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**CREATING INCENTIVES FOR
INDUSTRY SELF-POLICING:
AN EVALUATION OF THE
EPA'S AUDIT POLICY**

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Abstract

To encourage industry self-policing, the EPA offers rewards, in the form of reduced penalties, to firms that voluntarily conduct compliance audits and report any discovered violations to the EPA. This paper evaluates the EPA's audit policy by comparing the social costs when self-auditing occurs with the alternative of relying on agency inspections to uncover violations. Because of the need to maintain a credible deterrent, self-policing reduces, but does not eliminate inspection costs. When inspections or audits are costly compared to the damage caused by violations, self-auditing will not be socially beneficial.

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1. Introduction

Over the past five years, the United States Environmental Protection Agency (EPA) has begun adopting innovative approaches to achieving compliance with environmental regulations, to complement traditional monitoring and enforcement efforts. Among these efforts is the EPA's audit policy, *Incentives for Self-Policing: Discovery, Disclosure, Correction and Prevention of Violations*, introduced in December 1995. The policy authorizes reduced penalties for firms that conduct self-audits and voluntarily report any discovered violations to the EPA. To be eligible, the firm must also correct the violation and take steps to avoid further infractions.

The ultimate goal of the policy is to improve environmental quality by encouraging "greater compliance with laws and regulations ... [B]ecause government resources are limited, maximum compliance cannot be achieved without active efforts by the regulated community to police themselves" (EPA 1995, p. 66706-7). By creating an incentive for firms to police themselves, scarce enforcement resources can be freed up to identify and tackle the most serious offenders. Both inspection and litigation costs may be reduced when firms self-police.

In a recent evaluation, the EPA claims that the audit policy has been a success. The benefits of the policy are described as "removed pollutants from the air and water, reduced health and environmental risks and improved public information on potential environmental hazards" (EPA 1999c, p. 26745). The significant number of multi-facility disclosures, which the EPA wants to encourage because they "effectively leverage resources of the Agency", has enhanced these benefits (EPA 1999c, p. 26746). In addition, the EPA describes its industry specific initiatives as "an efficient and economical means of ensuring and improving compliance with environmental laws and regulations" (EPA 1999a, p.2).

In contrast, many in the regulated community and the legal profession, while acknowledging that the audit policy is a step in the right direction, believe that the incentives in the policy are insufficient to induce widespread self-auditing. Firms fear that their own audit reports could be used against them in court, effectively providing a road map for prosecution. In an

attempt to allay these fears, a number of states have enacted legislation that gives qualified evidentiary privilege to audit documents. The EPA however, remains firmly opposed to any such privilege, citing two facts to support their stance. First, audit reports are rarely used as evidence, and secondly, environmental auditing has rapidly expanded over the past decade despite the absence of privilege. The latter claim is supported by a recent study, which found no significant difference in auditing rates between states, regardless of whether or not the state allowed audit privilege.¹

The purpose of this paper is to evaluate the EPA's audit policy in light of the benefits claimed by the EPA. Social costs when self-auditing occurs are compared with the alternative of relying on agency inspections to uncover violations, in order to determine the conditions under which self-auditing will be preferred. Two key results emerge. Firstly, since self-policing transfers some costs from the agency to firms, this can free up inspection resources and lead to greater improvements in environmental quality. However, these gains are limited by the need to maintain a credible deterrent. In particular, when agency inspections are relatively expensive, industry self-policing is no longer desirable. Self-auditing reduces, but does not eliminate, the need for inspections. A credible threat of inspection must be maintained, in order for firms to have an incentive to audit. Self-policing will be socially beneficial when both audits and inspections are inexpensive compared to the benefits of uncovering and correcting violations. For high inspection costs, the cost of maintaining a credible deterrent will be too high to warrant encouraging self-policing.

A secondary result concerns the audit policy fine structure. The current structure is found to be consistent with the model results derived here, but need not be so restrictive: some fine mitigation can be allowed for firms that audit without meeting all the conditions of the audit policy. While the issue of evidentiary privilege is considered only briefly, the results indicate that the agency will always wish to create incentives for voluntary reporting whenever the firm audits, making this issue irrelevant.

¹ The results of this study, undertaken by the National Conference of State Legislatures, are summarized in EPA (1999a), p. 8.

The existing literature that considers the audit policy is limited.² One of the only papers that explicitly analyzes the audit policy of the EPA is Pfaff & Sanchirico (1998). In their model, firms need to undertake environmental audits in order to discover the magnitude of the harm caused by their operations. The focus of their paper is determining the structure of fines that can provide correct incentives for *both* auditing and correction of harms. Three remedies are suggested, all of which differ from the EPA audit policy. Pfaff and Sanchirico challenge the claim that agency enforcement costs will be reduced by self-auditing, noting that a credible threat of inspection must be maintained and inspection must still occur for those firms that do not audit themselves. Throughout most of their paper however, enforcement costs and hence, the probability of detection, remain fixed. One of the goals of this paper is to examine the claim of reduced enforcement costs more closely.

The paper most closely related to this one is Mishra, Newman and Stinson (1997), who show that, contrary to the claims of industry, the right of a regulator to access reports actually increases the incentive to audit. In addition, reducing penalties for firms that undertake compliance audits and correct violations, also results in more audits being conducted. In their model, the goal of the regulator is to minimize the sum of pollution damages and enforcement costs, which include both accessing and inspection costs. No account is taken of firm audit and clean-up costs. Agency inspections are also perfect. In addition, correction is assumed to occur automatically following discovery of a violation.

There are four innovations in this paper that differentiate the model from previous analysis. First, the social welfare consequences of the policy are considered by examining the social costs, including compliance and audit costs, of possible outcomes. Second, the inspection probability necessary to maintain a credible deterrent is explicitly calculated and included in the evaluation. Third, correction of damages is by no means assured, and is a decision of the firm along with undertaking an audit and reporting to the agency any discovered violations. These correction costs can be significant. For instance, the EPA reported that polluters spent more than \$2 billion to correct violations in 1998, compared to the total amount of assessed

² The self-reporting literature has focused on the issue of penalty mitigation for self-reported violations. One of the key results from this literature is that fines should *not* always be set as large as possible, in order to encourage self-reporting of violations, and thereby reduce the need for agency inspections. See, for instance, Heyes (1996), Kaplow and Shavell (1994), and Malik (1993).

finances and penalties of only \$1.5 billion (EPA 1999b, p. 3). Fourth, inspections may fail to detect some violations, on the other hand audits are assumed to uncover all violations. The agency's inspection power however, is increased if the firm has already conducted an audit.

