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A dissolving paradox: Firms' compliance to environmental regulation

Karine Nyborg^ψ and Kjetil Telle^{ζ1}

Abstract

It has often been claimed that firms' compliance to environmental regulations is higher than predicted by standard theory, a result labeled the "Harrington paradox" in the literature. Enforcement data from Norway presented here appears, at first glance, to confirm this "stylized fact": Firms are inspected less than once a year, detected violators are seldom fined, but still, serious violations seem relatively rare. However, at a closer look, the paradox dissolves: Enforcement of minor violations is lax, but such violations do flourish; serious violations are more uncommon, but such violations are subject to credible threats of harsh punishment. This seems quite consistent with predictions from standard theory. Although our finding may of course apply to Norway only, we argue that the empirical existence of the Harrington paradox is not well documented in the literature. Hence, the claim that firms' compliance with environmental regulations is higher than predicted by standard theory should be viewed with skepticism.

Keywords: Environmental performance, compliance, enforcement, Harrington paradox

JEL classification: K32, K42, Q28, L51

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1. Introduction

According to Gary Becker's (1968) theory of rational crime, a profit-maximizing firm will comply with an environmental regulation only as long as the expected penalty of violating exceeds the compliance cost. On this background, economists have been puzzled by evidence seeming to indicate that firms comply to a much higher degree than predicted by this theory. Harrington (1988, p.29) summarized this phenomenon in the following three statements:

- (i) *For most sources the frequency of surveillance is quite low.*
- (ii) *Even when violations are discovered, fines or other penalties are rarely assessed in most states.*
- (iii) *Sources are, nonetheless, thought to be in compliance a large part of the time.*

Harrington's three statements appear to be at odds with the theory of rational crime: If the probability that a violator gets punished is low, why would any firm bother to comply at all? This description, denoted the "Harrington paradox" by Heyes and Rickman (1999), initiated a substantial amount of theoretical work.²

Harrington's (1988) paper was mainly theoretical, focusing on optimal enforcement. He showed that if the maximum penalty level is restricted, a regulator's enforcement can be made more efficient by dividing firms into groups, contingent on each firms' past performance, and then subject recent violators to a stricter monitoring and sanctioning policy than others. His paper was followed by several others, discussing his theory and/or suggesting alternative explanations; some examples are Harford and Harrington (1991), Raymond

² To establish a paradox, it must also be documented that (marginal) compliance costs are large enough to exceed the expected value of (marginal) penalties, even if the latter are low. . Systematic and reliable data on firms' compliance costs are generally difficult to obtain. This is an additional reason to doubt that the Harrington paradox can be viewed as an empirically established fact. Below, we will assume that compliance costs are strictly positive and non-negligible.

(1999), Heyes and Rickman (1999), Livernois and McKenna (1999), Lai et al. (2003), Decker (2003), Heyes (1996), Harford (2000), and Friesen (2003).

In spite of Harrington's (1988) theoretical focus, his paper is frequently quoted as support for empirical claims that firms' environmental performance is better than predicted from standard theory. Cohen (2000) refers to the Harrington paradox as a "stylized fact". Heyes (2000) calls it one of the "best known empirical 'results' in the field". Harrington's (op.cit.) empirical statements were based on studies of monitoring, enforcement and compliance with environmental regulations in the US in the late 1970s/early 1980s, among them Russell et al. (1986). Livernois and McKenna (1999) mention some evidence from Canada, but without analyzing the data in any depth.³ Apart from this, studies of the empirical existence of the Harrington paradox seem to be scarce. Several studies document a rather lax enforcement practice in the US and British environmental protection agencies (Hawkins 1984, Russell 1990, White 1996, Rechtschaffen 1998). However, it is much less clear that firms' compliance in these cases has been high; indeed, both White (1996) and Russell (1990) report quite high violation rates – often far in excess of 50 percent.⁴

Several papers in the theoretical literature in fact seem to end up relying only on Harrington's original paper or on his sources as their documentation for the alleged pre-established empirical existence of the Harrington paradox. For example, Livernois and McKenna (1999) and Lai et al. (2003) both quote Russell et al. (1986) and Cropper and Oates (1992) on this point; the former of these two papers is Harrington's (1988) main source, while

³ "Evidence from Statistics Canada shows a similar pattern. Data on industrial compliance rates over the period 1986-1989 show that six of the nine industrial sectors were in compliance with all monthly pollution standards more than 70 % of the time." (Livernois and McKenna 1999, p. 416.) In a footnote they state that no comprehensive data set exists on enforcement activity, but quote data showing that few fines were levied.

