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Violation of environmental regulations in Sweden: Economic motives, environmental attitudes, and social capital.

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Abstract: This paper tests the explanatory power of traditional enforcement instruments, environmental attitudes and abundance of social capital for violation of environmental regulations in Sweden. A count data model is used on a panel data set obtained from a survey to inspectors at the local and regional jurisdictions in Sweden. Regressions analyses are carried out for all firms but also for different firm categories depending on environmental impacts. The results indicate that traditional enforcement weapons, measured as number of inspection and a formal inspection style, curb violation by all types of firm categories. On the other hand, significant results are that environmental attitudes and abundance of social capital deter violation by large firms, but have no impact on violation by firms with minor environmental impacts.

Key words; environmental regulations, violation, economic motives, environmental attitudes, social capital, heterogeneous firms, count data model, Sweden

JEL; K33, K42, Q58

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1. Introduction

Environmental policies are implemented by formal punishment of detected violation in most countries. This deters violation by creating a cost of violation in terms of expected penalty. However, there is a tendency in many countries to a larger extent rely on voluntary mechanisms for policy implementation (Gray and Shimshack, 2011). Such a move from traditional enforcement can be justified if the presumption that other mechanisms than expected penalties have sufficient impact on firms' environmental performance. This question has been raised and analysed by a large number of studies since the seminal contribution by Becker (1968). The main focus since then in the economics literature has been on investigating the role of economic factors, in particular expected penalties from violation (see Cohen 1999 and Gray and Shimshack 2011 reviews of empirical studies). Harrington (1988) provides one of the early recognition of other factors affecting compliance when he found that firms in general comply with regulations to a larger extent then would be expected based on only expected penalty cost and benefits from violation, the so called Harrington paradox.

Normative and social motives have been suggested as explanatory factors for compliance with regulations in addition to economic motives, where the latter are defined as the direct expected costs and benefits from violation (McGraw and Scholz, 1991; Honneland 1999; Jensen and Aarset, 2008; Bouvier, 2009). Normative motives refer to the desire to fulfil one's own moral beliefs, and social motives to please others. The managers of the regulated firms may themselves hold values about the importance/duty of following regulations in general, and environmental directives in particular. They may for example stress that there is a moral obligation to comply with the rules in a society and that there is a moral obligation to protect the environment. Social motives arise from the role of others perception of the firm. Even if the manager/decision maker holds no environmental concern, others may do so who are important for the manager such as employees, customers, friends and other regulated firms.

Another factor, abundance of social capital, has turned out to have significant influence on compliance with regulations in general (e.g. Glaeser et al., 1996; Lederman et al., 2002; Lazzarini et al., 2004; Yamamura, 2009). The term "social capital" is somewhat vaguely defined but is often understood as, following the use of Putnam et al. (1993), horizontal relations and networks acting towards reciprocity in cooperation. As such, it is related to normative and social motives, but the concepts differ since these motives not necessarily result in expectations of reciprocity in voluntary cooperation. In principle we can find three mechanisms through which social capital can impact violation of environmental regulations. One is through the effect on violating firms' benefits from losses of access to local transactions that build on trust. The other two mechanisms act through suspected or detected violation. Social capital may facilitate the creation of lobbying activities that result in private reporting of environmental activities without permits, and the other is the damaging impact on firms' transaction by a quick and widespread of reputation as 'environmental criminal'.

There is a relatively large body of literature on the empirical test of the explanatory power of economic motives for violation of environmental regulations (see Cohen 1999 and Gray and Shimshack 2011 for reviews, and Hatcher et al. 2000 for a review of compliance with fishery regulations). The number of studies adding normative and social motives, environmental attitudes or social capital is much more scant (Regens et al., 1997; Hatcher et al., 2000; Kagan et al., 2003; Earnhart, 2004; Nostbacken, 2008; Jones, 2010). Several of these studies include explanatory variables reflecting social and normative motives or social capital (Regens et al. 1997; Earnhart 2004; Jones, 2010). Kagan et al. (2003) is one of the few addressing the role of environmental attitudes. However, none of the studies is explicitly addressing the explanatory power of all three factors, i.e. economic motives, environmental attitudes, and social capital. Common to most empirical studies is their application to environmental regulations in the US and we find very few studies with application to environmental regulations in other countries.

