Organized Crime, Insider Information and Optimal Leniency[*]

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October 12, 2014

Abstract

When 'low-rank' criminals are offered the option to cooperate with the justice in exchange of judicial leniency, their insider information generates ex-post rents that may actually favor their heads and increase the crime profitability. Hence, an optimal leniency policy must trade off the positive impact of helpful disclosure of insider information and the positive externality that these rents exert on the organization's returns from crime. Due to this tension, the amnesty that minimizes the probability of crime induces the Legislator to ration the access to the program, by excluding informants owning potentially useful insider knowledge. This rationing result survives to a number of robustness checks, which include the case of multiagent organizations, the possibility of self-reporting by the boss, the presence of career concerns and the introduction of an endogenous information structure.

JEL CLASSIFICATION: K14, K42

KEYWORDS: Accomplice-witnesses, Adverse Selection, Leniency, Organized Crime.

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1. Introduction

Successful prosecution of criminal organizations often rests upon the testimonies of cooperating accomplices (whistleblowers). This is because the most culpable and dangerous individuals rarely do the 'dirty job': even if they are ultimately responsible for the crimes committed by their 'soldiers', these people hardly get convicted because they mainly deal through intermediaries and push their own participation up to behind-the-scenes control and guidance — see, e.g., Jeffries and Gleeson (1995).

As a result, many countries have introduced innovative legal rules (leniency programs) facilitating the use of insider information in criminal proceedings, in exchange of lighter sanctions for criminals who flip and offer their 'help' to the justice. The logic of these programs is based on the well known divide-and-conquer principle, which has been extensively applied in the IO literature dealing with price fixing — see, e.g., Motta and Polo (2003) and Spagnolo (2008). But, while cartels are horizontal organizations, in which each member has equal power, criminal organizations are typically hierarchical, and base their strength on the ability to punish disloyalty. The testimonies released in trial by low-rank criminals can, indeed, provide a richly detailed context to a case, which can help making the public proceeding against their former heads compelling. However, these people turn informants and cooperate with the justice only when the 'deal' they are offered warrants legal benefits that (at least) cover the costs of remaining loyal to the organization, which tend to be obviously higher when there is more exposure to risk of retribution by their former partners — see, e.g., Schur (1988).

To capture these features, we study a model in which low-rank criminals, who are offered the option to flip and cooperate with the justice in exchange of judicial leniency, own insider knowledge that, if disclosed, can be used by the legal system to prosecute and convict their former heads. Within this framework, we show that ex-post and ex-ante efficiency mandate quite different policies. The ex-post efficient rule would require low-rank criminals to always blow the whistle, because the probability of convicting their heads is higher with rather than without insider information. Conversely, ex-ante efficiency may induce the Legislator to purposefully ration the access to the program through the choice of an amnesty that does not appeal to all potential informants, and in some cases even to shut down the program. This tension is purely due to the Legislator's lack of knowledge about the whistleblowers' insider information: if the Legislator knew this evidence, she would choose a type-contingent amnesty that makes every informant just indifferent between accepting to cooperate with the justice and facing the trial. But, this is not feasible when the potential evidence that these criminals may disclose is not known by the judicial authority. The reason is that whistleblowers enjoy an information rent, which tends to worsen deterrence because it reduces the (ex-ante) wage that they are willing to accept in order to pursue the crime (as it will be explained shortly).

The analysis involves a hierarchical criminal organization and a Legislator. The criminal

organization is formed by two mobsters that are in a 'principal-agent' type of relationship: a boss and a fellow, each with specific skills. The boss plans the crime and delegates its execution to the fellow. After the crime has been committed, some evidence about the boss's involvement into the crime materializes. This evidence is observed only by the organization members but not by the judicial authority, and if disclosed it spurs the prosecutors' ability to convict and jail the boss. The crime triggers an investigation and, at this stage, the fellow can opt to blow the whistle by disclosing all, or only part of his private information. When he does so, the boss will punish his disloyalty: the fellow will undergo a retaliation loss. The prize for cooperation is an amnesty announced by the Legislator at the outset of the game.

We show that, when low-rank criminals own useful insider knowledge about the involvement of their heads into criminal activities, the Legislator must grant rents to whistleblowers in order to elicit such information. These rents increase the expected utility of low-rank criminals, whereby exerting a positive vertical externality on the boss's expected return from crime. The point is that more valuable testimonies imply a higher conviction probability for the boss, whose retribution ability weakens when convicted and jailed. Hence, accomplices with better information enjoy an ex-post rent that stifles the ex-ante wage they need to be offered by the boss to accept the illegal deal, thus increasing the overall crime profitability to the detriment of society. To mitigate the dark side of judicial leniency, the Legislator is forced to design a policy that purposefully rations the access to the program by excluding informants owning potentially useful knowledge: a novel rationing result that hinges on the hierarchical nature of criminal organizations and on the hypothesis that cooperating criminals own insider knowledge.

Yet, this policy is feasible only if the retribution power of the organization from which the informant runs away is not too strong, otherwise the Legislator will (optimally) shut down the program and give up acquiring insider information. This constraint becomes less binding when the penalties inflicted to low-rank criminals grow larger, and when the insider information they provide can be used more productively by the judiciary. We also find that the Legislator is less interested in rationing the access to the program when the boss is exposed to a harsher sanction, which amplifies the negative externality that a whistleblower imposes on the organization through his cooperation with the justice. As for the optimal amnesty, we find that it decreases with the ability of the legal system to use the informants' testimonies: when the judiciary can better exploit the informant's knowledge to convict and jail the boss, the fellow bears a lower risk of retribution, and is thus more willing to cooperate. Most interestingly, the optimal amnesty is positively correlated with the boss' sanction. This is because, if the boss is punished more harshly, the Legislator has less incentive to ration the access to the program, which in turn spurs the amnesty that must be offered to the 'marginal' type — i.e., to the fellow that is just indifferent between cooperating with the justice and remaining loyal to the organization. Yet, the impact of a stronger retribution power of the organization on the optimal amnesty is

ambiguous. On the one hand, a larger retribution power (ceteris paribus) increases the fellow's expected retribution loss, which will call for a more generous amnesty to induce disclosure of information. On the other hand, a stronger retribution power also makes it more likely for the fellow to remain loyal to the organization, and (ceteris paribus) this reduces the probability of being curtailed for the 'marginal' type, who then demands a lower prize for his cooperation.

Finally, we also show that these programs perform better in terms of prosecution and conviction rates when the heads of the criminal organizations are punished more severely by the judicial system, when the retaliation power of these organizations becomes less strong and, obviously, when prosecutors are more able to use the whistleblowers' insider knowledge. This suggests a novel and non-obvious empirical prediction of our model: in countries where the people who plan and organize criminal activities are punished relatively more harshly, one should expected more prosecution and higher conviction rates.

Building on the basic trade-off discussed above, in the second part of the paper we perform a number of robustness checks and study how the tension between ex-ante and ex-post efficiency changes when additional ingredients are added to the model. First, we study how the presence of multiple fellows affects the need for leniency. It is argued that dark and bright side of leniency remains essentially unaltered. Second, the analysis is extended to the case where the benefit of an amnesty is also awarded to a 'self-reporting' boss — i.e., when the boss is induced to confess his involvement in the crime, and his testimony allows to convict the fellow. In this case, we show that allowing the boss to plea guilty and cheat the fellow may enhance ex-ante efficiency when the latter's information is sufficiently valuable. Essentially, enabling the boss to self-report reduces the set of contingencies in which the fellow blows the whistle, which in turn reduces the latter's information rent, whereby inducing less crime in equilibrium: an instance in which the divide-and-conquer principle works in both directions. As a final result of this partial substitution between law-rank criminals, who blow the whistle and bosses who self-report, the optimal policy induces more cooperation in equilibrium. Yet, the boss can be induced to talk only when also the fellow is willing to do so. Hence, when it is easier to induce low-rank criminals to blow the whistle, then it is also more likely to induce the boss to self-report: a sort of 'domino effect' that squares with the anecdotal evidence reported in Hammond (2004). Third, we study how the trade off between the bright and the dark side of leniency varies when the Legislator's incentives to restrict the access to the program are shaped by career and political concerns. It is argued that the optimal policy induces less rationing and excessively high amnesties when political and career concerns inefficiently distort her incentives away from ex-ante efficiency.

On the whole, the basic insights offered by the baseline model are robust to these extensions, and they even survive when the boss can optimally choose the amount of information flowing to the fellow. Finally, we show that the value of leniency weakens when the boss can buy the

fellow's silence by means of loyalty prizes and strengthens when the fellow enjoys being part of the organization over and above the monetary reward he obtains from the boss. In both these cases the Legislator finds it optimal to offer high-powered incentives to whistleblowers — i.e., full amnesty in the latter case and rewards in the former.

2. Related literature

Our analysis is related to the literature on organized crime. Traditionally, this literature has stressed welfare comparisons between monopoly and competitive supply of bads — see, e.g., Buchanan (1973) and Backhaus (1979). More recently, Jennings (1984), Polo (1995), Konrad and Skaperdas (1997, 1998) and Garoupa (2000) started to model criminal organizations as vertical structures whose heads need to discipline their fellows.[1] But, these models have overlooked the role of accomplice-witnesses programs as a tool to generate conflict within criminal organizations, which is instead the starting point of our analysis. Koffman and Lawarree (1996) offer a first model where collusion in a hierarchy can be prevented by leniency. Buccirossi and Spagnolo (2006) show that a moderate form of leniency can have the counterproductive effect of facilitating occasional illegal transactions. Differently from us, in Buccirossi and Spagnolo (2006) criminal organizations are not modeled as vertical structures and reported evidence is not a by-product of the crime, but it is collected by criminals to be used as a threat to strengthen the sustainability of the organization itself. Conversely, Chen and Rey (2007) show that forms of partial amnesty may be optimal in an oligopoly context where the Antitrust Authority is uncertain about the market characteristics — e.g., whether demand is high or low. Although both models highlight the potential benefits of partial amnesties, a key difference with Rey and Chen (2007) is that in our setting the cost of partial amnesty is directly related to the information content of the testimonies that whistleblowers are willing to deliver and on the effect that this possibility has on the monetary incentives offered by the boss ex-ante. This feature seems peculiar to the hierarchical nature of criminal organizations.

By analyzing the relation between the optimal design of criminal organizations and the information flow diffused through their echelons, our paper shares common features also with Baccara and Bar-Isaac (2008). They consider both vertical and horizontal structures. We focus only on the former type of organizations, but (in contrast to them) we highlight the link between (endogenously designed) leniency programs and insider information. Recently, Acconcia *et al.* (2014) have developed a simple model of hierarchical criminal organizations where the Legislator grants legal benefits to low-rank criminals who decide to cooperate with the justice. By using data collected for Italy, they identify the positive effect of the Italian accomplice-witness program introduced in 1991 on prosecution and argue that it also strengthened deterrence.[2]

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[1]See also Fiorentini and Peltzman (1995), Kugler *et al.* (2005) and Mansour *et al.* (2006).

[2]Similar evidence for antitrust cases is presented in Miller (2009).

Our analysis is motivated by this evidence and it departs from the stylized model developed in Acconcia *et al.* (2014) in several dimensions. The basic departing feature, among many others, is that we consider a setting where accomplices are heterogenous with respect to their private information, a feature that is missed in most of the existing papers on leniency programs.

Most remarkably, our paper adds to the existing literature by studying the case of a self-reporting boss. In this dimension, our work also relates to the literature on 'self-reporting'. In Kaplow and Shavell (1994), for instance, self-reporting saves enforcement resources because individuals who report their harmful acts need not be detected, and it reduces risk because these individuals bear certain rather than uncertain sanctions. In our model, instead, the bright side of self-reporting stems from the hierarchical nature of criminal organizations, and it hinges on the asymmetry of information between the Legislator and the cooperating accomplices.