⁴ See also Earnhart (e.g. 1997, 2000) on environmental performance in the Czech republic under and after the communist regime, and Haagenen et al. (1991) on environmental regulations and punishment of violators in the Nordic countries. For econometric studies on firms' responses to the enforcement practices of environmental regulators, see e.g. Magat and Viscusi (1990), Deily and Gray (1991), Gray and Deily (1996), Laplante and Rilstone (1996), Nadeau (1997), and Dasgupta et al. (2001). For a survey of the literature on monitoring and enforcement, see Cohen (2000).

the latter contains no independent empirical evidence and just refers back to Harrington (1988)⁵.

In the current paper, we present Norwegian data on enforcement and compliance which, at first glance, appears to confirm the existence of a Harrington paradox: Inspections of permit holding firms are performed less frequently than once a year; criminal penalties are imposed upon only a marginal proportion of all detected violations; but still, the Norwegian Pollution Control Authority⁶ (NPCA) rarely detects persistent, severe violations. We will argue, however, that this way to summarize the data is more misleading than illuminating. When looking closely at the detailed information, and taking the nature of the enforcement policy into account, the paradox seems to dissolve: Those types of violations that are not sanctioned or sanctioned mildly, do indeed occur frequently, while the kind of violations which are faced with harsh punishment are seldom observed. The data thus seems quite consistent with the theory of rational crime. Although this finding may of course apply only to Norway, and the Harrington paradox may certainly exist elsewhere, we believe that the empirical existence of the Harrington paradox is not well documented in the literature. Until further research has provided more comprehensive evidence, this “stylized fact” should be viewed with skepticism.

2. A sketch of the Norwegian regulatory system

The main rule of the Norwegian Pollution Control Act⁷ is that any pollution is prohibited unless an explicit permit has been issued. “Pollution” is defined to cover all emissions that may cause damage or be disadvantageous to the environment. This wide definition means that

⁵ Another example is Friesen (2003, p. 72) who relies solely on Harrington (1988) and Livernois and McKenna (1999) when stating that “compliance is generally considered to be high, despite low inspection probabilities and small fines”. Russell et al. (1986), one of Harrington’s sources, in fact contains evidence of widespread violations.

⁶ Statens forurensningstilsyn.

at the outset, practically any emission is illegal. The most important general exceptions from this main rule are one for transportation and one for “ordinary” pollution from private homes and office buildings. However, most firms in manufacturing industries need an emission permit to operate legally.⁸

The Norwegian Pollution Control Authority (NPCA) grants permits and monitors the environmental performance of firms. A permit may specify maximum emission levels per unit of time or per unit of spill water or production. However, permits also emphasize qualitative regulations concerning institutional aspects within the firm: An almost universal requirement, for example, is that internal routines and audition systems for environmental surveillance must be properly implemented. Violation of such qualitative regulations may not immediately influence the environment, but is viewed as increasing the probability that an environmentally harmful situation occurs. NPCA appears to place substantial emphasis on monitoring these requirements.

NPCA monitors the environmental performance of operations⁹. NPCA’s cost of an inspection must be covered by the inspected firm, and this cost can be considerable (up to about 25 000 euros, Gebyrforskriften 1996). In addition, inspections may inflict substantial work on the firm’s own staff.

Inspections normally focus on routines and general maintenance of equipment rather than actual emissions. There are several reasons for this. First, emissions may legally fluctuate during a day, week, or year; therefore, to measure emissions at the time of an inspection may say little about the firm's actual compliance with the regulations. Second, emissions may be

⁷ Forurensningsloven (1981).

⁸ Our description of rules, routines and firm behavior relates to enforcement of the Pollution Control Act in the period 1992-2002. Firms’ performance as well as NPCA’s enforcement practice have changed considerably since the 1970s (Golombek et al. 2000). Time series on violation data may not indicate trends in emission levels, since the requirements specified in firms’ emission permits generally change over time. Other laws than the Pollution Control Act will not be considered.