A detailed description of the audit policy and the conditions for eligibility is provided in the next section. Section 3 introduces the basic model, while the firm's choice is analyzed in Section 4. The equilibrium outcome is presented in Section 5, followed by some extensions in Section 6. Conclusions appear in Section 7.

2. The Audit Policy

To qualify for penalty mitigation under the EPA's audit policy the following conditions must be satisfied (EPA 1995, pp. 66708-66710):

- (1) Discovery of the violation through an environmental audit or due diligence
- (2) Voluntary discovery and prompt disclosure
- (3) Discovery and disclosure independent of government or third party plaintiff
- (4) Correction and remediation
- (5) Prevent recurrence
- (6) No repeat violations
- (7) Other violations excluded
- (8) Cooperation.

When all of these conditions are satisfied, the EPA will not seek the gravity-based component of the penalty for the reported violation.³ However, an amount equal to the economic benefit from noncompliance may still be collected, unless this component is deemed insignificant. If all the conditions except (1) are met, the gravity-based component will be reduced by only 75%. A second benefit of voluntary disclosure is that the EPA will typically not recommend criminal prosecution, except when serious harm to the environment or human health has

³ EPA penalties are comprised of two parts. The first is the economic benefit component, designed to recoup any costs the source may have avoided or delayed by violating. The second part is the gravity component, which is to reflect the seriousness of the violation.

occurred, where high-level corporate officials are involved, or where the corporate practice is to conceal or condone violations. In addition, the audit policy states that the EPA will not routinely request access to audit reports, except where criminal wrongdoing is suspected.

The audit policy defines an environmental audit as “a systematic, documented, periodic and objective review by regulated entities of facility operations and practices related to meeting environmental requirements” (EPA 1995, p. 66710). The size and nature of the operation will determine the specific procedure for an audit. This could range from the simple visual inspection of the facilities, permits, and records of a company conducted by management personnel, through to extensive investigations by outside consultants, which may include the collection and analysis of soil and water samples. The main costs involved in conducting an audit are related to administration and personnel. Regardless of its complexity, an audit must have a well-defined beginning and end.

“Due diligence” is described as an entity’s systematic effort to prevent, detect and correct violations. These efforts can be demonstrated by the existence of explicit company policies regarding compliance, incentives within the company for staff to perform in accordance with the policy, and regular staff training, for example.

Audits are necessary to evaluate compliance because environmental laws and regulations are both numerous and complex. “Since 1972, the federal government has promulgated an average of 600 pages of environmental statutes and rules every year, which in turn, have spawned thousands of pages of notices, proposed rulemakings, and final rulemakings in the *Federal Register*” (Hawks 1998, p. 235). Firms are also subject to additional requirements at both the state and local level, which may overlap or conflict with those at the federal level. Compounding this, firm processes, machinery, production and personnel are constantly changing. For a firm to determine what regulations apply to it can be a time-consuming and expensive task.

Condition (2) severely restricts the applicability of this policy by requiring that the violation be discovered through actions not required by regulation. Violations of regulations that contain regular monitoring and reporting requirements, such as for permits issued under the

Clean Air Act (CAA) and the Clean Water Act (CWA), are excluded. It should be noted however, that truthful reporting of violations even under these regulations is typically treated far more leniently than false reporting. For example, this can mean the difference between civil or criminal prosecution. In addition, condition (3) requires that the disclosure not be prompted by a pending EPA investigation or laying of charges, or a citizen suit.

It is not sufficient to merely report the violation, the firm must also take serious action to correct the violation, and clean up any damage that has occurred, as well as undertake measures to prevent a recurrence of the violation. Correction must occur promptly, usually within 60 days of discovery. The firm must certify, in writing, to the appropriate authorities that all violations have been corrected. With all these conditions, the burden of proof for eligibility rests on the firm seeking penalty relief.

As the policy is aimed at firms that are making genuine efforts to comply, firms with a history of noncompliance are excluded. The exact condition is that the “same or a closely related” violation has not occurred at the same facility within the past three years, or within the past five years for the regulated entity. In addition, conditions (7) and (8) exclude cases involving serious actual or potential harm, and firms that fail to cooperate with the EPA.

Each year since the final policy statement was issued on December 22, 1995, the EPA has received an increasing number of voluntary disclosures from companies. As of April 30, 1999 the EPA had granted penalty relief to 166 entities. In the majority of these cases, no monetary penalty was assessed, since the economic benefit from violation was deemed insignificant. The majority of the violations disclosed (84%) involve administrative infractions related to monitoring, sampling, recordkeeping, and reporting. The remaining portion (16%) involved the unauthorized release of pollutants or the incorrect storage or disposal of wastes (EPA 1999c, p. 26751). A breakdown of settlements by statute reveals that disclosure occurred most commonly for violations under the Emergency Planning and Community Right-to-Know Act (61.6%), followed by the Clean Water Act (22.2%), the

Resource Conservation and Recovery Act (9.0%) and the Toxic Substances Control Act (5.3%).⁴

One of the largest settlements to date involved the waiving of \$2.38 million in penalties for GTE Corporation, leaving a penalty of only \$52,264 to pay, equal to amount of money saved by the company during its period of noncompliance (EPA 1998). The company disclosed 511 violations under the Emergency Planning and Community Right-to-Know Act, for failure to notify local authorities of the presence of sulfuric acid filled batteries. This information is needed to prepare and protect the community in the case of a spill. Another 89 violations were disclosed for failure to develop spill prevention plans required under the Clean Water Act for diesel fuel stored at their facilities. As part of their January 1998 settlement, GTE corrected all these violations, which occurred at 314 facilities in 21 states.

The EPA has also used the audit policy as a means of focusing attention on specific sectors of the regulated community. Typically, the EPA has informed firms in the targeted industry about the existence of the audit policy, giving them a period of time to voluntarily conduct audits and report discovered violations. After the grace period is over, the EPA conducts inspections where necessary. The requirements for relief are sometimes also relaxed during this period. For example, in August 1998, the EPA sent letters to approximately 1000 facilities in the Industrial Organic Chemical sector. The facilities were given until January 31, 1999 to voluntarily audit and report to the EPA any violations that were uncovered. The disclosure time was extended beyond the usual 10-day period. As a result of this program, the EPA received about 45 disclosures.

