Whistleblowers and Financial Fraud*

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Abstract

Whistleblowers who report financial crimes are treated differently than whistleblowers in other sectors. This is because of the potential for partial recovery of the loss caused by financial fraud. The paper shows that the optimal whistleblower reward is a fraction of the amount that is recovered from fraud loss, which is capped at the level that can no longer attract additional whistleblowers. The paper also analyzes how rewards to whistleblowers affect heterogeneous potential fraudsters' decision to commit fraud and why additional penalties in the form of monetary fines and/or jail time are needed.

Keywords: Whistleblowers; financial crimes; financial fraud; fraud loss recovery; optimal reward to whistleblowers.

JEL Classification Numbers: G14, G18, K14, K42.

*The views expressed here are the author's and not necessarily those of the Federal Reserve Bank of Atlanta or the Federal Reserve System.

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1. Introduction

A whistleblower in the financial sector is an individual who (i) provides information and evidence on financial misconduct, and (ii) acting on this information and evidence could lead to a recovery of some of the money lost from this misconduct. Financial regulatory agencies offer high rewards to whistleblowers. Most rewards are based on the dollar amount that the agency recovers using this information. Table 1 displays data from the United States Securities and Exchange Commission (SEC) on fraud cases that resulted in rewards to whistleblowers.

Year	Highest $ millions	Total $ millions	Number fraud cases	Total per case $ mil.	Number awards	Number awards per fraud case
2012	0.05	0.050	1	0.050	1	1.000
2013	14.00	14.150	2	7.075	2	1.000
2014	30.00	31.325	4	7.831	5	1.250
2015	3.00	5.925	5	1.185	5	1.000
2016	22.00	79.150	11	7.195	14	1.273
2017	16.00	42.300	9	4.700	12	1.333
2018	88.00	151.800	6	25.300	9	1.500
2019	50.00	60.060	6	10.010	11	1.833
2020	114.00	342.867	34	10.084	50	1.471
2021	50.00	283.200	31	9.135	67	2.161
2022	37.00	141.750	10	14.175	13	1.300
2023	279.00	501.000	9	55.667	26	2.889
2024	98.00	208.000	5	41.600	9	1.800

Table 1: SEC awards and fraud cases based on whistleblower-provided information: 2012–2024.

Source: SEC press releases. See Appendix A for the methodology used to construct this table and links to data sources, more detailed tables, and the R-code.
Note: The SEC rounds each award dollar amount to conceal whistleblowers' identifies.

For example, in 2024 the SEC issued a $98 million award to two whistleblowers ($82 and $16 millions), a $24 million award to two different whistleblowers ($20 and $4 millions), a $12 million award to three whistleblowers ($4 million each), and two $37 million awards to two whistleblowers. All these sum up to $208 million for 5 separate fraud cases. Table 1 also shows that the highest award nearly $279 million was issued in May

2023, which was twice the previous highest award of $114 million issued in October 2020.

In 2012, the United States Internal Revenue Service (IRS) paid $104 million to a whistleblower who provided information that exposed how the Swiss bank UBS actively concealed taxable income of United States clients by hiding assets in secret offshore accounts.[1] Section 2.1 describes the regulatory system that protects whistleblowers and allows regulatory agencies to issue these high rewards.

Financial misconducts include fraud, theft, illegal activities such as money laundering, false reporting, and underpayment of taxes. In general, financial fraud could be viewed as an unlawful falsification or manipulation of financial information to benefit the fraudsters at the expense of others (customers, investors, borrowers, government). It typically involves fraudulent accounting, forged documentation, and active circumvention of internal control systems.[2] The analysis of whistleblowers in this paper applies mainly to corporate fraud and less to personal fraud in which scammers target specific individuals.

Financial crimes are different from other crimes because of the potential for a partial or full recovery of the money involved in the fraud. For that reason, whistleblowers reporting financial crimes are treated differently from other types of whistleblowers. Currently, several authorities are committed to paying whistleblowers a fraction of the amount that is actually recovered from the fraud loss. The paper shows that the optimal reward is a fraction of the amount that is actually recovered from fraud loss which is capped at the reward level that can no longer attracts additional whistleblowers to report a fraud.

The paper analyzes a regulatory authority that designs the optimal reward to whistleblowers in the financial sector by taking into consideration the effect of rewards on the incentive to blow the whistle and report financial fraud. The goal of this authority is to maximize the expected partial or full recovery of the amount lost due to fraud less the cost of paying rewards to the whistleblower.

[1] For the UBS case see, Ventry (2014). Large corporate financial frauds that led to the total collapse of Enron and WorldCom involved employees who tried to address the fraud internally (instead of reporting to the SEC), see Brickey (2003).

[2] Reviewing the vast literature on financial fraud is beyond the scope of this paper. See Reurink (2018) for a review of this literature.

Whereas rewards for blowing the whistle apply to frauds that were already committed, the use of whistleblowers may have a deterring effect on potential fraudsters. Therefore, the benchmark model is extended by integrating heterogeneous potential fraudsters into the model and analyzes how rewards to whistleblowers affect the decision to commit fraud. The analysis also shows that additional penalties in the form of monetary fines and/or jail time are needed to further reduce the incentive to commit fraud.

The article is organized as follows: Section 2 describes the legal system that facilitates whistleblowing. It also provides a short overview of the academic literature on whistleblowers. Section 3 constructs the benchmark model of financial fraud and analyzes optimal whistleblower reward for providing information leading to a partial or full recovery of the fraud loss. Section 4 analyzes the effect of rewarding whistleblowers on the incentives to commit fraud by heterogeneous potential fraudsters. Section 5 presents two extensions and calibrations of whistleblowers' preferences. Section 6 concludes. Some derivations are relegated to appendices.

2. Regulatory system, incentives, and related literature

Most employees, managers in particular, and even people outside the company will not blow the whistle even if they have evidence that a fraud has been committed within the company. The main reasons for that are: (a) Information provided by a whistleblower is likely to be ignored.[3] (b) Fear of breaking a code of silence among the group of other employees and peers in the financial sector. (c) Fear of retaliation from other employees and managers. These explain why the legal system in many countries provides protection and rewards for blowing the whistle on financial fraud.

Subsection 2.1 describes the legal system in the United States that facilitates whistleblowing. Note that other countries have also enacted similar whistleblower protection laws.[4] Subsection 2.2 briefly describes some of the academic literature on whistleblowers.

[3] A good example is Harry Markopolos who, from 2000 to 2005, warned the Securities and Exchange Commission that Bernie Madoff's wealth management business was announcing unrealistic returns. See, `https://en.wikipedia.org/wiki/Harry_Markopolos`.

[4] See `https://www.oecd.org/en/publications/committing-to-effective-whistleblower-`

2.1 The legal system of whistleblower reward and protection

Responding to corporate failures and fraud that resulted in substantial financial losses to institutional and individual investors, the United States Congress passed the Sarbanes-Oxley Act (SOX) in 2002.[5] Part of this law provides whistleblower protections for employees of public companies. Section 806 prohibits a publicly-traded company from retaliating against an employee because of any lawful act by the employee to: (a) assist in an investigation of fraud or other conduct by Federal regulators, Congress, or supervisors; and (b) file or participate in a proceeding relating to fraud against shareholders. It cites remedies for such aggrieved employees, including reinstatement, back pay, and compensatory damages.

Section 922 of the 2011 Dodd-Frank Wall Street Reform and Consumer Protection Act provides that the Securities and Exchange Commission (SEC)[6] "shall pay rewards to eligible whistleblowers who voluntarily provide the SEC with original information that leads to a successful enforcement action yielding monetary sanctions of over $1 million. The reward amount is required to be between 10 percent and 30 percent of the total monetary sanctions collected in the Commission's action or any related action such as in a criminal case."

The Commodity Futures Trading Commission (CFTC) in the United States maintains a website where individuals can submit tips and report violations of the Commodity Exchange Act.[7] Rewards are offered to whistleblowers "when the CFTC obtains a final judgment or settlement for more than $1 million in monetary sanctions." Since 2014, the CFTC has rewarded approximately $390 million to whistleblowers for enforcement actions that resulted in monetary relief totaling more than $3.2 billion.