The purpose of this paper is to estimate the explanatory power of variables categorized in the three categories of drivers for violation of environmental regulations in Sweden, a country in north-east Europe with a relatively long tradition of environmental regulations manifested by the hosting of the first UN environmental conference in 1972. Econometric tests are carried out by using a count data modelling approach on a data set obtained from a survey to inspectors of compliance with regulations in Swedish at the local (municipalities) and regional (counties) jurisdictional levels. This survey is complemented with data from another survey to the Swedish population reflecting, among others, environmental attitudes and measurement of social capital (Holmberg et al., 2010). We see two main contributions of the paper. One is the simultaneous consideration of influence on violation from all three classes of factors, and the other is the empirical application to a country outside the U.S.

The paper is organised as follows. Section 2 gives a brief literature background, and data retrieval is presented in Section 3. Econometric modelling and results are presented in Section 4, and the paper ends with a summary and discussion in Section 5.

2. Brief literature review

Several studies have tried to explain the so-called Harrington-paradox, i.e. that firms comply in spite of very low expected penalties (Harrington, 1988), but in different ways. A vast majority of the literature on compliance motives attributes the phenomenon to economic motives (Magat and Viscusi, 1990; Gray and Scholz, 1993; Gray and Deily, 1996; Laplante and Rilstone, 1996; Nadeau, 1997; Winter and May, 2001; Stafford, 2002; Eckert, 2004; Shimshack and Ward, 2005; Nyborg and Telle, 2006; Eckert and Eckert, 2010). These studies investigate the effect on compliance of inspection design (including inspection frequency, threat of inspections, and inspections based on violation history and spread among regulated firms), and/or level of penalties. This section gives a very brief survey of these studies and we refer to Gray and Shimshak (2011) for a much more elaborative and comprehensive review.

Inspection design is the most commonly studied explanatory variable where Magat and Viscusi (1990) is one of the earliest study. They found that inspections have a positive effect on compliance in the paper and pulp industry in US, but that the regulation for that industry was an unusual success compared to other environmental regulations. In a study by Gray and Deily (1996) the positive relationship between compliance with regulations by steel mills in US and inspections frequency was confirmed. Nadeau (1997) made an econometric test of the ability of US EPA to reduce the time plants in the paper and pulp industry spend in a state of violation and found that the time period can be reduced by EPA's monitoring and enforcement activities.

Threat of inspection was considered by Laplante and Rilstone (1996) who showed that both actual and threat of inspections have significant effect on emissions of pollutants from the paper and pulp industry in Quebec. A significant impact of inspection warnings was found also by Eckert (2004) for compliance with regulations on petroleum storages in Canada. The same data set was used by Eckert and Eckert (2010) who showed that state dependent inspections and violation history of the inspected and neighbouring sites affect compliance. These results confirm earlier finding on a positive impact on compliance from state dependent inspection (e.g. Gray and Deily, 1996; Shimshack and Ward, 2005).

Impacts on compliance from changes in the penalty levels turn out to have some but relatively small effects (Winter and May, 2001; Gray and Scholz, 1993; Stafford, 2002). Nyborg and Telle (2006) provide one of the few studies of compliance outside US and Canada. Based on firm level panel data in Norway they found that violation is relatively high for firms facing lax enforcement and punishment, but low when expected penalty is harsh.

Another, but much less investigated, factor is the role of inspectors' behaviour and attitudes when controlling regulated firms, or the inspection style (Harrison, 1995; Laplante and Rilstone, 1996; Eckert, 2004). The inspection style may, as has been pointed out by political scientists, be

regarded as confronting if detection and punishing are in focus for the inspector or as cooperative if information and advising are in focus (Lundqvist, 1980; Vogel, 2003). These two inspection styles were compared by Harrison (1995) who found that the more confronting inspection style in US lead to higher compliance in the paper and pulp industry than the more cooperative style in Canada. Burby and Paterson (1993) showed, on the other hand, that cooperative enforcement strategies can improve the compliance with laws urban sedimentation and erosion control in the State of North Carolina.

An unusual explanation of the existence of over compliance is suggested by Brännlund and Löfgren (1995), who point at the role of asymmetric information within firms. Since a manager does not have full control of all employees activities, there is a risk of unintentional violation of environmental regulations. They found that the paper and pulp industry in Sweden responds to this by reducing the average emissions more than required by the regulation. This can be attributed to economic motives and the risk of costly sanctions if found in violation, but also to environmental concern.