⁴ Figures are for 1998 and come from EPA (1998, p. 4). The percentage given is number of facilities settling under policy. The remaining settlements were under a variety of Acts including the Clean Air Act at 0.9%.

3. The Model

The firm is subject to an environmental regulation, *without* any regular reporting requirements. For simplicity, the firm's probability of compliance with the regulation is assumed to be θ . This probability is exogenously given and the same for all firms. The randomness of compliance reflects elements such as weather conditions, and the breakdown or development of leaks in equipment, which affect the firm's compliance status.⁵ This could also reflect the firm's ignorance about new or changed regulations and whether the firm is subject to them. In addition, changes in the firm's production process or operations may also affect the compliance status of a firm.

To check its compliance status the firm must undertake a self-audit. An audit involves both reviewing the relevant regulations and determining how these apply to the firm. Undertaking a self-audit costs a per firm and perfectly reveals the firm's compliance status. For example, an audit may involve hiring an environmental consultant or allocating personnel from within the company to perform the task.

Whenever an audit reveals the firm is in violation, the firm faces two additional decisions. First, whether to correct the violation, at a cost of c , and move into compliance. Second, whether to voluntarily report the violation to the enforcement agency or to remain silent. The correction cost c includes clean-up costs, as well as the expenditures required to ensure future compliance, such as repairing equipment, reducing production levels and dedicating staff to monitoring compliance. Following the discovery of a violation, the firm has four possible responses as shown in Figure 1. The firm's strategy choice is between not auditing (NA) and the four audit options: audit correct report (ACR), audit correct silence (ACS), audit non-correction report (ANR), and audit non-correction silence (ANS). The firm will choose the strategy that minimizes its expected costs.

⁵ A firm's probability of compliance depends on *both* the control actions it chooses and random factors beyond its control. In this model, the firm's control actions are fixed. See Malik(1993) for a model where the probability of compliance depends on the control actions chosen by the firm.

The enforcement agency's goal is to minimize social costs (SC), which are the sum of pollution damages, firm correction costs, firm audit costs, and agency enforcement costs. A violation results in damages of d , whereas no damages occur when the firm is in compliance. The firm's correction effort is assumed to be sufficient to remedy any damages caused by its period of violation.⁶ The agency can influence the firm's strategy choice by changing the inspection probability and the fine structure.

Each inspection the agency undertakes to check the firm's compliance status costs m . The agency can differentiate its inspection activities based on whether a report is received or the firm remains silent. Let p_r be the monitoring probability following a reported violation, and p_s refer to the monitoring probability following silence. Unlike the firm's audit, agency inspections are subject to error. In particular, with probability β a violation remains uncorrected following an agency inspection. Such errors can occur if a violation goes undetected or if insufficient evidence is uncovered to prosecute even when a violation is indicated. For simplicity, the probability of a false indictment is assumed to be zero.

When the agency inspects a firm that has conducted an audit, the probability of a violation being missed is reduced to $\beta(1-\gamma)$. The parameter γ reflects industry concerns that the existence of an audit report increases their chance of prosecution by the agency. If inspections become perfect following an audit, then $\gamma=1$. On the other hand, if auditing has no effect on inspection power, then $\gamma=0$.

Upon discovery or voluntary reporting of a violation, the firm faces a penalty *and* is required to return to compliance, if it has not already done so. The agency is able to choose a potentially different fine for each of the five violation outcomes that may occur, where:

⁶ These correction costs are the same whether the violation is discovered by an audit or by inspection. See Mishra, Newman and Stinson (1997) for a case where correction costs increase if no audit is carried out, providing an additional incentive for the firm to self-audit.

- F_V is the fine for a violation, in the absence of a firm audit,
- F_{CR} is the fine for a corrected and reported violation,
- F_{CS} is the fine for a corrected violation, when the firm keeps silent,
- F_{NR} is the fine for a non-corrected, but reported violation, and
- F_{NS} is the fine for a non-corrected violation, when the firm keeps silent.

For instance, if the firm should receive penalty mitigation for simply conducting an audit, regardless of whether it corrects or reports a violation, then the four fines associated with auditing should all be lower than F_V . Current EPA policy allows for mitigation only when a firm voluntarily reports, and corrects, the violation. The agency is constrained by a maximum fine size of K .⁷ From the perspective of society, fines are assumed to be a costless transfer and the only enforcement costs are from conducting inspections.⁸ As a result, the agency will adjust the fine structure to minimize the number of costly inspections required in each case.

The penalties for false reporting are assumed to be high enough to induce truthful reporting if the firm chooses to report.⁹ If the firm is in compliance, there is no reason to report otherwise, as the probability of a false indictment is zero, and compliance carries no fine. The firm will also remain silent if no audit has been conducted, since its compliance status is unknown. The only remaining possibility is the firm falsely reporting correction when none has occurred. However, the burden of proof of correction falls on the firm, making it difficult to prove in the absence of such action actually occurring. In addition, elaborate fabrication would be required, involving considerable effort and expense in order to fool the agency. Such a flagrant conspiracy would almost certainly result in criminal prosecution if caught, with a significant term of imprisonment for the company personnel involved. As a consequence, only violating firms will voluntarily report to the agency. The agency will only

⁷ The maximum fine is the same regardless of the nature of the violation. In reality, however, the maximum penalty for flagrant or deliberate violation is considerably larger than for a violation committed out of ignorance or due to forces beyond the firm's control. Note however, that "wilful" ignorance is also punished more harshly.

⁸ See Malik (1993) for a model in which the imposition of penalties is socially costly.

⁹ An alternative is to add another stage following report whereby the agency investigates to see whether the firm is telling the truth.

inspect firms that remain silent ($p_r=0$) since nothing further will be uncovered by costly inspection of reporting firms.

The equilibrium is found by first considering the fine structure and inspection probability necessary to induce the firm to choose a particular strategy. Based on this, the social costs under each outcome are then compared.

4. Firm Choice and Social Costs

Given the inspection probability and fine structure chosen by the agency, the firm's costs under each outcome are given in Figure 1. To find the firm's expected cost (FC_i), the cost associated with each outcome must be weighted by the probability of each outcome occurring. If the firm chooses not to audit (NA), discovery of violations and correction occurs only through agency inspections. The firm's cost is:

$$FC_{NA} = (1-\theta)p_s(1-\beta)(F_V + c). \quad (1)$$

With auditing, the firm has four possible choices. If the firm audits, and then corrects and reports any discovered violations (ACR), its expected cost is:

$$FC_{ACR} = a + (1-\theta)(F_{CR} + c). \quad (2)$$

The audit cost is incurred regardless of whether or not a violation is uncovered. With probability $(1-\theta)$, the audit reveals a violation, at which time the firm incurs cost c to correct the violation, and then reports the violation to the agency, resulting in a fine of F_{CR} .