Finally, the United States Internal Revenue Service (IRS) provides a website where

protection_9789264252639-en.html for OECD countries and https://www.osc.ca/en/enforcement/osc-whistleblower-program for Ontario Canada.

[5]See, https://www.congress.gov/bill/107th-congress/house-bill/3763 and https://www.dol.gov/agencies/oalj/PUBLIC/WHISTLEBLOWER/REFERENCES/STATUTES/107_204_806 for Section 806.

[6]See, https://www.sec.gov/spotlight/dodd-frank/whistleblower.shtml and https://www.sec.gov/enforcement-litigation/whistleblower-program/whistleblower-protections.

[7]See, https://www.whistleblower.gov/.

whistleblowers can report possible tax law violations.[8] The IRS promises to "pay an award of at least 15 percent, but not more than 30 percent, of the proceeds collected attributable to the information submitted by the whistleblower. The reward percentage decreases for claims based on information from public sources or if the whistleblower planned and initiated the actions that led to the noncompliance."

2.2 Whistleblowers in the academic literature

Engstrom (2017) provides an extensive theoretical and empirical overview of whistleblower "bounty" schemes. Dyck, Morse, and Zingales (2010) analyze 216 fraud class-action lawsuits against large U.S. corporations between 1996 and 2004. In only 17-percents of them employees were the key players. In 37-percent of the cases whistleblowers concealed their identity which may indicate that the reputational costs exceed the expected reputational benefits of whistleblowing. In 82-percent of the cases, the whistleblower was fined, quit, or had altered responsibilities. Other literature on the characteristics and incentives of whistleblowers includes Bjørkelo et al. (2011), Butler, Serra, and Spagnolo (2020), Rothschild and Miethe (1999), and Gundlach, Douglas, and Martinko (2003). Empirical literature documenting how whistleblowing can deter financial misconduct includes Bowen, Call, and Rajgopal (2010), Johannesen and Stolper (2017), Wilde (2017), Call et al. (2018), Berger and Lee (2022), Raleigh (2024), and Leder-Luis (2025).

Theoretical models that analyze motivations for whistleblowing, incentives to commit fraud, and related issues such as peer pressure and rewards, include Benoît and Dubra (2004), Muehlheusser and Roider (2008), Aubert, Rey, and Kovacic (2006), Heyes and Kapur (2009), Friebel and Guriev (2012), Felli and Hortala-Vallve (2016), Givati (2016), and Shy (2025). Unlike the above papers, my analysis of reward focuses on financial fraud where some of the fraud loss can be recovered using whistleblower-provided information. The analysis shows that the recoverable amount plays a key role in the design of the optimal reward to whistleblowers.

[8] See, `https://www.irs.gov/compliance/whistleblower-office`.

Another branch of the literature that offers empirical studies related to retaliation against whistleblowers includes Near and Miceli (1986), Miceli and Near (1994), Bac (2009), and Buccirossi, Immordino, and Spagnolo (2021). Finally, laboratory experiments with whistleblowers are reported in Mechtenberg, Muehlheusser, and Roider (2020), Masclet, Montmarquette, and Viennot-Briot (2019), Bazart, Beaud, and Dubois (2020), Choo et al. (2019), Apesteguia, Dufwenberg, and Selten (2007), Reuben and Stephenson (2013), Wallmeier (2023), and Fiorin (2023).

3. A model of financial fraud and incentives to blow the whistle

Consider a company or a financial institution that commits financial fraud. The fraud results in a loss of L dollars, $L > 0$. Therefore, L will be referred to as both the *fraud loss* and also as the *fraud level* because the loss to the defrauded party is a gain to the fraudster.

Even if the authorities receive timely information about this fraud, there is no guarantee that the authorities would be able to produce sufficient evidence that would lead to conviction of the fraudsters and to a full or partial recovery of the fraud loss L. Therefore, let λ denote the probability that the authorities will be able to convict the fraudster conditional upon receiving timely information from a whistleblower, where $0 < \lambda \leq 1$.[9] Moreover, even under successful conviction, the authorities may not be able to recover the full amount L. Instead, the authorities may recover only a fraction ρ of the fraud loss, where $0 < \rho \leq 1$. To summarize, the model assumes that conditional on: (i) receiving timely information from a whistleblower and on (ii) successful conviction (probability λ), the dollar amount that can be recovered is ρL. Full loss recovery is achievable if $\rho = 1$ whereas $\rho < 1$ implies partial recovery.

Table 2 summarizes the notation introduced throughout the development of the model.

[9] $1 - \lambda$ could also be interpreted as the rate of "false negatives" in which the authorities err in their investigation and conclude that no fraud has been committed. The analysis in this section assumes that the conviction rate λ is constant. Section 4 extends the model by introducing heterogeneous potential fraudsters with different degree of sophistication to avoid getting convicted. Under this modification, the expected conviction rate $\mathrm{E}\lambda$ becomes an endogenous variable.

Notation	Type	Meaning	First introduced
L	EXO	Fraud loss ($)	Sec. 3
ρ	EXO	Fraction recovered	Sec. 3
λ	EXO	Probability of conviction	Sec. 3
R	END	Whistleblower reward ($)	Sec. 3.1
δ	EXO	Whistleblower discomfort parameter	Sec. 3.1: Eq. (1), Fig. 1
d	DIST	Continuum whistleblower types	Sec. 3.1: Eq. (1), Fig. 1
U_d	END	Utility of whistleblower type d	Sec. 3.1: Eq. (1), Fig. 1
γ	EXO	Convexity/concavity parameter	Sec. 3.1: Eq. (1), Fig. 1
p_W	END	Whistleblowing probability	Sec. 3.1: Assumption 1
B_{net}	END	Authority's objective benefit	Sec. 3.2: Eq. (3)
λ	DIST	Continuum conviction probabilities	Sec. 4.1: Fig. 4
π_λ	END	Payoff to type λ fraudster	Sec. 4.1: Eq. (6)
p_F	END	Probability of fraud	Sec. 4.1: Assumption 2
L_{net}	END	Authority's objective net loss	Sec. 4.3: Eq. (12)
τ	EXO	Time discount factor	Sec. 5.3: Eq. (13)
r	END	Whistleblower reward rate	Sec. 5.3: Eq. (19)

Table 2: Notation

Notes: "EXO" and "END" indicate exogenous and endogenous variables, respectively. "DIST" indicates a distribution of types.

3.1 Whistleblowers

A whistleblower is an employee of a company or a financial institution who can provide truthful information about financial fraud including information that may lead to conviction of the fraudster (probability λ). Conviction leads to a partial or full recovery of the lost funds (ρL). Blowing the whistle and reporting to the authorities is costly to a potential whistleblower for a wide variety of reasons such as: fear of retaliation, breaking group solidarity, termination of employment, skipped promotion, and loss of benefits. Therefore, it is safe to assume that an employee is unlikely to blow the whistle without some compensation such as the reward schemes that were described in Section 2.1.

Let $R \geq 0$ denote the total reward to a whistleblower who reports financial fraud that leads to conviction of the fraudsters (probability λ) and to a recovery of ρL from the initial loss L. Note that the reward R is not paid if the authorities do not collect sufficient evidence to convict the fraudsters (probability $1-\lambda$).[10]

There is a continuum of *potential* whistleblowers who are uniformly indexed by d on the unit interval $[0,1]$ according to a decreasing utility from blowing the whistle. The expected utility of a potential whistleblower indexed by $d \in [0,1]$ is given by[11]

$$\mathrm{E}U_d = \begin{cases} \lambda R - \delta d^\gamma & \text{if blows the whistle} \\ 0 & \text{does not blow the whistle.} \end{cases} \tag{1}$$

The parameter $\delta > 0$ measures the intensity of the disutility (discomfort) from blowing the whistle and also converts this disutility to monetary units. The parameter $\gamma > 0$ determines the shape of the distribution of whistleblower types as shown in Figure 1.