Studies on the explanatory power of variables reflecting non-economic motives not directly effecting regulated firms' expected profits from violation are much more scant (Regens et al., 1997; Kagans, 2003; Earnhart, 2004; Jones, 2010). A common approach in these studies has been to capture non-economic factors by measurements of different community characteristics, such as voting engagement and education. Regens et al. (1997) found that political factors influenced the investments in pollution control equipment in the US manufacturing industry. Earnhart (2004) included factors as population density, unemployment rate, voter engagement, education, income per capita and proportion of renter households and showed that such community characteristics affected the compliance level. Kagan et al. (2003) found that local governments, environmental activists and company culture were important factors to explain over compliance.

Several of these community characteristics, such as voter engagement, can be attributed to the role of social capital for compliance with regulations in general (e.g. Glaeser et al., 1996; Lederman et al., 2002; Yamamura, 2009; McCulloch et al., 2012). Two central elements in the parameterization of social capital is the membership in organisations and the degree of social trust (Rothstein, 2003). Using data from a survey of citizens in Greece, Jones (2010) tested the impact on compliance with waste treatment regulations from four different measurements of trust, all of which refer to trust in general or networking. It was found that general trust has significant impact on environmental behaviour.

3 Data retrieval

The brief review in Section 2 identified several common explanatory variables for compliance with environmental regulations, where the most frequently used variable is enforcement in terms of inspections of regulated firms. Such a variable is also included in this paper, together with a variable reflecting inspection style, since they affect firms' perceptions of credibility in enforcing regulations. It is more difficult to discern a common denominator for the choice of other explanatory variables, but we can identify variables reflecting environmental attitudes and social capital as relatively frequent. Before presenting choice of variables and associated data collection, we give a brief presentation of the Swedish context of supervision of environmental regulations.

3.1 Brief description of enforcement of Swedish environmental regulations

Supervision of environmental regulations in Sweden is made for command and control policies and is divided among three authorities: the Swedish Environmental Protection Agency (SEPA, 2009), County Administrative Boards (CAB), and municipalities. The SEPA has the overall responsibility for supervising environmental regulations, and the operative responsibility is

delegated to CAB and municipalities, where each jurisdictional unit obtains a given number of firms to supervise. These firms are classified into four different categories - A, B, C, and U – according to the Environmental Protection Act. Firms classified into the A and B categories require licences issued by CAB for operation, where an A classified firm is more environmentally hazardous than a B classified firm. Examples of A classified firms are nuclear power plants and firms operating in the steel, paper or pulp industries. Large farms and food producers provide examples of B classified firms. The C classified firms have to report their activities to the municipalities, and the U classified firms, such as petrol stations and laundries, need neither license nor reporting about their activities but are under observation by the municipalities for classification into any other class.

The CABs have the responsibility for supervision of firms classified in the A and B categories and municipalities for the C and U categories. However, upon voluntary request from municipalities, counties are allowed to delegate responsibility for supervising the A and B classified firms to the municipalities. According to Gren and Li (2012) the total number of regulated firms amounts to approximately 82000, of which a vast majority, 89%, are U firms and C firms, and 10% and 1% are B and A firms respectively. These firms are divided among 21 CABs and 287 municipalities. Supervision of approximately 30% of the A and firms are delegated to municipalities upon their request.

3.2 Variable definitions and measurement

The econometric test of the influence of these explanatory variables relies on two main data sources; *i)* a survey with questionnaires to all Swedish inspection authorities distributed in 2009 (Holstein, 2010), and *ii)* poll investigations of attitudes of the Swedish citizens carried out since early 1980s (Holmberg et al., 2010). Ordinal data on violation by regulated firms and inspection behaviour were obtained from the questionnaire, and categorical data on variables representing environmental attitudes and social capital were found in the poll investigation.

The main and unique data source for this study is the survey to municipality and CAB inspection authorities carried out in 2008 (Holstein, 2010). Out of 287 municipalities, 79 (27%) answered the questionnaire after two follow up surveys. In fact these represented 90 (31%) of the municipalities since some of them cooperate in their supervision. Out of 21 counties seven (33%) answered. In the questionnaire the authorities were asked to state the number of objects in each category, A, B, C, and U, for which they were supervising authority for the years 2005, 2006 and 2007. They were also asked to state the number of inspections/visits that were accomplished per year and firm category (A, B, C and U respectively). Thus, this survey contains data on total firms and firms in different categories, N_F, inspections, Ins_F, and violations, $Viol_F$, where $F=all,A,B,C,U$. Due to the short time perspective the commonly used explanatory variable on state dependent inspections could not be constructed.