The idea of applying leniency to criminal organizations builds upon the *antitrust* law enforcement literature, which started with the pioneering work by Motta and Polo (2003), and studies the effects of leniency programs on cartel formation in oligopolistic markets.[3] In this literature there are few papers that study the role of information disclosure. Feess and Walzl (2004), for instance, show that more informed (self-reporting) parties should receive more generous benefits than less informed ones, even though their main focus is not on the trade off between rents and efficiency that emerges when informants have private information, which is instead stressed in our analysis. In his analysis of optimal corporate leniency programs, Harrington (2008) shows that a leniency application is acceptable only if the government's case is sufficiently weak, which means that the applicant must satisfy some minimum conditions on the incremental value of his testimony. However, in his framework, the information reported is assumed to be common knowledge. Similar ideas are also developed by Silbye (2010), Sauvagnat (2010) and Harrington (2013). All these papers allow for some forms of private information on the probability of conviction when no firm has applied for leniency. Specifically, in Harrington (2013) each cartel member has private information on the likelihood that the authority will be able to convict them in the absence of any cooperation. Instead, Silbye (2010) assumes that the probability of conviction is common knowledge, but each firm can submit evidence that harms the other cartel members. In contrast to both these papers that characterize the equilibrium outcome of the game between the privately informed cartel members, we are more interested in the mechanism design problem connected to the design of an optimal leniency policy in criminal proceedings. Finally, differently from us, Sauvagnat (2010) studies an informed principal problem where the authority has private information about the strength of its case and decides strategically whether to open an investigation or not.[4]

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[3]Besides Motta and Polo (2003) see also Rey (2003), Spagnolo (2003 and 2008), Aubert *et al.* (2006), Chen and Harrington (2007), and Chen and Rey (2007).

[4]The literature on *plea bargaining* also shares common features with our paper. In these models the prosecutor that is concerned with achieving the greatest possible punishment, uses plea bargaining as a means to

3. The baseline model

Players and environment. Consider a game between a benevolent Legislator and two members of a (hierarchical) criminal organization: a boss and his fellow. The Legislator, having forbidden welfare reducing criminal acts, designs an accomplice-witnesses (leniency) program. The boss *plans* the crime and delegates its *execution* to the fellow. The crime yields a random (monetary) return $\tilde{\pi}$ that is distributed uniformly over the support $[0, \bar{\pi}]$.[5] The boss has full bargaining power and makes a take-it or leave-it offer to the fellow upon observing the realized crime return. The offer consists of a wage w to be paid after the crime is committed. If the fellow refuses the offer, the game ends and both criminals enjoy their reservation utility (normalized to 0 without loss of generality).[6]

Information. If the crime is committed, the agent (privately) learns a piece of hard information $\theta \in [0, 1]$ that he may disclose to the judicial authority. If disclosed, this information will help to make the case against the boss — i.e., it increases the probability with which the latter is convicted and jailed. As a convention, we assume that more valuable information corresponds to higher levels of θ. The parameter θ distributes according to the cumulative distribution function $G(\theta)$, with density $g(\theta)$.

Judicial rules. Once the crime is committed, a trial against the organization opens.[7] The conviction *technology* depends on the Legislator's policy and the fellow's behavior. Specifically:

- If the fellow remains loyal to the organization, the boss is not prosecuted, while the former is convicted with certainty and bears the sanction f.[8]

- If the fellow blows the whistle, he enjoys an amnesty ϕ and bears a discounted sanction $(1 - \phi) f$, where ϕf is the penalty that is waived by the policy. However, if allowed to talk, the fellow must decide how much information he will disclose to the judicial authority. That is, he chooses a testimony $t \in [0, \theta]$ to be delivered in trial. This testimony determines the probability of convicting the boss, hereafter denoted by

$$\Pr[\text{boss}|t] = \rho(t),$$

save scarce resources by avoiding taking all defendants to trial (Landes, 1971). More recently, Kobayashi (1992) interprets plea bargaining as a device through which a prosecutor "buys information", see also the survey by Gazal-Ayal and Riza (2009).

[5]The uniform specification is assumed to simplify the presentation in some extensions, although it is with no loss of generality in most of the analysis.

[6]We will analyze the effect of more complex contracts between the boss and the fellow in Section 4.5.

[7]The assumption that a trial opens with certainty is a normalization.

[8]The assumption that the boss cannot be prosecuted when the fellow does not talk is without loss of generality. Similarly, the hypothesis that the fellow is convicted with certainty when he remains loyal to the organization is inconsequential: any increase in his conviction probability has the same effect of an increase in the sanction f.

which is increasing in t: the more information the fellow discloses, the easier is for the judicial authority to convict and jail the boss. If convicted the boss bears the sanction s.

For simplicity, throughout, we assume that the amnesty ϕ cannot be contingent on θ. Appendix 2 shows that the Legislator cannot improve welfare by using more complex direct revelation mechanisms.

Intimidation risk and retribution. Criminal organizations seek to punish disloyalty. When they manage to do so, a loss $r > f$ is inflicted to the whistleblower. Retribution is successful only if the boss is not convicted, which occurs with probability $1 - \rho(t)$. This is with no loss of insights under the hypothesis that the retaliation ability of the boss weakens once he is convicted and jailed. Notice that, not only the boss's ability to retaliate weakens, but also it is less in his best interest to enact retribution. Indeed, the primary reason for the boss to harm a former accomplice who turns government witness is to deter other accomplices from doing so in the future. However, if the criminal activities of the boss are curtailed due to being in jail, he attaches less value to such a reputation and thus a weakened incentive to incur a costly action to maintain that reputation. Hence, the exogenous retaliation loss r is just a convenient shortcut to capture obvious reputational concerns.

Timing. The timing of the game is as follows:

τ=0 The Legislator commits to an amnesty ϕ to be granted to those low-rank criminals that flip and turn informants.[9]

τ=1 The crime return materializes, and the boss decides whether to commit the crime. He offers the wage w to the fellow. If the offer is rejected the game ends. Otherwise, once the illegal act is committed, the wage w is paid and the game proceeds to the next stage.

τ=2 The evidence θ that can be reported by the fellow to the judicial authority materializes and only the organization members observe it. The investigation opens and the fellow can opt to cooperate with the justice. If so, he decides how much information to disclose.

τ=3 The trial uncertainty resolves and sanctions (including the retribution loss) are imposed.

The solution concept is Subgame Perfect Nash Equilibrium.

Payoffs. All players are risk neutral. Following the literature, all sanctions will be interpreted as the monetary equivalent of the imprisonment terms, fines, damages, and so forth, to which

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[9]Commitment is typically recognized as a cornerstone of any form of leniency program — see, e.g., Hammond (2004, pp. 3).

the criminals expose themselves. The payoffs of the criminals before the trial uncertainty is resolved are as follows. The fellow's (expected) utility is

$$w - f(1 - \phi) - (1 - \rho(t)) r,$$

if he blows the whistle and reports t, otherwise it is equal to $w - f$. For any realization $\pi \in [0, \bar{\pi}]$ of the crime return, the boss's utility is

$$\pi - w - \rho(t) s,$$

if the fellow blows the whistle and reports t, and it is equal to $\pi - w$ otherwise.

Social goal. In the baseline model it is assumed that the Legislator's objective is to minimize crimes. For any amnesty ϕ, let $p(\phi)$ and $w(\phi)$ denote the boss's expected sanction and the agent's break-even wage, respectively. Committing the crime is profitable for the boss as long as the realized return π exceeds the expected costs — i.e., if and only if $\pi \geq p(\phi) + w(\phi)$. Hence, the Legislator's objective is to minimize the (expected) crime rate

$$\Pr[\pi \geq p(\phi) + w(\phi)],$$

subject to the relevant participation and incentive constraints (in the extensions we consider a more general social goal). For simplicity, we rule out cost considerations that include, among other things, the cost of leniency and/or the social cost of retaliation: our qualitative insights do not change if these costs are not so large to induce the Legislator to shut down the program.

Assumptions. The analysis will be developed under the following assumptions:

A1 The inverse hazard rate $(1 - G(\theta))/g(\theta)$ is decreasing in θ.

   This hypothesis is standard in the screening literature.

A2 Whenever indifferent between joining the program and facing the trial, criminals prefer the former option.

   This is just a convenient *tie-breaking* condition.

A3 $\rho(t) = \lambda t$, with $\lambda \leq 1$.

   Linearity of the conviction technology simplifies the analysis and does not involve loss of insights. The parameter λ will be interpreted as a measure of the the prosecution ability of the judicial authority — i.e., the extent to which the whistleblower's testimony can be exploited to make a case against the boss.

A4 No rewards: $\phi \in [0, 1]$.

This assumption implies that the fellow cannot enjoy (monetary) rewards from cooperating with the justice, which may reflect legislative constraints due to political and ethical concerns. Allowing for rewards ($\phi > 1$) would make the Legislator's maximization problem less constrained and thus easier to analyze. In Section 4.5 we will study an extension of the baseline model where rewards are needed to deter crime.

A5 The fellow cannot disclose more than what he knows — i.e., $t \leq \theta$.

Since the evidence observed by the fellow is hard information (once disclosed), a whistle-blower cannot make up additional information over and above what he has learned at stage $\tau = 2$, even though he may under-report by delivering a testimony t that falls short of his true knowledge θ. When this happens, there is no scope for unraveling: the judicial authority cannot make inference about the exact value of θ once the fellow has decided to disclose only part of his private information — i.e., if $t < \theta$.

3.1. Equilibrium analysis

In this section we characterize the equilibrium of the game and the optimal policy announced by the Legislator at stage $\tau = 0$. Our main result will show that ex-post and ex-ante efficiency mandate quite different outcomes of the game. Specifically, although ex-post efficiency would require the fellow to blow the whistle in all states of the world, because the probability of convicting the boss is nil in the absence of insider information while it is (always) positive when the fellow blows the whistle, ex-ante efficiency may induce the Legislator to purposefully ration the access to the program. This tension in our model is purely due to adverse selection: if the Legislator knew the exact value of θ, she would choose a type-contingent amnesty that makes the fellow just indifferent between cooperating and being convicted with probability 1, thereby implementing the ex-post efficient outcome in which the fellow never remains loyal to the organization. Yet, this outcome is not feasible with privately informed whistleblowers who enjoy rents because of their superior knowledge. Precisely the presence of these rents leads to the rationing result that we will highlight throughout.

We start the analysis by characterizing the fellow's behavior at the reporting stage. Suppose that in state θ he prefers to cooperate with the justice rather than remaining loyal to the boss and bear the sanction f with certainty — i.e.,

$$f(1 - \phi) + \min_{t \leq \theta} (1 - \lambda t) \, r \leq f.$$

How much information will he disclose? The next lemma shows that, if the fellow decides to blow the whistle, he will fully disclose his insider knowledge.

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Lemma 1. *When the fellow cooperates with the justice, he fully discloses his private informa-tion — i.e., $t^*(\theta) = \theta$ regardless of ϕ.*

The reason is that, when admitted into the program, the fellow is better off if the boss is convicted and jailed, as otherwise he would be curtailed and the probability that this event occurs is decreasing with his testimony t. Hence, given the amnesty ϕ announced by the Legislator at stage $\tau = 0$, the state of nature in which the fellow is indifferent between blowing the whistle and facing the trial (hereafter θ^*) is pinned down by the following condition

$$(1 - \phi)f + (1 - \lambda\theta^*)\,r = f \quad \Leftrightarrow \quad \theta^* \equiv \frac{r - \phi f}{\lambda r}. \tag{3.1}$$

As a result, the fellow is willing to cooperate only when he has enough information to disclose — i.e., $\theta \geq \theta^*$. By contrast, when he is poorly informed, the danger of being curtailed may overcome the positive impact of enjoying the amnesty ϕ. Note that, other things being equal, the fellow is more willing to talk if the judicial system is able to use his insider information more productively (i.e., when λ grows larger), if the retaliation ability of the boss is weaker (i.e., when r declines), when the Legislator is more lenient (i.e., when ϕ grows larger) and when the sanction is larger (i.e., when f increases).