⁹ The Pollution Control Act secures wide authorities for the NPCA in its surveillance of compliance with environmental regulations; on mere suspicion of violations of environmental regulations, the NPCA is entitled to show up anywhere at any time.

closely related to the technology used by the firm or the maintenance and condition of the abatement equipment. Third, the purpose of the inspections is not only to verify past and/or current violations, but also to prevent future environmental damage; and if a firm does not comply with the institutional requirements (e.g. maintaining an internal environmental audit system) this is believed to increase the probability of such future damages. For the purposes of the present paper, it is important to note that *any* violation of the conditions of the pollution permit, including the institutional requirements, is a violation of environmental regulations. Breaking institutional requirements makes the firm a violator even if its actual emission levels did not exceed emission caps.

Roughly half of all permit-holding firms are required by the NPCA to submit annual *self-reports* on their environmental performance. The operation must deliver a careful report containing exact information on emissions, production, energy consumption, violations, etc. These reports are legal documents, and a firm may be punished on the information given in such a report. Failure to report violations of environmental regulations, or conscious misreporting, is a serious crime that may be punished harshly. Below, we will use both inspections data and data based on self-reports.

The maximum criminal penalty for violations of environmental regulations is 15 years of imprisonment¹⁰. In a criminal trial, fines may also be imposed upon persons or corporations, and profits gained through non-compliance may be confiscated¹¹. A criminal penalty (i.e. imprisonments or criminal fines) requires investigation by the police, prosecution and a court conviction. In cases where imprisonment is not considered, the prosecution authority

¹⁰ The Norwegian Criminal Act §152b.

¹¹ We have used the following translations of Norwegian legal concepts; bot: criminal fine, forelegg: fine in lieu of prosecution, tvangsmulkt: coercive fine.

normally suggests a fine in lieu of prosecution. If the alleged criminal accepts the fine, the case is settled without a trial¹². NPCA can initiate prosecution by filing a formal accusation.

Usually, however, the first thing NPCA does when a violation is detected (or suspected) is to mail the firm a warning letter, stating in what ways the firm is believed to be out of compliance, indicating the seriousness of the violations, requesting documentation that the firm is in compliance within a given deadline, and pointing out the firm's legal duty to comply with the instructions. If a firm provides the requested documentation within the deadline, the NPCA will normally take no further action. Violators failing to respond adequately to the warning, however, seem to be met by more formal and direct sanctions.¹³ Coercive fines or even withdrawal of emission permits are available to the NPCA (without prosecution). The use of administrative sanctions has not, at least until recently, been considered to rule out criminal sanctions. In practice, NPCA often awaits filing formal accusations till informal and administrative sanctions are unsuccessfully exhausted. This implies that if a criminal sanction is imposed, the firm will usually already have paid (additional) administrative fines.

3. Inspection frequency and detection probability

In this section we will see that on average, Norwegian permit holding firms are inspected less frequently than once a year. This is even more seldom than what Harrington (1988) reports for the US. However, as will become clearer in the following, a low inspection frequency need not necessarily imply that the *detection probability* is low.

¹² This is not the "plea bargaining" known from criminal cases in the US. The size of a fine in lieu of prosecution is never subject to bargaining, and it is set with regard to the expected outcome of a court conviction. Finally, an acceptance of a fine in lieu of prosecution does not require or imply that the accused accepts any guilt.

¹³ This appears to be in line with the US EPA practice described by Russell (1990, p. 252): "Many states claim to pursue a so-called voluntary compliance policy, by which they mean that no penalties are ordinarily levied for violations initially. Rather, if penalties are used, it is to punish sources that refuse to correct violations or otherwise prove notably uncooperative."

It is the articulated policy of NPCA that the frequency, thoroughness and focus of an inspection vary with firm characteristics. NPCA divides operations with emission permits into four *risk classes*, where the potentially most environmentally harmful operations are put in Risk Class 1 and the less potentially harmful operations are placed in Risk Class 4. Potentially more risky operations are inspected more frequently and thoroughly than less environmentally risky operations. According to the inspection scheme of NPCA firms in Risk Class 1 are subjected to thorough inspections every other year and normal (less thorough) inspections every other year. Firms in Risk Class 4 are rarely inspected at all. Based on each inspection result, NPCA inspection officers make explicit recommendations concerning future inspection frequencies. Bad performers may receive a new inspection prior to what follows from the inspection scheme for firms in that risk class, and vice versa.¹⁴ In cases where the inspector found no evidence of violation, but still suspects that something is wrong, he may also record a need for more frequent inspections of the firm.

