ISSN 1936-5349 (print)
ISSN 1936-5357 (online)

# HARVARD

JOHN M. OLIN CENTER FOR LAW, ECONOMICS, AND BUSINESS
FELLOWS' DISCUSSION PAPER SERIES

A MODEL OF CORPORATE SELF-POLICING AND SELF-REPORTING

Masaki Iwasaki

Forthcoming in *International Review of Law and Economics* (2020)

Discussion Paper No. 88
*Revision*

08/2020

Harvard Law School
Cambridge, MA 02138

# A model of corporate self-policing and self-reporting☆

Masaki Iwasaki*

*Harvard Law School, Cambridge, MA 02138, United States*

**Abstract**

What are the effects of corporate self-reporting schemes on deterrence of corporate crime? This paper presents a model to analyze this question for the case in which a firm's manager, who has stock-based compensation, commits a corporate crime and the firm conducts self-policing and self-reporting. Corporate self-reporting schemes may enhance deterrence if the level of corporate leniency is within a certain range. But the level of corporate leniency has a non-monotonic relationship with deterrence in that range: as the level of corporate sanctions decreases, receding from the upper limit of the range, the probability of crime occurring first decreases and then increases. The paper also considers the case in which both individual and corporate self-reporting programs are introduced. The social desirability of individual self-reporting schemes depends on whether firms can commit to a certain level of self-policing efforts.

*Keywords:* corporate crime, self-policing, self-reporting, deterrence
*JEL Classification*: G38, K14, K22, K42, M48

## 1. Introduction

### *1.1. Motivation and main results*

This paper answers a fundamental but not fully understood question: if enforcement agencies reduce sanctions for corporations that self-report an offense, how does this affect deterrence of corporate crime? The importance of this question has grown considerably in many jurisdictions as there is an increasing reliance on corporate self-reporting to detect and deter corporate crimes, which are defined as crimes committed by members of an organization, such as managers and employees, to pursue both organizational and individual interests.

A striking change in some jurisdictions, such as the United States and the United Kingdom, is the strengthening of corporate self-reporting programs to detect violations in many areas of law, such as securities fraud and foreign bribery. Traditionally, those programs have been used to detect cartels, where the collusion of multiple companies is of significance, but now they are expected to detect a single company's violation as well. The present paper studies the latter type of corporate self-reporting programs.

In those corporate self-reporting programs, prosecutors usually have discretion to grant leniency to companies, but the relationship between the level of leniency and deterrence is not yet fully understood. On the one hand, corporate sanctions are necessary to induce firms to prevent their organizational members' corporate crimes ex ante, but on the other hand, those sanctions should be reduced to induce firms to detect and self-report those crimes ex post (Arlen 1994, 2012; Arlen and Kraakman 1997).

By giving corporations rewards in the form of reduced sanctions, corporate self-reporting programs incentivize them to detect and self-disclose their members' wrongdoings. If firms detect and self-report their corporate crimes, individual wrongdoers, such as executives and employees, may be prosecuted and receive direct punishment, such as fines and imprisonment. Thus, reducing corporate sanctions may increase the expected direct punishment of individual wrongdoers by increasing the probability of crime detection.

However, the question arises as to the degree to which corporate sanctions should be reduced. Without theoretical guidance, prosecutors may misuse their discretion. This paper argues that the following two points should be particularly considered in determining the level of corporate leniency.

First, since the conditional probability of prosecution of an individual wrongdoer given the detection of a corporate crime is low, this limits the degree to which corporate leniency can raise the expected direct punishment of individual wrongdoers. In practice, the difficulties of proof in individual prosecutions are more serious than those in corporate prosecutions (e.g., Fisse and Braithwaite 1993; Garrett 2015). In particular, the prosecution of executives may be difficult because they may set inappropriate

☆The author is grateful to Bala Dharan, Reinier Kraakman, J. Mark Ramseyer, Steven Shavell, Holger Spamann, Kathryn E. Spier, and Wataru Tanaka for helpful comments, and for a Terence M. Considine Fellowship through the John M. Olin Center for Law, Economics, and Business at Harvard Law School for financial support. He is also grateful to the editor Emanuela Carbonara and an anonymous referee for useful comments that significantly improved the paper.

*E-mail address: miwasaki@sjd.law.harvard.edu

policies or strategies but not be engaged in day-to-day conduct. Hence, the conditional probability of prosecution of an individual, particularly a senior executive, given a revelation of a corporate crime will be far below one. Therefore, corporate self-reporting schemes have limitations in increasing the expected direct punishment of individual wrongdoers, even if stipulated sanctions, including fines and jail time, are set high.

Second, even if individual wrongdoers succeed in escaping prosecution, they may receive indirect punishment through a value decrease in their wealth, such as stocks and bonuses, when their company receives sanctions. Individual wrongdoers, including managers and employees, receive compensation whose value has some association with their firm's value. For example, in the United States, chief executive officers (CEOs) in public companies have significant stocks and options (Bebchuk and Fried 2004; Larcker and Tayan 2019). If a firm is sanctioned, its value will decrease, and its managers' and employees' compensation may decrease as well. In general, if corporations are sanctioned, they will need to disgorge all of their illicit profits; furthermore, they will bear fines and suffer reputational loss, which decreases their stock prices and thus affects the wealth of managers and employees.

Based on these observations, this paper presents a simple model of corporate self-policing and self-reporting to analyze the relationship between the level of corporate leniency and the level of deterrence of individual wrongdoers, particularly senior executives. Senior executives often play a leadership role in large-scale corporate crimes (e.g., Steinzor 2014; Rolnik 2016), and their compensation is more strongly tied to their firm's value than that of lower-level employees. Therefore, understanding the effects of reducing corporate sanctions on the direct and indirect punishments of senior executives should be a matter of policy interest.

The model consists of two players, a firm's manager and a firm's board, and three time periods. The manager has a certain proportion of the firm's shares and maximizes his or her expected payoff, and the board maximizes the firm value. In the first period, the manager privately decides whether to commit a corporate crime. In the second period, the board decides whether to conduct an internal investigation (ex post investigation) to detect the crime. If the board detects the crime and self-reports it to an enforcement agency, the firm receives a reduced sanction under a corporate self-reporting program, and with a certain conditional probability, the manager is prosecuted. In the third period, if the board fails to investigate in the second period, the enforcement agency investigates the firm with some probability. If the enforcement agency detects the crime, the firm receives a regular sanction, and with a certain conditional probability, the manager is prosecuted.

With this setup, this paper shows that there may be a range of reduced sanctions for corporate self-reporting wherein both the corporation's incentive to self-report and deterrence of the manager increase. In this range, the level of corporate sanctions has a non-monotonic relationship with deterrence: as the level of corporate sanctions decreases, receding from the upper limit of the range, the probability that the crime will occur first decreases and then increases.

The reason for the result can be summarized as follows. In committing the crime, the manager is exposed to two expected punishments: indirect and direct punishments. If the corporation receives the corporate sanction, the manager receives the indirect punishment through a value decrease in the manager's shares. In addition, if the manager is prosecuted, the manager receives the direct punishment of the individual sanction. When the enforcement agency needs to enhance deterrence, it can use the corporate self-reporting program to incentivize the firm to detect the manager's crime by reducing the corporate sanction. If there is a certain threat of crime detection by the enforcement agency and the degree of leniency is reasonable, the firm will have the incentive to detect and self-report the crime. If the probability of crime detection increases, the indirect and direct punishments are more likely to be imposed on the manager. While the size of the direct punishment of the manager (i.e. the size of the individual sanction) is fixed, the size of the indirect punishment of the manager is reduced because of the reduction of the corporate sanction.

If the corporate sanction is insufficiently reduced, the probability of crime detection remains almost unchanged, and the total of the expected indirect and direct punishments of the manager remains almost unchanged as well. However, if the corporate sanction is sufficiently but not excessively reduced, the probability of crime detection is increased, and the total expected punishment of the manager is increased as well despite the decrease in the indirect punishment of the manager. If the corporate sanction is excessively reduced, since this means that the size of the indirect punishment of the manager is also excessively reduced, the total expected punishment of the manager remains almost unchanged or decreases despite the increase in the probability of crime detection. Because of this mechanism, the corporate self-reporting program can enhance deterrence within a certain range of reduced sanctions for corporate self-reporting. But the level of corporate leniency has a non-monotonic relationship with deterrence in that range.

This paper also considers the case in which an individual self-reporting program, as well as the aforementioned corporate self-reporting program, is introduced. In this case, if the manager self-reports, he or she receives a reduced individual sanction, and the corporation receives a reduced corporate sanction. The social desirability of the individual self-reporting program depends on whether the firm can commit to an ex post investigation, which is defined here as an investigation that is conducted by the firm after the manager may have committed the crime but before the authority may investigate the firm.[1] If there is a probability that the manager self-reports, the firm's incentive to investigate decreases because of a smaller probability of crime detection. If the firm cannot commit to a certain level of ex post investigation to keep deterrence unchanged, the probability of crime occurring increases. Consequently, the individual self-reporting program may weaken deterrence when compared to the case in which only corporate leniency is available, although individual leniency may economize the investigation costs of the firm and the authority because of the manager's self-reporting. By contrast, if the firm can commit to a certain level of ex post investigation, the probability of crime occurring remains unchanged. Hence, the individual self-reporting program economizes the investigation costs without weakening deterrence.

### *1.2. Related literature*

This study contributes to two strands of literature: corporate crime and self-reporting. Regarding corporate crime, prior literature has studied the optimal corporate and individual liabilities (e.g., Segerson and Tietenberg 1992; Polinsky and Shavell 1993; Arlen 1994, 2012; Arlen and Kraakman 1997; Shavell 1997). Among them, a series of studies by Arlen (1994, 2012) and Arlen and Kraakman (1997) presented an optimal enforcement regime, where an authority reduces corporate sanctions to incentivize firms to detect and self-report crimes.

The results of this paper complement the findings of a series of studies by Arlen (1994, 2012) and Arlen and Kraakman (1997) by considering the case where an individual wrongdoer's payoffs are explicitly associated with a firm's value. The crucial difference between this paper and their papers is that this paper assumes that the conditional probability of individual prosecution given the detection of corporate crime is less than one while their papers assumed it to be equal to one. If the conditional probability of individual prosecution is far below one, this limits the ability of corporate self-reporting schemes to increase the expected direct punishment of individuals even if stipulated sanctions, such as the fine amount and the jail time, are set maximal. In such a case, the tradeoff between the direct and indirect punishments of individuals is particularly important for prosecutors in determining the level of corporate leniency.

This paper also contributes to the literature on self-reporting. While some studies have focused on a single wrongdoer's violation and self-reporting (e.g., Malik 1993; Kaplow and Shavell 1994; Arlen 1994, 2012; Arlen and Kraakman 1997; Innes 1999; Gerlach 2013), others have focused on the self-reporting of cartels in antitrust leniency programs, where the collusion of multiple wrongdoers is of significance (e.g., Motta and Polo 2003; Aubert, Rey, and Kovacic 2006; Miller 2009; Chen and Rey 2013; Harrington 2013; Landeo and Spier 2018a, b). This paper relates to both strands of the literature. While this paper studies the case of a single company's violation, a competition to be the first self-reporter occurs between its manager and the company, which relates to the literature of multiple wrongdoers' self-reporting.

Regarding a single wrongdoer's self-reporting, this paper particularly relates to Kaplow and Shavell (1994). They analyzed the self-reporting of individual crimes and showed that self-reporting schemes may save enforcement resources without weakening deterrence because self-reporting individuals need not be investigated. The present study analyzes the self-reporting of corporate crimes and shows that self-reporting schemes may enhance deterrence as well as save enforcement resources if the level of corporate sanctions is appropriately set. This paper also relates to Gerlach (2013) that advanced the analysis of Kaplow and Shavell (1994) by considering the case where an enforcement agency cannot commit to an ex post investigation effort to detect individual crimes. This paper applies his arguments to the case where a firm may not be able to commit to an ex post investigation effort to detect corporate crimes.