Assuming that ϕ is such that $\theta^* < 1$, the minimal wage that the fellow must be offered in order to be willing to undertake the crime is

$$w(\phi) \equiv \int_0^{\theta^*} f\, dG(\theta) + \int_{\theta^*}^1 \left[(1 - \phi)\,f + (1 - \lambda\theta)\,r\right] dG(\theta),$$

which, given (3.1), can be rewritten as

$$w(\theta^*) \equiv f + \int_{\theta^*}^1 \lambda r(\theta^* - \theta)\, dG(\theta).$$

Similarly, the boss's expected sanction is

$$p(\theta^*) \equiv \int_{\theta^*}^1 \lambda\theta s\, dG(\theta).$$

As a result, the crime is committed if and only if its monetary benefit exceeds the implied (expected) costs — i.e., as long as the following condition is met

$$\pi \geq w(\theta^*) + p(\theta^*). \tag{3.2}$$

Hence, the Legislator must choose the policy that maximizes the right-hand side of (3.2) to optimally deter crime. Differentiating with respect to θ^*, the first-order necessary and sufficient

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condition for an interior solution is

$$s\theta^* - \frac{1 - G(\theta^*)}{g(\theta^*)} r = 0. \tag{3.3}$$

The interpretation of this condition is as follows. Expanding the set of reporters (i.e., reducing θ^*) by means of a more generous amnesty strengthens the prosecutors' ability to convict the boss: a negative (welfare enhancing) externality that a whistleblower imposes on his former boss. At the same time, committing to a more lenient amnesty has also a dark side insofar as it increases the rent of the infra-marginal types (i.e., $\theta > \theta^*$), thereby reducing the wage that must be paid to induce the fellow to join the criminal organization. In a sense, the discount in fines helps matching the participation constraint of the fellow, reducing the burden on the boss. This is because, for any amnesty ϕ promised by the Legislator, the fellow enjoys an 'information rent' when his insider knowledge is of good enough quality. That is, his (indirect) utility of cooperating with the justice,

$$- (1 - \phi) f - (1 - \lambda\theta) r,$$

is increasing in θ. This implies, in turn, that at the stage in which the wage is offered, the boss internalizes the positive impact of such rent on the fellow's expected utility and pay him less accordingly. Obviously, this lower wage translates onto a higher return from crime, thereby weakening deterrence and thus reducing welfare: a positive (crime enhancing) externality that a whistleblower imposes on his former boss. Notice that, as long as the boss's retribution power declines — i.e., as r becomes smaller — the fellow's information rent tends to vanish, so that all 'types' could be attracted at a relatively low amnesty.[10]

In the next proposition we study how the tension between these two effects shapes the optimal policy.

Proposition 1. *A leniency program is viable only if*

$$r < r^* \equiv \frac{f}{1 - \lambda}. \tag{3.4}$$

In this region of parameters the optimal policy is such that

$$\phi^* = (1 - \lambda\theta^*)\frac{r}{f} < 1. \tag{3.5}$$

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[10]In the contract theory jargon condition (3.3) represents the Legislator's 'virtual surplus': the first term captures the negative externality that the marginal type θ^* imposes on the boss by means of his testimony, which obviously enhances welfare; the second term measures the positive impact of the whistleblower' rent on the boss's expected return from crime, which worsens deterrence and thus reduces welfare — i.e., the inverse hazard rate $(1 - G(\theta^*))/g(\theta^*)$ measures the mass of types that enjoy this rent when the optimal amnesty is such that type θ^* is just indifferent between blowing the whistle and facing the trial. Appendix 2 shows that this trade-off also shapes the optimal direct mechanism.

The fellow applies to the program if only if $\theta \geq \theta^*$, with θ^* being the unique solution of (3.3). Finally, his break-even wage is non-negative — i.e., $w(\theta^*) \geq 0$.

Condition (3.4) implies that granting amnesties to low rank criminals willing to disclose useful knowledge about their former partners is a viable option for the Legislator only if these people belong to organizations with relatively low retaliation power — i.e., when $r < r^*$. This is because criminal organizations that are particularly violent, and expose disloyal members to serious dangers, are able to undo the effect of the policy through the threat of retribution. By inspection of condition (3.4), it is easy to conclude that the region of parameters where the introduction of a leniency program is viable expands when low-rank criminals face a higher sanction (i.e., when f grows larger) and when the judicial system is able to use their insider information more productively (i.e., when λ grows larger).

As already explained above, the optimal policy trades off the bright and the dark sides of granting sanction discounts to low-rank criminals willing to cooperate with the justice. As a result, not all potential informants join the program, even if their testimony would be potentially helpful to convict the boss. That is, even though ex-post efficiency would mandate an unrestricted access to the program since $\rho(\theta) \geq 0$ for any $\theta \in [0,1]$, from an ex-ante point of view it is efficient to ration the access to the leniency program so as to balance out the tension between the bright and dark side of the policy.

In the next proposition we perform a comparative statics analysis that emphasizes how the optimal policy responds to the model's underlying parameters.

Proposition 2. *Suppose that $r < r^*$. The optimal policy has the following features:*

- *The threshold θ^* is decreasing in s and increasing in r.*

- *The amnesty ϕ^* is decreasing in λ and f, and increasing in s. The impact of r on ϕ^* is ambiguous — i.e.,*

$$\frac{\partial \phi^*}{\partial r} \geq 0 \quad \Leftrightarrow \quad 1 - \lambda \theta^* \geq \lambda r \frac{\partial \theta^*}{\partial r}.$$

Inducing more entry into the program (i.e., setting a lower θ^*) increases the probability of convicting the boss and it is obviously more effective when the sanction for the boss s is more severe, which amplifies the welfare enhancing externality that the whistleblower imposes on the organization. Conversely, a stronger retaliation power (as measured by an expansion of r) spurs the dark side of the leniency program. That is, inducing more entry into the program is less efficient when larger rents (as implied by a higher loss r) translate onto a lower wage that the boss has to pay to the fellow, amplifying the crime enhancing effect of the policy. Interestingly, a reduction of r can be interpreted as an improvement in the protection effort of the State. This implies that the introduction of a protection program may be a necessary condition for a leniency

program to be welfare enhancing, especially when dealing with strong criminal organizations that are committed to punish severely disloyalty of their members. Protecting more intensively the whistleblower reduces his exposure to the risk of being curtailed, and thus (ceteris paribus) tends to reduce the bonus required by the indifferent type. This allows the Legislator to ration less the access to the program by choosing an amnesty that induces the fellow to talk in a larger set of contingencies.

Note that by equation (3.1) it can be easily inferred that there is a one-to-one mapping between the amnesty rate ϕ and the threshold θ^*. Combined with the optimality condition (3.3), this implies that while the parameter λ does not affect the states of nature where the fellow blows the whistle — i.e., θ^* evaluated at the optimal amnesty ϕ^* — it has a direct impact on the optimal amnesty. Specifically, a larger λ tends to reduce ϕ^* because when the judicial system can better exploit the informant's knowledge to convict and jail the boss, the fellow bears a lower risk of retribution (everything else being equal). In turn, this makes it easier for the Legislator to attract the fellow with relatively lower amnesties. A larger f also reduces ϕ^* because the higher is the fellow's sanction when convicted if he remains loyal to the organization, the lower his outside option is, and hence the smaller the amnesty he has to be offered as a prize for cooperation is. An interesting result of our model is that the agent's optimal amnesty is positively correlated with the boss' sanction s. This is because, as explained above, a larger sanction s induces the Legislator to ration less the access to the program, which in turn spurs the amnesty that must be offered to the marginal type θ^* that is now exposed to a higher risk of retaliation.

The impact of a stronger retribution power of the organization on the optimal amnesty ϕ^* is ambiguous. On the one hand, a larger r (ceteris paribus) increases the retaliation loss of the fellow, which will thus demand a more generous amnesty to disclose his private information. On the other hand, a larger r also expands the set of the states of the world in which the fellow remains loyal to the organization, and (ceteris paribus) this reduces the probability of being curtailed for the marginal type θ^*, who will thus demand a lower amnesty. Interpreting again a lower r as an more efficient protection program, it should be noted that an improvement in the State's protection effort does not necessarily lead to lower amnesties: the reason is that the positive impact of protection on the retaliation risk might be counterbalanced by the effect of a less intense rationing, which by reducing the indifferent type leads to higher amnesties other things being equal.

Finally, it is useful to notice that the (ex-ante) probability of convicting the boss — i.e.,

$$\int_{\theta^*}^{1} \lambda \theta dG\left(\theta\right),$$

is increasing in λ and s, and decreasing in r. This implies that a peculiar and non-obvious

testable prediction of our model is that (ceteris paribus) it should be relatively easier to convict the heads of criminals in countries where their crimes are punished more harshly (i.e., when s grows larger).

A closed-form example. To provide an example with a closed-form solution, let us consider a simple specification of the Burr type XII distribution function, whose cdf is $G(\theta) = 1 - (1 - \theta)^{\frac{1}{\sigma}}$. Notice that $G(\theta)$ is decreasing in σ. Hence, distributions parametrized by a higher value of σ first-order stochastically dominate those parametrized by lower values of σ. This means that when σ grows larger the mass distributed on the upper tail of the types' support is higher, thereby implying that the whistleblower is more likely to have decisive evidence to convict the boss. With this class of distributions it is easy to show that

$$\frac{1 - G(\theta)}{g(\theta)} = (1 - \theta)\sigma.$$

Hence,

$$\theta^* = \frac{r\sigma}{r\sigma + s}, \tag{3.6}$$

which is increasing in σ. This means that when the fellow is more likely to learn valuable information about his former boss, the Legislator's optimal policy induces less participation into the program: since the negative externality that the whistleblower imposes on the boss is more severe in expected terms (as reflected by a larger σ), it is optimal for the Legislator to induce less entry into the program so as to weaken the negative impact of the policy on deterrence — i.e., its crime enhancing effect. For instance, this would be optimal to fight the Calabrian 'Ndrangheta, an Italian criminal organization that typically features a low number of whistleblowers. One possible explanation for this fact, which is suggested by our model, is that, since the recruitment process of this gang is based exclusively on blood-relationship, perspective informants coming from this organization are very likely to own decisive information about their former heads (which in most cases are their close relatives).

The (expected) utility of the whistleblower when the state of nature commands participation into the program (i.e., $\theta \geq \theta^*$) is

$$u^*(\theta) = -f + \lambda r \left[\theta - \frac{r\sigma}{r\sigma + s}\right],$$

which is clearly decreasing in σ. This is because, as just said, distributions with higher values of σ induce a more selective admission policy, whereby reducing the informants' rent.

Similarly, we can study the impact of σ on the amnesty ϕ^*. Substituting (3.6) into (3.5) we have that

$$\phi^* = \frac{r}{f(r\sigma + s)}\left[r\sigma(1 - \lambda) + s\right].$$

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Differentiating with respect to σ we get

$$\frac{\partial \phi^*}{\partial \sigma} = -\frac{s\lambda r^2}{(r\sigma + s)^2 f} < 0.$$

This simple exercise shows that high-powered incentives — i.e., very large amnesties — are needed when criminal organizations are very secretive and avoid spreading information to low rank criminals, giving rise to distributions with low values of σ. High powered amnesties would be needed, for instance, to fight the Sicilian Mafia, which often delegates the execution of its illicit traffics to low-rank criminals that are quite unlikely to own decisive evidence about their heads.

Finally, notice that in this example the derivative of the optimal amnesty with respect to r is always positive — i.e.,

$$\frac{\partial \phi^*}{\partial r} = \frac{\sigma r (1 - \lambda)(r\sigma + 2s) + s^2}{(r\sigma + s)^2 f} > 0,$$

which means that the (positive) direct impact of the retaliation loss on the optimal amnesty overcomes the (negative) indirect effect due to a more severe rationing.

Optimal Sanctions and Endogenous Retribution. In the analysis developed above the boss's and the fellow's sanctions have been treated as exogenous primitives of the model. Absent imprisonment costs, this assumption captures the idea that more severe penalties provide the greatest inducement to cooperation — see, e.g., Hammond (2004, pp. 8). Indeed, it can be easily verified that the Legislator's objective function is increasing in s and f. By contrast, when there are imprisonment costs, additional confounding forces may come into play. First, the scope for leniency cannot be weaker (relative to the baseline model) if there are social costs of imprisoning the fellow: in this case there would be an additional reason to avail an amnesty to whistleblowers so to hamper the social cost of their detention. Second, since there is complementarity between the amnesty and the boss' sanction (recall that the bright side of leniency is increasing in s as shown in equation 3.3) when imprisoning the boss is costly, there is less need for leniency. On balance, the net effect is unclear and may depend on the relative size of the imprisonment costs, and the benefits of leniency.

The retribution loss r is another ingredient of the model that could be endogenized. If retaliation is not costly, it can be shown that the derivative of the boss's expected profit with respect r is equal to

$$-\frac{\partial}{\partial r} \int_{\theta^*}^1 [\lambda \theta s - \phi f + (1 - \lambda \theta) r] \, dG(\theta) = -\int_{\theta^*}^1 (1 - \lambda \theta) \, dG(\theta) + \lambda \theta^* s g(\theta^*) \underbrace{\frac{\partial \theta^*}{\partial r}}_{+}.$$

This suggests that, even if there are no direct costs of retaliation, the boss may face a trade off when committing to an optimal retaliation strategy. On the one hand, inducing more retaliation induces less cooperation, which tends to increase the crime rate (other things being equal). On the other hand, a harsher retribution also increases the break-even wage that must be paid ex-ante to the fellow, whereby reducing the crime rate.

Obviously, there are at least two more forces that may shape retaliation in reality. First, as discussed before, criminal organizations typically punish disloyalty to intimidate future potential cheaters: being harsh today may act as a signaling device to discourage future defections. Second, there may be indirect costs of enacting a strong retaliation strategy as this may trigger a reaction by the State in the form of stronger repression. Again, all these effects may interplay in a non-trivial manner, but our main qualitative insights still go true as long as the boss has an incentive to enact at least a minimal amount of retaliation.