Table I shows the inspection frequency during the period 1992 – 2000 among permit holding firms subject to the self-report requirement¹⁵. This includes all firms in Risk Class 1 and 2, but very few in Risk Class 4 (Walle 2003). Over this whole period 1891 reports were submitted. The inspection frequency of the firms submitting reports was .44 per year, i.e. an average of one inspection every 27 months. The inspection frequency increases with risk class: The potentially most environmentally harmful firms are inspected every 15 months, while firms in Risk Class 4 are inspected on average only every 70 months.

(Table I about here)

¹⁴ Information from the public, environmental organizations, or the police may also initiate a higher than regular inspection frequency.

Based on data on inspections from 1992 -2002, we performed a regression with the number of days till next inspection as the dependent variable (see the appendix for details). The results confirm that when NPCA inspectors recommend a higher inspection frequency than indicated by the regular scheme, firms are actually being inspected again *significantly* and *substantially* earlier than other firms in the same risk class. Hence, it is clear that if the NPCA receives indications (from inspections, careless self-reporting, the general public, the police, or other sources) that a firm may not be complying, the firm will face a higher inspection frequency than reported in Table I.

Whether inspections are frequent or not is of course a relative question. For example, consider the purpose of catching with hot hands someone who pours hazardous liquid into a river. Say that he spends five minutes every month doing this, and that after those five minutes nothing can be verified. Clearly, for such a purpose an inspection every other year is hopelessly infrequent.

The inspections of the NPCA, however, focus heavily on the functioning and maintenance of abatement and auditing equipment, whether the technology is adequately implemented, and whether internal routines and auditing systems are implemented as required in the permits. For the purpose of monitoring compliance with such regulations, one may not need very frequent inspections. NPCA inspectors can spend several days in the firm, interviewing any employee, inspecting books and equipment; and through such extensive visits it may be very difficult for a firm manager to hide a systematic neglect of institutional or equipment-related environmental regulations. Recall that such requirements are not merely

¹⁵ See the section on compliance for a closer presentation of the data. The data does not allow calculation of inspection frequencies for firms not subject to self-reporting, since we do not know the number of such firms that are not inspected.

formalities. They are there to reduce the probability that damage occurs. Hence, a low inspection frequency is not necessarily the same as a low detection probability.¹⁶

Harrington (1988) and Russell (1990) distinguish between *initial compliance*, meaning mainly compliance to requirements of installing abatement equipment, and *continuous compliance*, meaning the keeping over time of emission caps. They seem to regard these types of compliance as rather independent, and focus on the latter. However, there is a relationship between the two: While installing abatement equipment – and probably also establishment of sound environmental auditing routines – can be associated with large fixed cost, such measures also often reduce the *variable* abatement costs, and hence the profitability of violating emission caps. If so, a firm with the necessary equipment and routines in place will be less likely to exceed its emission caps.

4. Are most firms in compliance?

In this section, we will use data from inspections and the self-reports to study compliance to environmental regulations among Norwegian firms. The data indicates that persistent, severe violations are rare. However, this does not mean that most firms are in compliance: Most inspections, and even most self-reports, reveal minor violations of some kind. Moreover, serious violations are not altogether uncommon, even if they usually do not prevail over time after they have been detected.

4.1. The data

Any data on compliance must be viewed with a certain skepticism, since firms may have incentives to conceal violations. Whether a violation has occurred is also a legal judgment

¹⁶ Moreover, the inspections give priority to those firms that are believed to have the largest potential for causing

which is to some extent subjective, since this is usually not simply a question on whether emission caps are exceeded or not.¹⁷ The data presented here are based on the reports filed by NPCA's auditors, as well as firms' self-reports. After each inspection, and following each self-report, NPCA officers file their judgment of whether findings represent a deviation from the regulatory requirements, and whether findings justify changes in the inspection frequency of the firm. Below, we will use these data as indicators for firms' compliance. Only firms with pollution permits are included, implying that while the potentially most environmentally harmful firms are included, many firms with only "ordinary" emissions from transport, heating of office building etc. are excluded. The majority of the firms with pollution permits are in the manufacturing industries.

The *inspection data set* includes 794 different firms with a permit, and covers the period from 1992 to 2002¹⁸. Before 1997, the most important recorded variable for our purpose is the inspector's recommendation concerning future inspection frequency. The NPCA's routines imply that if severe violations are detected, more frequent inspections are usually recommended; hence this variable can be used as a rough indicator of the degree of compliance. In 1997, however, data quality improved, and from this date on we have direct information on whether an inspection revealed violation(s). Since potentially environmentally harmful operations and suspected violators are inspected more frequently than other firms, such firms are generally overrepresented in the inspection data. NPCA usually focuses on some parts of an operation during an inspection, and may thus not discover all violations actually present.

environmental damage. This means that those firms, which are most likely to have serious violations, are monitored more often than others.