Figure 1 displays the distribution of potential whistleblower utilities with respect to their types $d \in [0,1]$. Potential whistleblowers indexed by d close to 1 have the lowest utility because they bear high discomfort from blowing the whistle (measured by $-\delta d^\gamma \approx -\delta$). In contrast, potential whistleblowers indexed by d close to 0 have the highest utility as they hardly bear any discomfort from blowing the whistle (measured by $-\delta d^\gamma \approx 0$). Any individual who blows the whistle is compensated with R dollars provided that the whistleblower-provided information leads to conviction (probability λ). Therefore, expected reward for blowing the whistle equals λR which is marked on the vertical axis in Figure 1.

In view of the utility functions (1) and Figure 1, a potential whistleblower $\widehat{d}$ who is indifferent between becoming a whistleblower and not blowing the whistle is implicitly

[10] This implies that there are no "false positives" in the investigation of financial fraud. That is, whistleblowers will not be rewarded if no money is recovered. Hence, unlike other types of whistleblowing (such as reports on safety and environmental violations), whistleblowers do not benefit from submitting false reports.

[11] The expected utility (6) reflects risk-neutral potential whistleblowers. Because the reservation payoff is zero, assuming risk aversion in the form of $\mathrm{E}U_d = (\lambda R - \delta d^\gamma)^\theta$ (where $0 < \theta < 1$) would not affect the indifferent whistleblower (2). However, it will make a difference if the reservation utility is not zero.

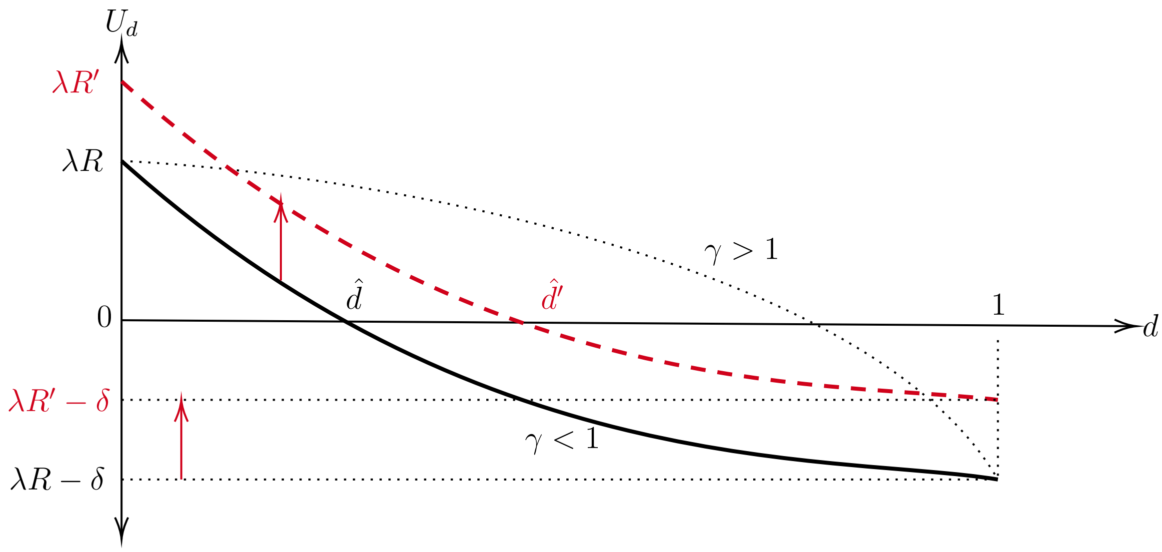

Figure 1: Whistleblowers' utility by type $d \in [0, 1]$.

Note: The utilities are drawn from (1). The solid and dashed curves correspond to $\gamma < 1$. The dotted curve illustrates $\gamma > 1$. The fraction who blow the whistle $\widehat{d}$ is computed in (2). The arrows illustrate an increase in whistleblower reward from R to R'.

determined by $0 = \lambda R - \delta \widehat{d}^{\gamma}$. Hence,

$$\widehat{d} = \begin{cases} \left(\frac{\lambda R}{\delta}\right)^{\frac{1}{\gamma}} & \text{if } R < \frac{\delta}{\lambda} \\ 1 & \text{if } R \geq \frac{\delta}{\lambda}. \end{cases} \tag{2}$$

Therefore, in view of Figure 1, for a given level of reward R, any potential whistleblower indexed by $d \leq \widehat{d}$ would blow the whistle and any potential whistleblower indexed by $d > \widehat{d}$ would not. Finally, because $d \in [0, 1]$, $\widehat{d}$ could be interpreted as follows:

ASSUMPTION 1. *For any given whistleblower reward level R and the probability of conviction λ, the probability p_W that an individual will become a whistleblower after observing a fraud equals the fraction $\widehat{d}$, where $\widehat{d}$ is determined in (2).*

Assumption 1 is more of a result than an assumption but it establishes the reason why the fraction $\widehat{d}$ of the population could also be interpreted as the probability of whistleblowing $p_W = \widehat{d}$.

3.2 The authority's choice of optimal reward

Facing a fraud loss L, the objective of the regulatory authority is to maximize the expected amount that can be recovered from this loss less the cost of having to compensate the whistleblower for reporting this fraud to the authority. This net expected recovered amount, denoted by B_{net}, is returned to those who suffered the loss L from this fraud. Formally, $B_{\text{net}} = \lambda(\rho L - R)$ which equals the probability of conviction λ multiplied by the amount recovered from the loss ρL less the reward level R. Hence, the authority chooses the whistleblower reward R^* to solve

$$\max_R \mathrm{E}B_{\text{net}} = p_W \lambda(\rho L - R) = \underbrace{\left(\frac{\lambda R}{\delta}\right)^{\frac{1}{\gamma}}}_{\text{WB probability}} \underbrace{\lambda(\rho L - R)}_{\text{expected recovery less WB reward}}, \tag{3}$$

where the whistleblowing probability p_W was substituted from (2). "WB" is a shortcut for "whistleblower" and "whistleblowing."

The expected net revenue function (3) exhibits a tradeoff with respect to the reward level R. Higher R increases the whistleblowing probability p_W but it also increases the cost associated with having to compensate a whistleblower whose information leads to conviction (probability λ). However, (2) indicates that there is a threshold reward level $R = \frac{\delta}{\lambda}$ above which the whistleblower probability equals 1 because 100-percent of the potential whistleblowers would find it beneficial to become whistleblowers. This proves the following result.

Result 1. *The optimal whistleblower reward is capped at* $\max R = \frac{\delta}{\lambda}$.

Results 1 contributes to an ongoing debate on whether to limit rewards to whistleblowers with an absolute dollar amount.[12] It shows that there are no gains from compensating whistleblowers beyond the level that is needed to attract all potential whistleblowers to report on frauds that they witness.

[12] See for example, `https://www.reuters.com/article/us-usa-sec-whistleblower/us-sec-chair-says-agency-will-not-impose-caps-on-whistleblower-rewards-idUSKBN1YE2BA` and `https://www.whistleblowers.org/assessing-whistleblower-reward-incentives-and-caps-what-the-data-demonstrates`.

The remaining analysis focuses on cases where the optimal whistleblower reward is lower than the capped amount. Appendix B derives the optimal reward as a function of the amount that can be recovered ρL.

$$R^* = \begin{cases} \frac{\rho L}{1+\gamma} & \text{if } \frac{\rho L}{1+\gamma} < \frac{\delta}{\lambda} \\ \frac{\delta}{\lambda} & \text{otherwise.} \end{cases} \tag{4}$$

Intuitively, in view of individuals' utility functions (1), when the ratio of the whistleblowing disutility (discomfort) parameter δ to the conviction probability λ is high, individuals indexed by a high d will not blow the whistle. In contrast, a sufficiently low ratio $\frac{\delta}{\lambda}$ implies lower discomfort relative to the conviction probability which would induce all individuals to blow the whistle. The optimal reward scheme (4) is illustrated in Figure 2 as a function of the amount that can be recovered ρL.