On the other hand, correcting any discovered violation but remaining silent (ACS) costs:

$$FC_{ACS} = a + (1-\theta)(p_s(1-\beta(1-\gamma))F_{CS} + c). \quad (3)$$

The firm is fined only when its violation is discovered by an agency inspection.

Auditing, non-correction and reporting (ANR) costs the firm:

$$FC_{ANR} = a + (1-\theta)(F_{NR} + c). \quad (4)$$

This case is similar to ACR, because as soon as the firm reports the violation it will be required to correct it.

Remaining silent when not correcting (ANS) means the firm can avoid both the correction cost and the fine unless detected by the agency, giving expected costs of:

$$FC_{ANS} = a + (1-\theta)p_s(1-\beta(1-\gamma))(F_{NS} + c) \quad (5)$$

No Auditing (NA)

The firm will choose not to audit when the expected cost of not auditing is smaller than the cost of the other four strategies. Comparing expressions (1)-(5) and rearranging, yields the following condition for the firm not to audit:

$$p_s(1-\beta)F_V \leq \min \begin{cases} \frac{a}{1-\theta} + F_{CR} + (1-p_s(1-\beta))c \\ \frac{a}{1-\theta} + p_s(1-\beta(1-\gamma))F_{CS} + (1-p_s(1-\beta))c \\ \frac{a}{1-\theta} + F_{NR} + (1-p_s(1-\beta))c \\ \frac{a}{1-\theta} + p_s(1-\beta(1-\gamma))F_{NS} + p_s\beta\gamma c \end{cases}$$

The left-hand side of the inequality is the firm's expected fine if it does not audit and a violation occurs. The firm must weigh this fine against, firstly, the cost of conducting an audit, taking into account that the audit cost is incurred regardless of whether violation or compliance is revealed. The fine on the other hand is payable only in the case of a violation. This audit cost is the same for all four audit strategies. The firm must also factor into its comparison that the fine size may differ when it chooses to audit. Correction will also occur

more frequently when the firm chooses to audit, and the additional cost associated with this must also be factored in.

The first expression on the right hand side of the inequality represents the costs associated with the strategy audit, correct and report (ACR). With this strategy, a certain fine of F_{CR} results in the case of violation. The firm will also correct more often, whenever a violation occurs, rather than only when discovered via an inspection, which will typically be with probability less than one. The second alternative is to audit, correct, and keep silent (ACS). The difference in expected costs with ACR arises because the firm is only fined F_{CS} when inspected and a violation is uncovered. The next strategy available to the firm is to audit, not correct, and report (ANR). However, since the firm must correct upon filing its report, the additional correction cost is the same as in the previous two cases. The fine F_{NR} is incurred with certainty upon reporting. Finally, if the firm chooses to remain silent and not correct (ANS), it is fined only when an inspection reveals a violation. The additional correction cost with auditing is smaller in this case than for the other audit options, reflecting that correction occurs more often only because of the improved detection rate during an inspection when the firm has undertaken a self-audit.

To induce the firm not to audit, the agency must choose the appropriate fine structure. Because of the additional costs associated with auditing, this inequality will hold even if all the fines are set equal. In fact, some penalty relief for auditing can still be granted, so long as the reduction in penalty is insufficient to compensate for the audit costs and greater correction costs associated with auditing.

If the agency chooses $p_s=0$, the firm will clearly never conduct a self-audit, regardless of the fine structure.¹⁰ In this case, all violations remain uncorrected, resulting in social costs equal to the damages incurred, or:

$$SC_{NA}^0 = d(1-\theta), \tag{6}$$

¹⁰ Negative fines are not allowed.

where SC_i^j is the social cost associated with firm strategy i , when the inspection probability (p_s) equals j .

When the firm does not audit, violations are corrected only when discovered through agency inspections. If the benefits of correction are sufficiently large, the agency will want to undertake inspections even though the firm does not audit. To see this, consider the social costs from an arbitrary value of p_s : $SC_{NA}^p = d(1-\theta) - p_s[(1-\theta)(1-\beta)(d - c) - m]$. When correction occurs, damages are remedied, and social costs fall by an amount equal to the expected reduction in damages, net of correction costs. The final component of social cost is the cost of inspections, which is incurred regardless of whether or not a violation is uncovered. When inspections are relatively cheap to conduct, or:

$$m \leq (1-\theta)(1-\beta)(d - c) = m^{01}, \quad (7)$$

social costs are decreasing in p_s and the agency will chose certain inspection ($p_s=1$). Social costs will fall to:

$$SC_{NA}^1 = d(1-\theta) - (1-\theta)(1-\beta)(d-c) + m. \quad (8)$$

Audit, Correct, and Report (ACR)

The firm will choose to undertake a self-audit, and correct and voluntarily report any discovered violations, when:

$$F_{CR} \leq \min \begin{cases} p_s(1-\beta)F_V - (1-p_s(1-\beta))c - \frac{a}{1-\theta} \\ p_s(1-\beta(1-\gamma))F_{CS} \\ F_{NR} \\ p_s(1-\beta(1-\gamma))F_{NS} - (1-p_s(1-\beta(1-\gamma)))c \end{cases} .$$

Allowing complete penalty mitigation only if the firm audits, corrects and reports any violation ($F_{CR}=0$; $F_{CS}, F_{NR}>0$) will ensure the firm prefers ACR to both ACS and ANR.

However, for the firm to prefer ACR to NA and ANS, silent firms must be inspected sufficiently often, even with the associated fines set equal to the maximum value of K . Suppose $F_{NS}=F_V=K$, then for any given inspection probability the expected costs associated with NA will be smaller than those from ANS for three reasons. Both the expected fine and the expected correction cost are larger following an audit due to the increase in the detection power of agency inspections. In addition, the audit cost is also incurred. The binding constraint is therefore NA.¹¹ The inspection probability must be no less than:

$$p_{acr} = \frac{c}{(1-\beta)(K+c)} + \frac{a}{(1-\theta)(1-\beta)(K+c)} \quad (9)$$

if the firm is to choose strategy ACR. Since inspections are costly, the agency will choose a frequency exactly equal to this expression.