¹⁷ See Bugge (1999).

¹⁸ The data for the year 2002 is likely not to include all inspections performed. On average 2.7 inspections per firm are reported during this period. Note, however, that due to factors like entry and exit, some firms will not be included in the dataset in every year.

The *self-reports data set* covers 304 different firms over the period from 1992 to 2000. On average each firm has submitted 6 reports during this period¹⁹. Only firms with a certain potential for environmental damage are subject to the self-reporting requirement; hence, more environmentally risky operations are overrepresented.²⁰ However, as self-reports are due once a year for all firms, irrespective of any suspicions by NPCA, suspected violators are not necessarily overrepresented. One must of course keep in mind that firms may report untruthfully to the NPCA, even if the punishment for conscious misleading reporting is harsh.

4.2. Violation frequency

Since NPCA started to register data on violations in 1997, one or more violations are found in about 79 percent of all inspections. This overall violation frequency is relatively stable over the years (see Table II).

Table III shows that the high detection of violations in inspections is not due to many inspections in a few notoriously violating firms: 93 percent of the firms inspected at least once over the period 1997 – 2002 were registered with at least one deviation. The table confirms that a higher prevalence of both violations and major violations in risk classes with high environmental risk. Although we know that suspected offenders are monitored more often than others, these numbers seem very high.

NPCA registers violations and categorizes observations in inspections into three classes; "no deviations", "deviations" and "major deviations" from the regulations. *Major deviations* were detected in 12 per cent of the inspections (Table II), and were found at least once in 21 percent of inspected firms during the period 1997 – 2002 (Table III).

¹⁹ All firms required to submit a report did actually do so.

²⁰ See Section 3.

(Tables II and III about here)

The self-reports indicate much the same pattern of violation as the inspection data. 57 percent of all self-reports were judged to indicate violations, a number which has increased slightly over the period. 14 percent of all self-reports indicate serious violations. These numbers are not directly comparable to the inspection data. First, the fact that NPCA inspects suspected violators more often, while self-report frequencies are fixed, works in the direction of more violations in the inspection sample than in the self-report sample. Second, it may be easier to establish a deviation in an inspection than from a report. Third, the reports focus more on emissions than the inspections, while inspections focus more on internal routines and implementation of equipment. Finally, self-reporting firms consist only of a subset of the inspected firms. Nevertheless, violations seem frequent regardless of the data source.

Since 1992, NPCA has records of officers' recommendations for future inspection frequency following each inspection. Recommendations are one of the following: "inspect less frequently than the regular scheme", "inspect according to the regular scheme", "inspect more frequently than the regular scheme", or "consider prosecution". In the latter case, the report is forwarded to NPCA's lawyers. If the inspection did not reveal important deviations, the recommendation would usually be to inspect less frequently or as regular, while more serious violations would result in one of the two latter recommendations. Figure 1 shows how inspection results have been classified from 1992 to 2002. Officers found reason to increase the inspection frequency, but without suggesting prosecution, for 10-15 percent of the firms. In addition, prosecution was considered as a result of about 3 percent of all inspections from 1992-2002.

(Figure 1 about here)

4.3. Persisting or successive violations

If some firms consider their compliance costs to be permanently higher than the expected penalties, one would expect that the firm violates the regulation (Becker 1968); and not just once, but again and again. It is thus of interest to know whether those firms that violate do so repeatedly.

Table IV focuses on the subset of firms whose audit resulted in one of the recommendations "inspect more frequently" or "consider prosecution" at least once. The table shows the characterization such firms received in the *next* inspection, i.e. the first inspection following the above characterization.²¹ In the vast majority of cases, inspector recommendations do not express similar degrees of concern in the next inspection. Only one firm was considered (once) for prosecution in two successive audits. As much as 76 percent of the firms that got one of the two worst characterizations in the previous inspection got one of the to best in the successive one. Although these data do not record violations directly, and must hence be interpreted with care, the results in Table IV seem to indicate that persistent or successive severe violations are uncommon.

(Table IV about here)

Of those firms who submitted a self-report classified as containing "more serious deviations", 13 percent received the same classification on their next self-report. This is nearly the same as the overall frequency of serious deviations in self-reports (14 percent). For 38 percent, the next report was classified by "no deviations"; while in the remaining cases, deviations were found, but not major ones. Hence, it seems to be the case that firms found to be in severe violation of the environmental regulations seldom keep this status over time.