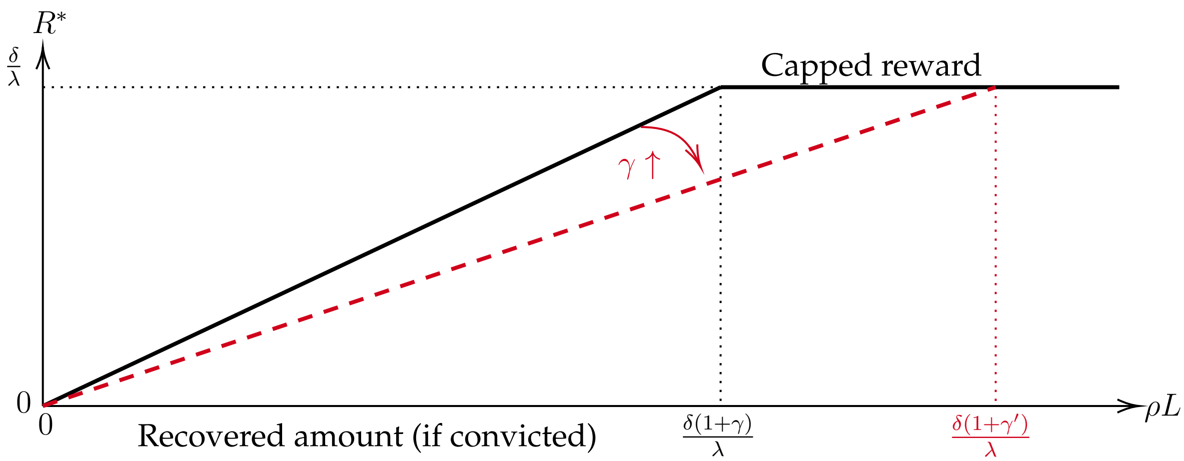

Figure 2: Optimal reward R^*.

Notes: The optimal whistleblower reward is drawn from (4). γ measures the degree of concavity/convexity of the distribution of whistleblower types defined in (1) and is illustrated in Figure 1.

Inspection of (4) reveals the following results:

Result 2. *Suppose the authority adjusts the optimal reward R^* according to (4). Then,*

(a) The optimal reward increases with the amount that can be recovered ρL up to the capped level $\max R^* = \frac{\delta}{\lambda}$.

(b) *Optimal reward decreases with the degree of concavity of the distribution of whistleblower types. Formally,* $\frac{\partial R^*}{\partial \gamma} = -\frac{\rho L}{(1+\gamma)^2} < 0$.

Results 2(a) shows that the optimal reward should rise with the recovered amount ρL up to the capped level. Hence, it is optimal to share the recovered amount from the fraud ρL between the whistleblower ($\frac{1}{1+\gamma}$) and the defrauded party ($\frac{\gamma}{1+\gamma}$). Result 2(b) and Figure 2 show that this share declines with γ. Recall that γ measures the degree of concavity/convexity of the distribution of potential whistleblower types. For example, Figure 1 show that $\gamma > 1$ corresponds to a fast-increasing aversion to blow the whistle for individuals indexed by higher values of d.

The optimal reward level R^* uniquely determines the optimal probability that an individual becomes a whistleblower. Substituting R^* from (4) into (2) yields the whistleblowing probability when the authority promises to compensate an amount of R^* for receiving information that leads to conviction (probability λ) and the recovery of ρL from the fraudster.

$$p_W^* = \widehat{d}^* = \begin{cases} \left[\frac{\lambda \rho L}{\delta(1+\gamma)}\right]^{\frac{1}{\gamma}} & \text{if } \frac{\rho L}{1+\gamma} < \frac{\delta}{\lambda} \\ 1 & \text{otherwise.} \end{cases} \tag{5}$$

The optimal probability p_W^* in (5) is illustrated in Figure 3.

Result 3. *Under the optimal whistleblower reward* R^**, the probability of whistleblowing increases with the amount to be recovered. Formally,* $\frac{\partial p_W^*}{\partial (\rho L)} > 0$*. It decreases with the whistleblower's disutility parameter from becoming a whistleblower, that is* $\frac{\partial p_W^*}{\partial \delta} < 0$.

4. Whistleblowers and the incentive to commit financial fraud

The analysis has so far focused on finding the optimal reward to whistleblowers who provide information that leads to conviction and then to a partial or full recovery of the fraud loss. That is, the potential use of whistleblowers was evaluated *ex-post* after a fraud is committed. It therefore neglected to investigate how the potential use of whistleblowers can deter fraud.

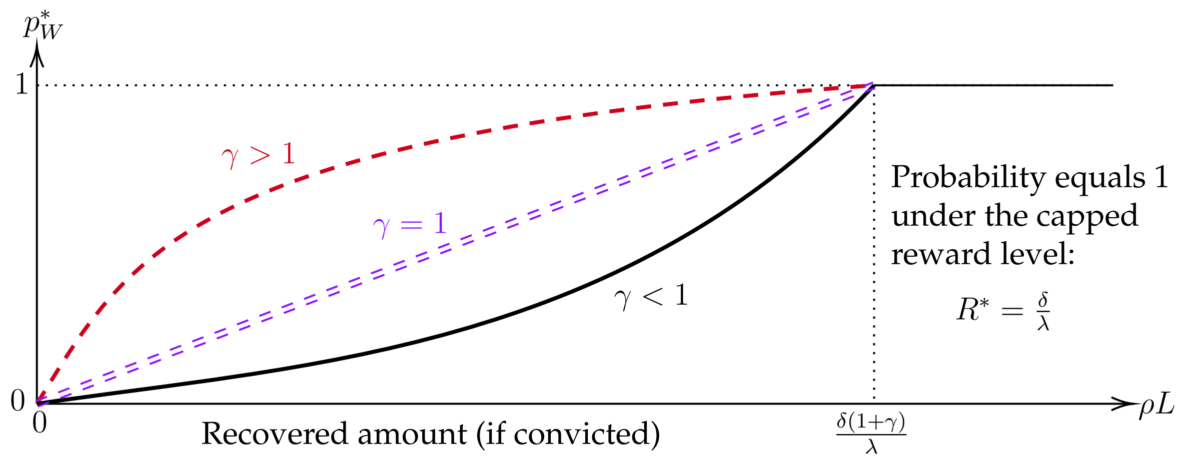

Figure 3: Whistleblowing probability p_W^* under the optimal reward R^*.

Notes: The optimal whistleblowing probability is drawn from (5). γ measures the degree of concavity/convexity of the distribution of whistleblower types defined in (1) and is illustrated in Figure 1.

This section extends the model by analyzing the decision to commit fraud. It then characterizes the conditions under which the use of whistleblowers can reduce the expected benefit from fraud. The analysis also endogenizes the expected probability of conviction $\mathrm{E}\lambda$. Intuitively, potential fraudsters recognize the probability that whistleblower-provided information may lead to their identification and conviction. Following Becker (1968), a fraud will be committed if the fraud level less the expected cost associated with being convicted is positive.[13]

To analyze the incentive to commit fraud, the fraudster's payoff from financial fraud must be specified. Recall that fraud generates a loss of L dollars. This loss constitutes an initial gain to the fraudster. The use of whistleblower-provided information may lead to conviction which then leads to:

(i) A partial or full recovery of the loss from the fraudster (ρL out of L).

(ii) Additional penalties (fines and/or jail time) imposed on the fraudster that are valued at ϕ dollars in total.

[13]The decision to commit fraud involves several other individual-specific behavioral factors that will not be analyzed here because the focus of the paper is on whistleblowers. In the context of tax evasion see Slemrod (2007) and Pickhardt and Prinz (2014) for literature surveys.

Note that (i) was already assumed throughout the entire analysis. That is, acting on whistleblower-provided information that leads to conviction, the authority will be able to force the fraudster to return ρL out of the total loss L. Part (ii) introduces penalties for committing fraud that could be combinations of a monetary fine and a monetary equivalent of jail time.

