variable IMPROVE that relates to the less dirty firms, since increasing compliance of the dirtier firms will have a higher impact on the environmental quality. Moreover, the environmental agency can find it beneficial to target firms that discharge in surface waters, since the effluent disposed in sewers is carried to water treatment plants for additional treatment, while those disposed in surface water are not. As a result, we expect a positive sign for the variable SURFACE. This expectation is reinforced by the yearly report of AMI in which we read that the agency has the intention to inspect firms that discharge in surface water more frequently (AMI 2005, p.70). This report also states that inspections are determined by the waste load that is discharged. This leads us to expect a positive sign for the variables BOD and QFLOW (daily waste load)[13].

We can also expect more frequent inspections during the project's execution in the year 2002, since P216 implied a thorough scanning of the textile firms. We expect, therefore, a positive sign for the dummy variable Y2002.

Table 3: Variable definitions

Variable name	***Unit***	***Definition***
Dependent variables		
COMP	0/1	=1 if firm observed in compliance during inspection at time t
INSPQ	0/1	=1 if firm inspected at time t
Independent variables		
INSPQ1/2	0/1	= 1 if firm inspected one/two quarters ago
COMP1/2/3/4	0/1	= 1 if firm was observed to be compliance or was not inspected 1/2/3/4 quarters ago
NOV		= number of NOV in previous four quarters
COMPLAINT		= number of complaints received in previous four quarters
MONSAN	0/1	= 1 if firm had to pay monetary sanction in past eight quarters
SANCTION	Euro	= amount of monetary sanctions paid in past eight quarters
EXPSAN	Euro	= expected fine (INSPQ x SANCTION)
IMPROVE	0/1	= 1 if independent textile improvement firm
CAPACITY	Ton/day	= firm's capacity for pre-treatment and dyeing
SURFACE	0/1	= 1 if firm discharges in surface water
QFLOW	m^3	= daily load of waste water (one data point per calendar year)
BOD	Kg O2	= daily load of BOD5 (one data point per calendar year)
RETURN	%	= annual gross rate of return on firm's total assets
AGE	In years	= age of firm
Y2002	0/1	= 1 if year 2002

V. Estimation Results

The estimation results using a bivariate probit model with partial observability are presented in table 4 for three specifications for the compliance and inspection decisions[14].

[13] The VMM data provide us with an estimate of the daily load for each calendar year for each firm.

The significant coefficients are put in bold in table 4. The hypothesis that the correlation coefficient ρ between the two errors $(\varepsilon_{1it}, \varepsilon_{2it})$ is zero can be rejected at the one percent level. The joint estimation of the agency's inspection decision and the firms' compliance decisions in a bivariate probit model is clearly justified. The three specifications presented in table 4 differ with respect to the way the monetary sanction is included:

specification (1): includes the dummy variable MONSAN

specification (2): uses the continuous variable SANCTION

and specification (3): includes the variable SANCTION and the variable EXPSAN.

Table 4: Estimation results: Coefficients (p-value)

	Specification (1) # obs = 964 Log lik. = -958.7		Specification (2) # obs = 964 Log lik. = -959.1		Specification (3) # obs = 964 Log lik. = -958.8	
	Insp	Comp	Insp	Comp	Insp	Comp
INSPQ1	**-0.1878*** (0.0570)	-0.0972 (0.2872)	**-0.1853*** (0.0614)	-0.1023 (0.2610)	**-0.1866**** (0.0375)	-0.0901 (0.3232)
INSPQ2	-0.0465 (0.5902)	**0.1897**** (0.0306)	-0.0463 (0.5921)	**0.1847**** (0.0344)	-0.0491 (0.5551)	**0.1813**** (0.0372)
IMPROVE	-0.0771 (0.4161)	0.0024 (0.9779)	-0.0848 (0.3694)	0.0081 (0.9265)	-0.0877 (0.2903)	0.0081 (0.9267)
CAPACITY	-	0.0001 (0.9464)	-	0.0002 (0.8780)	-	0.0002 (0.8856)
COMP1	-0.0188 (0.8852)	**0.7232***** (0.0000)	-0.0084 (0.9489)	**0.7185***** (0.0000)	-	**0.7126***** (0.0000)
COMP2	0.0132 (0.9222)	-0.0951 (0.4333)	0.0138 (0.9195)	-0.1021 (0.4042)	-	-0.0914 (0.4226)
COMP3	-0.1128 (0.4064)	**0.2305*** (0.0814)	-0.1104 (0.4151)	**0.2257*** (0.0884)	-	0.1742 (0.1475)

[14] The correlation coefficients of all variables are (well) below $|0.35|$ except for the variables COMP1, COMP2, COMP3 and COMP4 which are correlated and the variables EXPSAN and SANCTION which have a correlation coefficient of 0.90. The estimated (significant) coefficients are, however, robust to alternative specifications of the model despite the correlation of the lagged variables.