To conclude, both data sources strongly indicate that most firms violate regulations. Indeed, the inspection data indicates that violations abound. Even serious violations are not particularly infrequent. However, persistent or successive serious violations seldom occur.

5. Are observed violators fined?

Table III shows that the NPCA reveals violations in 79 per cent of the inspections, while the data underlying Figure 1 shows that it considers prosecution in only 3 percent of the inspections. Table V shows the number of formal accusations actually filed by the NPCA over the last years²².

(Table V about here)

Literally all firms being formally accused by the NPCA end up facing criminal penalties. In addition to fines, individuals can be sentenced to up to 15 years of imprisonment, and excess profits due to violations may be confiscated. Usually cases are settled with fines in lieu of prosecution. There have been several examples of fines in the magnitude of several hundred thousands euros²³. Hence, strict sanctions are available,²⁴ but the data suggests that criminal sanctions are seldom assessed.

²¹ Note that this implies that some firms may be recorded several times in the table.

²² The figures do not only include accusations according to the Pollution Control Act but also another law surveyed by NPCA; hence compared to other data given in this paper, the data in Table V tends to overstate the number of accusations filed.

²³ In 2001 a manufacturing plant accepted a fine in lieu of prosecution of more than 0.5 million euros for extensive emissions of mercury to a fjord. The year before, an aluminum recycling plant accepted a fine of about 250 thousand euros. In addition about 250 thousand euros were confiscated and members of the management were prosecuted for perjury. In 1997 a man was sentenced to 120 days of imprisonment for pouring an environmentally damaging liquid into a river.

²⁴ Some of the theoretical studies assume that sanctions sufficiently strict to secure compliance are *not* available to the regulator (Harrington 1988, Heyes and Rickman 1999). In the case of NPCA, sufficiently strict sanctions appear to be available, at least formally.

Nevertheless, the fact that firms are not *actually* prosecuted does not necessarily mean that they are not faced with a *credible threat* of harsh punishment. Indeed, according to theory, if the expected penalty is sufficiently harsh, and if firms did not make mistakes, we would never observe that penalties were levied at all, since no firm would choose to violate. Our data shows that firms do violate. However, we also know (see Section 2) that the NPCA normally does not prosecute a firm unless it fails to comply after being warned. A firm is thus *not* faced with strict penalties for *temporary, minor* violations (provided that it demonstrates a willingness to cooperate with the NPCA). This is precisely the kind of violations that seem to abound. But a firm with major violations, which does not respond adequately to NPCA's warnings, *does* face a credible threat of prosecution and harsh sanctions. What we observe is what we would expect from theory, namely that persistent, major violations are rare.

Finally, one should note that a firm that violates environmental regulations may face criminal, administrative, or informal sanctions. In practice, firms face some economic incentives to comply even in the absence of prosecution. Since the firm must cover the inspection costs, an increased inspection frequency is costly. Further, when a warning letter is received, the firm must provide adequate documentation to the NPCA that it has moved into compliance, and this is generally resource demanding for the firm (for example, external consultants may need to be hired). In addition, firms may of course fear bad publicity, which may not depend on formal prosecution.

6. Concluding discussion

Harrington (1988) summarizes the pollution control system in the US in the late 1970s/early 1980s as one where most firms comply, despite low expected penalties. This

apparent puzzle has received much attention by theoretical researchers. However, the empirical evidence for this phenomenon is scarce.

In this paper, we have reported Norwegian data that, at first glance, seems to confirm Harrington's paradox: Inspections are relatively infrequent; few of the detected violators are prosecuted; and still, major, persistent violations of the environmental regulations are rare. However, at closer scrutiny, our findings appear less paradoxical. The enforcement procedures used by the Norwegian Pollution Control Authority (NPCA) implies that firms almost universally get a second chance before prosecution, in terms of a warning letter. If they move into compliance upon receipt of this warning, prosecution is usually not carried through; but in the case of repeated or persistent serious violations, or a consistently ignorant attitude from the firm's management, prosecution is not unlikely. Accordingly, assuming profit-maximizing behavior, standard theory would predict a lot of minor and/or temporary deviations, but few serious and persistent violations. And this is precisely the pattern that we observe. In fact, almost 80 percent of all inspections reveal some kind of deviation from the requirements of the firm's pollution permit.