4.1 The decision to commit fraud

Potential fraudsters are heterogeneous with respect to their fraud sophistication to avoid getting convicted. Formally, let the probability of conviction λ be uniformly distributed on the unit interval $[0, 1]$ as illustrated in Figure 4.

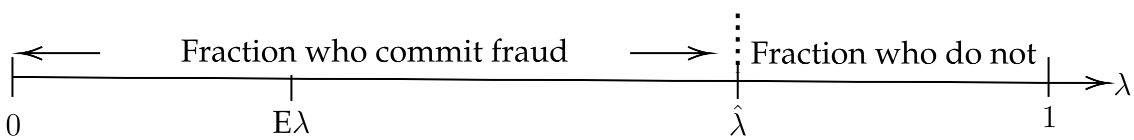

Figure 4: Fraction $\widehat{\lambda}$ of potential fraudsters who commit fraud.

Notes: λ indexes heterogeneous potential fraudsters according to increasing probability of getting convicted. $\widehat{\lambda}$ is the equilibrium fraction who commit fraud which is equal to the probability of fraud p_F. $\mathrm{E}\lambda$ is the expected conviction rate. $p_F = \widehat{\lambda}$ is derived in (7) and (10). $\mathrm{E}\lambda$ is derived in (8) and (10).

The expected payoff from committing fraud to a potential fraudster indexed by λ is[14]

$$\mathrm{E}\pi_\lambda = \begin{cases} \overbrace{L}^{\text{initial gain}} - \overbrace{p_W \lambda(\phi + \rho L)}^{\text{expected penalty and recovered amount}} & \text{commits fraud} \\ 0 & \text{does not commit fraud.} \end{cases} \tag{6}$$

As before, p_W is the whistleblowing probability, λ is the individual-specific probability of conviction multiplied by the sum of the penalty ϕ and the amount ρL that the fraudster will be forced to return to the defrauded party.

The expected payoff from fraud given in (6) implies that fraud is beneficial to an indi-

[14]The expected payoff (6) reflects risk-neutral potential fraudsters. Because the reservation payoff is zero, assuming risk aversion in the form of $\mathrm{E}\pi_\lambda = [L - p_W\lambda(\phi + \rho L)]^\theta$ (where $0 < \theta < 1$) will not affect the cutoff conviction probability (7). However, it will make a difference if the reservation payoff is not zero.

vidual with conviction probability λ if $\mathrm{E}\pi_\lambda \geq 0$, hence if λ satisfies

$$\lambda \leq \widehat{\lambda} = \begin{cases} \frac{L}{p_W(\phi+\rho L)} & \text{if } p_W \geq \frac{L}{\phi+\rho L} \\ 1 & \text{otherwise.} \end{cases} \tag{7}$$

Note from (7) that the fraction of fraudsters $\widehat{\lambda}$ and the whistleblowing probability p_W are inversely related. An increase in the whistleblowing probability p_W increases the risk from committing fraud thereby reducing the fraction of potential fraudsters who benefit from fraud. $\widehat{\lambda}$ also decreases with the recoverable amount ρL and the penalty level ϕ.

Because the distribution of the probability of conviction among potential fraudsters lies in $\lambda \in [0, 1]$, the analysis interprets $\widehat{\lambda}$ as follows:

ASSUMPTION 2. *Let $\widehat{\lambda}$ be specified in (7). For any given whistleblowing probability p_W, $p_F = \widehat{\lambda}$ is the probability that a fraud will be committed.*

Similar to Assumption 1, Assumption 2 is more of a result than an assumption but it establishes the reason why the fraction of potential fraudsters $\widehat{\lambda}$ could also be interpreted as the probability of committing fraud.

4.2 Whistleblower reward and equilibrium probabilities

To obtain closed-form solutions, the remainder of this section relies on the following simplifying assumption:[15]

ASSUMPTION 3. *The whistleblower utility function (1) is linear. Formally, $\gamma = 1$.*

As shown in Figure 4, all potential fraudsters with conviction probabilities $\lambda \leq \widehat{\lambda}$ will choose to commit fraud. Therefore, for a given whistleblowing probability p_W, the *expected conviction rate* can be computed by

$$\mathrm{E}\lambda = \int_0^{\widehat{\lambda}} \lambda \, d\lambda = \frac{\widehat{\lambda}^2}{2} = \frac{1}{2}\left[\frac{L}{p_W(\phi+\rho L)}\right]^2, \tag{8}$$

[15]The results derived under this simplification may not generalized to other utility functions that are nonlinear with respect to d. Nevertheless, the model is not solvable without this assumption. Subsection 5.3 calibrates the parameter γ as a function of the observed reward rates $\frac{R}{\rho L}$.

where $\widehat{\lambda}$ was substituted from (7).

Back to whistleblowers, note that the decision whether to blow the whistle is directly affected by the expected conviction rate $\mathrm{E}\lambda$ given in (8). This is because whistleblowers are compensated only if their information leads to actual conviction. Therefore, substituting $\mathrm{E}\lambda$ from (8) for λ in the whistleblowing probability (2) and extracting p_W yields

$$p_W = \sqrt[3]{\frac{RL^2}{2\delta(\phi + \rho L)^2}}. \tag{9}$$

Substituting p_W from (9) into (7) and (8) yields the fraud probability and the expected conviction rate

$$p_F = \widehat{\lambda} = \sqrt[3]{\frac{2\delta L}{R(\phi + \rho L)}} \quad \text{and} \quad \mathrm{E}\lambda = \sqrt[3]{\frac{\delta^2 L^2}{2R^2(\phi + \rho L)^2}}. \tag{10}$$

The probabilities p_W and p_F are depicted in Figure 5 as functions of the level of whistleblower reward R. Figure 5 shows that an increase in whistleblower reward R increases

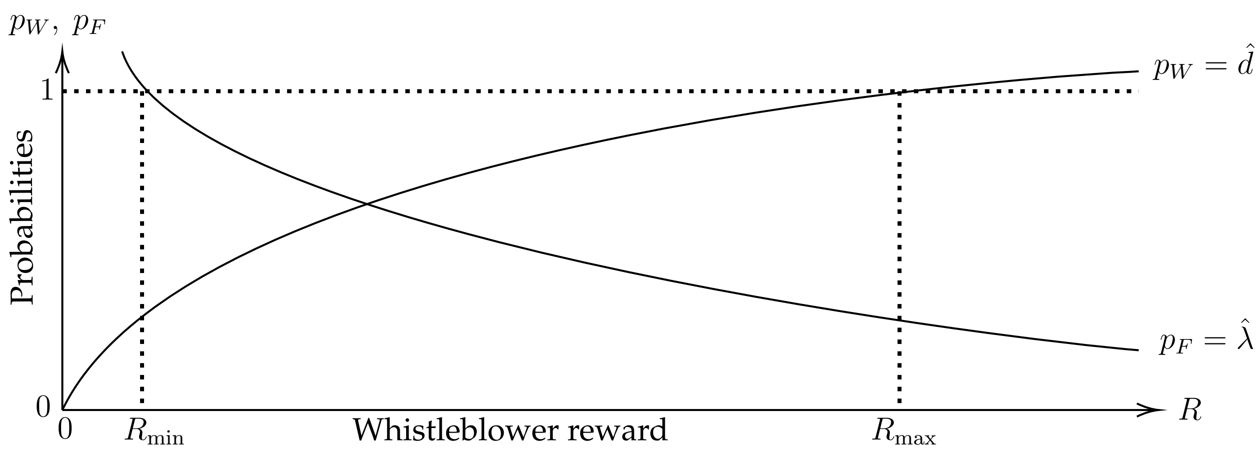

Figure 5: Whistleblowing probability p_W and fraud probability p_F as functions of whistleblower reward R.

Notes: $p_W = \widehat{d}$ is drawn from (9) and $p_F = \widehat{\lambda}$ is drawn from (10). The boundaries $R_{\min}$ and $R_{\max}$ are defined in (11). The figure assumes high penalty relative to the nonrecoverable fraud loss, $\phi > (1 - \rho L)$.

the whistleblowing probability p_W, decreases the fraud probability p_F, and consequently the expected conviction rate $\mathrm{E}\lambda$ (not shown in Figure 5).