COMP4	0.0974 (0.4024)	0.0709 (0.5487)	0.1011 (0.3854)	0.0694 (0.5552)	-	0.1081 (0.2987)
NOV	**0.2389**** (0.0218)	-0.0737 (0.4103)	**0.2519**** (0.0145)	-0.0913 (0.3029)	**0.2541**** (0.0101)	-0.0918 (0.2996)
COMPLAINT	**0.1644***** (0.0003)	**-0.0979***** (0.0002)	**0.1673***** (0.0002)	**-0.1004***** (0.0001)	**0.1666***** (0.0002)	**-0.0998***** (0.0001)
MONSAN	0.2025 (0.1846)	**-0.2552*** (0.0616)	-	-	-	-
SANCTION	-	-	0.00007 (0.2907)	**-0.000072*** (0.0977)	0.000059 (0.3843)	0.02455 (0.8259)
EXPSAN	-	-	-	-	-	-0.0001 (0.3018)
SURFACE	**-0.2535**** (0.0266)	0.0427 (0.6894)	**-0.2534**** (0.0266)	0.0448 (0.6744)	**-0.2537**** (0.0227)	0.0428 (0.6873)
BOD	-0.000005 (0.9727)	0.00008 (0.5455)	-0.00002 (0.8747)	0.000099 (0.4290)	-0.00002 (0.8725)	0.0001 (0.4159)
QFLOW	**0.00028***** (0.0007)	-	**0.00028***** (0.0007)	-	**0.00028***** (0.0005)	-
RETURN	-	-0.0049 (0.4497)	-	-0.0049 (0.4421)	-	-0.0053 (0.4107)
AGE	-	**0.0058***** (0.0014)	-	**0.0058***** (0.0016)	-	**0.0057***** (0.0016)
Y2002	**0.7131***** (0.0000)	**-0.5901***** (0.0000)	**0.7018***** (0.0000)	**-0.5735***** (0.0000)	**0.7019***** (0.0000)	**-0.5741***** (0.0000)
Rho (1,2)	**-0.8441*****		**-0.8423*****		**0.8373*****	

With * / ** / *** indicating respectively 10% / 5% / 1% significance levels.

The results suggest that firms are more likely to be inspected if they were not inspected during the previous quarter, if they received a NOV in the previous four quarters, if a high number of complaints were submitted during the previous four quarters, if they discharge their effluent in the sewer system, if their daily waste load is higher, or in the year 2002. Further we find that we are more likely to observe compliant behavior with firms that were found to be compliant in the previous quarter, that were inspected two quarters ago, that received no or only few complaints in the previous four quarters, that did not pay a monetary sanction during the previous eight quarters, that are older, or in years other than 2002.

VI. DISCUSSION

In this section we first make some general observations concerning the estimated results. Next we concentrate specifically on the monitoring and enforcement variables.

6.1 General observations

The significant results for the variables COMP1 and COMP3 indicate that a firm that was compliant during the last period is more likely to be compliant in the current period. This result is consistent with previous empirical studies such as Gray and Deily (1996) and Nadeau (1997). The firms’ compliance status seems to be persistent over time. This result is obvious for abatement decisions that involve investments in technologies or infrastructure, but it is not evident if violations consist of sporadic incidents.

The significant results for the variable COMPLAINT show the importance of involving neighborhoods in the monitoring process. Complaints submitted by citizens to the environmental agency provide a reliable signal of an increased probability of finding the firm in violation with environmental regulations. The inspection agency has picked up on this and it visits firms with complaints more frequently. This type of practice is an example of the targeting approach discussed by Harrington (1988).

Harrington (1988) proves that inspecting those firms that are more likely to be in violation allows a more efficient use of the agency’s budget and increases expected compliance. For Flanders, the analysis of the agency’s inspection decision indeed shows that the regulator targets firms that are more likely to be in violation and thus confirms previous empirical studies such as Gray and Deily (1996), Laplante and Rilstone (1996) and Stafford (2002).

Contrary to the official inspection policy, firms that discharge their waste water in surface water are inspected less frequently than sites that are connected to the sewer system. However, the positive coefficient for QFLOW indicates that the policy of inspecting firms with a higher waste load is indeed being implemented by the environmental inspection agency. As Gray and Deily (1996) mention the public might be more sensitive to plants emitting large absolute amounts of pollution and indeed they find that such plants are inspected more frequently in the US steel industry, even if the plant is in compliance.

Finally it seems that older firms are more likely to be compliant than more recently established plants. The longer firms are active, the more information they are likely to have about their production processes, the technological possibilities and their compliance status. Moreover, these firms will have a more established relationship with the environmental inspection agency. This might lead to faster solutions to detected problems since the policy in Flanders is essentially a problem-solving one rather than a penalizing one (Billiet and Rousseau, 2005 and Rousseau, 2007).

6.2 Impact of different monitoring and enforcement actions

Now we discuss the impact of inspections and monetary sanctions on compliance decisions by firms.

Impact of inspections

Looking at the impact of inspections, we see that firms have a lower probability to be inspected if they were inspected in the previous quarter. Also we find that firms that were inspected two quarters ago have a significantly higher probability of being observed complying environmental regulations. This positive effect of inspections on the firms' compliance status is widely reported in the empirical literature (e.g. Eckert, 2004, Nadeau 1997, Gray and Deily, 1996, and Helland, 1998) and is also predicted by theoretical models such as Becker (1968). The time lag between inspections and compliance can be explained by looking at the agency's procedures. Typically when a firm was found in violation, a notice of violation is issued and this notice is always accompanied by a compliance order. Such a compliance order will give the violator at least three months (one quarter) time to correct the situation and conform to the regulations. The time lag observed in our results might therefore be caused by the time given to firms to obey the rules.