The survey also contained questions on inspection style, which can be measured along two dimensions; whether the authority perceives its duties to supervise compliance or to provide information, and, given that the main task is regarded as supervision of compliance, whether the inspector uses 'strict' or 'soft' supervision. The 'strict' style is regarded as a relative formal approach to firms and the 'soft' as more of making friends (Johannesson et al., 1999). In the questionnaire inspection authorities were asked for their perceptions of themselves as being advisor-supervisor along a 0-100 scale where 0 is pure supervisor and 100 is a pure advisor. The same scale was used for assessing the perception of being soft versus strict where 0 is purely soft and 100 is entirely strict or formal. The variables are denoted *Insadv* and *Insfor* respectively.

The municipalities and counties differ considerably with respect to wealth and income where the urban regions with the largest cities have the highest average income. This may reflect opportunities for firms to earn income, which may have a negative or positive effect on violation. Following Earnhaert (2004) we therefore include income per capita, *Inc,* as an explanatory variables. If it reflects firms' losses of incomes from complying with regulations, it should have

a positive impact on violation. If it instead is negative, it can be interpreted as profits showing firms' affordability to comply with regulations.

Data on explanatory variables not directly related to economic motives, environmental attitudes and social capital, are obtained from a regular poll survey of Swedish citizens attitudes (Holmberg et al., 2010). The statistics report results from attitudes towards a number of different social concerns, where environmental attitudes are represented in two categories; general environmental attitudes and organisation in environmental organisations. We use both these variables in our regression equations; general environmental interests, *Envint*, and activity in environmental organisation, *Envorg*. For both these variables people were asked to rank their general interest in environmental questions on a scale where 1 indicates "very interested", 2 "fairly interested, 3 "not very interested" and 4 "not interested at all". Hence, if more interest means higher compliance the variable *Envint* should have a positive sign as explanatory variable to violation. The variable for environmental organisation, *Envorg*, is indexed in the opposite way, where a higher index, ranging from 1-5, implies higher level of activity.

Variables for two parameterizations of social capital, organisational engagement and general trust, are used in this study. Data on both variables are obtained from (Holmberg et al., 2010) as cardinal measurements. The variable, engagement in organisations, denoted *Org,* constitutes a cardinal measurement where people were asked about their level of engagement in different organisations. Here, 1 indicates "not member", 2 "member but have not participated in any meeting last year", 3 "member and have participated in meeting last year", and 4 "member with some kind of commission". The variable for general trust, *Trust* , is measured on a cardinal scale between 0 and 10, where 0 is no trust and 10 is full trust on 'people in general'.

In addition to these explanatory variables, we introduce dummy variables for two years, *D2005* and *D2006*, and for inspection authority, *Dauth*, which is 1 for a county and 0 for a municipality. In order to avoid too much influence of out layers a dummy is introduced for very large

violations, *Dlarge*, which is 1 for violations exceeding 400 and 0 otherwise. All variables with abbreviations, explanation, and data sources are presented in Table 1 followed by descriptive statistics in Table 2.

Table 1: Abbreviations, description of variables and data sources

Dependent variables:	
$Viol_F$	violations of F classified firms where F=all, A,B,C,U
Explanatory variables:	
Economic motives;	
Ins_F	number of inspections of F classified firms where F=all, A.B,C,U (Holstein, 2010)
Insfor	index of inspection style as formal (Holstein, 2010)
Insadv	index of inspection style and confronting (Holstein)
Inc	income/capita, 1000 SEK/year (SCB, 2010)
Environmental attitudes;	
Envint	general environmental interest (Holmberg et al., 2010)
Envorg	organisational engagement in environmental organisations (Holmberg et al., 2010)
Social capital;	
Trust	trust index (Holmberg et al., 2010)
Org	organizational engagement (Holmberg et al., 2010)
Others;	
N_F	number of F classified firms where F=all, A,B,C,U (Holstein, 2010)
Dauth	dummy for county inspection
D2006	dummy for year 2006
D2005	dummy for year 2005
Dlarge	dummy for number of violations > 400