Define two threshold whistleblower reward levels by

$$R_{\min} = \frac{2\delta L}{\phi + \rho L} \quad \text{and} \quad R_{\max} = \frac{2\delta(\phi + \rho L)^2}{L^2}, \tag{11}$$

and note that $R_{\min} < R_{\max}$ if $\phi > (1-\rho)L$. The two threshold reward levels are marked in Figure 5. The restriction $R \geq R_{\min}$ ensures that the fraud probability satisfies $p_F \leq 1$. The restriction $R \leq R_{\max}$ ensured that the whistleblowing probability satisfies $p_W \leq 1$.

4.3 Minimizing fraud loss with endogenously-determined fraud

The remaining analysis of endogenous fraud investigates the optimal whistleblower reward that takes into consideration the effect of whistleblowing on the incentive to commit fraud. Recall that the revenue maximization problem (3) captured an ex-post situation after a fraud has been committed. The limited goal of that analysis was to maximize the expected net amount that can be recovered with the use of whistleblower-provided information. The analysis in this section characterizes an ex-ante regulatory optimization problem before a fraud is committed. Formally, the regulating/enforcing authority chooses the level of whistleblower reward R^* to minimize

$$\begin{aligned} \mathrm{E}L_{\text{net}} &= \min_R \left\{ p_F \left[L - p_W \mathrm{E}\lambda \left(\phi + \rho L - R \right) \right] \right\} \\ &= \sqrt[3]{\frac{2\delta L}{R(\phi + \rho L)}} \left[L - \sqrt[3]{\frac{RL^2}{2\delta(\phi + \rho L)^2}} \sqrt[3]{\frac{\delta^2 L^2}{2R^2(\phi + \rho L)^2}} \left(\phi + \rho L - R \right) \right], \end{aligned} \tag{12}$$

where p_F was substituted from (10) and p_W from (9). The expected net fraud loss (12) is the fraud probability p_F multiplied by the initial fraud loss L less the expected net amount to be recovered. The latter is the product of the whistleblowing probability p_W given in (9), the expected conviction rate $\mathrm{E}\lambda$ in (10), and the net recovered amount $\rho L + \phi - R$, which includes the penalty ϕ.

Appendix C provides some characterizations of the expected fraud loss function (12). As it turns out, these expressions are very complex because of the multiplication of two probabilities p_F and p_W and the expected conviction rate $\mathrm{E}\lambda$, where all three are functions of R. Specifically, an increase in R lowers the fraud probability p_F, the expected conviction rate $\mathrm{E}\lambda$, and the net recovered amount $(\rho L + \phi - R)$. However, it also increases the whistleblowing probability p_W as shown in Figure 5. This explains the following results:

Result 4. *Let $R_{\min}$ and $R_{\max}$ be defined in (11) (see Figure 5).*

(a) Suppose the penalty imposed on convicted fraudsters is larger than the amount that cannot be recovered from the fraud loss. Formally, suppose $\phi > (1-\rho)L$. Then, the level of whistleblower reward that minimizes expected net fraud loss (12) lies in the range $R_{\min} \le R^* \le R_{\max}$.

(b) Under the above condition on ϕ, $R = R_{\max}$ yields a lower social loss than $R = R_{\min}$ if the penalty ϕ is large and satisfies $\phi > (1-\rho)L + 2\delta$.

(c) If the penalty is lower than the unrecoverable amount so that $\phi \le (1-\rho)L$, then $R^* = R_{\max}$ is the unique whistleblower reward that minimizes the expected fraud loss (12).

The Result 4(a) follows first from (11) and Figure 5 which define the lower and higher limits on whistleblower rewards. Then, numerical simulations show that even within the range where $\phi > (1-\rho L)$, the loss function (12) could be increasing, falling, and non-monotonic with respect to the reward level R. Thus, $R_{\min}$ or $R_{\max}$ could become the whistleblower reward level that minimizes the expected net loss (12).[16]

Result 4(b) is derived in Appendix C. Intuitively, a very large penalty ($\phi > (1-\rho)L+\delta$) implies that the authority has a lot to gain from maximizing the whistleblowing probability as this will decrease the expected loss by collecting this fee. Otherwise, a low penalty implies that the authority should focus on minimizing the cost of paying rewards by setting $R = R_{\min}$ despite knowing that fraud will be committed.

To prove Result 4(c), note that $R_{\min} > R_{\max}$ when $\phi < (1-\rho)L$ so that $R_{\max}$ becomes the lower limit. In terms of Figure 5, the two boundaries are reversed. In this case, the probability of whistleblowing reaches $p_W = 1$ at $R^* = R_{\max}$ (now the lower limit on R). A

[16]The R-code for the numerical simulations can be downloaded from `https://github.com/ozshy/fraud`.

higher reward is not needed because it cannot further increase the probability of whistle-blowing p_W and therefore cannot further reduce the probability of fraud p_F.

5. Extensions

This section derives two extensions of the benchmark model (Section 3) and provides a simple calibration of the distribution of whistleblower preferences. The applications of these extensions to the full model (Section 4) may require separate models that go beyond the scope of this article.

5.1 "Wait to inflate" whistleblower strategy

Financial fraud could be a one-time event in which fraudsters hide or transfer money against the law or against their company's policy. Alternatively, financial fraud could be a continuous process in which funds are repeatedly misappropriated.

Consider now a potential whistleblower who has information about a fraud L that is repeated over time. The potential whistleblower debates three options: (i) Not to report to the authorities. (ii) Report fraud loss of L immediately, say in period 1. (iii) Report fraud loss of $2L$ in period 2. The advantage of the third option to the whistleblower is that a delayed report may result in a higher expected reward because the recovered amount would increase to $\lambda\rho 2L$ compared to $\lambda\rho L$ if the whistleblower rushes to report in period 1.

Let τ denote the time discount factor, where $0 < \tau \leq 1$. Then, under the optimal reward to whistleblowers (4), the utility function (1) implies that a whistleblower indexed by d will choose to delay reporting if

$$\underbrace{\tau\left(\lambda\frac{\rho 2L}{1+\gamma} - \delta d^\gamma\right)}_{\text{delayed whistleblowing}} > \underbrace{\lambda\frac{\rho L}{1+\gamma} - \delta d^\gamma}_{\text{immediate whistleblowing}}, \quad \text{hence if } \tau > \overline{\tau} = \frac{\lambda\rho L - (1+\gamma)\delta d^\gamma}{\lambda\rho 2L - (1+\gamma)\delta d^\gamma}. \tag{13}$$

This explains the following result.

Result 5. *Consider a fraud loss L that is repeated over time unless stopped by the authority. Then, a simple way to induce potential whistleblowers to avoid delaying their report is to cap the* *reward at the level corresponding to a one-time loss L. That is $R^* = \frac{\rho L}{1+\gamma}$ regardless of whether the whistleblower files a delayed report (period 2) or an immediate report (period 1).*

Result 5 presents a simple reward policy to motivate whistleblowers not to delay making a fraud report. It sends a message to potential whistleblowers that their reward will not increase over time even if the accumulated loss increases each period until it is stopped by the authority.

For the sake of completeness, delays in whistleblowing could also be prevented even with a higher cap than R^*. The highest cap $\overline{R}$ that can prevent delays is computed from

$$\tau\left(\lambda\overline{R} - \delta d^\gamma\right) \leq \lambda\frac{\rho L}{1+\gamma} - \delta d^\gamma \quad \text{hence} \quad R \leq \overline{R} = \frac{\rho L}{\tau(1+\gamma)} - \frac{(1-\tau)\delta d^\gamma}{\lambda\tau}. \tag{14}$$

Note that $\overline{R} \to R^* = \frac{\rho L}{1+\gamma}$ as $\tau \to 1$, which is the simple capped reward level described in Result 5.

Finally, it is worth noting that potential whistleblowers may avoid delaying their report even if the reward is not capped. This happens when the authority compensates only the first whistleblower. In this case, if several potential whistleblowers compete on being the first to report, they will avoid delaying their report even if the reward grows over time.