Although the use of warnings may seem to imply an unnecessarily lax enforcement practice, there are also several arguments in favor of warnings. Whether a policy of warnings before prosecution is rational from the regulator's point of view is outside the scope of this paper, however.²⁵ Nevertheless, note that this policy bears some resemblance to the enforcement practice recommended by Harrington (1988), which implies that persistent violators should be subject to stricter enforcement than others.

Our data is concerned with the situation in Norway. The Harrington paradox, termed a "stylized fact" by Cohen (2000), may of course still provide an adequate description of the

²⁵ In Nyborg and Telle (2003) we show that if prosecution is costly to the regulator, there may be multiple equilibria in the economy, including one with very low compliance and one with very high compliance; and under certain conditions,

situation in other countries. However, as noted in the introduction, the empirical evidence of this seems to be very scarce. Moreover, important features of the Norwegian enforcement scheme, such as the practice of giving warnings, seem to be shared by environmental protection agencies in other countries as well (see e.g. Hawkins 1984, Harrington 1988, or Rechtschaffen 1998). If the enforcement policy in use implies, for example, that minor, temporary violations are hardly sanctioned at all, while major, persistent violations are faced with credible threats of harsh punishment, then in order to test a hypothesis that firms comply to a larger extent than predicted by theory, one needs data that distinguishes between these two types of violation. The data provided in Livernois and McKenna (1999), for example, is much too aggregated to allow such distinctions. In the absence of additional empirical evidence, the claim that firms comply with environmental regulations to a surprisingly high degree should be viewed with sound skepticism.

warnings will then reduce the probability that the economy switches from the high compliance equilibrium to the low compliance equilibrium.

Appendix

The regression was performed on the following random effect panel model with individual effects:

$$Days_till_next_inspection_{it} = Intercept + Risk_class_i\beta + Inspection_character_{it}\gamma + u_i + \varepsilon_{it},$$

where i is the firm index, t is the number of the actual inspection of a given firm, $Risk_class$ is a vector of risk class dummies, $Inspection_character$ is a vector of inspection character dummies, u is the random disturbance characterizing firm i , and ε is the random disturbance.

The vector $Risk_class$ comprises of two elements: “Risk Class 2” and “Risk Class 3 or 4” are set to one if the firm belongs to Risk Class 2, or 3 or 4, respectively; zero otherwise. The vector $Inspection_character$ comprises of one element: “Inspect more frequent” is set to one if the inspector’s recommendation is “inspect more frequent than regular” or “consider prosecution” (inspection recommendations are elaborated on in Section 4)²⁶; zero otherwise²⁷.

The unbalanced panel (firms with only two inspections are excluded) comprises of $i=1,\dots,306$ firms and $t=1,\dots,47$ inspections of one firm. Altogether there are 1186 observations.

Coefficient of...	Parameter estimate	p-value
Intercept	493	<.0001
Dummies (set to one if...)		
Risk Class 2	286	<.0001
Risk class 3 or 4	553	<.0001
Inspect more frequent than regular	-241	<.0001

Table AI: Results from a regression explaining the number of days till the firm was inspected again with dummies for risk class and inspection characterization. Data source: NPCA (2003).

²⁶ Note that “inspect more frequent” refers to the regular scheme of the NPCA for inspection frequency of firms in a given risk class, and not to the actual historical inspection frequency of firm i . Endogeneity problems could occur in the regression model if e.g. the history of environmental performance makes NPCA move the firm to another risk class. However, the main criterion for putting a firm in a specific risk class is the environmental risk of the operation when the permit is issued.

²⁷ These qualitative results are robust against a separation of “Risk class 3 or 4” into two separate dummies, or “Inspect more frequent” into two separate dummies. They are also robust against a two-way random effect specification, where a random disturbance characterizing inspection number t of the firm is included. Further, the estimated coefficient (and standard deviation) of “Inspect more frequent” remains very similar under both a one way and a two way fixed effect specification. A hypothesis of no fixed effects can be rejected (F-test, $p<.001$). A random effect model may be preferred to the fixed effect model (a Hausman test of the hypothesis that individual effects are uncorrelated with the other independent variables in the model cannot be rejected, $p>0.36$).

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	Risk class				
	Total	1	2	3	4
Number of self-reports from different firms ²⁸	1891	459	479	924	29
Number of inspections	839	361	216	257	5
Mean inspection frequency per year	.44	.79	.45	.28	.17

Table I: Inspection frequency for firms that submit compulsory annual reports 1992-2000.