More frequent inspection is needed to induce self-auditing when audits are expensive to conduct; the maximum fine, K , is small; inspections frequently fail to uncover violations (large β); compliance is likely (large θ); or the correction cost (c) is large.¹² If conducting an audit is very costly, relative to the maximum fine and probability of violation, the required inspection frequency may exceed one. In this case, even certain inspection would be insufficient incentive for the firm to audit. From (9), $p_{acr}>1$ if:

$$a > (1-\theta)(1-\beta)K - (1-\theta)\beta c \quad (10)$$

When auditing is very costly, the benefits of auditing are never sufficient to induce the firm to audit. This condition will be more likely to hold for small values for the maximum fine, and when violation occurs only occasionally.

¹¹ A further implication is that $F_{NS}<F_V$ is permissible.

¹² Note that $\frac{dp_{acr}}{dc} = \frac{(1-\theta)K - a}{(1-\theta)(1-\beta)(K+c)^2} > 0 \quad \forall p_{acr} \leq 1$.

All violations are discovered and corrected as a result of the firm auditing. Social costs are simply equal to the sum of correction costs, audit costs and inspection costs, or:

$$SC_{ACR}^p = c(1-\theta) + a + p_{acr}\theta m. \quad (11)$$

Under this alternative, only silent firms are inspected. The firm is silent when an audit uncovers compliance, which occurs with probability θ . Since the firm is already auditing and correcting all violations, there is no gain from inspecting more frequently unlike in the NA case. The agency will choose the minimum inspection probability (p_{acr}) necessary for the firm to select ACR.

Audit, Correct, Silence (ACS)

The firm will choose to audit, and correct, but remain silent when:

$$p_s(1-\beta(1-\gamma))F_{CS} \leq \min \begin{cases} p_s(1-\beta)F_V - (1-p_s(1-\beta))c - \frac{a}{1-\theta} \\ F_{CR} \\ F_{NR} \\ p_s(1-\beta(1-\gamma))F_{NS} - (1-p_s(1-\beta(1-\gamma)))c \end{cases}$$

Setting $F_{CS}=0$ and both F_{CR} and $F_{NR}>0$ is sufficient to make ACS a better choice than either ACR or ANR. When $F_V=K$ and $F_{NS}=K$, the differential costs for the remaining two choices are the same as in the previous section and therefore, so is the required inspection probability ($p_{acs}=p_{acr}$).

The firm cost component of social costs is identical to ACR, since under both strategies the firm audits and corrects any discovered violations. Inspection costs however are higher since when the firm remains silent, agency inspections can no longer be conditioned on the firm's report.

$$SC_{ACS}^p = c(1-\theta) + a + p_{acs}m \quad (12)$$

Audit, No Correction, Report (ANR)

The firm will choose to audit, not correct, and report when:

$$F_{NR} \leq \min \begin{cases} p_s(1-\beta)F_V - (1-p_s(1-\beta))c - \frac{a}{1-\theta} \\ p_s(1-\beta(1-\gamma))F_{CS} \\ F_{CR} \\ p_s(1-\beta(1-\gamma))F_{NS} - (1-p_s(1-\beta(1-\gamma)))c \end{cases}$$

For the firm, this option is essentially the same as ACR, because upon reporting its violation to the agency, correction is required. The agency's choice will be the same as for ACR, except with $F_{CR} > 0$ and $F_{NR} = 0$, and the same social costs resulting. Since the two outcomes are the same, no further discussion is made of this option.

Audit, No Correction, Silence (ANS)

The firm will choose to audit, not correct, and remain silent, when:

$$p_s(1-\beta(1-\gamma))F_{NS} \leq \min \begin{cases} p_s(1-\beta)F_V - p_s\beta\gamma c - \frac{a}{1-\theta} \\ F_{CR} + (1-p_s(1-\beta(1-\gamma)))c \\ p_s(1-\beta(1-\gamma))F_{CS} + (1-p_s(1-\beta(1-\gamma)))c \\ F_{NR} + (1-p_s(1-\beta(1-\gamma)))c \end{cases}$$

If the fines for violation when auditing are set equal ($F_{NS} = F_{CR} = F_{CS} = F_{NR}$), then ANS will be preferred over any of the other audit options, which entail more frequent correction. However, if the firm is to prefer ANS to NA, the inspection probability must be no smaller than:

$$p_{ans} = \frac{a}{(1-\theta)((1-\beta)K - \beta\gamma c)}. \quad (13)$$

The fine for violation has been set as large as possible ($F_V=K$), while complete penalty mitigation is granted for auditing ($F_{NS}=0$).

If the right hand side of (13) is negative, $FC_{NA} < FC_{ANS}$ for all values of p_s and ANS will never be chosen by the firm. For this to occur, the additional correction cost incurred when auditing must be very large compared to the maximum fine. This would be the case when either c is very large or the probability of detection improves dramatically following an audit, or both. In addition, if the audit cost is very large, even complete penalty mitigation will not be enough to induce auditing. From (13), $p_{ans} > 1$ when:

$$a > (1-\theta)((1-\beta)K - \beta\gamma c). \quad (14)$$

A greater audit cost can be sustained if the probability of violation is greater, or if the probability of detection or fine in the absence of auditing is large.

Note that less frequent inspection is required to induce ANS than ACR. From (9) and (13),

$$p_{ans} < p_{acr} \text{ if } a < \frac{(1-\theta)((1-\beta)K - \beta\gamma c)}{1-\beta(1-\gamma)}. \text{ Since the denominator of this expression is less than}$$

or equal to one, this condition will be violated only when, from (14), $p_{ans} > 1$. Both p_{ans} and p_{acr} are increasing in a , and since $p_{acr} \geq 1$ when $p_{ans} = 1$, the possibility that $p_{ans} > 1$ and $p_{acr} \leq 1$ is ruled out.

In the ANS case, even though the firm audits, correction occurs only when violations are uncovered during an inspection. The social costs under this option are:

$$SC_{ans}^p = d(1-\theta) - p_{ans}[(1-\theta)(1-\beta(1-\gamma))(d-c) - m] + a. \quad (15)$$

As in the case of no audit (NA), it may be advantageous for the agency to increase p_{ans} up to 1. This will occur whenever $m < (1-\theta)(1-\beta(1-\gamma))(d-c)$, yielding social costs equal to:

$$SC_{ANS}^1 = d(1-\theta) - [(1-\theta)(1-\beta(1-\gamma))(d-c) - m] + a. \quad (16)$$

5. Equilibrium Outcome

The agency will choose the inspection probability and fine structure to ensure the firm chooses the strategy that minimizes social cost. The desired outcome will depend on the parameters in the social cost expression. Two firm strategies can be eliminated since they are dominated for all parameter values. First, if the firm audits and corrects, reporting is preferred over silence. The reason for this result is that when the firm reports, the agency can concentrate its inspection efforts on silent firms, thereby decreasing inspection costs. A comparison of (11) and (12) reveals that $SC_{ACR}^p \leq SC_{ACS}^p$ since $p_{acs}=p_{acr}$ and $\theta \leq 1$.