As for multiple wrongdoers' self-reporting, this paper relates to Landeo and Spier (2018a, b). They analyzed ordered-leniency policies, where a group of wrongdoers commits a crime and the level of their fine reduction depends on the chronological order of their self-reporting. The earlier a wrongdoer self-reports the crime, the more his or her fine is reduced. They showed that ordered-leniency policies detect crimes faster and strengthen deterrence by creating "a race to the courthouse" among multiple wrongdoers. This paper shows that the use of a corporate and an individual self-reporting program can incentivize a company's manager to self-report earlier than the company to apply for individual leniency, which can be considered a unilateral version of ordered-leniency policies.

This paper is organized as follows. Section 2 justifies the assumption about the conditional probability of individual prosecution by presenting some facts. Section 3 develops the model of corporate self-policing and self-reporting. Section 4 presents the conclusions of this paper and discusses the policy implications of the model.

## 2. Facts

This section shows that, in reality, the conditional probability of individual prosecution given the detection

[1] The ex post investigation here corresponds to the firm's investigation in the second period ($t = 1$) in the model. See Section 3.1. The present paper distinguishes this type of ex post investigation from an internal investigation that a firm may conduct once an authority investigates it. In practice, if an authority commences an investigation of a company, the company would immediately start an internal investigation parallel with the authority's investigation. The purpose of the company's investigation at this stage is to earn so-called cooperation credit, such as reduced sanctions, and to determine the company's defense strategy. The model in the present paper does not consider this latter type of investigation for simplicity; incorporating it to the model does not alter the conclusions.

Table 1: Direct and Indirect Punishments of CEOs

| | | |
|---|---|---|
| 1. Probabilities | | |
| Probability of crime detection | 33% | $a$ |
| Conditional probability of CEO prosecution | 8.5% | $b$ |
| 2. Direct punishment | | |
| Individual fine | \$381,000 | $c$ |
| Jail time | 18 months | $d$ |
| Expected direct punishment ($e = a \cdot b \cdot c$ or $a \cdot b \cdot d$) | \$10,687 | $e$ |
| | 0.5 months | $e$ |
| 3. Indirect punishment | | |
| Change in CEO wealth with a 1% stock change | \$193,000 | $f$ |
| Impact of corporate prosecution on stock price | 11% | $g$ |
| Expected indirect punishment ($h = a \cdot f \cdot g$) | \$700,590 | $h$ |

Source: Data for $a$ from Dyck, Morse, and Zingales (2017), data for $b, c, d$ from Garrett (2015), data for $f$ from Larcker and Tayan (2019), data for $g$ from Pierce (2018).

of a corporate crime may be far below one. As Section 3 shows, this limits the degree to which corporate leniency can increase deterrence by raising the expected direct punishment of individual wrongdoers. In such a case, the tradeoff between the direct and indirect punishments is of significance in determining the level of corporate leniency. This section also presents rough estimates of the expected direct and indirect punishments of individual wrongdoers to provide a better picture of the situation that the model of this paper analyzes.

Table 1 reports rough estimates of the expected direct and indirect punishments of CEOs of U.S. public companies using aggregate data reported in previous studies. First, regarding the probabilities of crime detection and CEO prosecution, Dyck, Morse, and Zingales (2017) estimated that, for fraud cases, the probability of crime detection is approximately 33%, based on a sample of large U.S. public companies.[2] Moreover, the conditional probability of CEO prosecution is approximately 8.5%, based on the data of Garrett (2015), which consists of deferred and non-prosecution agreements with U.S. companies regarding corporate crimes, including fraud and other types of crime.[3] We use these numbers as the rough estimates of the probabilities of crime detection and CEO prosecution, respectively.

Second, regarding the direct punishment, the same study by Garrett reported that the mean fine for individuals prosecuted and fined is \$381,000, and the mean jail time for individuals sentenced is 18 months. Therefore, the expected direct punishment (the probability of crime detection multiplied by the conditional probability of CEO prosecution multiplied by the size of individual fine or jail time) is estimated at \$10,687 and 0.5 months of jail time. Since the individuals comprising the data of the mean fines and jail time include both senior executives and lower-level employees, the actual direct punishment of CEOs will be higher than the estimated direct punishment.[4] It should be also noted that CEOs are exposed to the risk of being fired and reputational losses, although we do not calculate the sizes of these additional sanctions due to limited data availability.

Finally, regarding the indirect punishment, Larcker and Tayan (2019) estimated the median change in the wealth of CEOs in U.S. public companies with a 1% stock change is \$193,000.[5] Moreover, Pierce (2018) estimated that the mean impact of corporate prosecution on the stock price of U.S. public companies is 11%.[6] Therefore, the expected indirect punishment (the probability of crime detection multiplied by the change in the wealth of CEOs with a 1% stock change multiplied by the impact of corporate prosecution on stock price) can be estimated at \$700,590.

These data suggest that the expected direct punishment of CEOs may not be much greater than the expected indirect punishment, even if we consider the additional individual sanctions associated with the direct punishment, such as reputational loss and the risk of being fired. What

[2] Their sample is U.S. public companies with more than \$750 million in assets during the period 1996-2004.

[3] His data comprise 306 deferred and non-prosecution agreements with U.S. public and private companies during the period 2001-14. In these cases, 26 CEOs were prosecuted (8.5%). The data including only public companies are not available.

[4] The data including only CEOs are not available in Garett (2015).

[5] Their sample is the largest 4,000 U.S. public companies, fiscal years ending June 2013 to May 2014. The wealth of CEOs includes stock options, restricted stock, performance plans, and direct stock ownership but excludes personal wealth outside of company stock. Their calculation does not take into account potential equity hedges.

[6] His sample includes 177 U.S. public companies during the period 1991-2002.

should be noted for the direct punishment is that executives would suffer considerable disutility from being in prison, even if the jail time is short; their disutility from imprisonment would mainly come from the stigma and loss of earning power, both of which are associated with the fact of being in prison itself rather than the length of imprisonment terms (Polinsky and Shavell 1999). Therefore, if the probabilities of crime detection and individual prosecution are sufficiently large, even if the jail time is not long, the expected direct punishment may be large enough to deter crimes. However, in the case of the United States, since both probabilities are low, this is likely to reduce the expected direct punishment significantly.

These facts have an important implication for law enforcement regarding corporate self-reporting. As explained in Section 1.1, reducing sanctions for self-reporting corporations sacrifices the indirect punishment of individual wrongdoers for the direct punishment of them. Whether corporate self-reporting programs work well depends on how large the expected direct punishment can become by increasing the probability of crime detection. If the conditional probability of individual prosecution given the detection of a corporate crime is low as explained above, this limits the ability of corporate self-reporting schemes to raise the expected direct punishment of individual wrongdoers. In such a case, the tradeoff between the direct and indirect punishments of individual wrongdoers is of significance because the reduction of corporate sanctions may decrease deterrence rather than increase it. We will see this in the next section.

## 3. The model

### *3.1. Setup*

The model has two risk-neutral players: a firm's manager and its board. There are three periods and no time discounting: $t \in \{0, 1, 2\}$. The firm value is $v \in (0, \infty)$, and the manager owns an $\alpha \in (0, 1]$ proportion of the firm's shares. We assume that the manager maximizes his or her expected payoff, and the board maximizes the expected firm value.

At $t = 0$, the manager privately decides whether to commit a corporate crime. If the manager commits the crime, the firm obtains illicit profit $\pi$, which has the cumulative distribution function (CDF) of $F(\cdot)$ and the probability density function (PDF) of $f(\cdot)$ on the full support $[0, \bar{\pi}]$, where these functions are common knowledge and $\bar{\pi}$ is the upper limit of $\pi$. The manager privately learns the realization of $\pi$ before making a decision on the crime. The crime causes a social harm of $h \in (\bar{\pi}, \infty)$. For simplicity, we assume that, if the crime is committed, the illicit profit $\pi$ is immediately distributed to the firm's shareholders.

At $t = 1$, the firm's board, which is uninformed about the manager's misconduct, decides whether to conduct an internal investigation to detect the crime, which costs $c$ that has the CDF of $G(\cdot)$ and the PDF of $g(\cdot)$ on the full support $[0, \infty)$, where these functions are common knowledge. The firm's board privately learns the realization of $c$ before making a decision on the internal investigation.

At $t = 2$, if the firm's board fails to investigate at $t = 1$, an enforcement agency investigates the firm with probability $p \in [0, 1]$, bearing the cost of $e \in [0, \infty)$. This means that the enforcement agency can verify whether the firm conducted the internal investigation and its result. We can alternatively assume that the enforcement agency investigates the firm if the firm does not self-report at $t = 1$, which does not alter the conclusions.

Each investigation by the firm's board or the enforcement agency accurately determines whether the manager committed the crime. However, because of the difficulties of proof in individual prosecution, the manager is prosecuted only with a conditional probability $q \in (0, 1)$ if the crime is detected, regardless of who detects it.[7]

If the enforcement agency detects the crime, the firm receives a regular sanction $s \in (0, \infty)$. By contrast, if the firm's board detects the crime and self-reports it to the enforcement agency, the firm receives a reduced sanction $r \in [0, s)$ under a corporate self-reporting program.[8] If the manager is prosecuted, the manager receives an individual sanction $i \in (0, \infty)$. We assume that $s$, $r$, and $i$ are socially costless to impose. For simplicity, $s$ and $i$ are assumed to be maximal. The maxima of $s$ and $i$ are generally determined by factors such as the wealth of wrongdoers (e.g., Kaplow and Shavell 1994) and considerations of fairness (Miceli 1991).

Policy instruments in the model are $p$ and $r$: the probability of investigation by the enforcement agency and the reduced sanction for corporate self-reporting, respectively.

The timeline is summarized in Figure 1, and the notation for variables is summarized in Table 2.

The model is a dynamic game with incomplete information, and we use a Perfect Bayesian Equilibrium (PBE)

[7]We can alternatively assume that the conditional probability of the manager's prosecution is larger in the case where the firm detects the crime than in the case where the enforcement agency detects it. Under the alternative assumption, while the main results remain unchanged, deterrence can be raised with less reduction of corporate sanctions because the expected direct punishment of the manager increases to a larger degree due to a larger conditional probability of prosecution. However, little evidence exists as to whether corporate internal investigations increase the conditional probability of individual prosecution.

[8]For simplicity, the model does not consider the possibility that the firm engages in activities to reduce the probability of crime detection, such as destroying the evidence of misconduct, after detecting the crime; incorporating this point into the model does not affect the non-monotonicity between the level of sanctions and deterrence and the main conclusions of this paper. If the model allows this possibility, the firm will engage in such activities if doing so is more advantageous than self-reporting. To address such a problem in practice, authorities can not only increase sanctions for these activities but also use whistleblower reward programs and offer monetary rewards to employees for reporting corporate misconduct. These programs will increase firms' costs from engaging in illegal activities to escape the detection of crime. For the use of whistleblower reward programs with corporate self-reporting schemes, see also Section 4.