4. Extensions

In this section we study whether the trade off between the bright and the dark side of leniency programs highlighted above survives to a number of robustness checks. The objective is to extend the baseline model in a few natural dimensions to understand under what conditions the need for partial amnesties becomes more pronounced and when, instead, it weakens.

4.1. Multi-agent organizations

Consider a criminal organization with more than one low-rank criminal. For simplicity, assume that the boss can hire two fellows (each denoted by $i = 1, 2$) that commit the same crime, which yields a random monetary return $\tilde{\pi} \sim U[0, \bar{\pi}]$ — e.g., both agents commit the same crime in different but alike geographic areas. At stage $\tau = 2$ both fellows receive the same piece of information θ about the boss, which is again a random variable with support $[0, 1]$ and cdf $G(\theta)$. Noteworthy, while the hypothesis that both fellows receive the same information will simplify the technical analysis, it can be naturally interpreted as a situation in which they perform the same job, have an identical position in the organization, and thus share the same insider knowledge.[11]

Following Harrington (2013) and Chen and Rey (2007), we assume that when both fellows blow the whistle, the selection criterion is such that:

A6 The amnesty ϕ announced by the Legislator is granted to the first informant only if both fellows disclose the same information. In this case, they are equally likely to be the first

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[11] The qualitative insights of the analysis do not change if the fellows' insider information is less than perfectly correlated.

informant. By contrast, when they disclose different information, the amnesty is granted only to the one that has provided the most valuable evidence.

Under assumption **A6** it is easy to show that fellows always report truthfully their insider information.[12] Hence, fellow-i's expected utility from blowing the whistle, when fellow j does so too, is

$$u_i^B(\cdot) \equiv (1 - \tfrac{\phi}{2})f + (1 - \lambda\theta)\, r.$$

This means that a race to the courthouse occurs (in equilibrium) when

$$\theta \geq \hat{\theta} \equiv \frac{r - \frac{\phi}{2}f}{\lambda r}.$$

By contrast, when $\theta < \hat{\theta}$ fellows never report jointly. Of course, as in the baseline model, when $\theta < \theta^*$ none of them is willing to report regardless of what the other does. Note, however, that $\hat{\theta} > \theta^*$. Hence, each fellow would like to blow the whistle when the other does not, but they prefer to be convicted rather than engaging in a race to the courthouse when $\theta \in [\hat{\theta}, \theta^*]$. Let

$$u_i^T(\theta) \equiv -(1 - \lambda\theta)\, r - f + \phi f \left[1 - \tfrac{\varepsilon_j}{2}\right],$$

be the expected utility of fellow i when he blows the whistle given that the other randomizes between talking and remaining loyal to the boss with probability ε_j and $1 - \varepsilon_j$, respectively. Define, by $u^N \equiv -f$ the utility of remaining loyal to the boss. The next result shows that a symmetric equilibrium of the game must feature mixed strategies at the reporting stage.

Proposition 3. *For any amnesty ϕ promised to the first informant, there exists a unique symmetric equilibrium of the reporting (sub)game which involves mixed strategies when $\theta \in [\theta^*, \hat{\theta}]$. In this equilibrium each fellow blows the whistle with probability*

$$\varepsilon^*(\theta) = 2 \left[1 - \frac{(1 - \lambda\theta)\, r}{\phi f}\right] \in [0, 1],$$

with $\varepsilon^*(\theta)$ being the unique solution of $u_i^T(\theta) = u^N$. Moreover, $\frac{\partial}{\partial\theta}\varepsilon^*(\theta) \geq 0$, $\varepsilon^*(\hat{\theta}) = 1$ and $\varepsilon^*(\theta^*) = 0$.

Building on Proposition 3 we can characterize the Legislator's optimal policy. To gain intuition on the forces that drive the result, it is useful to first define the boss's expected sanction and the fellows' break-even wage.

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[12]Of course, differently than before, here the assumption of a type-uncontingent amnesty is crucial. This is because, in principle, the Legislator could use the Crémer and McLean (1988) mechanism by playing the fellows one against the other, and achieve full surplus extraction. Nevertheless, these mechanisms are difficult to enforce because they usually require complex lottery contracts that are rarely observed in practice.

The boss's expected sanction is

$$p(\theta^*, \hat{\theta}) \equiv \int_{\theta^*}^{1} \lambda \theta s dG(\theta) - \int_{\theta^*}^{\hat{\theta}} \lambda \theta s (1 - \varepsilon^*(\theta))^2 dG(\theta) \leq p(\theta^*).$$

This expression shows that, other things being equal, the boss faces a lower risk of prosecution when he deals with two fellows. This is due to the coordination problem previously mentioned and to the resulting mixed strategy equilibrium highlighted in Proposition 3. Hence, ceteris paribus, there seems to be more need for leniency with larger organizations (or gangs active in more than one territory).

The zero profit wage offered by the boss to each fellow is

$$w(\theta^*, \hat{\theta}) \equiv f - \int_{\hat{\theta}}^{1} \left[\tfrac{\phi}{2} f - (1 - \lambda \theta) r \right] dG(\theta) \geq w(\theta^*).$$

This expression shows that, other things being equal, the break-even wage paid to each fellow is larger than in the baseline model. The reason is simple: since fellows engage in a courthouse race, each will enjoy less often the benefit of an amnesty, which calls for a higher ex-ante wage. This effect tends to hamper the dark side of leniency: the 'stake' offered by the Legislator creates distrust among the fellows, who need to be compensated for this extra risk — see, e.g., Hammond (2004) for an informal discussion of this mechanism applied to corporate leniency.

It is then easy to verify that the optimal amnesty maximizes the sum of the boss's expected sanction and the fellows' aggregate wage — i.e.,

$$2f + 2\int_{\hat{\theta}}^{1} \left[(1 - \lambda \theta) r - \tfrac{\phi}{2} f \right] dG(\theta) + \int_{\theta^*}^{1} \lambda \theta s dG(\theta) - \int_{\theta^*}^{\hat{\theta}} \lambda \theta s (1 - \varepsilon^*(\theta))^2 dG(\theta).$$

This expression shows that there are two components that must considered when minimizing crime: the impact of a higher amnesty on the sum of the fellows' wages (first and second terms in the objective function above) and its effect on the boss's expected sanction (third and fourth terms).

The first-order condition for an interior maximum is

$$\underbrace{2\int_{\theta^*}^{\hat{\theta}} \lambda \theta s (1 - \varepsilon^*(\theta)) \frac{\partial \varepsilon^*(\theta)}{\partial \phi} dG(\theta)}_{\text{Bright Side}} = \underbrace{(1 - G(\hat{\theta})) f}_{\text{Dark Side}}. \tag{4.1}$$

The dark side of leniency remains essentially unaltered: higher ex-post rents, as induced by a more generous amnesty, reduce the ex-ante wage and therefore enhance crime. As for the bright side, a higher amnesty increases the propensity of each fellow to blow the whistle when $\theta \in [\theta^*, \hat{\theta}]$ (recall that $\varepsilon^*(\theta)$ is increasing in ϕ), thereby increasing the boss's expected sanction

and reducing crime.[13]

4.2. Self-reporting by the boss

Up to this point, we have considered a policy that recognizes an amnesty to the fellow. What would happen if this benefit is also extended to a self-reporting boss? Would such a policy be desirable from an efficiency point of view? If so, why?

The historical evidence shows that, occasionally, even leaders of criminal organizations decide to cooperate with the justice by cheating their relatives, former allies and 'employees'.[14] In this section we modify the baseline model to take this possibility into consideration. Suppose that the Legislator grants an amnesty β to the self-reporting boss as a reward for his 'confession'. The structure of the game is similar to that analyzed before.

Once the crime is committed, a trial against the organization opens. Both criminals can cooperate with the justice. The boss may *self-report,* while (as before) the fellow may *blow the whistle.* Specifically:

- If the boss self-reports, the organization members are convicted with certainty but the boss enjoys an amnesty β. Intuitively, it is as if the information that the boss can report to the Legislator is always of highest quality — i.e., $\theta = 1$.[15]

- If the boss does not self-report, the game is as before.

The sequence of moves is as follows:

$\tau{=}0$ The Legislator commits to a pair of amnesties $(\beta, \phi) \in [0,1]^2$.

$\tau{=}1$ The crime return π materializes, and the boss decides whether to commit the crime. He offers the wage w to the fellow. If the offer is rejected the game ends. Otherwise, once the illegal act is committed, the wage w is paid and the game proceeds to the next stage.

$\tau{=}2$ A realization of θ materializes and only the organization members observe it. The investigation opens and, if the leniency program is in place, both criminals can opt to cooperate with the justice. The boss moves first.[16]

$\tau{=}3$ The trial uncertainty resolves and sanctions (including the retaliation loss) are imposed.

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[13]It is easy to verify that condition (4.1) always admits a solution $\phi^* \in (0,1)$.

[14]For instance, once convicted, Frank Lucas (the leader of one of the most powerful criminal organizations in New York during the 70s) provided evidence that led to more than 100 convictions.

[15]The qualitative insights of the analysis would remain unaltered as long as the boss is imperfectly but better informed than the fellow.

[16]This assumption is made only for simplicity and to avoid uninteresting coordination problems that might emerge when both criminals decide simultaneously to cooperate.

Consistently with the previous analysis we assume that: whenever indifferent between joining the program and facing the trial, both criminals prefer the former option.

Before characterizing the optimal policy it is worthwhile discussing some key features of an equilibrium outcome of the game with a self-reporting boss. To make the problem interesting, we will focus on equilibria in which, to improve efficiency, the Legislator grants a positive amnesty to the boss and this bonus is large enough to guarantee self-reporting in equilibrium.

Recalling that the fellow always fully discloses his information when admitted into the program and that the boss is never prosecuted if the fellow does not report, an equilibrium in which the boss self-reports in state θ can exist only if the fellow is willing to talk in this state and the boss's expected sanction when he does not confess exceeds the utility from self-reporting — i.e.,

$$\lambda\theta \geq 1 - \beta. \tag{4.2}$$

We look for a cut-off equilibrium such that in some states neither the fellow nor the boss talk, in some other states only the fellow blows the whistle, while in the rest of the cases both apply to the program, but only the boss is allowed to self-report (while the agent's application is rejected). Let θ^F denote the state of nature in which the fellow is indifferent between talking and facing the trial, which as usual is pinned down by the indifference condition (3.1). Similarly, define by $\theta^B \equiv (1 - \beta)/\lambda$ the solution with respect to θ of (4.2) taken as an equality. The following preliminary result will turn useful in characterizing the optimal policy:

Lemma 2. *In any equilibrium of the game in which the boss self-reports, θ^F must be lower than θ^B.*

Essentially, if the policy (β, ϕ) is such that $\theta^F > \theta^B$, then whenever $\theta \in [\theta^B, \theta^F)$ the boss will not self-report because he correctly anticipates that, in this case, the fellow will never blow the whistle. Hence, a policy that induces the boss to self-report must be such that $\theta^F \leq \theta^B$ — i.e., whenever the boss self-reports also the fellow must be willing to blow the whistle. This suggests that, in our model, whistleblowing and self-reporting are complements on the 'extensive margin' rather then substitutes.

The fellow's break even wage is

$$w(\cdot) \equiv \int_0^{\theta^F} f dG(\theta) + \int_{\theta^F}^{\theta^B} [(1-\phi)f + (1-\lambda\theta)r] dG(\theta) + \int_{\theta^B}^1 f dG(\theta) \geq 0,$$

while the boss's expected sanction is

$$p(\cdot) \equiv \int_{\theta^F}^{\theta^B} \lambda\theta s dG(\theta) + \int_{\theta^B}^1 (1-\beta) s dG(\theta).$$

Hence, the Legislator's maximization problem is

$$\max_{\phi\in[0,1],\beta\in[0,1]} \left\{ f + \int_{\theta^F}^{\theta^B} \left[\lambda\theta s - \phi f + (1-\lambda\theta)\, r\right] dG\left(\theta\right) + \int_{\theta^B}^{1} \left(1-\beta\right) s dG\left(\theta\right) \right\},$$

subject to (3.1) and (4.2) taken as an equality.

The next result summarizes the main features of the optimal policy with a self-reporting boss.