Data source: NPCA (2003) and NPCA (2001).

²⁸ A few firms hold multiple permits and must submit multiple self-reports.

	1997- 2002	1997	1998	1999	2000	2001	2002
Number of inspections	878	185	153	127	172	144	97
Per cent of inspections with deviation(s)	79	77	80	78	84	79	77
Per cent of inspections with major deviation(s)	12	15	12	8	12	14	11

Table II: Observations of deviations from the regulations in inspections of permit holding firms. Data source: NPCA (2003).

	Risk Class ²⁹				
	All	1	2	3	4
Number of inspected firms	415	84	77	202	46
Per cent of inspected firms with at least one deviation	93	100	95	91	87
Per cent of inspected firms with at least one major deviation	21	35	25	16	11

Table III: Inspected firms' observed deviations over the period 1997-2002. Data source: NPCA (2003).

²⁹ Data on the firm's risk class was missing for 6 firms.

	Percent with given inspector recommendation in the successive inspection		
Inspector recommendation of previous inspection	"consider prosecution"	"inspect more frequently"	"inspect less frequently" or "inspect as regular"
"consider prosecution"	2	16	82
"inspect more frequently"	4	22	74
"consider prosecution" or "inspect more frequently"	3	21	76

Table IV: Inspector recommendations in the *first* inspection following an inspection resulting in the recommendations "consider prosecution" or "inspect more frequently", 1992-2002.

Data source: NPCA (2003).

1998	1999	2000	2001
5	5	7	17

Table V: Number of formal accusations filed by the NPCA. Source: NPCA (2002).

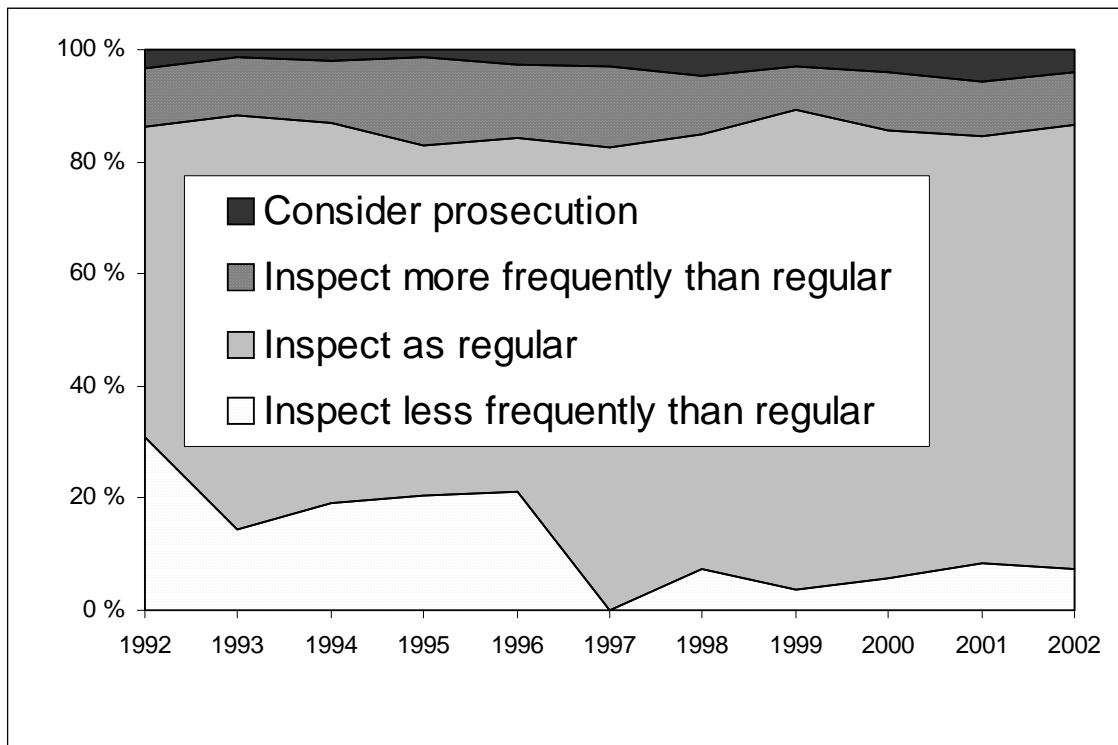


Figure 1: Characterization of inspections of permit holding firms. Data source: NPCA (2003).