Figure 1: Timeline

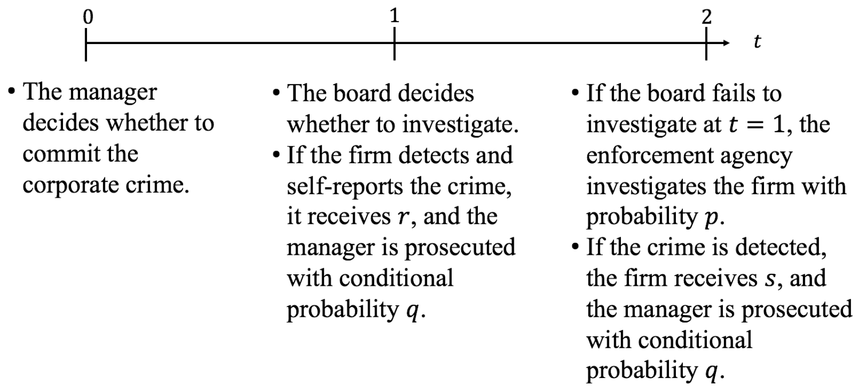



Table 2: Notation for Variables

| Symbol | Definition |
|---|---|
| $v$ | firm value; $v \in (0, \infty)$ |
| $\alpha$ | proportion of the manager's shares; $\alpha \in (0, 1]$ |
| $\pi$ | illicit profit to the firm; $\pi \in [0, \bar{\pi}]$ |
| $F(\cdot)$, $f(\cdot)$ | CDF and PDF of $\pi$ |
| $h$ | social harm caused by the crime; $h \in (\bar{\pi}, \infty)$ |
| $c$ | firm's cost of internal investigation; $c \in [0, \infty)$ |
| $G(\cdot)$, $g(\cdot)$ | CDF and PDF of $c$ |
| $p$ | probability of the agency's investigation; $p \in [0, 1]$ |
| $e$ | enforcement agency's cost of investigation; $e \in [0, \infty)$ |
| $q$ | conditional probability of individual prosecution; $q \in (0, 1)$ |
| $s$ | regular corporate sanction; $s \in (0, \infty)$ |
| $r$ | reduced corporate sanction; $r \in [0, s)$ |
| $i$ | individual sanction; $i \in (0, \infty)$ |

as an equilibrium concept. The PBE in this game involves two thresholds, $\{\pi^*, c^*\}$, where $\pi^*$ is the threshold profit above which the manager commits the crime, and $c^*$ is the threshold cost below which the board conducts an internal investigation. As explained in Section 3.2, both players, the manager and the board, use the cutoff strategy with the thresholds $\pi^*$ and $c^*$, respectively.

The model can be applied to other wrongdoers besides a manager, such as a lower-level employee, as long as those wrongdoers' payoffs have some correlation with their firm's value in forms such as bonuses, retirement bonuses, and promotion.

### *3.2. Analysis*

#### *3.2.1. Manager's decision on corporate crime*

We first consider the manager's decision whether to commit the crime at $t = 0$. As explained in Section 3.2.2, the probability that the board investigates internally at $t = 1$ can be expressed as $G(c^*)$, where $c^*$ is the board's threshold cost of internal investigation. Given the belief about $G(c^*)$, the manager commits the crime if the expected benefit from committing the crime is greater than or equal to the expected cost:

$$\alpha\pi \geq G(c^*)(\alpha r + qi) + (1 - G(c^*))p(\alpha s + qi). \tag{1}$$

The left side is the expected benefit from committing the crime. If the manager commits the crime, the value of his or her shares increases by the amount of $\alpha\pi$, the proportion of the manager's shares to the total firm shares times the illicit profit.

The right side is the expected cost from committing the crime. As the first term shows, the board investigates with probability $G(c^*)$, and in that case, since the firm self-reports and receives the reduced sanction $r$, the value of the manager's shares decreases by the amount of $\alpha r$. The manager receives the expected individual sanction $qi$, the conditional probability of individual prosecution times the individual sanction. The term $\alpha r$ is the indirect punishment through the corporate sanction, and the term $qi$ is the direct punishment through the individual sanction.

In comparison, as the second term shows, the board fails to investigate with probability $1 - G(c^*)$, and in that case, the enforcement agency investigates with probability $p$. If the firm is investigated, the firm receives the regular sanction $s$, and the value of the manager's shares decreases by the amount of $\alpha s$. Also, the manager receives the expected individual sanction $qi$. The term $p\alpha s$ is the indirect punishment through the corporate sanction, and the term $pqi$ is the direct punishment through the individual sanction.

From the comparison of the first and second terms, it is observed that, if the firm investigates and self-reports, the indirect punishment of the manager changes from $\alpha ps$ to $\alpha r$. As explained in Section 3.2.2, the probability of the firm's investigation $G(c^*)$ is positive if and only if $r < ps$. This means that the corporate self-reporting program that can induce the firm to investigate and self-report always reduces the indirect punishment of the manager through a reduction in the corporate sanction. By contrast, it is also observed that, if the firm investigates and self-reports, the direct punishment of the manager changes from $pqi$ to $qi$. Unless $p = 1$, the direct punishment always increases. Therefore, in essence, the corporate self-reporting program sacrifices the indirect punishment for the direct punishment of the manager, and thus the tradeoff exists between the indirect and direct punishments of the manager.

It should be noted that if the conditional probability of individual prosecution $q$ is low, the direct punishment of the manager when the firm self-reports $qi$ may be also low, even if the individual sanction $i$ is set maximal. The low $qi$ limits the degree to which the corporate self-reporting program can increase deterrence by raising the expected direct punishment. In such a case, the tradeoff between the indirect and direct punishments is particularly important because the reduction of corporate sanctions may decrease deterrence rather than increase it.

By rearranging expression (1), we obtain

$$\pi \geq \pi^* = G(c^*)(r + \frac{qi}{\alpha}) + (1 - G(c^*))p(s + \frac{qi}{\alpha}). \tag{2}$$

The right side of the inequality is the manager's threshold profit for committing the crime. If the illicit profit $\pi$ is greater than or equal to the threshold $\pi^*$, the manager commits the crime. The threshold $\pi^*$ can be interpreted as the expected punishment of the manager per $\alpha$ (the proportion of the manager's shares).

From expression (2), the probability that the manager commits the crime can be expressed as

$$Pr(\pi \geq \pi^*) = 1 - F(\pi^*). \tag{3}$$

From expressions (2) and (3), we obtain the following lemma.

**Lemma 1.** *If the probability of the firm's investigation $G(c^*) > 0$, then the probability of crime occurring $1 - F(\pi^*)$ decreases with the use of the corporate self-reporting program if and only if*

$$r > ps - \frac{(1-p)qi}{\alpha}. \tag{4}$$

The right side is the lower limit of the reduced sanction $r$ that achieves at least the same expected cost to the manager from committing the crime as the regular sanction $s$. If the firm investigates with a positive probability (i.e. $G(c^*) > 0$), as long as $r$ exceeds the lower limit, the probability of crime occurring $1 - F(\pi^*)$ decreases with the use of the corporate self-reporting program. If the expected individual sanction when the firm investigates $qi$ becomes larger, the lower limit becomes smaller. If $p = 1$, the corporate self-reporting program cannot further increase the expected cost to the manager because the expected cost is already maximal.

*3.2.2. Board's decision on internal investigation*

We next consider the board's decision whether to conduct an internal investigation at $t = 1$. As explained in Section 3.2.1, the probability that the manger commits the crime at $t = 0$ can be expressed as $1 - F(\pi^*)$, where $\pi^*$ is the manager's threshold profit for committing the crime. Given the belief about $1 - F(\pi^*)$, the board investigates internally if the expected firm value in that case is greater than or equal to the expected firm value in the case of no internal investigation:

$$v - (1 - F(\pi^*))r - c \geq v - (1 - F(\pi^*))ps. \tag{5}$$

The left side is the expected firm value in the case of internal investigation. If the board investigates internally, it detects the crime with probability $1 - F(\pi^*)$, and the firm receives the reduced sanction $r$ by self-reporting. In addition, internal investigation costs $c$. In comparison, the right side is the expected firm value in case of no internal investigation. If the board fails to investigate, the firm receives the expected sanction $(1-F(\pi^*))ps$ at $t = 2$. The manager commits the crime with probability $1-F(\pi^*)$, the enforcement agency detects the crime with probability $p$, and the firm receives the regular sanction $s$.

From expression (5), we obtain the board's threshold cost for internal investigation:

$$c^* = \max\{(1 - F(\pi^*))(ps - r), 0\} \geq c. \tag{6}$$

If the firm's cost of internal investigation $c$ is less than or equal to the threshold $c^*$, the board investigates internally. The threshold $c^*$ can be interpreted as the expected benefit to the firm from internal investigation.

From expression (6), the probability that the board investigates internally can be expressed as

$$Pr(c^* \geq c) = G(c^*). \tag{7}$$

From expressions (6) and (7), we obtain the following lemma.

**Lemma 2.** The probability of the firm's investigation $G(c^*) > 0$ *if and only if the probability of crime occurring* $1 - F(\pi^*) > 0$ *and*

$$r < ps. \tag{8}$$

If there is a positive probability of crime occurring (i.e. $1 - F(\pi^*) > 0$) and if the reduced sanction $r$ for self-reporting is less than the expected regular sanction for the non-self-reporting criminal firm $ps$, the board always has incentive to investigate and self-report with a positive probability ($G(c^*) > 0$). If $p = 0$, the corporate self-reporting program cannot be used to encourage the board to investigate because the expected sanction to the firm is zero even if the firm fails to investigate internally.

*3.2.3. Effects of reducing corporate sanctions on deterrence*

From Lemma 1 and 2, we obtain the following proposition.

**Proposition 1 (the deterrence-enhancing sanction range).** *The probability of crime occurring $1 - F(\pi^*)$ decreases with the use of the corporate self-reporting program if and only if*

$$ps - \frac{(1-p)qi}{\alpha} < r < ps. \tag{9}$$

Now we obtain the following proposition.

**Proposition 2 (the non-monotonicity between the level of the corporate sanction and deterrence).** *The level of the reduced corporate sanction $r$ has a non-monotonic relationship with the probability of crime occurring $1 - F(\pi^*)$ in the deterrence-enhancing sanction range of (9): as the level of the reduced corporate sanction $r$ decreases, receding from the upper limit of the range, the probability of crime occurring $1-F(\pi^*)$ first decreases and then increases.*

The proof of this proposition is in Appendix A, and the intuition of this result is as follows. As $r$ decreases, receding from the upper limit of the deterrence-enhancing sanction range $ps$, the expected indirect punishment monotonically decreases, but the expected benefit to the firm from self-investigation $c^*$ monotonically increases, and thus the probability of the firm's self-investigation $G(c^*)$ monotonically increases as well. Because of this monotonic increase in the probability of crime detection, with the reduction of $r$, the expected direct punishment monotonically increases in the deterrence-enhancing range. Therefore, in this range, the total expected punishment of the manager (per $\alpha$), $\pi^*$, is the sum of a monotonically increasing function and a monotonically decreasing function, which is non-monotonic given Proposition 1.[9]

When $r$ is relatively high among the values located in the deterrence-enhancing sanction range, even if $r$ is marginally reduced, the increase in the probability of crime detection can bring the increase in the expected direct punishment that is greater than the decrease in the expected indirect punishment. If the firm self-reports, along with the direct punishment, a certain size of the indirect punishment still will be imposed on the manager. Consequently, the sum of expected direct and indirect punishments increases, and thus the total expected punishment of the manager (per $\alpha$) $\pi^*$ increases; therefore, the probability of crime occurring $1 - F(\pi^*)$ decreases.

However, when $r$ is relatively low among the values located in the deterrence-enhancing range, if $r$ is marginally reduced, the increase in the probability of crime detection can only bring an increase in the expected direct punishment that is smaller than the decrease in the expected indirect punishment. The size of the indirect punishment of the manager when the firm self-reports becomes excessively small by reducing $r$ from an already low level. As a result, the sum of expected direct and indirect punishments decreases, and thus $\pi^*$ decreases; therefore, the probability of crime occurring $1 - F(\pi^*)$ increases.