Strategy ANS can also be ruled out as an equilibrium outcome. When the firm chooses ANS, some violations will remain uncorrected, resulting in higher damages (net of correction costs) than with ACR, where all violations are corrected. This difference arises because with ANS only those violations uncovered during agency inspections are corrected. The second difference has to do with inspection costs. If $p_{ans} \geq p_{acr}\theta$, then inspection costs will also be greater with ANS. In this situation, $SC_{ANS}^p > SC_{ACR}^p$ for all values of m . This includes the case where $p_{ans}=1$. On the other hand, if $p_{ans} < p_{acr}\theta$, then for sufficiently large monitoring costs, ANS will result in lower social costs than ACR. In particular, if $m > \frac{(d-c)(1-\theta)(1-p_{ans}(1-\beta(1-\gamma)))}{p_{acr}\theta - p_{ans}} = \bar{m}$, then $SC_{ANS}^p < SC_{ACR}^p$. However, in this range, monitoring is costly enough that the agency is better off by inducing the firm not to audit. Specifically, $SC_{ANS}^p > SC_{NA}^0$, when $m > (d-c)(1-\theta)(1-\beta(1-\gamma)) - \frac{a}{p_{ans}} = \underline{m}$. Since $\bar{m} > \underline{m}$, there is no range of inspection costs where ANS is preferred.

Only three options remain for the agency: NA^0 , NA^1 , and ACR, all of which will be chosen for some range of the parameter values. The key parameters are the firm's audit cost and the agency's inspection cost. Creating the incentive for firms to self-audit has several potential advantages. Firstly, some inspection costs can be transferred to the firm. From society's perspective, this will be beneficial when audits are cheaper to conduct than inspections. In addition, because self-auditing is perfect, all violations are uncovered, compared to some

being missed during agency inspections. This will be beneficial when violations are quite damaging, compared to the correction cost. Note that if $d < c$, then the best option is never to inspect (NA^0). The damage from violations is not large enough to outweigh the correction costs, let alone cover the costs associated with inspections or auditing. For the remainder of this section it is assumed that $d > c$.

To find the equilibrium outcome, first compare the two non-auditing options. Certain inspection will be chosen when inspections are cheap relative to the benefits. In particular, $SC_{NA}^1 < SC_{NA}^0$ when $m < m^{01}$ where $m^{01} = (1-\theta)(1-\beta)(d-c) \geq 0$ as given in (7). This is illustrated in Figure 2. The superscript on the critical m values refers to the two options being compared.

The next step is to compare ACR with the two non-auditing options. Since $p_{acr} \theta \leq 1$, SC_{ACR}^p will have a flatter slope than SC_{NA}^1 with respect to inspection cost (m). Three possibilities arise, depending on where SC_{ACR}^p lies in relation to the intersection of the two non-audit options.

Case 1. Audits are so costly that ACR is never social cost minimizing. In this case SC_{ACR}^p intersects SC_{NA}^1 to the right of m^{01} as shown in Figure 2, where:

$$m^{1A} = \frac{a - \beta(1-\theta)(d-c)}{1 - p_{acr}\theta} \quad (17)$$

$$m^{0A} = \frac{(1-\theta)(d-c) - a}{p_{acr}\theta}. \quad (18)$$

To find the critical audit cost, substitute for p_{acr} and solve for the audit cost that makes $m^{1A} \geq m^{01}$. This case arises when $a \geq \bar{a}$, where:

$$\bar{a} = (d-c)(1-\theta) \frac{K + c(1-\theta)}{K + c(1-\theta) + d\theta} \quad (19)$$

Case 2. ACR is social cost minimizing for intermediate values of a , as shown in Figure 3. The intersection of SC_{ACR}^p and SC_{NA}^1 occurs to the left of m^{01} , so that $m^{1A} < m^{01}$. For this case to arise $a < \bar{a}$. A further restriction is required however, to avoid the situation in Figure 4, where $m^{1A} \leq 0$. The necessary condition is that $a > \beta(1-\theta)(d-c)$. In this case, when inspections are inexpensive, the agency will prefer inspection over firm self-auditing. For moderate inspection costs, self-auditing will be preferred because transferring some responsibility to firms can reduce inspection costs. However, because of the necessity of maintaining a credible deterrent, even when firms audit, a high inspection cost will mean the agency never inspects.

Case 3. Audit costs are sufficiently low that $m^{1A} \leq 0$ and ACR is always preferred over NA^1 , as illustrated in Figure 4. The required condition is $a \leq \beta(1-\theta)(d-c)$. Because audits are relatively inexpensive, self-auditing will be the preferred option for both low and moderate inspection costs. This is a situation where the increased detection of violations from audits, as opposed to inspections, is important, either because β is large or the damage caused is considerable compared to the cost of correction. If agency inspections perfectly uncover violations ($\beta=0$), then this case never arises.

The three cases are summarized in the following proposition.

Proposition 1. *The equilibrium outcome, when the agency minimizes social costs and $d > c$*

$$\begin{aligned}
 \text{is:} \quad (1) \text{ if } a \geq \bar{a}, & \begin{cases} NA^1 \text{ if } m \leq m^{01} \\ NA^0 \text{ if } m > m^{01} \end{cases} \\
 (2) \text{ if } \bar{a} > a > \beta(1-\theta)(d-c), & \begin{cases} NA^1 \text{ if } m \leq m^{1A} \\ ACR \text{ if } m^{1A} < m \leq m^{0A} \\ NA^0 \text{ if } m > m^{0A} \end{cases} \\
 (3) \text{ if } a \leq \beta(1-\theta)(d-c), & \begin{cases} ACR \text{ if } m \leq m^{0A} \\ NA^0 \text{ if } m > m^{0A} \end{cases} .
 \end{aligned}$$

Industry self-policing is not always socially beneficial, especially when audit costs and inspection costs are large relative to the benefits of violation discovery and correction.