Proposition 4. *A leniency program is viable only if* $r \leq r^*$. *In this region of parameters the optimal policy has the following properties,* θ^F *and* θ^B *solve simultaneously*

$$s\theta^F - \frac{G(\theta^B) - G(\theta^F)}{g(\theta^F)} r = 0, \tag{4.3}$$

$$r(\theta^B - \theta^F) - \frac{1 - G(\theta^B)}{g(\theta^B)} p = 0. \tag{4.4}$$

with $\theta^F < \theta^*$ *and* $\theta^B > \theta^F$. *Hence, for* $\theta < \theta^F$ *the fellow is convicted with certainty and remains loyal to the boss, who will not be prosecuted; for* $\theta \in [\theta^F, \theta^B]$ *only the fellow blows the whistle and the boss is convicted with probability* $\lambda\theta$; *while for* $\theta \geq \theta^B$ *the boss self-reports and the fellow is convicted with certainty. The optimal amnesties are determined by (3.1) and (4.2) and the fellow's optimal amnesty is larger than* ϕ^*.

The economic intuition of the first-order conditions (4.3) and (4.4) is as follows. As before, the optimal amnesty granted to the fellow must trade off the positive effect of the whistleblower's privileged information on the boss's higher conviction risk and the crime enhancing effect due to the downward pressure that a higher amnesty exerts on the fellow's break-even wage. However, when the boss is allowed to self-report, the latter effect weakens because the fellow does not enjoy a rent in the states of nature where the boss opts to self-report — i.e., the fellow flips and reports his information only when θ is larger than θ^F because he has no incentive to talk for values of θ lower than this bound, but he actually enjoys the amnesty only for values of θ lower than θ^B because in these states the boss has no incentive to self-report. As a result, it is optimal to choose an amnesty ϕ that induces more participation than in the baseline model — i.e., $\theta^F < \theta^*$.

The impact of a higher self-reporting bonus β on the probability of crime has also a bright and a dark side. On the one hand, it allows to reduce the set of contingencies in which the fellow blows the whistle, thereby lowering the expected rent that he enjoys thanks to his superior information. This effect weakens the dark side of leniency emphasized above. On the other hand, a larger β tends to increase the ex-post utility of the boss, which again induces a greater (ex-ante) incentive to commit the crime. In this case, a stronger retaliation power (i.e., a larger

r) tends to induce more reliance on self-reporting because it spurs the fellow's rent, thereby inducing the Legislator to substitute whistleblowing with self-reporting. Note that the impact of leniency on the boss' behavior is more in line with the 'traditional' effect of amnesty. Indeed, the negative effect goes through a reduced expected fine on the wrongdoer (the boss), as it is the case in cartels, rather than on the new, indirect effect of relaxing the participation constraint of the agent, making hiring less costly and increasing the incentive to commit the crime.

Overall, when the optimal policy can include also a prize for self-reporting, the Legislator always prefers to use both instruments. First, it is never feasible to induce only the boss to self-report: for this to happen, the fellow must be willing to blow the whistle in some states of nature. Second, choosing a policy that does not induce the boss to self-report is suboptimal because this allows the Legislator to save on the rents granted to the fellow, and thus minimize crime. However, this substitution between whistleblowing and self-reporting is worthwhile only up to the point that the boss does not obtain a so high discount on his sanction that he will self-reports more often than necessary.

4.3. Endogenous information structure

This section provides an example where the distribution of the parameter θ is chosen endogenously by the boss, rather than being an exogenous primitive of the model. Suppose that the parameter θ distributes according to a cdf $G(\theta|\sigma)$, where $\sigma \in [0, \overline{\sigma}]$ measures an endogenous parameter that induces first-order stochastic shifts in the distribution of the fellow's private information — i.e., $G_{\sigma}(\theta|\sigma) < 0$. So that, distributions associated with a higher σ assign more mass to higher values of θ. To guarantee that the boss's objective function is single peaked and that it features an interior maximum, we also assume that $G_{\sigma\sigma}(\theta|\sigma) < 0$ and that $\overline{\sigma}$ is large enough.

Moreover, to capture the idea that more informed fellows better perform their job, we assume that the crime yields a random (monetary) return $\tilde{\pi} + \alpha\sigma$, where (as before) $\tilde{\pi}$ is a random variable uniformly distributed over the support $[0, \overline{\pi}]$, and the parameter $\alpha \geq 0$ measures how a better information structure affects the profitability of the crime.[17] The timing of the game is as before, with the following amendment: after $\tilde{\pi}$ has realized, the boss chooses σ so as to maximize his expected profit.

Solving the model backward, it is easy to show that the boss chooses σ so as to solve the following maximization problem

$$\max_{\sigma \in [0, \overline{\sigma}]} \left\{ \alpha\sigma - \int_{\theta^*}^{1} [\lambda\theta s + (1 - \lambda\theta) r - \phi f] \, dG(\theta|\sigma) \right\}, \tag{4.5}$$

---

[17]The results that will be established under this additive specification continue to hold qualitatively with a multiplicative specification at the cost of additional analytical complexity.

whose solution leads to the following result:

Proposition 5. *For any ϕ such that $\theta^* \in (0,1)$, problem (4.5) features an interior maximum $\sigma^* \in (0, \bar{\pi})$ if and only if $r < s$, with σ^* being the unique solution of*

$$\alpha = \int_{\theta^*}^1 \lambda\theta\,(s-r)\,|G_\sigma\,(\theta|\sigma^*)\,|d\theta. \tag{4.6}$$

In this case, σ^* is decreasing in ϕ. By contrast, if $r \geq s$, then $\sigma^* = \bar{\sigma}$ regardless of ϕ.

Condition (4.6) reveals that the boss's optimal information structure is determined by a potential trade-off between three effects. First, other things being equal, the boss has an incentive to choose a higher σ because more informed fellows perform a better job ($\alpha \geq 0$). Second, since a larger σ also makes the fellow more likely to blow the whistle, an information structure that assigns more mass to larger values of θ increases the boss's expected sanction. Third, since a larger σ generates more cooperation — i.e., when σ grows larger it is more likely that the fellow ends up with a value of θ larger than θ^* — the dark side of leniency magnifies as σ grows larger. This is because fellows with insider information of high quality enjoy a larger ex-post rent, which shifts onto a lower ex-ante wage, thereby making the crime more profitable. On balance, if $s > r$, the second effect prevails on the third one, so that there is an internal solution for σ. When $r \geq s$ the opposite obtains: dealing with more informed fellows cannot hurt the boss in this region of parameters. This suggests that the criminal organizations that are more likely to rely on more transparent information structures are those with a stronger retaliation and military power (i.e., $r \geq s$).

Solving the model backward, it is easy to verify that the Legislator's maximization problem is

$$\max_{\phi \in [0,1]} \left\{ f + \int_{\theta^*}^1 \left[\lambda\theta s - \phi f + (1-\lambda\theta)\,r\right] dG\,(\theta|\sigma^*) - \alpha\sigma^* \right\},$$

whose first-order condition is

$$s\theta^* - \frac{1 - G\,(\theta^*|\sigma^*)}{g\,(\theta^*|\sigma^*)} r = 0,$$

which shows that making the information structure endogenous does not affect the bright side of leniency, but it only endogenizes its dark side.

4.4. Limits to the dark side of leniency

The dark side of leniency highlighted throughout has been based on the inverse relation between the ex-post rent that the fellow enjoys when cooperating with the justice and his ex-ante break-even wage. In the previous analysis this wage was always non-negative, implying that extremely generous amnesties may actually facilitate crime. However, when loyal fellows enjoy extra rents at later dates of their criminal career, the dark side of leniency may disappear. This

might happen when loyalty is rewarded with promotions, or if fellows enjoy being in a criminal network as this secures private benefits over and above the wage received by the boss — e.g., extra monetary returns that these people manage to extract from honest citizens or any other form of psychological gratification associated with the position of a 'men of respect'.

To capture this possibility in the simplest possible way, let $B > 0$ denote the private benefits that the fellow obtains ex-post by accepting the boss's job offer. The break-even wage that he must be offered in order to be willing to commit the crime in the boss's behalf is

$$w(\phi, B) \equiv f - B + \int_{\frac{r-\phi f}{\lambda r}}^{1} \left[(1 - \lambda\theta) r - \phi f \right] dG(\theta),$$

which is decreasing[18] in ϕ and non-negative as long as B is not too large — i.e.,

$$B \leq \underline{B} \equiv f + \int_{\frac{r-f}{\lambda r}}^{1} \left[(1 - \lambda\theta) r - f \right] dG(\theta) \quad \Rightarrow \quad w(\phi, B) \geq 0.$$

In this case, the optimal policy is still determined by the trade-off between the bright and the dark side as stated in Proposition 1. By contrast, in the region of parameters where $B > \underline{B}$, the fellow's break-even wage is negative at $\phi = 1$ and, of course, positive at $\phi = 0$. As a result, there exists an amnesty level $\underline{\phi}$ such that $w(\underline{\phi}, B) = 0$, and $w(\phi, B) < 0$ for every $\phi > \underline{\phi}$.

Recalling that ϕ^* is the solution of the Legislator's maximization problem in the baseline model, we have:

Proposition 6. *As long as $\phi^* < \underline{\phi}$, the optimal policy does not change relative to the baseline model. If $\phi^* \geq \underline{\phi}$, the dark side of leniency disappears and the optimal policy requires full amnesty — i.e., $\phi^* = 1$.*

This result has an interesting interpretation. In reality, the size of the private benefit B should be higher for members of strong criminal organization whose market power is not expected to be challenged by potential competitors. In these cases, very aggressive leniency policies are required to minimize crime. By contrast, the trade-off between the dark and bright side of leniency highlighted in the baseline model seems to be more relevant in environments where criminal organizations are more likely to face external threats, which induce a lower B.

4.5. Ex-post contracting and the role of rewards

In this section we allow the organization members to stipulate more complex contractual rules. Suppose that, in addition to offering a fixed wage w, the boos can also commit to pay a bonus $b(\theta)$ which depends on the information received at stage $\tau = 2$ and is cashed by the fellow only if he remains loyal to the organization.

---

[18]See the proof of Proposition 1.

Solving the model backward, it is easy to check that the fellow refrains from blowing the whistle if only if

$$b(\theta) - f \geq -(1 - \phi)f - (1 - \lambda\theta)r, \tag{4.7}$$

that is, if the boss offers enough money to compensate the rent he forgoes by refusing to cooperate with the justice. Since the boss has full bargaining power, the equilibrium bonus (if any) satisfies (4.7) as an equality — i.e., $b^*(\theta) = \phi f - (1 - \lambda\theta)r$. Yet, the boss is willing to pay this price if and only if the expected sanction he avoids by inducing the fellow not to blow the whistle is large enough — i.e., if

$$S(\theta) \equiv \lambda\theta s - b^*(\theta) \geq 0 \quad \Leftrightarrow \quad \lambda\theta s + (1 - \phi)f + (1 - \lambda\theta)r \geq f.$$

However, since the fellow is convicted with certainty when he remains loyal to the organization, the extra bonus will be enjoyed with delay — i.e., after imprisonment. Accordingly, we assume that the utility he obtains ex-post is discounted by the factor $\delta \leq 1$.

The following result offers an interesting insight on the role of ex-post rewards:

Proposition 7. $S(\theta) > 0$ for every θ provided that $\phi \leq 1$. Hence, a leniency program is effective if and only if it rewards informants — i.e., $\theta^* < 1$ as long as $\phi > 1$.

This result suggests that when the boss can design complex internal rules that reward the fellow based on the quality of the information he can disclose, the Legislator is forced to rely on more powerful incentives to induce cooperation.

Before characterizing the optimal policy it is worth noting that, when θ grows larger, the boss is more likely to be convicted if the fellow reports. Therefore, other things being equal, he is willing to pay a higher loyalty prize when the fellow's insider information is of high quality, and even more so if s is large. However, as θ grows larger, the fellow is also less likely to be curtailed if he blows the whistle, which increases the utility he obtains from cooperation and therefore reduces the surplus $S(\cdot)$. The incentive to refuse the bonus and run to the courthouse is more pronounced when r is low — i.e., when the boss has low retaliation power. On balance, the net effect depends on the relative magnitude of r and s. When the retaliation power of the boss is weak — i.e., $r < s$ — the first effect dominates so that $S(\cdot)$ is increasing in θ. By contrast, when the retaliation power of the boss is strong enough — i.e., $r \geq s$ — the second effect dominates and $S(\cdot)$ is decreasing in θ. In what follows we will characterize the optimal policy in both cases.