5.2 Sharing rewards among multiple whistleblowers

Table 1 in the Introduction shows that whistleblowing which leads to a successful partial recovery of the fraud loss often involves multiple whistleblowers. In this case, the reward is divided among several whistleblowers. The rewards are not always shared equally among the whistleblowers. Instead, authorities such as the SEC use an opaque process to divide the reward according the degree of importance of the whistleblowers' reports in the recovery of the fraud loss. That is, the division of the reward is decided on a case-by-case subjective criteria rather than by a general rule. For this reason, this extension assumes that the reward is *equally divided* among all the whistleblowers who provide information leading to the partial recovery of ρL of the fraud loss.

In view of Figure 1 and because the model assumes a uniform density of potential whistleblowers, the endogenously-determined variable $\widehat{d}$ measures both (i) the fraction of potential whistleblowers who report fraud and (ii) the number of whistleblowers. To analyze the effects of whistleblower reward sharing, the expectations of potential whistleblowers must be explicitly specified.

ASSUMPTION 4. *Potential whistleblowers can correctly predict the fraction and number $\widehat{d}$ of potential whistleblowers who choose to report a fraud.*

Assumption 4 and Figure 1 imply that each whistleblower's share in the reward R is $\frac{R}{\widehat{d}}$, which declines with the number (and fraction) of whistleblowers $\widehat{d}$. The whistleblower utility (1) now becomes $\mathrm{E}U_d = \lambda \frac{R}{\widehat{d}} - \delta d^\gamma$ for a whistleblower indexed by d. Note that each whistleblower d perceives $\widehat{d}$ as a constant. Under Assumption 4, in equilibrium, $d = \widehat{d}$ is the whistleblower who is indifferent between reporting and not reporting. Therefore, setting $0 = \mathrm{E}U_d = \lambda \frac{R}{\widehat{d}} - \delta \widehat{d}^\gamma$ yields

$$\widehat{d}\Big|_{\text{multiple WB}} = \begin{cases} \left(\frac{\lambda R}{\delta}\right)^{\frac{1}{1+\gamma}} & \text{if } R < \frac{\delta}{\lambda} \\ 1 & \text{if } R \geq \frac{\delta}{\lambda}. \end{cases} \tag{15}$$

Comparing (15) with (2) implies that for any given total reward to whistleblowers $R < \frac{\delta}{\lambda}$,

$$\widehat{d}\Big|_{\text{multiple WB}} < \widehat{d}\Big|_{\text{single WB}}. \tag{16}$$

Hence, in view of Assumption 1, the probability of whistleblowing p_W is lower when there are multiple whistleblowers relative to a single whistleblower.

Next, with multiple whistleblowers, the authority's reward choice problem (3) now becomes

$$\max_R \mathrm{E}B_{\text{net}} = \widehat{d}\Big|_{\text{multiple}} \lambda(\rho L - R) = \left(\frac{\lambda R}{\delta}\right)^{\frac{1}{1+\gamma}} \lambda(\rho L - R). \tag{17}$$

Appendix D derives the optimal total reward to whistleblowers and the resulting fraction of potential whistleblowers who file a report

$$R^*|_{\text{multiple}} = \begin{cases} \frac{\rho L}{2+\gamma} & \text{if } \frac{\rho L}{2+\gamma} < \frac{\delta}{\lambda} \\ \frac{\delta}{\lambda} & \text{otherwise} \end{cases} \quad \text{and} \quad \widehat{d}\Big|_{\text{multiple}} = \begin{cases} \left[\frac{\lambda \rho L}{\delta(2+\gamma)}\right]^{\frac{1}{1+\gamma}} & \text{if } \frac{\rho L}{2+\gamma} < \frac{\delta}{\lambda} \\ 1 & \text{otherwise.} \end{cases} \tag{18}$$

A comparison of the optimal total whistleblower reward (18) (shared among multiple whistleblowers) with (4) (single whistleblower) yields the main result.

Result 6. *Total whistleblower reward is lower when the reward is shared among multiple whistleblowers compared to when the reward is given to a single whistleblower.*
Formally, $R^*|_{multiple} < R^*|_{single}$.

At first glance, Result 6 is surprising because it raises the question why would the authority spend less on whistleblowers when they are multiple whistleblowers than what it spends when there is only one whistleblower. But, as shown in (16), the probability of whistleblowing is lower when rewards are shared among multiple whistleblowers. Therefore, rewards are less effective when more employees become whistleblowers.

Another way of looking at this finding is to compare how the recovered amount from the fraud loss ρL is shared between the authority and the whistleblowers. In the single whistleblower case, (4) reveals that the authority rewards the whistleblower with a fraction $\frac{1}{1+\gamma}$ of the recovered amount and keeps $\frac{\gamma}{1+\gamma}$ for reimbursing the defrauded party. However, when the reward is shared among multiple whistleblowers, (18) implies that the share allocated to rewards falls to $\frac{1}{2+\gamma}$ and the share that the authority keeps for reimbursement increases to $\frac{1+\gamma}{2+\gamma}$.

5.3 Calibrations of whistleblowers' preference distribution

Recall from (1) and Figure 1 that the parameter γ determines the shape of the distribution of potential whistleblowers' utility with respect to their discomfort type d. The parameter γ can be calibrated from the optimal rewards R^* that are specified in (4) for a single whistleblower and in (18) for shared rewards. Define the *reward rate* by

$$r = \frac{R}{\rho L}, \tag{19}$$

which is the ratio of the reward R (or total rewards in case of multiple whistleblowers) to the amount recovered from the fraud ρL. Then, if the authority pays the optimal rewards (4) and (18), the calibrated values of γ are computed from

$$\gamma_s = \frac{1}{r} - 1 \quad \text{and} \quad \gamma_m = \frac{1}{r} - 2, \tag{20}$$

where γ_s is the calibrated value according to (4) when the reward is given to a single whistleblower, and γ_m is calibrated from (18) when reward is shared among multiple whistleblowers. Table 3 displays the calibration results of (20) assuming reward rates in the range of 10 to 80 percent.

r	γ_s	γ_m
0.1	9.00	8.00
0.2	4.00	3.00
0.3	2.33	1.33
0.4	1.50	0.50
0.5	1.00	0.00
0.6	0.67	-0.33
0.7	0.43	-0.57
0.8	0.25	-0.75

Table 3: Calibrations of the parameter γ.

Notes: γ measures the degree of concavity/convexity of whistleblower utilities (1), see also Figure 1. γ_s and γ_m are computed from (20). Negative values of γ are not plausible.

As discussed in the Introduction, the SEC in the United States rewards whistleblowers who provide information yielding to a recovery of more than \$1 million with $r = 10\%$ to $r = 30\%$ of that amount. Similarly, the IRS rewards $r = 15\%$ to $r = 30\%$. Under these rates, Figure 1 shows that the distribution of potential whistleblowers' utilities is concave to the origin ($\gamma > 1$). This distribution becomes linear (Assumption 3) when $\gamma_s = 1$ if the reward rate is $r = 50\%$ and $\gamma_m = 1$ if the reward rate is $r = \frac{1}{3} \approx 33.33\%$.

6. Conclusion and takeaways

Whistleblowers play a different role when it comes to reporting on financial misconduct compared with whistleblowers in other sectors. This is because whistleblowers who report financial crimes may lead to a recovery of some of the loss caused by the fraud. This makes it possible to compensate whistleblowers with the amount recovered from the fraud loss. In contrast, there is no simple method for how to compensate whistleblowers who report issues related to product safety, manufacturing defects, abuse of power, or environmental pollution. This is because no significant amount of money can be recovered from these violators. Even if a violating producer is ordered to pay a penalty for damages, this penalty constitutes a direct transfer from the producer to the injured party but not a payment to the whistleblower who provided the information that lead to the conviction of the violator.