Several other features of the equilibrium are worth noting. First, the fact that audits result in increased detection, denoted by parameter γ , is irrelevant. The reason is that this parameter only matters when the firm audits and remains silent. The agency never wants to induce such an outcome. Secondly, consider the fine structure necessary for the firm to audit. The agency will want to allow complete penalty mitigation for firms that audit, correct and report ($F_{CR}=0$) and no mitigation for firms that do not audit ($F_V=K$) in order to minimize p_{acr} . It is possible to allow some fine reduction for auditing only. In the case of correction or reporting, any positive fine will satisfy the incentive ($F_{CS}, F_{NR}>0$). In the case of auditing, non-correction and silence, some mitigation can be allowed ($F_{NS}<F_V$) but only to a lower bound. Current EPA policy fits within these bounds. A different fine structure is required if NA^1 is to be the outcome. In particular, the degree of fine mitigation for auditing must be insufficient to compensate for audit costs.

6. Model Extensions

No Consideration of Firm Costs

Suppose now that the agency is concerned only about minimizing the sum of damages and inspection costs, placing zero weight on the audit and correction costs incurred by the firm. As in the previous section, the agency's choice comes down to three options: NA^0 , NA^1 or ACR. When firm costs are not considered, certain inspection by the agency (NA^1) is clearly dominated by ACR, because all damages are avoided, *and* inspection costs are saved when the firm adopts ACR. The choice between the remaining two strategies, ACR and NA^0 , depends on the size of inspection costs, as given in the following proposition.

Proposition 2. *The equilibrium outcome, when the agency places no weight on firm costs, is:*

- (1) ACR, when $m \leq \frac{d(1-\theta)}{p_{acr}\theta}$, and
- (2) NA^0 when $m > \frac{d(1-\theta)}{p_{acr}\theta}$.

When inspections are relatively cheap, compared to the benefit of reduced damages, the agency will inspect silent firms with sufficient frequency to maintain a credible threat and make self-auditing worthwhile for the firm. Under this policy, inspection costs and damages are reduced compared to the situation where the firm does not audit. Inspection costs are reduced because some of the cost of uncovering violations is transferred to the firm. Damages are reduced because audits perfectly reveal violations, while inspections leave some violations uncovered. To the extent that the savings in inspection costs can be used to enforce other regulations, further improvements in environmental quality are also possible. For regulations and industries where inspections are costly compared to damages, the agency will choose not to inspect and all violations will remain uncorrected.

7. Conclusion

Two main conclusions follow from this analysis. The first is that self-auditing, and more generally self-policing, clearly has a role in improving environmental quality and reducing social costs, supporting the claims of the EPA. This conclusion however, must be cautioned by the fact that self-policing is not always beneficial. In particular, when inspections are costly relative to the benefits of correction, self-auditing can actually increase social costs. Consideration must be given to the need to maintain a credible deterrent to make auditing worthwhile for firms. The current fine structure is consistent with the model results, while the increased detection following an audit did not factor in the analysis.

The following limitations should be recognized. First, violations are assumed to occur randomly, with the firm's control efforts held constant. This could be modelled differently by allowing firm control efforts to reduce, but not eliminate, the probability that the firm is in violation. The result would be a much richer and more complicated model. Complete penalty mitigation may no longer be the optimal choice because it reduces the incentive for control actions. The outcome will clearly depend on the relationship between control costs, correction costs, and damages. For instance, if correction is much more costly than preventive action, the penalty structure should be chosen to encourage control action by the

firm. The role of audits would also need to be redefined as showing the firm how well its actions are working.

A second simplifying assumption in this model is that firms are assumed to have the same correction cost. In addition, the agency is assumed to know this cost, and the cost to the firm of self-auditing. The model could be extended to allow for two types of firm, one with high correction costs and the other with low correction costs. Firms could also differ in the severity of damage their violations cause, due to differences in location, for example. Different firm types would probably not change the qualitative results of the model, although the range of parameter values where different outcomes are preferred will be altered.

Thirdly, violation is an all-or-nothing occurrence. That is, the firm is either in compliance or in violation, and no consideration is given to the size or length of the violation. For the types of violations that are eligible under EPA's audit policy, mostly reporting requirements, this does not seem too unreasonable, at least in terms of violation size. The extent of violation is more important for regulations that stipulate upper limits on emissions. Allowing firms to differ in terms of damages caused by a violation could also reflect differences in the extent of the violation.

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Figure 1. The Firm's Decision Tree