High retaliation power. Assume first that $r \geq p$. In this case

$$S(\theta) < 0 \quad \Leftrightarrow \quad \theta \geq \theta^{**} \equiv \frac{r - \phi f}{\lambda(r - s)},$$

which means that buying the fellow's silence is not profitable for the boss as long as there is enough insider information to be disclosed. Note that $\theta^{**} > \theta^*$, so that ex-post contracting nullifies the effect of the policy when $\theta \in [\theta^*, \theta^{**}]$. Using the techniques developed above, it can be shown that the Legislator's maximization problem is

$$\max_{\phi \geq 1} \left\{ f + \int_{\theta^{**}}^{1} [r + \lambda\theta(s - r) - \phi f] \, dG(\theta) + (1 - \delta) \int_{\theta^*}^{\theta^{**}} [\phi f - (1 - \lambda\theta) r] \, dG(\theta) \right\},$$

whose first-order condition, in an interior solution, is

$$\underbrace{(1 - \delta) \frac{G(\theta^{**}) - G(\theta^*)}{g(\theta^{**})}}_{\text{Bright Side}} = \underbrace{(1 - \delta) \frac{p\theta^{**}}{r - s} + \frac{1 - G(\theta^{**})}{g(\theta^{**})}}_{\text{Dark Side}}. \tag{4.8}$$

A more generous amnesty has again a bright and a dark side. When the boss can offer a type-dependent bonus to the fellow, the source of the bright side is very different from the baseline model: a higher ϕ increases the fellow's utility from cooperation, thereby inflating $b^*(\theta)$. Yet, a higher loyalty prize also reduces the ex-ante return from crime, thereby increasing welfare. Note that this effect is decreasing in δ: the (negative) impact of the ex-post bonus on the ex-ante crime return is larger when the fellow discounts more the prize for his silence — for example because of longer incarceration. The dark side hinges on two effects. The first is captured by the hazard rate $(1 - G(\theta^{**}))/g(\theta^{**})$ as in the baseline model. The second effect is novel: a higher ϕ reduces the set of contingencies in which the boss if forced to buy the fellow's silence to avoid conviction. But this increases the ex-ante return from crime, thereby reducing welfare.

Notice that when $\delta = 1$ only the dark side survives: the leniency program is ineffective because the boss can always undo, through ex-post contracting, the effect of the policy.[19]

Low retaliation power. Next, suppose that $r < s$. In this case

$$S(\theta) < 0 \quad \Leftrightarrow \quad \theta \leq \tilde{\theta} \equiv \frac{\phi f - r}{\lambda(r - s)}.$$

Hence, the boss has no incentive to buy the fellow's silence when his insider information is of low quality. Note that $\tilde{\theta} > 0$ implies $\theta^* < 0$.[20] As a result, absent ex-post contracting, the fellow would always blow the whistle. However, since ex-post contracting occurs when $\theta \geq \tilde{\theta}$, only poorly informed fellows blow the whistle (in equilibrium).

---

[19]It can be shown, however, that for any $\delta < 1$ equation (4.8) has a solution $\phi^* > 1$ if

$$\frac{1 - G\left(\frac{r-s}{r}\right)}{g(1)} > \frac{s}{r - s}.$$

[20]Indeed, $\tilde{\theta} > 0$ if and only if $\phi > \frac{r}{f}$, which directly implies $\theta^* < 0$.

The Legislator's maximization problem is

$$\max_{\phi \geq 1} \left\{ f + \int_0^{\tilde{\theta}} [r + \lambda\theta(s-r) - \phi f] \, dG(\theta) - (1-\delta) \int_{\tilde{\theta}}^1 [\phi f - (1-\lambda\theta)r] \, dG(\theta) \right\},$$

whose first-order condition, in an interior solution, is

$$\underbrace{(1-\delta)\frac{1-G(\tilde{\theta})}{g(\tilde{\theta})}}_{\text{Bright Side}} = \underbrace{(1-\delta)\frac{p\tilde{\theta}}{s-r} + \frac{G(\tilde{\theta})}{g(\tilde{\theta})}}_{\text{Dark Side}}. \tag{4.9}$$

The interpretation of this condition is as before. The difference with the previous case is that now the fellow blows the whistle in the states of nature where θ is low, while he remains loyal to the organization when his insider information is of high quality. Again for $\delta = 1$ only the dark side survives, so that any attempt to induce whistleblowing is ineffectual.[21]

Summing up, the interesting empirical prediction of this extension is that organizations with low retaliation power are forced to bribe fellows with high quality information in order to avoid cooperation. By contrast, organizations with strong retaliation and military power are more likely to use monetary incentives for fellows owning low quality information, but are exposed to defections by those with high quality information.

4.6. Career and political concerns

Consider now a framework where (differently than before) the Legislator's objective is to maximize a weighted sum of the boss's conviction probability and the reciprocal of the crime rate. The idea is that, in many instances, governments are influenced by electoral concerns (e.g., because aggressive conviction scores may increase their chance of being reappointed), and prosecutors are motivated by career concerns (e.g., because their monetary incentives and career prospects may be responsive to past conviction scores). Accordingly, denote by $\gamma \in [0,1]$ the weight that the Legislator assigns to the boss's conviction probability, which captures his career and political concerns. Let $\Pr[\text{boss}]$ denote the expected probability of convicting the boss. The Legislator's objective function is

$$\gamma \Pr[\text{boss}] + (1-\gamma)\Pr[\pi \leq p(\phi) + w(\phi)].$$

The fellow's behavior is as before: when joining the program, he fully discloses his private information, and he does so when his information is good enough. Hence, using the same

---

[21]It can be shown that for any $\delta < 1$, condition (4.9) admits a unique solution as long as the inverse hazard rate $\frac{G(\theta)}{g(\theta)}$ is non-decreasing.

technique as before, the Legislator's maximization problem is

$$\max_{\phi \in [0,1]} \left\{ \gamma \int_{\frac{r-\phi f}{\lambda r}}^{1} \lambda \theta dG(\theta) + \frac{1-\gamma}{\bar{\pi}} \left(f + \int_{\frac{r-\phi f}{\lambda r}}^{1} \left[\lambda \theta s - \phi f + (1-\lambda\theta) r \right] dG(\theta) \right) \right\}.$$

The next result summarizes the main features of the optimal policy.

Proposition 8. *Even with career concerns, a leniency program is viable only if $r < r^*$. The optimal policy requires an amnesty*

$$\phi^C = (1 - \lambda\theta^C)\frac{r}{f} \geq \phi^*,$$

with $\theta^C \leq \theta^*$ being the unique solution of

$$\theta^C \left[s + \frac{\bar{\pi}\gamma}{1-\gamma} \right] - \frac{1 - G(\theta^C)}{g(\theta^C)} r = 0 \tag{4.10}$$

The fellow joins the program only if $\theta \geq \theta^C$. Moreover, θ^C (resp. ϕ^C) is decreasing (resp. increasing) in γ and $\bar{\pi}$.

When the objective function is a convex combination of the crime rate and the probability of convicting the boss, the optimal policy avails an amnesty too generous relative to the baseline model. This suggests that an excessive use of insider information in criminal proceedings may partly reflect political and career concerns.[22] This danger has often thrown doubts on the opportunity of setting up leniency programs for members of criminal organizations: a point that finds support in our analysis.

Finally, while in the baseline model the distribution of the crime return does not matter, here it affects the optimal policy as long as $\gamma \in (0,1)$. Specifically, if the crime becomes more profitable in expected terms — i.e., if $\bar{\pi}$ grows larger — the Legislator cares relatively more about deterrence than prosecution. This means that relying on insider information becomes more important when criminal organization engage in more profitable activities.

5. Empirical and anecdotal evidence

In this final section we discuss the main legislative provisions approved to facilitate witnesses cooperation in organized crime investigations, and argue that they the support the model's results.

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[22] For example, under pure career concerns — i.e., for $\gamma = 1$ — the optimal policy features no rationing: the Legislator does not care about deterrence and welcomes all types into the program.

Measures for cooperating accomplice witnesses. The use of insider information in criminal proceedings is usually debated both on the efficiency and fairness grounds. In Germany, for instance, arguments against leniency programs are based on: "The principle of equal treatment and principles of proportionality and legality" (Huber, 2001). In other countries, like those of Anglo-Saxon tradition, the necessary role played by accomplice witnesses is well acknowledged, especially when a state of emergency is justified because of organized crime. However, the efficiency of these programs cannot be taken for granted, whereby calling for more empirical research on this ground — see, e.g., Acconcia *et al.* (2014) for a study of the Italian experience.

Nevertheless, while assessing the efficacy of these policies is an empirical matter still under debate, a judicial system that values the quality of the evidence provided in exchange for reduced sentences will certainly punish less harshly leaders of criminal organizations. In other words, as explained by Fyfe and Sheptycki (2006): "creating an environment in which providing 'substantial assistance' is the main way informant witnesses get reduced sentences may generate a range of 'unfair results'. It risks the so-called 'cooperation paradox' whereby 'kingpins' receive lower sentences than their underlings because the 'kingpins' have more information to exchange for a 'substantial assistance' recommendation'. This feature is consistent with our rationing result stating that only whistleblowers with insider information of sufficiently high quality can (will) apply for leniency.

The magnitude of the amnesty. There are substantial differences in the generosity of measures favoring accomplice witnesses around the world. For instance, "...whereas in the USA, the criminal who turns state witness and testifies against himself and his former associates is no longer going to be prosecuted; in Italy, despite his collaboration, the criminal will be prosecuted and if found guilty serves one-quarter of the sentence in prison or 10 years in the case of a life sentence" (Allum and Fyfe, 2008, pp. 95). This evidence could be rationalized by stronger political and career concerns in the USA — see Proposition 8. Indeed, while in Italy the judge who may decide not to sentence or to impose a less severe sentence in light of cooperation is a public official with life tenure, the American Attorney General is accountable to voters.

Dark side of amnesties. Practitioners and criminologists recognize the existence of a dark side of leniency. For instance, Kelly et al. (1994, pp. 501) argue that witness protection and immunity for criminal informants "represents an exit strategy for career criminals". Citing data from the US General Accounting Office (GAO), Albanese (1996, pp. 195) observed that approximately 21% of protected witnesses were arrested within two years of being put on the program. According to Dunningham and Norris (1999, 1996a,b) negative consequences of leniency abound "...crime is facilitated as well as repressed; criminals are licensed to commit crime rather than apprehended for their violations." Our model highlights a novel potential

drawback of these policies.

The witnesses protection programs. The first and better known witnesses protection program is the US Federal Witness Security Program, which was established by the 1970 Organized Crime Control Act following the Justice Department failure in the fight against Italian-American organized crime in the 60s. Since then, many other countries have adopted a witness protection program as a key tool against organized crime and terrorism. Despite some discrepancies due to country specific legal traditions and to differences in nature and scale of organized crime, the eligibility criteria and the forms of protection are very similar across these programs: "The witness needs to be giving evidence in relation to the most serious crimes and those who are close to the witness who might be endangered are also eligible for protection. The forms of protection available are also quite similar and normally involve the relocation of a witness and his/her close family, the possibility of formally changing their identity and help with social and economic assimilation in the communities to which they are moved" (Fyfe and Sheptycki, 2006). In Germany, for instance, it is eligible for protection a person crucial to criminal proceedings, who faces serious danger if testify (the 2001 Witness Protection Harmonisation Act). In the UK, a protection provider must, between other things, have regard to: the nature and extent of the risk to the person's safety, the cost of the arrangements, and the importance of his being a witness in those proceedings (the 2005 Serious Organized Crime and Police Act ch.4, 82). The attention to the extent of the risk corroborates the comparative statics stated in Proposition 2 suggesting that protection may be a necessary condition for a leniency program to enhance welfare, especially in the presence of strong criminal organizations that are committed to punish severely disloyalty of their members.

Empirical evidence from organized crime leniency. Acconcia *et al.* (2014) show that some predictions of the theoretical model developed above appear to be corroborated by the evidence available for Italy. In fact, consistently with this evidence, our model predicts a positive correlation between the number of crimes (deterrence), the probability of convicting the boss and the introduction of a leniency program.