Impact of monetary sanctions

If we look at the impact of monetary sanctions (MONSAN, SANCTION and EXPSAN), we find some surprising results. Apparently firms that had to pay a monetary sanction during the previous two years are more likely to be violators, when inspected, than firms that did not have to pay a fine or settlement. This group of firms does not seem to be deterred by the monetary sanctions and continue to violate environmental regulations. One reason for this behavior can be found in figure 2, which represents the abatement cost curve for textile firms in Flanders[15]. It is clear that the abatement costs for textile firms are often much higher than the fine that might be imposed (maximum 7165 Euro, see table 2). The low expected sanction (i.e. 176 Euro) does not provide all firms with sufficient incentives to abate their emissions and obey regulations. The results might also indicate that the firms' ex-ante and ex-post estimations of the monetary sanctions differ. Firms that did not have to pay a fine in the recent past are less able to correctly anticipate the expected level of the sanction and might overestimate the expected fine.

[15] The investments in abatement technologies are expressed in annual terms since the investments typically last ten to twenty years.

Firms that were fined recently, however, have a more accurate impression of the true expected sanction, which might be lower than initially projected.

INSERT FIGURE 2 ABOUT HERE

The low sanctions are not dictated by the associated legislations and the discretion of judges in imposing sanctions is substantial in Flanders. The Labor Safety Law (ARAB 1946), the Environmental Permit Decree (Milieuvergunningsdecreet 1985) and the Manure Decree (Meststoffendecreet 1991) allow sanctions up to 500000 Euro. More recent legislation includes even higher maximum fines: for example, a fine up to 50 million Euros is possible within the Waste Decree (Afvalstoffendecreet 1981, as amended in 1994) and the Soil Clean-up Decree (Bodemsaneringsdecreet 1995) (Billiet and Rousseau, 2003). Thus there are no legal inhibitions why the level of fines imposed for environmental offenses might not be higher.

The results with respect to the monetary sanctions suggest that marginal increases in the fine levels are probably useless. The estimated model, however, does not allow us to comment on non-marginal changes in the sanctions imposed. Substantially higher penalties might increase compliance as suggested by economic models of crime (Becker, 1968). In figure 2 we see that abatement costs typically range from 10000 Euros to 150000 Euros in annual terms[16]. In order to significantly increase compliance using criminal fines, expected fine levels of the same order of magnitude are needed and thus the imposed absolute fine levels would have to be even higher. The full range of legally allowed fines might be necessary. However, this ignores the role of other enforcement instruments used in practise. As mentioned in section 3, the targeting approach of the inspection agency as well as the range of alternative sanctions, such as firm closure, will

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[16] The abatement costs are based on data collected through a survey of textile firms (Rousseau and Proost, 2005)

lead to higher compliance levels than predicted by the standard model of crime studied by Becker (1968).

VII. Conclusion and Policy Recommendations

In line with previous empirical and theoretical research, the estimation results indicate that increasing the number of inspections will lead to more observed compliance. However, the findings do not confirm the deterrence effect of monetary sanctions. Despite very high legal ceilings, monetary sanctions for environmental violations are so low in Flanders that they are not able to convince firms to comply. On the contrary, the fact that a firm has paid a monetary sanction in the recent past can act as an indicator of violating behavior by textile firms. However, the environmental inspection agency does not seem to target firms based on previously imposed monetary sanctions. These results lead us to suggest that substantial increases in the monetary sanctions will be necessary to provide sufficient incentives for firms to comply with environmental regulations. The costs of investing in abatement technologies are, after all, much higher for textile firms than the current fines that are imposed by the courts.

In conclusion, the impact of inspections and sanctions on firms' compliance decisions is significantly different. For this reason it is important that the regulator investigates the precise circumstances in the policy region and the industrial sector before deciding how to allocate resources to improve monitoring and enforcement of environmental regulations.

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Figure 1 : Ayres and Braithwaite's enforcement pyramid

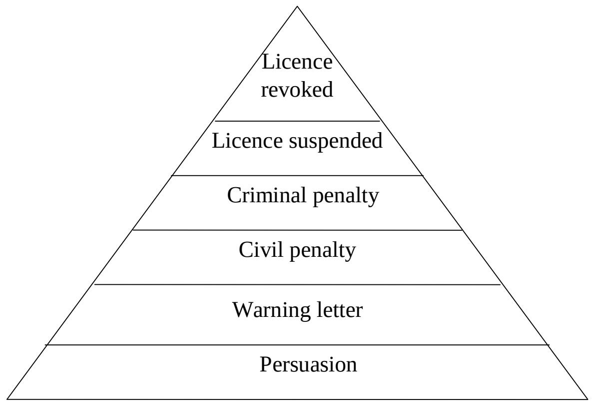

Figure 2: Abatement cost curve