The model analyzes the effects of rewards to whistleblowers on three related uncertain outcomes: (i) the probability that a whistleblower will emerge given (ii) the probability that the fraudster will get convicted, and (iii) the probability of committing fraud. All these three probabilities are interrelated and are endogenously determined within the model. The main findings from this analysis are:

I. The optimal reward is capped at the level where higher rewards can no longer attract additional potential whistleblowers (Result 1 and Figure 2).

II. The optimal reward to whistleblowers who provide information that leads to the actual conviction of the fraudster increases with the amount recovered from the fraud loss (Result 2 and Figure 2).

III. Higher rewards to whistleblowers increase the probability of whistleblowing and also lowers the probability of fraud (Figure 5).

IV. The use of whistleblowers is insufficient to deter financial fraud. Additional penalties on fraud are needed (Results 4 and Figure 5).

V. A cap on rewards could be used to provide an incentive for whistleblowers to avoid delaying reporting on repeated frauds (Result 5).

VI. The total optimal reward is lower when the reward is shared among multiple whistleblowers compared to a single whistleblower (Result 6).

The results imply that it is beneficial to invest in technologies that provide early detection of financial fraud. For example, Cecchini et al. (2010) derive machine learning algorithms that can distinguish between fraudulent and nonfraudulent companies using only publicly available quantitative financial data. However, it is highly unlikely that financial institutions and external auditors will have the incentives to invest in technologies that provide early detection of financial fraud.[17]

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Appendix A Detailed information for Table 1

Table 1 is based on 133 separate SEC press releases during 2012–2024 (13 years), see `https://www.sec.gov/whistleblower/pressreleases`. I manually inserted the relevant information on each reward into a spreadsheet which is publicly available at `https://github.com/ozshy/fraud`. This spreadsheet provides details on each reward and fraud case that the SEC handled using whistleblower-provided information. It also contains Internet links to each of the 133 press releases.

Then, I wrote an R-code (also available for downloading) that computes the yearly summaries that are displayed in Table 1. In seven (out of the 133) fraud cases, the SEC did not reveal the number of whistleblowers who shared the reward. The SEC just stated that the “reward was given to joint whistleblowers” which means two or more. For these seven cases I assumed that the reward was shared by three whistleblowers. It should also be noted that rewards that are given to multiple whistleblowers need not be equally shared. To the contrary, in most cases one whistleblower whom the SEC views as the main contributor receives the largest share of the reward.

Finally, the reward dollar amounts described in the SEC press releases are rounded to conceal the identifies of the whistleblowers who provided the fraud information. The SEC press releases use the following language for each reward: “The SEC today announced rewards of [“more than,” “nearly,” “approximately”] $X to...” This means that the SEC may be rounding to the nearest one-million for large rewards and perhaps to the nearest $100,000 for rewards smaller than $1 million.

Appendix B Derivation of (4)

Differentiation of (3) with respect to R yields the first- and second-order conditions

$$\frac{\partial \mathrm{E}B_{\text{net}}}{\partial R} = \frac{R^{\frac{1-\gamma}{\gamma}} \delta^{-\frac{1}{\gamma}} \lambda^{\frac{\gamma+1}{\gamma}} \left[\rho L - R(\gamma+1)\right]}{\gamma} = 0, \tag{B.1}$$

$$\frac{\partial \mathrm{E}B^2_{\text{net}}}{\partial R^2} = -\frac{R^{\frac{1-2\gamma}{\gamma}} \delta^{-\frac{1}{\gamma}} \lambda^{\frac{\gamma+1}{\gamma}} \left[R(\gamma+1) + \rho L(\gamma-1)\right]}{\gamma^2} < 0. \tag{B.2}$$

Solving (B.1) for R yields R^* in (4). The second-order condition (B.2) holds for $R > \frac{\rho L(1-\gamma)}{1+\gamma}$ which is satisfied when $R = R^*$ in (4).

Appendix C Characterizations of the expected fraud loss function (12)

Differentiation of (12) with respect to R yields

$$\frac{\partial \mathrm{E}L_{\text{net}}}{\partial R} = \frac{\sqrt[3]{4L^4\delta}\left[R\sqrt[3]{L\delta} - \sqrt[3]{4R(\phi+\rho L)^4} + 2\sqrt[3]{L\delta}(\phi+\rho L)\right]}{6\sqrt[3]{R^5(\phi+\rho L)^5}}, \tag{C.1}$$

$$\frac{\partial^2 \mathrm{E}L_{\text{net}}}{\partial R^2} = -\frac{\sqrt[3]{4L^4\delta}\left[R\sqrt[3]{L\delta} - 2\sqrt[3]{4R(\phi+\rho L)^4} + 5\sqrt[3]{L\delta}(\phi+\rho L)\right]}{9\sqrt[3]{R^8(\phi+\rho L)^5}}. \tag{C.2}$$

In particular, when $R = R_{\min}$, where $R_{\min}$ is specified in (11), the second derivative (C.2) becomes

$$\left.\frac{\partial^2 \mathrm{E}L_{\text{net}}}{\partial R^2}\right|_{R_{\min}} = -\frac{\rho^2 L^2 + 2L(\delta+\rho\phi) + \phi^2}{36 L\delta^2} < 0, \tag{C.3}$$

which proves that the (12) is locally concave at $R = R_{\min}$. Therefore, $R_{\min}$ is a possible optimal whistleblower reward level that minimizes the expected fraud loss (12). Evaluating the second derivative (C.2) at $R_{\max}$ yields

$$\left.\frac{\partial^2 \mathrm{E}L_{\text{net}}}{\partial R^2}\right|_{R_{\max}} = \frac{L^5\left[L^2(4\rho-5)+2L(2\phi-\delta\rho)-2\delta\phi\right]}{36\delta^2(\phi+\rho L)^6}, \tag{C.4}$$

which requires additional assumptions to prove negativity.

To derive Result 4(b), evaluating (12) at $R = R_{\min}$ yields

$$\mathrm{E}L_{\text{net}}|_{R_{\min}} = \frac{L\left[L^2\rho^2+2L(\delta+\rho\phi)+\phi^2\right]}{2(\phi+\rho L)^2}. \tag{C.5}$$

Evaluating (12) at $R = R_{\max}$ yields

$$\mathrm{E}L_{\text{net}}|_{R_{\max}} = \frac{L\left[L^2(2\rho-1)+2L(\delta\rho+\phi)+2\delta\phi\right]}{2(\phi+\rho L)^2}. \tag{C.6}$$

Then,

$$\mathrm{E}L_{\text{net}}|_{R_{\min}} - \mathrm{E}L_{\text{net}}|_{R_{\max}} = \frac{L\left[L^2(\rho^2-2\rho+1)+2L(1-\rho)(\delta-\phi)-\phi(2\delta-\phi)\right]}{2(\phi+\rho L)^2}. \tag{C.7}$$

Finally, $\mathrm{E}L_{\text{net}}|_{R_{\max}} < \mathrm{E}L_{\text{net}}|_{R_{\min}}$ if $\phi > (1-\rho)L + 2\delta$ which is the condition specified in Result 4(b).

Appendix D Derivation of (18)

The first-order condition for (17) is

$$0 = \frac{\partial \mathrm{E}B}{\partial R} = \frac{R^{\frac{-\gamma}{1+\gamma}}\delta^{\frac{-1}{1+\gamma}}\lambda^{\frac{2+\gamma}{1+\gamma}}\left[\rho L - R(2+\gamma)\right]}{1+\gamma}. \tag{D.1}$$

The second-order condition for a maximum is

$$\frac{\partial^2 \mathrm{E}B}{\partial R^2} = -\frac{R^{\frac{-(1+2\gamma)}{1+\gamma}}\delta^{\frac{-1}{1+\gamma}}\lambda^{\frac{2+\gamma}{1+\gamma}}\left[\gamma\rho L + R(2+\gamma)\right]}{(1+\gamma)^2} < 0. \tag{D.2}$$

Solving (D.1) for R yields $R^*|_{\text{multiple}}$ in (18). Substituting $R^*|_{\text{multiple}}$ from (18) for R in (15) yields $\left.\widehat{d}\right|_{\text{multiple}}$ in (18).