Table 2: Descriptive statistics

Variables	*n*	*Mean*	*Stand. dev.*	*Minimum*	*Maximum*
Dependent variables:					
$Viol_{all}$	258	43	124	0	1080
$Viol_A$	74	1.6	4.7	0	26
$Viol_B$	197	8.1	28	0	275
$Viol_C$	230	16	34	0	200
$Viol_U$	198	26	106	0	889
Explanatory variables:					
N_{all}	258	233	352	7	2955
N_A	77	5.5	7.2	1	46
N_B	197	27	44	1	290
N_C	230	75	72	14	548
N_U	198	187	317	2	2339
Ins_{all}	258	49	58	0	380
Ins_A	77	7.3	17	0	111
Ins_B	197	13	18	0	114
Ins_C	230	23	31	0	211
Ins_U	198	22	30	0	149
Insfor	225	58	27	10	100
Insadv	234	38	17	10	90
Inc	258	213	26	174	372
Envorg	258	1.1	0.1	1.0	1.3
Envint	258	2.2	0.2	1.9	2.6
Trust	258	6.4	0.4	5.3	7.0
Org	258	1.4	0.1	1.2	1.9

The descriptive statistics show that average number of U-classified firms is approximately 34 times larger than that of A-classified firms, which is in line with the entire population measured in early 1990s (Gren and Li, 2011). On the other hand, the average level of violation among A-classified firms is approximately 16 times larger than that of U firms. It can also be noted that in average, an A classified firm is inspected 1.33 times during the three year period, and a U

classified firm 0.12 times. This may imply that the practice of spending relatively much budget resources for inspecting large firms in early 1990s shown by Gren and Li (2011) is exercised also in the period 2005-2007. We can also note from the descriptive statistics that the standard deviations of the response variables are quite large relative to the means, which may be an indication of over-dispersion.

4 Econometric models and results

In order to test the explanatory power of the different independent variables displayed in Tables 1 and 2, we carry out regressions for all firms and for different firm categories. A quadratic 'production function' of violation in inspections is specified, and the regression equation is then written as

$$\begin{aligned} Viol_{Fit} = {} & Intercept^F + \beta^{F1} Ins_{Fit} + \beta^{F2} (Ins_{Fit})^2 + \chi^F Insfor_{it} + \phi^F Insadv_{it} + \gamma^F Inc_{it} \\ & + \phi^F Envorg_{it} + \varphi^F Envin_{it} + \nu^F Org_{it} + o^F Trust_{it} + \theta^F N_{Fit} \\ & \eta^F Dauth + \kappa^F D2005 + \nu^F D2006 + \lambda^F Dl\arg e + \varepsilon_{Fit} \end{aligned} \quad (1)$$

where *F=all, A, B, C, U* firm categories and ε_{Fit} is the error term.

The response variable, number of violating firms, is characterised as an event count, i.e. the realisation of a non-negative positive integers (Cameron and Trivedi, 1998). Ordinary least square method then gives rise to biased and inefficient estimates, and researchers have therefore developed nonlinear models that are based on Poisson or negative binomial distributions (e.g. Long, 1997). A Poisson distribution is a discrete probability distribution where the probability that an event occurs in a given time interval is independent from the occurrence of the last event but at a known average rate, implying that the mean equals the variance. Thus the number of occurrences fluctuates around its mean. Since the variance in the response variable is

considerably larger than the mean (see Table 2), the dispersion parameter is statistically significant and we therefore apply a negative binomial regression model, which is written with the dependent variables, $Viol_F$, as a random variable and $Viol_{Fi}$ number of occurrences