Figure 2 shows a numerical example of the relationship between the probability of crime occurring $1 - F(\pi^*)$ and the reduced sanction $r$ when $p = 0.5$ with the following parameters: $v = 1000$; $\alpha = 0.1$; $\pi$ follows a truncated normal distribution with mean 200 and standard deviation 50 in the interval $[0, 400]$; $h = 5000$; $c$ follows a truncated normal distribution with mean 10 and standard deviation 30 in the interval $[0, \infty)$; $e = 600$; $q = 0.5$; $s = 300$; $i = 20$. If $r \geq ps = 150$, the reduced sanction is not smaller than the expected regular sanction for the non-self-reporting criminal firm $ps$, and thus no firm investigates and self-reports. Hence, the probability of crime occurring in these cases, 0.5 (50%), is the same as when no leniency exists. If $r$ lies in the deterrence enhancing range of (9) ($ps - (1-p)qi/\alpha = 100, ps = 150$), the probability of crime occurring is smaller than when no leniency exists. In the deterrence enhancing range, as $r$ decreases, receding from the upper limit $ps$, the probability of crime occurring $1 - F(\pi^*)$ first decreases and then increases.

Figure 3 provides the relationship between the probability of the firm's self-investigation $G(c^*)$ and $r$; in the deterrence-enhancing range, as $r$ decreases, $G(c^*)$ monotonically increases. Figure 4(a)-(c) shows how the direct, indirect, and total punishments of the manager (per $\alpha$) change in their expected values with the reduction in $r$. As Figure 4(a) shows, as $r$ decreases, the expected direct punishment monotonically increases because of the monotonic increase in the probability of the firm's self-investigation $G(c^*)$. On the other hand, as Figure 4(b) shows, the expected indirect punishment monotonically decreases with the reduction in $r$. Figure 4(c) shows that, as $r$ decreases, the sum of the direct and indirect punishments $\pi^*$ first increases and then decreases in the deterrence enhancing range, and thus the probability of crime occurring $1 - F(\pi^*)$ first decreases and then increases as shown in Figure 2.

[9]Note that, in the deterrence-enhancing range, the expected indirect punishment is a monotonically increasing function, and thus it monotonically decreases as $r$ decreases; also, in the range, the expected direct punishment is a monotonically decreasing function, and thus it monotonically increases as $r$ decreases. The terms of monotonically increasing and decreasing functions are defined in terms of how an *increase* in an argument affects a value of a function.

Figure 2: The Non-Monotonicity between the Probability of Crime Occurring and the Level of Corporate Sanctions

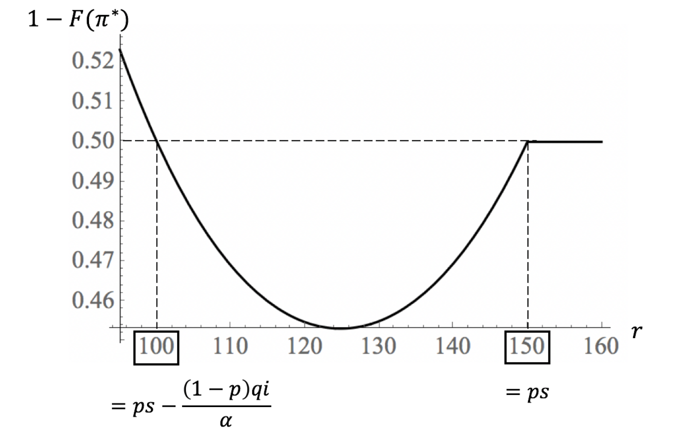



Figure 3: The Probability of the Firm's Self-Investigation

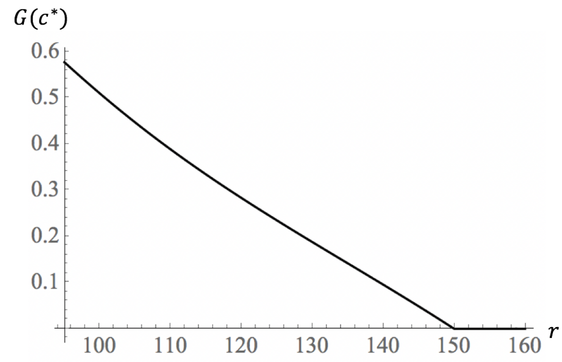
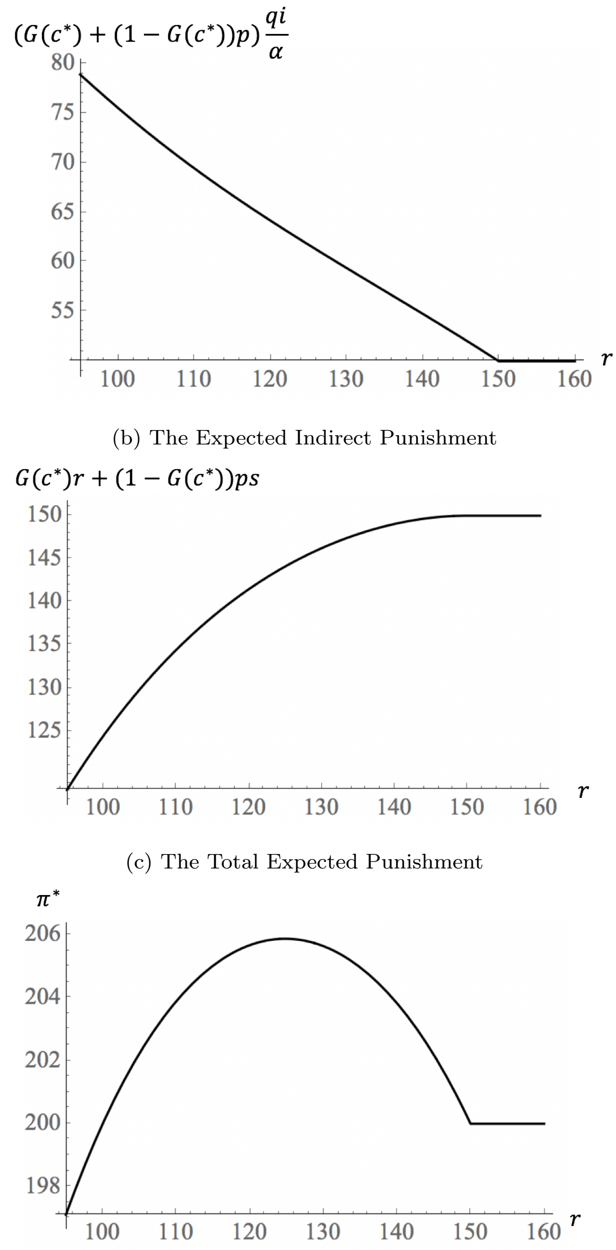



Figure 4: The Expected Punishment of the Manager

(a) The Expected Direct Punishment




(b) The Expected Indirect Punishment

(c) The Total Expected Punishment

*3.2.4. Optimal corporate leniency and investigations by the authority*

We now consider the optimal reduced sanction $r$ and the optimal probability of the authority's investigation $p$. The enforcement agency maximizes social welfare by choosing $p$ and $r$. To analyze this maximization problem, we first need to rewrite $\pi^*$ and $c^*$ as the functions of $p$ and $r$. Since $\pi^*$ and $c^*$ are dependent on each other, we cannot express either variable as the explicit function. We solve this issue by using the implicit function theorem (see Appendix A); $\pi^* = \Pi^*(p, r)$ is an implicit function defined by expression (19); $c^*(p, r)$ can be expressed as (21) using $\pi^* = \Pi^*(p, r)$. Let $W$ stand for social welfare, then $W$ can be written using $\Pi^*(p, r)$ and $c^*(p, r)$ as

$$W = v + \int_{\Pi^*(p,r)}^{\bar{\pi}} (\pi - h) dF(\pi) - \int_0^{c^*(p,r)} c dG(c) - \int_{c^*(p,r)}^{\infty} pe dG(c). \quad (10)$$

The first term is the firm's value. The second term is the benefit minus the harm from the crime. The third term is the cost of the firm's internal investigation, and the fourth term is the cost of the enforcement agency's investigation. The sum of the third and fourth terms is the total investigation cost to the economy. The enforcement agency maximizes $W$ with respect to $p$ and $r$, subject to the constraints that $0 \leq p \leq 1$ and $0 \leq r < s$.

We leave the technical explanations of optimality conditions to Appendix B and consider the tradeoffs that the enforcement agency faces. These results change depending on whether the socially optimal $r$ lies in the deterrence-enhancing range. In reality, the level of a reduced sanction would be usually set within the deterrence-enhancing range so that corporate self-reporting programs do not weaken deterrence, because the social harms caused by corporate crimes usually would be large; thus, we focus here on the case in which the socially optimal $r$ is in the deterrence-enhancing range.[10]

In choosing $p$ and $r$, the authority faces the tradeoff between the expected harm from the crime and the total investigation cost to the economy. If the cost of the authority's investigation, $e$, is sufficiently small, this tradeoff does not matter; however, it would not be realistic, and thus we ignore such a case here. First, with regard to $p$, if the authority raises it, $\pi^* = \Pi^*(p, r)$ (the expected punishment of the manager per $\alpha$) monotonically increases, and thus the expected harm from the crime monotonically decreases as a result of the reduction in the probability of crime occurring; this means that the second term in expression (10) monotonically increases. A marginal increase in $p$ raises the expected punishment of the manager for the case when the firm fails to self-police. Although a marginal increase in $p$ also may impact the expected punishment of the manager by influencing the probability of the firm's investigation $G(c^*(p, r))$, regardless of this impact, both direct and indirect punishments increase by raising $p$ marginally.

On the other hand, a marginal increase in $p$ changes the total investigation cost to the economy. If $p$ is marginally increased, this raises the expected cost of the authority's investigation for the case when the firm fails to self-investigate, $pe$; the fourth term in expression (10) decreases. Although a marginal increase in $p$ also may impact the total investigation cost to the economy by influencing the probability of the firm's self-investigation $G(c^*(p, r))$, regardless of this impact, unless the cost of the authority's investigation $e$ is sufficiently small, a marginal increase in $p$ around its socially optimal level increases the total investigation cost to the economy.

At the social optimum, if $p$ is marginally increased, the additional decrease in the expected harm from the crime (the marginal social benefit) must be equal to the additional increase in the total investigation cost to the economy (the marginal social cost); this is the optimality condition for choosing $p$. If the enforcement agency can choose $p$ without constraints, such as budgetary and political ones, it can choose $p$ according to this optimality condition. However, in reality, enforcement agencies face these constraints and would not be able to raise the probability of their investigations to a sufficiently high degree. In such a case, corporate self-reporting programs can be a useful tool to increase deterrence as well as economize the cost of authorities' investigations.

Bearing this in mind, we next consider the optimality condition for choosing $r$. As we saw in Proposition 2, as $r$ decreases, receding from the upper limit of the deterrence-enhancing range $ps$, the expected indirect punishment monotonically decreases, and the expected direct punishment monotonically increases. Some portion of indirect punishment is sacrificed to raise the expected direct punishment; consequently, with a reduction of $r$, the sum of direct and indirect punishments $\pi^* = \Pi^*(p, r)$ first rises and then declines. This affects the second term in expression (10); with a reduction of $r$, the expected harm from the crime first decreases and then increases. What should be noted here is that, when compared to the case of no leniency, reducing $r$ can achieve a lower probability of crime occurring and, thus, a lower expected harm from the crime as long as $r$ lies in the deterrence-enhancing range.

On the other hand, as $r$ decreases, the threshold cost for the firm's investigation $c^*(p, r)$ monotonically increases, and thus the probability of the firm's investigation monotonically increases as well; if the firm is more likely to self-investigate, the authority's investigation becomes less necessary. This increases the expected cost of the firm's investigation but decreases the expected cost of the authority's investigation; in expression (10), the third term decreases, and the fourth term increases. What we can notice from these terms is that the total investigation cost can be reduced by having the firm self-investigate in the cases when the threshold cost for the firm's self-investigation $c^*(p, r)$ is cheaper than the expected cost of the authority's investigation for the case when the firm fails to self-investigate, $pe$, that is, $c^*(p, r) < pe$. In other words, the total investigation cost decreases with a reduction in $r$ until $c^*(p, r)$ reaches $pe$.