Concerning the optimality of using a leniency program, Acconcia *et al.* (2014) show that the Italian leniency program engendered a sensible reduction of mafia related crimes. Moreover, they document an increasing trend in prosecution rates of mafia related crimes, a pattern that is not present when looking at prosecution rates of similar but not mafia related crimes for which a leniency program is not available. They also argue that the leniency program creates a shift of prosecutions towards higher ranks of the organization, when a fellow talks, the boss is more likely to fall. This result motivates our assumption that the testimony of the fellow determines the probability of convicting the boss. Most importantly, they provide evidence that the criminal incentive to cooperate is related to the local legal environment. In particular,

variations in the proportion of acquittals in mafia trials (a measure of judicial efficiency) are exploited to reveal any impact of the perceived probability of being convicted on the number of whistleblowers. This evidence is consistent with the fact that θ^* is decreasing in λ, which means that the fellow is willing to talk if the judicial system can use his insider information more productively.[23]

Empirical evidence from corporate leniency. Although the deterrence effects of antitrust policies are difficult to evaluate, exactly as leniency programs meant to fight organized crime, indirect methods developed by Brenner (2009), Harrington and Chang (2009) and Miller (2009), among others, address this problem. These papers identify empirically the effects of antitrust policies using changes in observables such as the number of detected cartels or their duration. For a sample consisting of 61 cartel cases investigated and prosecuted by the European Commission between 1990 and 2003, Brenner (2009) does not find evidence that cartels become more fragile after adoption of the leniency program. Conversely, Miller (2009) shows that the introduction of the US leniency program in 1993 led to a substantial increase in the rate of detection and decrease in the rate of cartel formation. This difference in the level of deterrence between the US and the EU is in line with the prediction of our model that conviction should be relatively easier in countries where crimes are punished more harshly. Recall that in our model the region of parameters where the introduction of a leniency program is viable expands as crimes are punished more harshly (Proposition 1). The comparison of the previous papers is therefore a good test of our theory. In fact, while forming a cartel in the U.S. is a criminal offense for which individuals can be subject to severe prison sentences, in Europe managers do not face this threat.

Finally, the model also offers some predictions concerning individual leniency policy. Consistently with Proposition 3, Hammond (2004, pp. 11-12) argues that, when dealing with complex organizations, stimulating a race between the company's culpable employees is a winning strategy. He also claims that "...the real value and measure of the Individual Leniency Program is not in the number of individual applications we receive, but in the number of corporate applications it generates", which is consistent with Proposition 4.

6. Concluding remarks

The use of insider information in criminal proceedings is widely recognized as one of the most effective tools in the modern fight against organized crime. Yet, the implementation of these

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[23]Note that the optimal policy characterized in the baseline model is such that the set of contingencies in which the fellow blows the whistle is not affected by λ — i.e., when evaluated at the optimal amnesty ϕ^*, the threshold θ^* is unresponsive to λ. However, there is no reason to believe that this optimal policy is implemented in practice, which suggests that the negative relation between θ^* and λ is likely to be found in the data at any given ϕ different from ϕ^*.

rules is often challenged by ethical concerns. This skepticism calls for a better understanding of the right responses of the judicial system to the growing organizational complexity of criminal groups. To make a step forward in this direction, we studied the problem of a Legislator designing immunity for privately informed whistleblowers. Focusing on a hierarchical criminal organization, we have captured the basic trade-offs emerging when the efficacy of a leniency program is undermined by the natural asymmetry of information between prosecutors and criminals willing to testify against their former partners in exchange of lighter sanctions. Our key finding highlights a novel dark side of leniency programs. Because informants own insider knowledge (that is only partially verifiable by prosecutors) the policy that minimizes crime must ration the access to the program because whistleblowers owning particularly decisive evidence enjoy a rent from cooperation that enhances the organization's propensity to engage in criminal activities.

The model predictions are consistent with a number of legal provisions characterizing accomplice-witnesses regulations across the world. They suggest that the benefits of these programs in terms of reduced crime may justify, at least from an efficiency point of view, the recognition of legal benefits to cooperating accomplices whose testimonies can turn particularly useful to prosecute their heads and former partners. Yet, since the optimal policy also requires a selective admission process (rationing), the model confers a scientific argument in favour of those arguing that amnesties should not be granted with ease. This result survives to a number of robustness checks that include, among others, the case of multiagent organizations, the presence of career concerns, the possibility of self-reporting by the boss and the introduction of an endogenous information structure.

In addition to criminal organizations, the model insights appeal to a number of other interesting contexts where lawbreakers are organizations that feature hierarchal command chains and build their power on intimidation and retribution not only across their borders but also among their members — e.g., political and religious terrorism.

Appendix 1: Proofs

Proof of Lemma 1. The proof of this result follows immediately from the fellow's utility maximization problem. Suppose that he has decided to blow the whistle, then the testimony he will deliver in trial solves the following loss-minimization problem

$$\min_{t\in[0,\theta]} \left\{ (1-\phi)f + (1-\lambda t)\,r \right\},$$

which yields a corner solution $t^*(\theta) = \theta$. ∎

Proof of Proposition 1. Recall that θ^* is determined by the fellow's indifference condition

$$(1-\phi)f + (1-\lambda\theta^*)\,r = f. \tag{.1}$$

Hence, an optimal policy that induces the fellow to blow the whistle is feasible if and only if

$$\frac{r-f}{\lambda r} < 1 \quad \Leftrightarrow \quad r < r^* \equiv \frac{f}{1-\lambda}.$$

In this region of parameters the optimal policy solves the following maximization problem

$$\max_{\phi\in[0,1]} \left\{ f + \int_{\theta^*}^{1} [\lambda\theta s - \phi f + (1-\lambda\theta)\,r]\,dG(\theta) \right\}. \tag{.2}$$

subject to (.1).

Using the above definition of θ^*, a simple change of variables allows to rewrite this problem as

$$\max_{\theta^*\in[0,1]} \int_{\theta^*}^{1} [\lambda\theta s + \lambda(\theta^* - \theta)\,r]\,dG(\theta). \tag{.3}$$

Differentiating with respect to θ^* we have

$$\lambda r\,[1 - G(\theta^*)] - \lambda\theta^* s g(\theta^*) = 0,$$

rearranging terms this yields

$$s\theta^* - \frac{1-G(\theta^*)}{g(\theta^*)}r = 0,$$

which has a unique solution in $(0,1)$ since $(1-G(\cdot))/g(\cdot)$ is strictly decreasing. The optimal bonus ϕ^* then solves (.1)

$$\phi^* = \frac{(1-\lambda\theta^*)\,r}{f}.$$

Concavity of (.2) and (.3) can be immediately checked, while $\phi^* \in (0,1)$ is guaranteed by the assumptions that $r > f$ and $\lambda < 1$.

Finally, integrating by parts the fellow's break-even wage evaluated at the optimal amnesty

ϕ^* it is easy to show that

$$
\begin{aligned}
w\left(\phi^*\right) &= f - \int_{\frac{r-\phi^* f}{\lambda r}}^{1} \left[\phi^* f - (1-\lambda\theta)\, r\right] dG\left(\theta\right) = \\
&= f\left(1-\phi^*\right) + (1-\lambda)\, r + \int_{\frac{r-\phi^* f}{\lambda r}}^{1} \lambda r G\left(\theta\right) d\theta,
\end{aligned}
$$

which is strictly positive because, by assumption, $(r - f)/\lambda r < 1$, $\lambda < 1$ and $\phi^* \leq 1$. ∎

Proof of Proposition 2. Using the Implicit Function Theorem together with the fact that $(1 - G\left(\cdot\right))/g\left(\cdot\right)$ is strictly decreasing, we have

$$
\frac{\partial \theta^*}{\partial s} = -\frac{\theta^*}{s - r\, \frac{\partial}{\partial \theta}\left(\frac{1-G(\cdot)}{g(\cdot)}\right)\Big|_{\theta=\theta^*}} < 0,
$$

$$
\frac{\partial \theta^*}{\partial r} = \frac{1}{s - r\, \frac{\partial}{\partial \theta}\left(\frac{1-G(\cdot)}{g(\cdot)}\right)\Big|_{\theta=\theta^*}} \frac{1 - G\left(\theta^*\right)}{g\left(\theta^*\right)} > 0.
$$

Hence,

$$
\frac{\partial \phi^*}{\partial s} = -\frac{\lambda r}{f}\frac{\partial \theta^*}{\partial s} > 0, \qquad \frac{\partial \phi^*}{\partial f} = -\frac{(1-\lambda\theta^*)\, r}{f} < 0, \qquad \frac{\partial \phi^*}{\partial \lambda} = -\frac{\theta^* r}{f} < 0
$$

and

$$
\frac{\partial \phi^*}{\partial r} = \frac{1 - \lambda\theta^*}{f} - \frac{\lambda r}{f}\frac{\partial \theta^*}{\partial r},
$$

whose sign is ambiguous since θ^* is increasing in r. ∎

Proof of Proposition 3. First, observe that $\hat{\theta} > \theta^*$. Hence, for every $\theta \in [\theta^*, \hat{\theta}]$ each fellow is willing to blow the whistle if the other fellow remains loyal to the boss. Hence, in this region of parameters there exist two trivial asymmetric pure-strategy equilibria in which one fellow remains loyal to the organization while the other cooperates with the justice. It then follows that, in any symmetric equilibrium, fellows must randomize. This randomization, saying that (in equilibrium) each fellow flips with probability $\varepsilon^*(\theta)$, must solve the following indifference condition

$$
\varepsilon^*\left(\theta\right)\left[\left(1-\tfrac{\phi}{2}\right) f + (1-\lambda\theta)\, r\right] + \left(1 - \varepsilon^*\left(\theta\right)\right)\left[(1-\phi)\, f + (1-\lambda\theta)\, r\right] = f,
$$

which yields

$$
\varepsilon^*\left(\theta\right) = 2\left[1 - \frac{(1-\lambda\theta)\, r}{\phi f}\right],
$$

which is increasing in θ and, by construction, it is equal to 0 at $\theta = \theta^*$ and to 1 at $\theta = \hat{\theta}$. ∎

Proof of Lemma 2. The Lemma can be shown by contradiction. Suppose that $\theta^B < \theta^F$. Then, for every $\theta \in [\theta^B, \theta^F]$, the boss is willing to self report, while the fellow will not want to

blow the whistle. But this directly implies that it is profitable for the boss not to self-report in these states of the world. ∎

Proof of Proposition 4. Suppose that $r < r^*$. By Lemma 2 the optimal policy must satisfy $\theta^F \leq \theta^B$ for the boss to self-report in equilibrium. Suppose this is the case (such conjecture will be verified ex-post), then the Legislator's maximization problem is

$$
\max_{\phi \in [0,1], \beta \in [0,1]} \left\{ f + \int_{\theta^F}^{\theta^B} \left[\lambda \theta s - \phi f + (1 - \lambda \theta) r \right] dG(\theta) + \int_{\theta^B}^{1} (1 - \beta) s dG(\theta) \right\}.
$$

subject to

$$
\left(1 - \lambda \theta^F \right) r = \phi f, \tag{.4}
$$

$$
\lambda \theta^B = 1 - \beta. \tag{.5}
$$

Replacing the constraints (.4) and (.5) into the objective function, the above maximization problem simplifies to

$$
\max_{\theta^F \in [0,1], \theta^B \in [0,1]} \left\{ \int_{\theta^F}^{\theta^B} \left[\lambda \theta s + \lambda \left(\theta^F - \theta \right) r \right] dG(\theta) + \int_{\theta^B}^{1} \lambda \theta^B s dG(\theta) \right\}.
$$

Differentiating with respect to θ^F and θ^B the first-order necessary and sufficient conditions for an internal maximum are, respectively

$$
\lambda r \left[G(\theta^B) - G(\theta^F) \right] - \lambda \theta^F s g(\theta^F) = 0, \tag{.6}
$$

$$
\lambda(\theta^F - \theta^B) r g(\theta^B) + \lambda s \left[1 - G(\theta^B) \right] = 0. \tag{.7}
$$

Rearranging, we have

$$
s \theta^F = \frac{G(\theta^B) - G(\theta^F)}{g(\theta^B)} r, \tag{.8}
$$

$$
(\theta^B - \theta^F) r = \frac{1 - G(\theta^B)}{g(\theta^B)} s. \tag{.9}
$$

Next, we need to prove that conditions (.8) and (.9) yield a unique solution with $\theta^B > \theta^F$. To begin with, we show that condition (.8) has a unique solution in θ^F for any $\theta^B \in (\theta^F, 1]$. To this end, it is enough to verify that the modified (inverse) hazard rate

$$
\frac{G(\theta^B) - G(\theta)}{g(\theta)},
$$

is non-increasing. Observe that

$$
\frac{\partial}{\partial \theta} \frac{G(\theta^B) - G(\theta)}{f(\theta)} = -1 - \frac{G(\theta^B) - G(\theta)}{g(\theta)} \frac{g'(\theta)}{g(\theta)}.
$$

Then, when $g'(\theta) \geq 0$, it is obvious that

$$\frac{\partial}{\partial \theta} \frac{G(\theta^B) - G(\theta)}{g(\theta)} < 0.$$

So, consider the case in which $g'(\theta) < 0$. Then

$$-1 + \frac{G(\theta^B) - G(\theta)}{g(\theta)} \frac{|g'(\theta)|}{g(\theta)} \leq -1 + \frac{1 - G(\theta)}{g(\theta)} \frac{g'(\theta)}{g(\theta)} = \frac{\partial}{\partial \theta} \frac{1 - G(\theta)}{g(\theta)} \leq 0,$$

hence

$$\frac{\partial}{\partial \theta} \frac{G(\theta^B) - G(\theta)}{g(\theta)} \leq 0 \quad \forall \theta^B \geq \theta.$$

Next, note that $\theta^B = \theta^F$ cannot solve simultaneously the first-order conditions (.8) and (.9). Moreover, it is never optimal to set $\theta^B < \theta^F$ since, in this case, the left-hand side of (.7) would be strictly positive. Hence, the optimal policy must be such that $\theta^B > \theta^F$. Finally, (.7) also implies that $\theta^B < 1$, otherwise the left-hand side of (.7) would be negative, unless $\theta^F = 1$ which would, however, imply that the left-hand side of (.6) is negative and thus it would be optimal to reduce θ^F below 1.