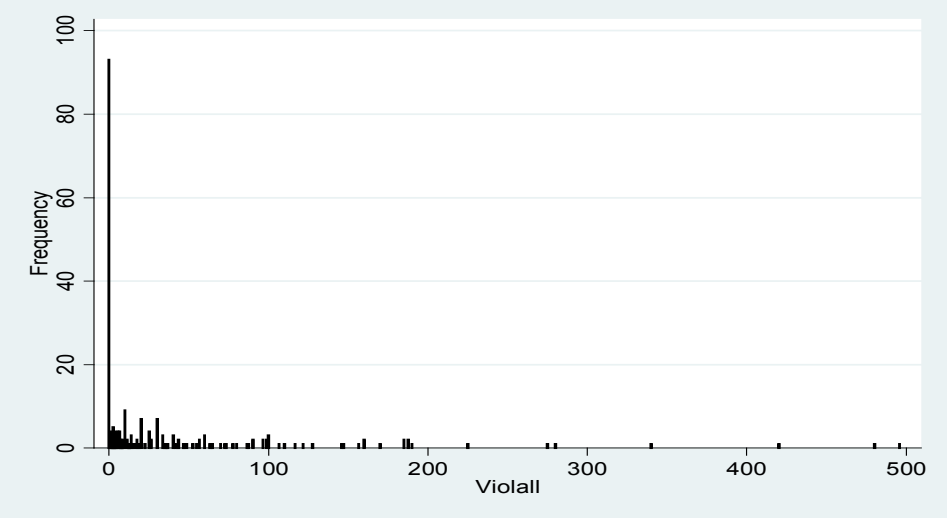
$$\Pr ob(Viol_F = Viol_{Fi} \frac{e^{-u_{Fi}} \mu_{Fi}^{\ y_{Fi}}}{Viol_{Fi}!} \quad (2)$$

and $$\ln \mu_{Fi} = x_{Fi}\beta^F{}' + \varepsilon_{Fi} \quad (3)$$

where μ_{Fi} is the average frequency of the dependent variable, x_{Fi} is a vector of explanatory variables, β^F is a vector of estimated coefficients, and $e^{\mu_{Fi}}$ is a Gamma distribution with mean 1 and variance α, which is a measure of dispersion. When $\alpha=0$ the probability distribution is a Poisson. We therefore display likelihood ratio tests of $\alpha=0$ when presenting the regression estimates.

However, the data contains a relatively large number of observations with the value zero on the response variable, which is displayed in Figure 1.

Figure 1: Frequency of the dependent variable $Viol_{all}$



Zero can arise when violation is present but not detected, but also as a true non-existent violation in the region. In order to account for these possibilities we will test methods that account for two processes; one for the existence of zeros and the other for the magnitude of the dependent variable. The expected count is then expressed as a combination of both these processes, i.e. the probability that the firm violates but is not detected and the probability of no violation given an inspection.

We might expect the independent variables Ins_F to be endogenous in the perspective of the local supervision authority since they are determined by perception of compliance and budget resources. If so, the estimators will not give consistent estimates. An augmented Hausmann test was therefore carried out with labour, community characteristics, and number of firms to regulate as independent variables (e.g Davidson and McKinnon, 1993). The result did not reveal endogenous Ins_F at the 10% confidence level. Another problem may arise from the existence of multicollinearity, which affects the precision of the coefficient estimates in all models. The correlation matrix (Table A1 in the appendix) does not show high correlation coefficients between any explanatory variables.

Tests were also carried out for the existence of heteroscedasticy, which turned out to be present. We therefore use robust estimates for all models. In Table 3 we present results from OLS and count data regressions with $Viol_{all}$ as dependent variable. The count data regressions are presented with and without corrections for large number of zeros, Standard and Zero inflated respectively.

Table 3: Results from robust OLS and count data regression estimates for all firm categories, n=213.

Variables	*OLS*		*Negative binomial: Standard*		*Zero inflated*	
	Coeff.	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*
Intercept	-157.9	0.087	0.121	0.975	-1.19	0.678
Ins_{all}	0.522	0.000	0.023	0.000	0.014	0.000
Ins_{all}^2	-0.001	0.006	-0.46-4	0.000	-0.273-4	0.000
N_{all}	-0.011	0.112	1.93-4	0.713	5.59-4	0.000
Inc	0.072	0.526	0.006	0.358	0.013	0.001
Insfor	-0.755	0.000	-0.021	0.000	-0.021	0.000
Insadv	-0.326	0.100	-0.004	0.581	-0.003	0.680
Envorg	-83.63	0.185	-6.26	0.000	-4.39	0.000
Envint	51.18	0.043	1.80	0.032	2.05	0.005
Trust	10.63	0.139	0.221	0.480	0.252	0.355
Org	61.91	0.078	2.01	0.078	0.305	0.760
Dlarge	206.1	0.000	0.481	0.288	0.731	0.044
Dauth	-13.02	0.069	-1.89	0.000	-1.38	0.001
D2005	0.629	0.943	-0.013	0.953	0.205	0.252
D2006	0.639	0.937	0.081	0.696	0.110	0.509
Inflate:						
Intercept					-0.503	0.111
Insall					-0.012	0.108
Adj. R^2	0.63					
Log likelihood	-1119.397		-801.80		-775.389	
Wald			570.82		477.37	
LR test of α			p=0.000		p=0.000	
Voung test					p=0.000	

The results presented in Table 3 show that the skewed distribution of the dependent variable is manifested in the LR test of *α,* which clearly shows the better performance of the negative binomial estimates. The Voung test reveals inflated zeros, and the negative sign of the coefficient

of the inflated variable Ins_{all} in the logistic regression shows that the log odds of being excessive zero decrease for every additional inspection, or, put it differently, the more visits in the group the lower is likelihood for an undetected violation.