Let $r^*$ be the level of $r$ that achieves the lowest probability of crime occurring. The optimality condition for $r$ changes depending on whether $c^*(p, r) < pe$ when $r$ equals $r^*$; If this is the case, a further reduction in $r$ from $r^*$ brings the decrease in the total investigation cost but the increase in the expected harm from the crime. In this case, the authority should further reduce $r$ from $r^*$ to a lower level at which the additional decrease in the total investigation cost resulting from a marginal reduction in $r$ (the marginal social benefit) equals the additional increase in the expected harm from a marginal reduction in $r$ (the marginal social cost). In contrast, if $c^*(p, r) > pe$ when $r$ equals $r^*$, the socially optimal $r$ is higher than $r^*$. In this case, the authority should set $r$ at a level where the additional increase in the total investigation cost resulting from a marginal reduction in $r$ (the marginal social cost) equals the additional decrease in the expected harm from a marginal reduction in $r$ (the marginal social benefit).

To summarize the arguments regarding the optimal $r$ so far, with a reduction of $r$ in the deterrence-enhancing range, the expected harm from the crime first decreases and then increases while the total investigation cost monotonically decreases or first decreases and then increases. A marginal reduction of $r$, that is, a marginal reduction of the indirect punishment, has two possible functions in the maximization problem of social welfare: (i) it has the function of reducing the expected harm from the crime by increasing the expected direct punishment, and (ii) it also has the function of economizing the total investigation

[10] Appendix B deals with the case in which $r$ lies out of the deterrence-enhancing range as well as the case in which $r$ lies in that range.

cost. However, these functions cannot be necessarily performed simultaneously. As long as a marginal reduction in $r$ can perform both functions, the tradeoff between the expected harm and the total investigation cost does not matter, and $r$ should be further reduced. If a marginal reduction in $r$ can perform only one of the two functions, the tradeoff matters. The socially optimal $r$ should be determined by the optimality condition; at the optimum, the marginal social benefit is equal to the marginal social cost.

### *3.3. Numerical example*

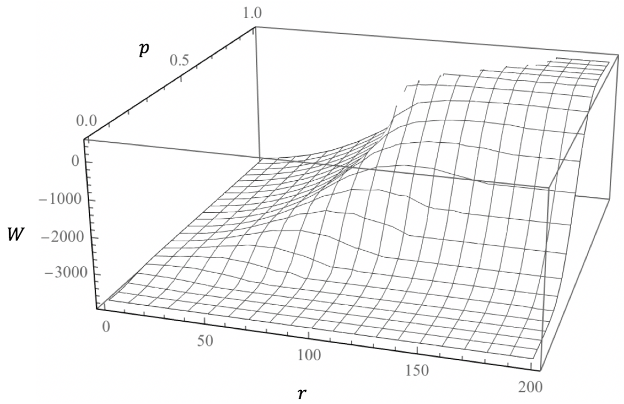
To understand the authority's maximization problem graphically, let us consider a numerical example. Figure 5 shows the graph of the social welfare $W$ with the same parameters as those of the example for Proposition 2. In the graph, at a higher $p$, the graph of $W$ is an almost horizontal line over the $r$ axis in a certain range of $r$; $W$ in this range is higher than in the other range of $r$. In this case, the crime is almost perfectly deterred without using the firm's self-investigation, and reducing $r$ cannot improve $W$ significantly.[11]

In contrast, at a lower $p$, the graph of $W$ is a concave downward curve over the $r$ axis in a certain range because of the non-monotonicity between the level of $r$ and deterrence (Proposition 2). Therefore, in this case, a reduction in $r$ has the potential to increase $W$. If $p$ is too low, W is an almost horizontal line over the $r$ axis, and thus a reduction in $r$ does not increase $W$ significantly; since a certain level of $p$ is necessary to provide a threat of crime detection to the firm so that self-reporting looks attractive to the firm, if $p$ is too low, the corporate self-reporting program does not work well.

Suppose that the authority can raise $p$ to 0.5 at most for some reasons such as budgetary and political ones. Figure 6 (a)-(c) shows the socially optimal $r$, relative sizes of direct and indirect punishments, and total investigation cost in the economy for two cases. The parameters of Case 1 are the same with those of the example for Proposition 2. For Case 2, the cost of the authority's investigation, $e$, is cheaper than in Case 1 (Case 1: $e = 600$, Case 2: $e = 1$), and the harm, $h$, is smaller than in Case 1 (Case 1: $h = 5000$, Case 2: $h = 410$); the other parameters are the same in the two cases.

Figure 6(a) shows the graph of the probability of crime occurring $1 - F(\pi^*)$ when $p$ is fixed at 0.5. Note that the graph of $1-F(\pi^*)$ is the same for the two cases because it is not affected by the differences in $e$ and $h$. (See expressions

Figure 5: Numerical Example: Social Welfare




(2) and (6).) For both cases, the deterrence-enhancing sanction range of $r$ is $(100, 150)$. If the corporate self-reporting program does not exist, the probability of crime occurring is 0.5 (50%). However, if the corporate self-reporting program is introduced, the probability of crime occurring can be reduced to at minimum 0.453 (45.3%); the level of $r$ that achieves the lowest probability of crime occurring $r^* = 124.8$.

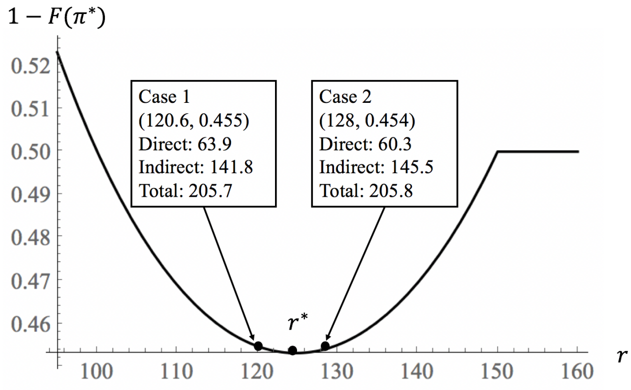
In Case 1, the socially optimal $r$ is 120.6, and at that $r$, the probability of crime occurring is 0.455 (45.5%). The sizes of expected direct and indirect punishments are 63.9 and 141.8, respectively, and the total expected punishment is 205.7. By contrast, in Case 2, the socially optimal $r$ is 128, and at that $r$, the probability of crime occurring is 0.454 (45.4%). The sizes of expected direct and indirect punishments are 60.3 and 145.5, respectively, and the total expected punishment is 205.8. The probability of crime occurring and the total expected punishment are almost the same in the two cases. However, the optimal $r$ in Case 1 is lower than $r^*$, and the optimal $r$ in Case 2 is higher than $r^*$. The expected indirect punishment accounts for a greater proportion in the total expected punishment in Case 2 than in Case 1.

These differences come from the differences in $e$ and $h$ between the two cases. In Case 1, the cost of the authority's investigation is more expensive than the firm's self-investigation. As Figure 6(b) shows, the total investigation cost in the economy decreases with a reduction of $r$ because the firm's cheap self-investigation is more likely to be used instead of the authority's expensive investigation. On the other hand, as we saw in Section 3.2.4, as $r$ decreases, the harm $h$ also decreases until $r$ falls to $r^*$. To what extent $r$ should be further reduced from $r^*$ is determined by considering the tradeoff between the additional decrease in the total investigation cost and the additional increase in the expected harm. As a result, the optimal $r$ in Case 1 is lower than $r^*$. The probability of crime occurring at the social optimum 0.455 (45.5%) is very similar to the lowest probability of crime occurring 0.453 (45.3%) thanks to the increase in the expected direct punishment.

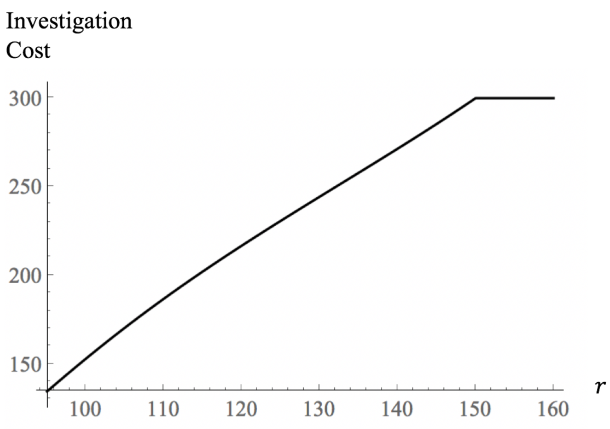
[11] In this example, the probability of crime occurring is close to zero, and thus reducing $r$ cannot further reduce it. Moreover, because of the low probability of crime occurring, the firm does not have incentive to self-investigate unless $r$ is reduced to a large extent; the total investigation cost cannot be saved unless $r$ is reduced largely. These factors make the graph of $W$ a line parallel to the $r$ axis in a certain range; $W$ remains almost unchanged with a change in $r$. If $r$ is reduced largely, the firm is more likely to self-investigate, but the probability of crime occurring increases because of a low indirect punishment, and thus $W$ decreases significantly.

Figure 6: The Comparison of Two Cases

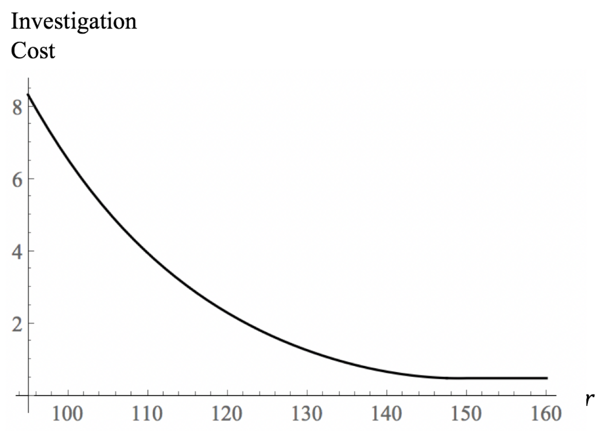
(a) The Socially Optimal $r$ and the Punishments in Each Case




(b) The Total Investigation Cost in Case 1




(c) The Total Investigation Cost in Case 2




By contrast, in Case 2, the cost of the authority's investigation is much cheaper than the firm's self-investigation. As Figure 6(c) shows, as $r$ decreases, the total investigation cost in the economy increases in almost all the range of $0 \leq r < 150$. Therefore, to what extent $r$ should be reduced is determined by considering the tradeoff between the additional increase in the total investigation cost and the additional decrease in the expected harm. As a result, the optimal $r$ in Case 2 is higher than $r^*$.

For these reasons, the proportion of the expected indirect punishment in the total expected punishment in Case 1 (141.8/205.7) is smaller than in Case 2 (145.5/205.8), although the total expected punishment is almost the same in the two cases. In Case 1, the firm's self-investigation is cheaper than the authority's investigation, and thus the use of the firm's self-investigation is more attractive to the authority in Case 1 than in Case 2; consequently, the reduction of the indirect punishment in Case 1 is larger than in Case 2. In reality, because of information asymmetry between firms' insiders and outsiders about firms' activities, firms' self-investigations would be cheaper than authorities' investigations in many cases.

Another reason why the differences occur in the two cases is that the harm $h$ in Case 2 is much smaller than that in Case 1 (Case 1: $h = 5000$, Case 2: $h = 410$). As the harm from the crime $h$ becomes smaller, the marginal social benefit from reducing $r$ decreases. For this reason, the socially optimal $r$ in Case 2 is higher than $r^*$.

### *3.4. Manager's self-reporting*

In the foregoing enforcement scheme, the manager is not allowed to self-report, but it is possible to design an enforcement scheme where an individual self-reporting program as well as the aforementioned corporate self-reporting program are introduced. Thus, we next consider how the introduction of an individual self-reporting program affects the arguments so far.

We modify the model's assumptions as follows, with other elements remaining unchanged. If the manager commits the crime at $t = 0$, he or she can self-report it to the enforcement agency at $t \in [0, 1]$ before the enforcement agency investigates the firm at $t = 2$.