Finally, using the indifference conditions (.4) and (.5), it follows that $\beta^B = 1 - \lambda \theta^B$ and $\phi^F = (1 - \lambda \theta^F) r / f$. Moreover, showing that the fellow's break-even wage is positive at the optimal policy follows exactly the same logic as before. ∎

Proof of Proposition 5. Consider a state $\pi \in [0, \bar{\pi}]$ in which the boss opts for committing the crime. His expected utility is

$$\pi + \alpha \sigma - \int_{\theta^*}^{1} [\lambda \theta s + (1 - \lambda \theta) r - \phi f] \, dG(\theta|\sigma),$$

integrating by parts, this is equal to

$$\pi + \alpha \sigma - \int_{\theta^*}^{1} \lambda (s - r) G(\theta|\sigma) \, d\theta,$$

whose derivative with respect to σ is independent of π and equal to

$$\alpha - \int_{\theta^*}^{1} \lambda (s - r) G_\sigma(\theta|\sigma) \, d\theta. \tag{.10}$$

Using the assumption that $G_\sigma(\cdot|\sigma) < 0$, it can be immediately seen that an interior solution to the boss's maximization problem exists only if $s > r$. In this case, the problem is concave and admits an interior solution because we have assumed $G_{\sigma\sigma}(\cdot|\sigma) > 0$ and $\bar{\sigma}$ large enough. Obviously, if $r > s$, there is a unique corner solution in which $\sigma = \bar{\sigma}$. ∎

Proof of Proposition 6. Suppose first that $\phi^* \leq \underline{\phi}$, then it is clear that optimal policy does not change relative to the baseline model because $w(\phi^*) \geq 0$. Next, assume $\phi^* > \underline{\phi}$: in this case $w(\phi^*) < 0$. Hence, the policy characterized in the second best is no longer optimal because

the fellow's limited liability binds. But this means that the Legislator can freely choose $\phi = 1$, without inducing any cost of leniency because $w(\cdot)$ is decreasing in ϕ. ∎

Proof of Proposition 7. Recall that $S(\theta) \equiv \lambda\theta(s-r) + r - \phi f$. Suppose first that $s \geq r$, so that $S(\theta) \geq r - f$ for every θ, which directly implies that $S(\theta) \geq 0$ since we assumed $r > f$. Next, suppose that $s < r$, so that $S(\theta) \geq -\lambda(r-s)r + r - f$, which directly implies that $S(\theta) > 0$ for every θ since we assumed that $\lambda \leq 1$ and $s \geq f$. ∎

Proof of Proposition 8. By the same logic used to prove Proposition 1, the Legislator's maximization problem with career concerns is

$$\max_{\theta^C \in [0,1]} \left\{ \gamma \int_{\theta^C}^1 \lambda\theta \, dG(\theta) + \frac{1-\gamma}{\bar{\pi}} \int_{\theta^C}^1 \left[\lambda\theta s + \lambda r(\theta^C - \theta) \right] dG(\theta) \right\}.$$

Differentiating with respect to θ^C we get

$$-\gamma\lambda\theta^C g(\theta^C) + \frac{1-\gamma}{\bar{\pi}} \left[\lambda r \left(1 - G(\theta^C) \right) - \lambda\theta^C s g(\theta^C) \right] = 0,$$

which yields

$$\theta^C \left[s + \frac{\bar{\pi}\gamma}{1-\gamma} \right] - \frac{1 - G(\theta^C)}{g(\theta^C)} r = 0. \tag{.11}$$

By the fellow's indifference condition it then follows that

$$\phi^C = \frac{\left(1 - \lambda\theta^C\right) r}{f}.$$

Next, showing that (.11) has a unique solution in $(0,1)$ is immediate since $(1 - G(\cdot))/g(\cdot)$ is strictly decreasing. Moreover, as in the proof of Proposition 1, it can be easily seen that an optimal policy that induces the fellow to blow the whistle is feasible if and only if

$$r < \frac{f}{1-\lambda}.$$

Finally, it is immediate to see that θ^C is decreasing in $\bar{\pi}$ and ρ. Hence, $\theta^C < \theta^*$ for any $\gamma > 0$, with $\theta^C = 0$ for $\gamma = 1$. This also implies that $\phi^C > \phi^*$ for any $\gamma > 0$. Notice that ϕ^C is increasing in $\bar{\pi}$ and γ. Moreover, showing that the fellow's break-even wage is positive at the optimal policy follows exactly the same logic as before. ∎

Appendix 2: Direct Revelation Mechanisms and 'Revenue Equivalence'

In the baseline model, we assumed that the Legislator's policy simply requires a fixed amnesty ϕ. In this section we take a mechanism design approach and show that this assumption is actually without loss of generality: a sort of 'revenue equivalence' result holds. To this purpose we will characterize the optimal non linear mechanism that maximizes the Legislator's objective function subject to the fellow's incentive and participation constraint.

To characterize the optimal policy we use (without loss of generality) the Revelation Principle (see, e.g., Laffont and Martimort, 2002). Our attention will be restricted to deterministic direct mechanisms that are piecewise continuously differentiable of class C^1. Hence, when launching a leniency program, the Legislator commits to a mechanism $\mathcal{M} \equiv \{\alpha(m), \phi(m), t(m)\}$ specifying: a probability $\alpha(\cdot)$ of being admitted into the program, with $\alpha : [0,1] \to [0,1]$, an amnesty $\phi(\cdot)$, with $\phi : [0,1] \to \Re$, and a testimony $t(\cdot)$, with $t : [0,1] \to [0,\theta]$, contingent on the whistleblower's report m about his actual information θ. Consistently with the idea that t cannot exceed θ, we also assume that $m \leq \theta$.

The timing of the game is as follows:

$\boldsymbol{\tau=0}$ The Legislator commits to a mechanism $\mathcal{M}$.

$\boldsymbol{\tau=1}$ The crime return π materializes, and the boss decides whether to commit the crime. He offers the wage w to the fellow. If the offer is rejected the game ends. Otherwise, once the illegal act is committed, the wage w is paid and the game proceeds to the next stage.

$\boldsymbol{\tau=2}$ A realization of θ materializes and the fellow learns it. The investigation opens and, if the leniency program is in place, he can opt to blow the whistle. If so, he reports a message m to the judicial authority, and is asked to deliver a testimony $t(m)$ in trial.

$\boldsymbol{\tau=3}$ The trial uncertainty resolves and sanctions (including the retaliation loss) are imposed.

In the following, we will conveniently adopt the change of variable $h = \theta - t$. Essentially, for any $t \leq \theta$, the new variable $h \in [0,\theta]$ denotes the amount of information that the whistleblower hides. Accordingly, throughout we will develop the analysis by assuming that the Legislator commits to the mechanism $\mathcal{M}_h \equiv \{\alpha(m), \phi(m), h(m)\}$, which is equivalent to $\mathcal{M}$.

The whistleblower's (expected) utility when he observes θ and reports m to the judicial authority is

$$u(\theta, m) \equiv -(1 - \alpha(m)) f - \alpha(m)((1 - \phi(m))f + (1 - \lambda(\theta - h(m)))r). \qquad (.12)$$

An incentive feasible policy must satisfy the following incentive and participation constraints

$$u(\theta, \theta) \geq u(\theta, m) \quad \forall (m, \theta), \qquad (.13)$$

$$u(\theta, \theta) \geq -f \quad \Leftrightarrow \quad \alpha(\theta) = 1. \qquad (.14)$$

That is, when the fellow is allowed to blow the whistle, he must truthfully reveal his information and (weakly) prefer to enter the program rather than facing the trial. As in the baseline analysis, the crime is committed if and only if its monetary benefit exceeds the implied (expected) costs — i.e.,

$$\pi \geq \int_0^1 [\alpha(\theta)(\lambda s(\theta - h(\theta)) - u(\theta)) + (1 - \alpha(\theta)) f] \, dG(\theta).$$

Hence, the Legislator's maximization problem is

$$\max_{\alpha(\cdot), h(\cdot), u(\cdot)} \int_0^1 [\alpha(\theta)(\lambda s(\theta - h(\theta)) - u(\theta)) + (1 - \alpha(\theta)) f] \, dG(\theta). \qquad (.15)$$

subject to $\alpha(\theta) \in [0,1]$, $h(\theta) \in [0,\theta]$, (.13) and (.14).

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In order to elicit truthful information revelation, the Legislator needs to give up an information rent to the whistleblower, and this rent generates a positive externality on the boss's ex-ante profit. This is because providing rents ex-post, translates onto lower wages that the boss has to pay to the fellow, which (other things being equal) makes the crime more profitable. Hence, due to this trade-off between crime rate and efficiency, the optimal policy under asymmetric information has to be distorted away from efficiency.

Denote by $u(\theta)$ the utility (rent) that the whistleblower obtains when he truthfully reports his information — i.e., $u(\theta) \equiv u(\theta, \theta)$. By standard arguments, it follows that

$$\dot{u}(\theta) = \lambda \alpha(\theta) r, \tag{.16}$$

implying that the rent $u(\theta)$ is increasing in θ. This is because, as explained above, whistle-blowers with better information have an incentive to overstate the risk of being curtailed in order to obtain a lighter sanction. Integrating equation (.16) we have an expression for the rent

$$u(\theta) = u(0) + \lambda r \int_0^\theta \alpha(x)\, dx, \tag{.17}$$

which is increasing in λ and r. Indeed, when retaliation is more severe — i.e., for larger values of r — the whistleblower has a greater incentive to understate his actual information. This is because the amnesty that the Legislator has to award to a fellow with weak information must be large due to a high exposure to the risk of retaliation. Similarly, when the prosecution ability of the judicial authority increases — i.e., for larger values of λ — the probability of convicting the boss is high and the risk of retaliation is low. Thus, the fellow's temptation to under-report his information becomes more pronounced insofar as this induces a lighter sanction still keeping the risk of retaliation low.

Inserting (.17) into the objective function of (.15) and integrating by parts, it can be shown that the Legislator's (relaxed) maximization problem rewrites as

$$\max_{\alpha(\cdot), h(\cdot)} \int_0^1 \alpha(\theta) \left[\lambda s(\theta - h(\theta)) - \lambda \frac{1 - G(\theta)}{g(\theta)} r \right] dG(\theta),$$

subject to $\alpha(\theta) \in [0,1]$ and $h(\theta) \in [0, \theta]$.

Differentiating with respect to $h(\cdot)$ it can be immediately seen that $h(\theta) = 0$ for all θ such that $\alpha(\theta) = 1$ — i.e., whistleblowers fully disclose their information. Moreover, differentiating with respect to $\alpha(\cdot)$ it immediately follows that

$$\alpha(\theta) = 1 \quad \Leftrightarrow \quad s\theta - \frac{1 - G(\theta)}{g(\theta)} r \geq 0.$$

Hence, the fellow is admitted into the program if and only if $\theta \geq \theta^*$. In this case the amnesty that he enjoys is pinned down by the following condition

$$-(1 - \phi(\theta))f - (1 - \lambda\theta) r = -f + \lambda r(\theta - \theta^*),$$

implying that

$$\phi\left(\theta\right) = \frac{\left(1 - \lambda\theta^*\right)r}{f},$$

for every $\theta \geq \theta^*$. This yields the following equivalence result.

Proposition 9. *The optimal policy with asymmetric information has the same features as the fixed bonus policy characterized in Proposition 1. That is, all types below θ^* are rationed, while types above $\theta^*$are admitted into the program and get an amnesty equal to ϕ^*.*

This shows that restricting attention to fixed bonus policies is without loss of generality.

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