Common significant results to all models are the positive coefficient of the linear and quadratic components of Ins_{all}, the negative coefficient of *Insfor* and *Dauth*, and the positive effect of *Envint*. The positive linear coefficient of Ins_{all} is surprising, but the negative coefficient of the quadratic term point at a peak where violation starts to decrease at higher levels of inspections or punishments. This peak level occurs, for the count data models, at 250 which correspond to the average level of inspections. Instead, inspection style, in particular formal treatment of firms, turns out to have significant mitigation effect on violation. It is also interesting to note that an advisory in contrast to a confronting strategy has a negative effect on violation, but the estimated coefficient is significant only in one of the regression models.

The estimated coefficients of two variables reflecting environmental attitudes, *Envint* and *Envorg,* show expected and robust signs (recall that the index for *Envint* is higher for lower interest), and that for *Envorg* is also significant in two models. On the contrary, none of the social capital variables show any significant impact. We would expect the *Trust* and *Org* coefficients to be negative if higher level of social capital curbs violation. However, the signs of these coefficients are positive in all models.

When choosing among the models in Table 3, the results of the LR test of α and the Voung test of zero inflation clearly favours the zero inflated negative binomial model. The main results for this model indicate that economic motives, as measured by inspections and inspection styles, and environmental attitudes, in terms of environmental organisation and interest, affect violation. In contrast, the chosen variables on social capital do not show any significant impact.

The pattern of results for all firms presented in Table 3 is partly reproduced for separate regressions of firm classes, see Table 4. The zero inflated negative binomial model is used for all firm categories except for A firms.

Table 4: Results from zero inflated count data regressions for different firm types

	A firms, n=58: (Poisson standard)		*B firms, n=164: (Negative binomial)*		*C firms, n=192; (Negative binomial)*		*U firms, n=172: (Negative binomial)*	
	Coeff.	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*
Intercept	91.436	0.057	-25.341	0.008	-0.021	0.995	1.208	0.777
Ins_F	0.070	0.010	-0.044	0.004	0.032	0.000	0.026	0.004
Ins_F^2	-4.16-4	0.129	2.861-4	0.068	-1.505-4	0.000	-1.9-4	0.007
N_F	0.270	0.029	0.019	0.002	0.005	0.007	-0.001	0.062
Inc	-0.062	0.005	0.028	0.000	0.007	0.181	0.020	0.007
Insfor	-0.102	0.012	-0.015	0.007	-0.013	0.001	-0.025	0.000
Insadv	0.014	0.420	-0.001	0.914	0.003	0.657	-0.010	0.202
Envorg	-29.197	0.082	-13.186	0.000	-1.229	0.490	-3.521	0.163
Envint	-0.903	0.829	4.598	0.000	1.769	0.025	0.378	0.672
Trust	-5.927	0.053	0.046	0.927	0.429	0.127	-0.032	0.921
Org	-4.786	0.663	17.998	0.000	-3.015	0.006	1.106	0.619
Large	0.927	0.280	2.158	0.000	0.697	0.053	2.035	0.000
Dauth	0.708	0.577	-2.641	0.000				
D2005	1.086	0.094	0.327	0.270	0.034	0.855	0.505	0.050
D2006	0.701	0.240	0.386	0.176	-0.020	0.911	0.171	0.452
Inflate:								
Intercept			1.347	0.000	-0.209	0.357	0.537	0.012
Ins_I			-0.329	0.000	-0.010	0.251	-0.041	0.000
Log pseudo likelihood	-39.75		-303.94		-574.54		-453.44	
Wald	124.77		237.14		239.50		199.12	
LR test of α	p=1.000		p=0.000		p=0.000		p=0.000	
Voung test	p=0.549		p=0.000		p=0.000		p=0.002	

The results presented in Table 4 show satisfactory statistical results for all firm categories, where the test results reveal the need for zero inflated negative binominal model for all categories except the A firms. The number of observations is relatively small for this category which may explain the relatively low values of overall test results as shown by the Wald test.