If the manager self-reports, he or she receives a reduced individual sanction $x \in [0, i)$, and the corporation receives the reduced sanction $r \in [0, s)$. The manager's self-report is accepted if and only if the enforcement agency has not detected the crime at the time the manager self-reports. For simplicity, we assume that if both the manager and the firm self-report at $t = 1$, only the firm's self-report is accepted.

Let us first consider the manager's decision on committing the crime and self-reporting. The manager self-reports if the total sanction when self-reporting is equal to or less than the expected total sanction when not self-reporting:

$$\alpha r + x \leq G(c^*)(\alpha r + qi) + (1 - G(c^*))p(\alpha s + qi). \tag{11}$$

The left side is the total sanction when self-reporting. If the manager self-reports, the manager's wealth decreases by $\alpha r$, and the manager receives the reduced individual sanction $x$. The right side is the expected total sanction when not self-reporting.

By rearranging this, we obtain the following expression:

$$x \leq x^* = G(c^*)(\alpha r + qi) + (1 - G(c^*))p(\alpha s + qi) - \alpha r. \quad (12)$$

The right side of the inequality is the threshold individual sanction where the manager is indifferent between self-reporting and not self-reporting.

To compare the enforcement schemes with and without the individual self-reporting program, suppose that the levels of $p$ and $r$ maximize the social welfare $W$ without the individual self-reporting program in expression (10) (i.e. $p$ and $r$ meet the optimality conditions of (25) and (26), respectively), use the same $p$ and $r$ to derive the threshold individual sanction $x^*$ in expression (12), and set $x$ as $x^*$.

Let $G(\hat{c})$ be the probability of the firm's investigation that maximizes the social welfare $W$ without the individual self-reporting program. To keep the same deterrence as that of the enforcement scheme without the individual self-reporting program, $G(c^*)$ in expression (12) must be equal to $G(\hat{c})$. However, the firm may not always have incentive to commit to an ex post investigation effort if it knows that the manager may self-report when he or she commits the crime. Also, if the manager is aware of this, he or she may not self-report.

If the firm can commit to investigate with probability $G(\hat{c})$, the manager will self-report with a probability of 1 if $x$ is reduced by a penny from $x^*$. This is because, even if the manager self-reports with a probability of 1, the firm's probability of investigation does not decrease because of the firm's commitment to the investigation, and thus the expected sanction on the manager when he or she fails to self-report remains unchanged. Therefore, the enforcement scheme with the individual self-reporting program when the firm can commit to the investigation can achieve the same deterrence as that of the enforcement scheme without the individual self-reporting program. The manager has no reason to wait to self-report until $t = 1$ because he or she cannot receive the reduced individual sanction $x$ if the firm investigates internally and self-reports at $t = 1$. Hence, the individual self-reporting program induces the manager's immediate self-reporting by creating a so-called race to the courthouse.

This is a unilateral version of ordered-leniency policies, which Landeo and Spier (2018a, b) analyzed. They explored self-reporting programs where a group of wrongdoers commits a crime and the level of their fine reduction depends on the chronological order of their self-reporting, which they call ordered-leniency policies. The earlier a wrongdoer self-reports the crime, the more his or her fine is reduced. By creating a race to the courthouse, ordered leniency policies detect crimes faster and strengthen deterrence. While each wrongdoer has an equal opportunity to be the first reporter in the model of Landeo and Spier, in the present model, the manager has an advantage over the firm in the timing of self-reporting because of information asymmetry. In addition, since the firm can receive the reduced sanction as long as its manager self-reports, the situation in the present model can be considered a unilateral version of ordered-leniency policies, where a race between the manager and the firm matters only for the manager.

In reality, if appropriately designed, laws can provide firms with incentives to commit to an ex post investigation. The relationship between a manager and a firm is almost a repeated game, not a one-time one. Although a manager is replaced over time, he or she can observe the frequency and degree of a firm's past investigations. If the net benefit to a firm from a commitment to investigation is larger than that from non-commitment in the long term, the firm will keep the commitment. An example of a law that may incentivize firms to commit to an ex post investigation is the Sarbanes-Oxley Act of 2002 in the United States. It requires companies' management and auditor to report annually on internal control over financial reporting. This type of disclosure will incentivize firms to establish appropriate internal control policies and investigate internally based on these policies because their activities can be monitored by third parties, such as future candidates for senior executives as well as enforcement agencies and investors.

If the firm cannot commit to investigate with probability $G(\hat{c})$, the manger will self-report with a probability of $y \in [0, 1]$. The board investigates internally if

$$v - (1 - F(\pi^*))(1 - y)r - c \geq v - (1 - F(\pi^*))(1 - y)ps. \quad (13)$$

The left side is the expected firm value in the case of internal investigation. The manager commits the crime with probability $1 - F(\pi^*)$, and he or she fails to self-report with probability $1 - y$. Therefore, if the board investigates internally, it detects the crime with probability $(1 - F(\pi^*))(1 - y)$ and the firm receives the reduced sanction $r$. In comparison, the right side is the expected firm value in the case of no internal investigation. If the board fails to investigate internally, the firm receives the expected sanction $(1 - F(\pi^*))(1 - y)ps$.

By rearranging this expression (13), we obtain

$$c^* = \max\{(1 - F(\pi^*))(1 - y)(ps - r), 0\} \geq c. \quad (14)$$

The left side of the inequality is the threshold cost for the firm's internal investigation. When compared to the threshold cost (6) for the firm's internal investigation in the enforcement scheme without the individual self-reporting program, the threshold cost in expression (14) decreases at a rate of $y$. The gain from the internal investigation decreases because the manager's self-reporting occurs with probability $y$. Consequently, since $c^*$ decreases, the probability of the firm's investigation $G(c^*)$ decreases, and the probability of crime occurring increases.

The social welfare $W$ when the individual self-reporting program is available can be written as

$$W = v + \int_{\Pi^*(p,r)}^{\bar{\pi}} (\pi - h) dF(\pi)$$
$$- (1 - (1 - F(\Pi^*(p,r)))y) \left[ \int_0^{c^*(p,r)} c dG(c) + \int_{c^*(p,r)}^{\infty} pe dG(c) \right]. \quad (15)$$

The social welfare $W$ in this expression (15) differs in the third term from $W$ in expression (10), where the individual self-reporting program is not available. The manager commits the crime and self-reports with probability $(1 - F(\Pi^*(p,r)))y$, and thus only with probability $1-(1-F(\Pi^*(p,r)))y$, the firm's and enforcement agency's probabilistic investigations are necessary. Hence, the individual self-reporting program economizes the costs of these investigations.

To compare the enforcement schemes with and without the individual self-reporting program, suppose again that the levels of $p$ and $r$ maximize $W$ in expression (10), and use the same $p$ and $r$ in expression (15). If the firm can commit to investigate with probability $G(\hat{c})$ (the socially optimal probability of the firm's investigation in expression (10)), the second term in expression (15) remains unchanged from that of expression (10). However, since the manager self-reports with probability $y = 1$, the third term in expression (15) is smaller in the absolute value than the total of the third and fourth terms in expression (10). Therefore, the enforcement scheme with the manager's self-reporting can achieve the same deterrence as the enforcement scheme without it while being less costly.

If the firm cannot commit to investigate with probability $G(\hat{c})$, the expected sanction on the manager decreases, and the probability of crime occurring increases. Consequently, the second term in expression (15) increases in the absolute value, which means that the net harm from the crime increases. At the same time, the costs of the firm's and enforcement agency's investigations may decrease because of the manager's self-reporting: the third term may decrease in the absolute value. If the harm of the crime $h$ is sufficiently small, the change in the third term may exceed in the absolute value the change in the second term, and thus the social welfare $W$ may increase. Therefore, the use of the individual self-reporting program is socially efficient if and only if $h$ is sufficiently small.

From the arguments so far, we obtain the following proposition.

**Proposition 3.** *If the firm can commit to investigate with probability $G(\hat{c})$, the enforcement agency can induce self-reporting from the manager with a probability of 1, and the use of the manager's self-reporting program is always socially efficient. If the firm cannot commit to investigate with probability $G(\hat{c})$, the use of the manager's self-reporting program is socially efficient if and only if $h$ is sufficiently small.*

This result is consistent with the model of Gerlach (2013) where an enforcement agency may not commit to an ex post investigation effort to detect individual crimes when a self-reporting program for individuals is available. In his model, the use of self-reporting programs is always socially efficient if the enforcement agency can commit to an ex post investigation effort. If the enforcement agency cannot commit, the use of self-reporting programs is socially efficient if and only if the harm of a violation by a wrongdoer is sufficiently small. As shown in this section, his model can be applied to the case where a firm may not be able to commit to an ex post investigation effort to detect corporate crimes when both corporate and individual self-reporting programs are available.

Even if we assume that the enforcement agency as well as the firm may not be able to commit to an ex post investigation in the model, the non-monotonicity between the level of corporate leniency and deterrence remains unchanged, and thus the main conclusions of the present study remain unchanged. Hence, we do not address that case here for simplicity.

## 4. Conclusions and policy implications

The model presented in this paper has shown the detailed mechanism of how reducing sanctions for self-reporting corporations affects deterrence. Corporate self-reporting schemes may enhance deterrence if the level of corporate leniency is within a certain range. But the level of corporate leniency has a non-monotonic relationship with deterrence in that range: as the level of corporate sanctions decreases, receding from the upper limit of the range, the probability of crime occurring first decreases and then increases. This paper also considers the case in which an individual self-reporting program as well as a corporate self-reporting program are introduced. The social desirability of individual self-reporting schemes depends on whether firms can commit to a certain level of self-policing efforts.

Detecting corporate crimes is notoriously difficult for enforcement agencies in every jurisdiction because of factors such as information asymmetry between the insiders and outsiders of corporations and the limited resources of enforcement agencies. In fact, parties other than enforcement agencies, such as employees and the media, have revealed the majority of corporate crimes (e.g., Dyck, Morse, and Zingales 2010). A potential source of crime detection today may be corporations themselves.

Corporate self-disclosure schemes have the potential to increase the probability of crime detection if enforcement agencies design them appropriately. The essence of corporate self-reporting policies is to sacrifice the expected indirect punishment of individual wrongdoers to increase the probability of crime detection or individual prosecution, which leads to an increase in the expected direct punishment of individuals. Thus, recognizing this tradeoff is particularly important for prosecutors in criminal settlements given the fact that the conditional probability of individual prosecution is low. If they reduce corporate sanctions excessively, then this will reduce deterrence of individual wrongdoers, particularly senior executives, who are likely to be most responsible for today's corporate crimes.

Many jurisdictions appear to recognize the importance of individual prosecutions in corporate self-reporting schemes. For example, in the United States, since then-Deputy Attorney General Sally Yates issued the so-called Yates Memo in 2015, the Department of Justice (DOJ) has required companies to provide it with information about individuals involved in offenses to be eligible for corporate leniency. In addition, under the DOJ's current Corporate Enforcement Policy, companies that self-report, fully cooperate, and timely and appropriately remediate may receive a declination of prosecution and no fines, if there are no aggravating factors such as the involvement by executives in the misconduct.[12] If there are aggravating factors, these companies may receive a 50% reduction off of the low end of the fine range in the U.S. Sentencing Guidelines. Whether the degree of fine reduction is appropriate is a matter of empirical question and should be further examined, but at least these facts suggest that the DOJ seeks the deterrence of individual wrongdoers in their enforcement practices.

Although requiring self-reporting companies to submit evidence about individual wrongdoers may increase the number of individual prosecutions to some degree, it would not lead to a significant increase in the prosecution of senior executives, all else being equal. The fundamental problem here is that executives may shift blame to lower-level employees and that evaluating evidence submitted by companies needs budgets and resources; without sufficient resources, prosecutors would find it difficult to verify related parties' claims. However, the budgets of enforcement agencies for regulating corporate crimes are usually very limited; for example, the DOJ's budget for corporate crimes has not been increased after the Yates Memo, and prosecutors' resources are limited. Enforcement agencies need some device to secure the truthfulness of information provided by self-reporting companies.