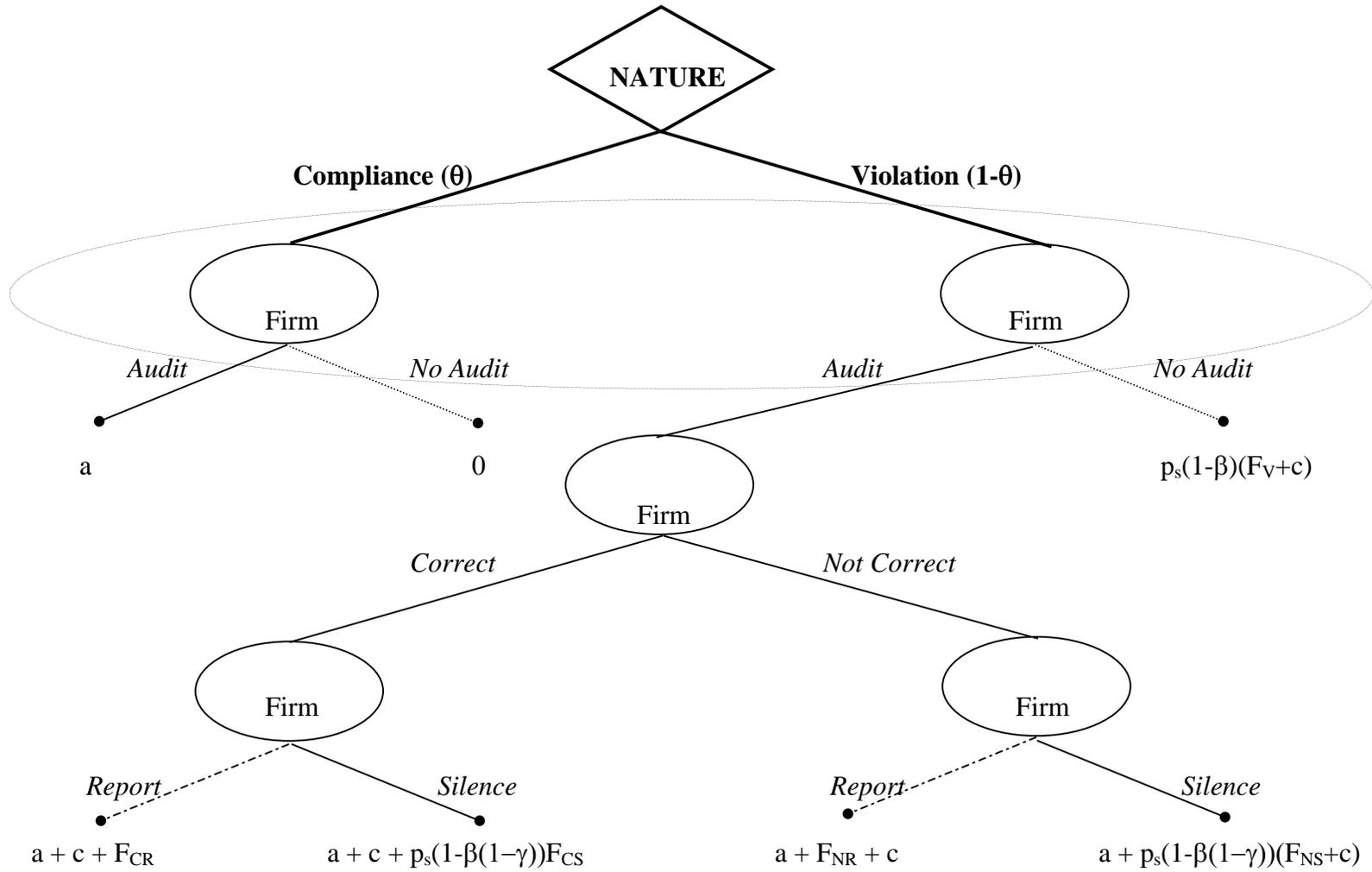


Figure 2. High Audit Costs: $a \geq \bar{a}$

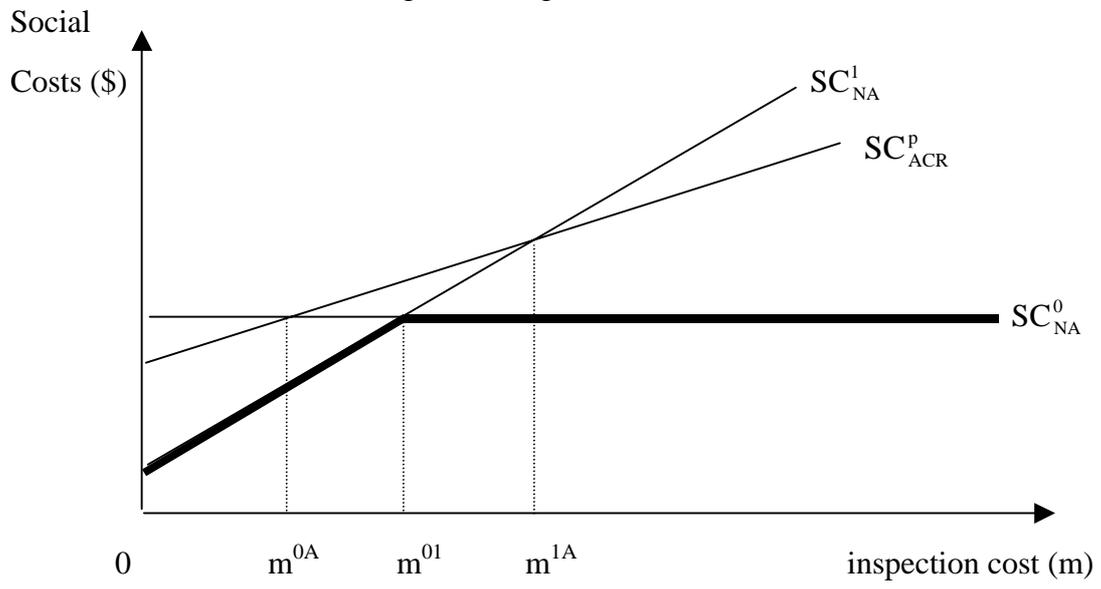


Figure 3. Intermediate Audit Costs: $\bar{a} > a > \beta(1-\theta)(d-c)$

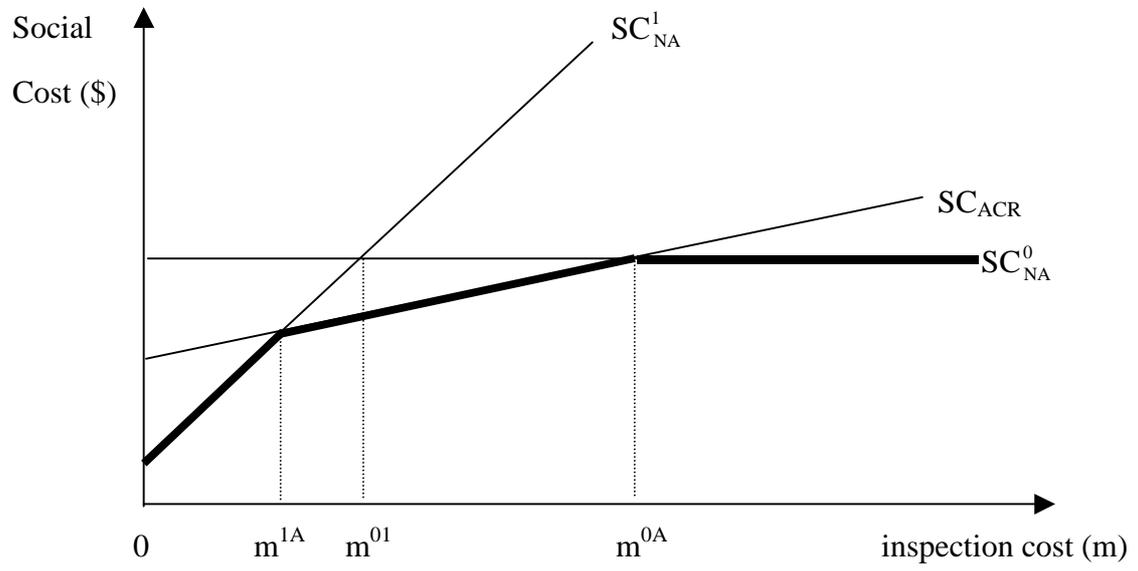


Figure 4. Low Audit Cost: $a \leq \beta(1-\theta)(d-c)$