One of the main results in Table 4 is that all three categories of variables, i.e. economic, environmental attitudes, and social capital, have impacts on violation by A, B, and C firms, but only economic variables act on U firms' violation. The U firms face the lowest environmental requirements, and the results indicate that only traditional enforcement activities affect their compliance.

Traditional enforcement also impacts violation by the A, B, and C firms but acts together with environmental attitude and social capital variables, but in slightly different ways. For these three firm categories, one of the environmental attitude variables is significant and has the expected sign. This is also the case for the social capital variables for the A and C but not the B firms. For the B firm category, the *Org* variable is positive, which is unexpected. On the other hand, both variables for environmental attitudes affect the violation by this firm category. It may be argued that *Envorg* can be regarded as a 'green' social capital variable, which shows significant effect on B firms' violation.

5. Summary and conclusions

The purpose of this paper has been to test the explanatory power of three classes of factors affecting firms' violation behaviour; economic motives, environmental attitudes, and social capital. A survey to Swedish inspectors at the municipality and county jurisdictional levels provides the main data source, which allows for testing violation behaviour for different firm categories. A count data model was used, which also adjusted for the relatively large number of observations with zero value on the dependent variable.

One of the main results from the econometric regressions is that traditional enforcement mechanisms, measured by number of inspections and inspection style, act on all firms and firm categories. In particular, the results indicate that a formal inspection style curbs violation, but an

advisory in contrast to confronting style has no significant impacts on violation by any firm category. The latter finding is in contrast with the findings in Burby and Patterson (1993).

In contrast to economic factors, variables reflecting environmental attitudes and social capital do not show clear and significant effects on violation by all firm categories. The category with the smallest firms with respect to environmental regulations responds only to traditional enforcement. On the other hand, violation by firms with the largest environmental impact and regulatory stringency is curbed by positive environmental attitudes and abundance of social capital in the community. Thus, our results are in accordance with other studies indicating the importance of traditional monitoring and enforcement activities for managers' decisions with respect to compliance with environmental regulations. For example, Delmas and Toffel (2008) showed in a survey of U.S. industrial manager that formal regulations and law have more influence on environmental performance than community organisations or media. On the other hand, it can be argued that the empirical research on the role of non-economic motives for violation is in a relatively early phase compared with that on traditional enforcement parameters and more research is needed to measure and test different variables reflecting non-economic motives.

A policy conclusion from the results obtained in this paper is thus to apply a precautionary approach with respect to reliance on voluntary mechanisms for implementation of environmental policies. While traditional enforcement instruments, in terms of monitoring and inspecting firms, deter violation by all firm categories, other mechanisms can be more selective. Relatively large firms seem to be more responsive to environmental attitudes and abundance of social capital than small firms. Considering that the number of small firms can be quite large, accounting for approximately 64% of all regulated firms in Sweden, traditional enforcement weapons may be necessary to reach targets set by environmental regulations.

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Appendix: Table A1

Table A1: Correlation matrix

	Violall	Insall	All	Inc	Insfor	Insadv	Envorg	EnvInt	Org	Trust	Large	Dauth	D2005	D2006
Violall	1													
Insall	.54	1												
All	.15	.10	1											
Inc	-.01	-.02	.12	1										
Insfor	-.31	-.12	-.20	-.05	1									
Insadv	-.01	-.12	.03	.09	.21	1								
Envorg	-.08	.02	-.07	-.09	-.01	-.07	1							
EnvInt	.16	-.01	-.12	-.18	-.04	.11	.02	1						
Org	-,04	-.07	.01	-.10	.12	.18	.26	-.20	1					
Trust	-.03	-.09	.08	.19	.01	-.09	-.18	-.30	.17	1				
Large	.68	.51	.23	-.05	-.03	-.02	-.08	.10	-.02	-.03	1			
Dauth	-.14	-.10	-.12	-.02	.24	.22	-.10	-.02	.02	.02	-.06	1		
D2005	-.00	-.02	-.01	-.22	-.03	-.03	-.01	-.02	-.00	.00	.00	-.01	1	
D2006	-.01	-.03	.00	-.01	-.02	-.01	.01	.01	.00	.01	.00	.01	-.49	1

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