A possible remedy for this problem is to combine corporate leniency programs with whistleblower reward programs, under which employees may receive monetary rewards for whistleblowing to enforcement agencies. Investigations of corporate crimes require the cooperation of employees. However, they may hesitate to cooperate with enforcement agencies for fear of retaliation by executives, which increases employees' costs from reporting. Whistleblower rewards increase employees' benefits from reporting, and thus employees may be incentivized to report criminal facts to enforcement agencies, which helps agencies' investigations. If there is a threat of whistleblowing, corporations may find it more difficult to conceal unfavorable information regarding senior executives. Companies may even provide internal rewards to employees for reporting corporate crimes internally so that they can self-report the issues to enforcement agencies for corporate leniency before agencies investigate them based on employees' whistleblowing. While the United States has several whistleblower reward programs, enforcement agencies appear to be able to harmonize them with corporate leniency policies to incentivize whistleblowers more effectively. This paper leaves this to future research.

[12] The DOJ's FCPA Corporate Enforcement Policy (Justice Manual § 9-47.120) is applied to all corporate crimes handled by the Criminal Division of the DOJ.

## Appendix A. Proof of Proposition 2

This appendix first provides the proof of Proposition 2 and then gives supplemental explanations. Recall that $\pi^*$ is the manager's threshold profit for committing the crime (the expected cost per $\alpha$ from committing the crime), and $c^*$ is the board's threshold cost for internal investigation (the expected benefit from internal investigation).

If the reduced corporate sanction $r$ equals the lower limit or the upper limit of the deterrence-enhancing range (9) of Proposition 1, the probability that the manager does not commit the crime can be expressed as

$$\bar{F}(\pi^*) \equiv F(p(s + \frac{qi}{\alpha})). \tag{16}$$

Hence, in those cases, the probability of crime occurring is $1 - \bar{F}(\pi^*)$. If $r$ equals the upper limit of the deterrence-enhancing range $ps$, this means that there is no reduction in the expected sanction to the firm, and thus no firm investigates. Therefore, the probability of crime occurring is the same as that in the enforcement scheme without the corporate self-reporting program. If $r$ equals the lower limit of the deterrence-enhancing range $ps - (1-p)qi/\alpha$, from Lemma 1, the probability of crime occurring is again the same as that when no leniency exists.

For any $r \in (ps - (1-p)qi/\alpha, ps)$, from Lemma 1, the probability of crime occurring $1 - F(\pi^*)$ meets the following condition:

$$\begin{aligned} 1 - F(\pi^*) &= 1 - F(G(c^*)(r + \frac{qi}{\alpha}) - (1 - G(c^*))p(s + \frac{qi}{\alpha})) \\ &< 1 - \bar{F}(\pi^*). \end{aligned} \tag{17}$$

Therefore, by continuity of $F(\cdot)$, as $r$ decreases, receding from the upper limit $ps$, the probability of crime occurring $1 - F(\pi^*)$ first decreases and then increases in the range $(ps - (1-p)qi/\alpha, ps)$. □

As shown above, Proposition 2 can be proved without using the partial derivatives of $c^*$ and $\pi^*$ with respect to $r$. In order to see the effect of the change in $r$ on the direct and indirect punishments, let us derive these partial derivatives. Since $\pi^*$ and $c^*$ are dependent on each other, we cannot express either variable as the explicit function. We solve this issue by using the implicit function theorem.

We first consider the effect of a marginal reduction in $r$ on $\pi^*$.

Because $c^*$ is the function of $\pi^*$, $p$, and $r$, expression (2) can be rewritten as follows:

$$\pi^* = G(c^*(\pi^*, p, r))(r+\frac{qi}{\alpha})+(1-G(c^*(\pi^*, p, r)))p(s+\frac{qi}{\alpha}), \tag{18}$$

where $c^*(\pi^*, p, r) = \max\{(1 - F(\pi^*))(ps - r), 0\} \geq c$ from expression (6).

We rewrite expression (18) as

$$\begin{aligned}\pi^* - G(c^*(\pi^*, p, r))(r + \frac{qi}{\alpha}) - (1 - G(c^*(\pi^*, p, r)))p(s + \frac{qi}{\alpha}) \\ = \eta(\pi^*, p, r) = \eta(\Pi^*(p, r), p, r) = 0, \end{aligned} \tag{19}$$

where $\pi^* = \Pi^*(p, r)$ is an implicit function defined by expression (19). Assuming that the conditions of the implicit function theorem are satisfied, it follows that

$$\begin{aligned} &- \frac{\partial \Pi^*(p, r)}{\partial r} = \frac{\partial \eta(\pi^*, p, r)}{\partial r} / \frac{\partial \eta(\pi^*, p, r)}{\partial \pi^*} \\ &= \frac{-\alpha G(c^*(\pi^*, p, r)) + g(c^*(\pi^*, p, r))(1 - F(\pi^*))\Delta}{\alpha + g(c^*(\pi^*, p, r))f(\pi^*)(ps - r)\Delta} \gtreqless 0. \end{aligned} \tag{20}$$

where $\Delta = \alpha(r - ps) + (1 - p)qi \gtreqless 0$ is the difference in the punishment of the manager between the cases when the firm investigates and when it does not: the first term is the decrease in the indirect punishment, and the second term is the increase in the direct punishment (Recall that the firm does not investigate if $r \geq ps$ from Lemma 2). If $r$ lies in the deterrence-enhancing range, $\Delta > 0$; if not, $\Delta \leq 0$. Because our interest lies in the effect of a marginal reduction in $r$ on $\Pi^*(p, r)$, the negative sign is added to $\partial \Pi^*(p, r)/\partial r$. The numerator represents the change in the total expected punishment of the manager resulting from a marginal decrease in $r$ without considering an interaction between $\pi^*$ and $c^*$, which is represented by the denominator. Regardless of whether $r$ lies in the deterrence-enhancing range (i.e. $\Delta > 0$), $\partial \Pi^*(p, r)/\partial r \gtreqless 0$.

We now consider how $\pi^*$ changes with a reduction in $r$ within the deterrence-enhancing range. In this range, $\Delta > 0$; the denominator is positive, and thus the sign of expression (20) is determined by the sign of the numerator. The first term of the numerator represents the decrease in the indirect punishment resulting from a marginal decrease in $r$ given the probability of the firm's investigation $G(c^*(\pi^*, p, r))$. As shown in the explanation of expression (22), with a reduction in $r$, in the deterrence-enhancing range, $c^*(\pi^*, p, r)$ monotonically increases. Therefore, as $r$ decreases, receding from the upper limit $ps$, $G(c^*(\pi^*, p, r))$ monotonically increases, rising from zero; hence, the first term monotonically decreases, receding from zero.

In comparison, the second term in the numerator represents the increase in the expected punishment resulting from the increase in the probability of the firm's investigation, which is induced by a marginal decrease in $r$. The second term can be decomposed into two parts by breaking down $\Delta$: $g(c^*(\pi^*, p, r))(1 - F(\pi^*))\alpha(r - ps)$ corresponds to the decrease in the expected indirect punishment, and $g(c^*(\pi^*, p, r))(1 - F(\pi^*))(1 - p)qi$ corresponds to the increase in the expected direct punishment. With a reduction in $r$, $\Delta$ monotonically decreases. Therefore, as $r$ decreases, receding from the upper limit $ps$, the second term decreases, receding from a positive value $g(c^*(\pi^*, p, r))(1 - F(\pi^*))(1 - p)qi$.

For these reasons, as $r$ moves from the upper limit to the lower limit of the deterrence-enhancing range, in the numerator of expression (20), the first term first falls below and then exceeds (in absolute value) the second term. Therefore, the numerator is first positive but then becomes negative; this means that the probability of crime occurring $1 - F(\Pi^*(p, r))$ first decreases and then increases. When $r$ is above a certain level, the increase in the probability of crime detection resulting from a marginal reduction in $r$ will lead to the increase in the expected direct punishment that is greater than the decrease in the expected indirect punishment.[13] The size of indirect punishment when the firm self-reports still remains at a certain level, and the total expected punishment increases. However, when $r$ is below a certain level, the increase in the probability of crime detection resulting from a marginal reduction in $r$ will lead only to an increase in the expected direct punishment that is smaller than the decrease in the expected indirect punishment. The size of the indirect punishment when the firm self-reports becomes excessively small by reducing $r$ from an already low level; the total expected punishment decreases.

Next, we consider the effect of a marginal reduction in $r$ on $c^*$. From expression (6), we obtain the following expression using the implicit function $\Pi^*(p, r)$:

$$c^*(p, r) = \max\{(1 - F(\Pi^*(p, r)))(ps - r), 0\}. \tag{21}$$

If $c^*(p, r)$ is not zero, by differentiating expression (21) with respect to $r$, we obtain

$$\begin{aligned} &- \frac{\partial c^*(p, r)}{\partial r} \\ &= (1 - F(\Pi^*(p, r))) + f(\Pi^*(p, r))\frac{\partial \Pi^*(p, r)}{\partial r}(ps - r) \\ &= \frac{\alpha\left[(1 - F(\pi^*)) + f(\pi^*)(ps - r)G(c^*(p, r))\right]}{\alpha + g(c^*(p, r))f(\pi^*)(ps - r)\Delta} \gtreqless 0. \end{aligned} \tag{22}$$

Because our interest lies in the effect of a marginal reduction in $r$ on $c^*(p, r)$, the negative sign is added to $\partial c^*(p, r)/\partial r$. On the one hand, as the first term in the second line shows, a marginal decrease in $r$ increases the expected benefit from internal investigation $c^*$ because of

[13]In the numerator, the decrease in the expected indirect punishment corresponds to the first term and $g(c^*(\pi^*, p, r))(1-F(\pi^*))\alpha(r-ps)$ in the second term, and the increase in the expected direct punishment corresponds to $g(c^*(\pi^*, p, r))(1-F(\pi^*))(1-p)qi$ in the second term.

a smaller leniency. On the other hand, as the second term in the second line shows, a marginal decrease in $r$ may also indirectly affect $c^*$ by influencing $\pi^*$. Since $\partial\Pi^*(p,r)/\partial r \gtreqless 0$, the second term can be positive, zero, or negative. To determine the relationship in size between the first and second terms, we rewrite the second line as the third line. The numerator is non-negative.

If $r$ lies in the deterrence-enhancing range (i.e. $\Delta > 0$), the denominator is positive; as long as there is a positive probability of crime occurring (i.e. $1 - F(\pi^*) > 0$), the numerator is positive, and thus $-\partial c^*(p,r)/\partial r > 0$. Therefore, in this case, as $r$ decreases, the probability of the firm's investigation $G(c^*(p,r))$ monotonically increases. In comparison, if $r$ lies out of the range (i.e. $\Delta \le 0$), the denominator is positive, negative, or zero, and thus $-\partial c^*(p,r)/\partial r \gtreqless 0$.

## Appendix B. Optimality conditions for corporate leniency and investigations by the authority

This appendix provides the optimality conditions for $p$ and $r$ in the authority's maximization problem of social welfare (expression (10)).

As a preliminary step, we first consider how a marginal increase in $p$ affects $\pi^* = \Pi^*(p,r)$, which is an implicit function defined by expression (19). Assuming that the conditions of the implicit function theorem are satisfied, it follows that

$$\begin{aligned}\frac{\partial\Pi^*(p,r)}{\partial p} &= -\frac{\partial\eta(\pi^*,p,r)}{\partial p}\Big/\frac{\partial\eta(\pi^*,p,r)}{\partial\pi^*}\\ &= \frac{\begin{array}{c}(1-G(c^*(\pi^*,p,r)))(s\alpha+iq)\\ +g(c^*(\pi^*,p,r))(1-F(\pi^*))s\Delta\end{array}}{\alpha+g(c^*(\pi^*,p,r))f(\pi^*)(ps-r)\Delta} \gtreqless 0, \end{aligned}\quad (23)$$

where $\Delta = \alpha(r-ps)+(1-p)qi \gtreqless 0$ is the difference in the expected sanction to the manager between the cases when the firm investigates and when it does not. As shown in the numerator, a marginal increase in $p$ directly increases the expected cost to the manager $\pi^*$. A marginal increase in $p$ may also indirectly affect $\pi^*$ by raising the probability of the firm's investigation because the expected benefit from the firm's investigation may increase with a greater expected sanction that can be avoided. Whether this raises $\pi^*$ depends on whether $r$ lies in the deterrence-enhancing range (i.e. $\Delta > 0$).[14] Moreover, as shown in the denominator, an interaction between $\pi^*$ and $c^*$ influences the overall effect of $p$ on $\pi^*$. As a result, if $r$ lies in the deterrence-enhancing range (i.e. $\Delta > 0$), $\partial\Pi^*(p,r)/\partial p > 0$, and if not (i.e. $\Delta \le 0$), $\partial\Pi^*(p,r)/\partial p \gtreqless 0$.

Next, we consider how a marginal increase in $p$ affects $c^*(p,r)$, which is expressed as (21). If $c^*(p,r)$ is not zero, by differentiating this expression with respect to $p$, we obtain

$$\begin{aligned}&\frac{\partial c^*(p,r)}{\partial p}\\ &= s(1-F(\Pi^*(p,r))) - f(\Pi^*(p,r))\frac{\partial\Pi^*(p,r)}{\partial p}(ps-r)\\ &= \frac{\begin{array}{c}\alpha s(1-F(\pi^*))\\ -f(\pi^*)(ps-r)(1-G(c^*(p,r)))(s\alpha+iq)\end{array}}{\alpha+g(c^*(p,r))f(\pi^*)(ps-r)\Delta} \gtreqless 0.\end{aligned}\quad (24)$$

On the one hand, as the first term in the second line shows, a marginal increase in $p$ increases the expected benefit from internal investigation $c^*$ because of a greater expected sanction that can be avoided. On the other hand, as the second term in the second line shows, a marginal increase in $p$ may also indirectly affect $c^*$ by influencing $\pi^*$. Since $\partial\Pi^*(p,r)/\partial p \gtreqless 0$, the second term can be positive, zero, or negative. To determine the relationship in size between the first and second terms, we rewrite the second line as the third line. The numerator can be positive, zero, or negative, and thus, regardless of whether $r$ lies in the deterrence-enhancing range (i.e. $\Delta > 0$), $\partial c^*(p,r)/\partial p \gtreqless 0$.

We now derive the optimality conditions for $p$ and $r$ in the maximization problem (expression (10)). The first order condition for an interior solution with respect to $p$ is

$$\begin{aligned}&\frac{\partial\Pi^*(p,r)}{\partial p}f(\Pi^*(p,r))(h-\Pi^*(p,r))\\ &= \frac{\partial c^*(p,r)}{\partial p}g(c^*(p,r))(c^*(p,r)-pe)) + \int_{c^*(p,r)}^{\infty} e\,dG(c).\end{aligned}\quad (25)$$

The left side is the social gain or loss that results from increasing $p$ marginally, that is, the change in the net harm from the crime. If $\partial\Pi^*(p,r)/\partial p > 0$, since the probability of crime occurring decreases, the left side is the social gain, and if $\partial\Pi^*(p,r)/\partial p < 0$, since the probability of crime occurring increases, the left side is the social loss. As explained above, if $r$ lies in the deterrence-enhancing range, $\partial\Pi^*(p,r)/\partial p > 0$, and if not, $\partial\Pi^*(p,r)/\partial p \gtreqless 0$.

Also, the right side is the social gain or loss that results from increasing $p$ marginally, the change in the total investigation cost to the economy. A marginal increase in $p$ changes the probability of the firm's investigation and correspondingly the probability that the authority investigates when the firm fails to self-investigate. This causes the change in the total investigation cost, which is represented by the first term. As explained, regardless of whether $r$ lies in the deterrence-enhancing range, $\partial c^*(p,r)/\partial p \gtreqless 0$. Whether a marginal increase in $p$ increases the first term depends on the sign of $\partial c^*(p,r)/\partial p$ and the relationship in size between $c^*(p,r)$ and $pe$. The second term represents the increase in the expected cost of the enforcement agency's investigation because of a marginal increase in $p$.

[14] If $r$ lies in the deterrence-enhancing range (i.e. $\Delta > 0$), $\pi^*$ increases if the probability of the firm's investigation increases. If not (i.e. $\Delta \le 0$), $\pi^*$ decreases or remains unchanged if the probability of the firm's investigation increases.

When the left side is the social gain, the right side is the social loss, and vice versa. These social gains and losses must be balanced at the social optimum. In reality, $r$ would usually be set within the deterrence-enhancing range so that the corporate self-reporting program does not weaken deterrence. Therefore, at the social optimum, the left side would be positive (i.e. $\partial\Pi^*(p,r)/\partial p > 0$) and become the social gain that results from increasing $p$ marginally; the additional decrease in the net harm from the crime. Accordingly, the right side would become the social loss that results from increasing $p$ marginally; the additional increase in the total investigation cost to the economy.

The first order condition for an interior solution with respect to $r$ is

$$\begin{aligned}-\frac{\partial\Pi^*(p,r)}{\partial r}&f(\Pi^*(p,r))(h-\Pi^*(p,r))\\&=-\frac{\partial c^*(p,r)}{\partial r}g(c^*(p,r))(c^*(p,r)-pe)). \quad (26)\end{aligned}$$

The left side is the social gain or loss that results from reducing $r$ marginally, that is, the change in the net harm from the crime. If $-\partial\Pi^*(p,r)/\partial r > 0$, the left side is the social gain, and if $-\partial\Pi^*(p,r)/\partial r < 0$, the left side is the social loss. As explained in expression (20), regardless of whether $r$ lies in the deterrence-enhancing range, $-\partial\Pi^*(p,r)/\partial r \gtreqless 0$. Also, the right side is the social gain or loss that results from reducing $r$ marginally, the change in the total investigation cost in the economy caused by the change in the probability of the firm's investigation. As explained in expression (22), if $r$ lies in the deterrence-enhancing range, $-\partial c^*(p,r)/\partial r > 0$, and, if not, $-\partial c^*(p,r)/\partial r \gtreqless 0$. Whether a marginal reduction in $r$ increases the right side depends on the sign of $-\partial c^*(p,r)/\partial r$ and the relationship in size between $c^*(p,r)$ and $pe$. When the left side is the social gain, the right side is the social loss, and vice versa; the additional change in the net harm from the crime and the additional change in the total investigation cost to the economy must be balanced at the social optimum.

## References


[1] Arlen, Jennifer. 1994. The Potentially Perverse Effects of Corporate Criminal Liability. *Journal of Legal Studies*, **23**(2), 833–67.

[2] Arlen, Jennifer. 2012. Corporate Criminal Liability: Theory and Evidence. *Pages 144–203 of:* Harel, Alon, & Hylton, Keith N. (eds), *Research Handbook on the Economics of Criminal Law*. Edward Elgar.

[3] Arlen, Jennifer, & Kraakman, Reinier. 1997. Controlling Corporate Misconduct: an Analysis of Corporate Liability Regimes. *New York University Law Review*, **72**(4), 687–779.

[4] Aubert, Cecile, Rey, Patrick, & Kovacic, William E. 2006. The Impact of Leniency and Whistle-Blowing Programs on Cartels. *International Journal of Industrial Organization*, **24**, 1241–66.

[5] Bebchuk, Lucian A., & Fried, Jesse M. 2004. *Pay without Performance: The Unfulfilled Promise of Executive Compensation*. Harvard University Press.

[6] Chen, Zhijun, & Rey, Patrick. 2013. On the Design of Leniency Programs. *Journal of Law and Economics*, **56**, 917–57.

[7] Dyck, Alexander, Morse, Adair, & Zingales, Luigi. 2010. Who Blows the Whistle on Corporate Fraud? *Journal of Finance*, **65**(6), 2213–53.

[8] Dyck, Alexander, Morse, Adair, & Zingales, Luigi. 2017. How Pervasive is Corporate Fraud? *mimeo*.

[9] Fisse, Brent, & Braithwaite, John. 1993. *Corporations, Crime and Accountability*. Cambridge University Press.

[10] Garrett, Brandon L. 2015. The Corporate Criminal as Scapegoat. *Virginia Law Review*, **101**(7), 1789–1854.

[11] Gerlach, Heiko. 2013. Self-Reporting, Investigation, and Evidentiary Standards. *Journal of Law and Economics*, **56**, 1061–90.

[12] Harrington, Joseph E. 2013. Corporate Leniency Programs When Firms Have Private Information: The Push of Prosecution and the Pull of Pre-Emption. *Journal of Industrial Economics*, **51**, 1–27.

[13] Innes, Robert. 1999. Remediation and Self-Reporting in Optimal Law Enforcement. *Journal of Public Economics*, **72**, 379–93.

[14] Kaplow, Louis, & Shavell, Steven. 1994. Optimal Law Enforcement with Self-Reporting of Behavior. *Journal of Political Economy*, **102**(3), 583–606.

[15] Landeo, Claudia M., & Spier, Kathryn E. 2018a. Optimal Law Enforcement with Ordered Leniency. *NBER Working Paper*, w25095.

[16] Landeo, Claudia M., & Spier, Kathryn E. 2018b. Ordered Leniency: An Experimental Study of Law Enforcement with Self-Reporting. *NBER Working Paper*, w25094.

[17] Larcker, David F., & Tayan, David F. 2019. CEO Compensation. *Stanford Graduate School of Business, Corporate Governance Research Initiative, Data Spotlight*.

[18] Malik, Arun S. 1993. Self-Reporting and the Design of Policies for Regulating Stochastic Pollution. *Journal of Environmental Economics and Management*, **24**, 241–47.

[19] Miceli, Thomas J. 1991. Optimal Criminal Procedure: Fairness and Deterrence. *International Review of Law and Economics*, **11**, 3–10.

[20] Miller, Nathan. 2009. Strategic Leniency and Cartel Enforcement. *American Economic Review*, **99**, 750–68.

[21] Motta, Massimo, & Polo, Michele. 2003. Leniency Programs and Cartel Prosecution. *International Journal of Industrial Organization*, **21**, 347–79.

[22] Pierce, Jason R. 2018. Reexamining the Cost of Corporate Criminal Prosecutions. *Journal of Management*, **44**(3), 892–918.

[23] Polinsky, A. Mitchell, & Shavell, Steven. 1993. Should Employees be Subject to Fines and Imprisonment Given the Existence of Corporate Liability? *International Review of Law and Economics*, **13**(3), 239–57.

[24] Polinsky, A. Mitchell, & Shavell, Steven. 1999. On the Disutility and Discounting of Imprisonment and the Theory of Deterrence. *Journal of Legal Studies*, **28**(1), 1–16.

[25] Rolnik, Guy. 2016. SEC and Revolving Doors: Q&A with Eric Ben-Artzi, the Deutsche Bank Whistleblower Who Rejected a Multimillion Dollar Award. *ProMarket*, https://promarket.org/sec–revolving–doors–qa–eric–ben–artzi–12–billion–dollar–deutsche–whistleblower/.

[26] Segerson, Kathleen, & Tietenberg, Tom. 1992. The Structure of Penalties in Environmental Enforcement: An Economic Analysis. *Journal of Environmental Economics and Management*, **23**, 179–200.

[27] Shavell, Steven. 1997. The Optimal Level of Corporate Liability Given the Limited Ability of Corporations to Penalize their Employees. *International Review of Law and Economics*, **17**, 203–13.

[28] Steinzor, Rena I. 2014. *Why Not Jail? Industrial Catastrophes, Corporate Malfeasance, and Government Inaction*. Cambridge University Press.