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Optimal Accomplice-Witnesses Regulation under Asymmetric Information

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Abstract

We study the problem of a Legislator designing immunity for privately informed cooperating accomplices. Our objective is to highlight the positive (vertical) externality between expected returns from crime and the information rent that must be granted by the Legislator to whistleblowers in order to break their code of silence (omertà) and elicit truthful information revelation. We identify the accomplices' incentives to release distorted information and characterize the second-best policy limiting this behavior. The central finding is that this externality leads to a second-best policy that purposefully allows whistleblowers not to disclose part of their private information. We also show that accomplices must fulfill minimal information requirements to be admitted into the program (rationing), that a bonus must be awarded to accomplices providing more reliable information and that, under some conditions, rewarding a self-reporting `boss' can increase efficiency. These results are consistent with a number of widespread legislative provisions.

Keywords: Accomplice-witnesses, Adverse Selection, Leniency, Organized Crime

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1. Introduction

Organized crime is a threat to citizens, businesses, state institutions, as well as the economy as a whole. Successful prosecution of criminal organizations often requires to draw upon the uncorroborated evidence provided by cooperating accomplices (whistleblowers). The reason being that the most culpable and dangerous individuals rarely do the 'dirty job' — see, e.g., Jeffries and Gleeson (1995). Even if these people are ultimately responsible for the crimes committed by their 'soldiers', they hardly get convicted because they mainly deal through intermediaries and push their own participation up to behind-the-scenes control and guidance. To face this difficulty many countries have introduced innovative legal rules (leniency programs) facilitating the use of insider information in criminal proceedings.

Allowing for uncorroborated testimonies is viewed as a crucial advantage in the prosecution of organized crime. Insider information can provide a richly detailed context to a case — e.g., that members of a criminal organization met at a particular location and that the witness was in a position to know about the types of criminal acts at issue — that can help making the public proceeding against a defendant compelling. However, accomplices cooperate only when they perceive that there will be adequate legal benefits to be gained from the deal, and this form of 'horse-trading' exacerbates the greater is the risk of intimidation and reprisal by their partners. As explained by Schur (1988), crime instigators' most effective tool against prosecution is murdering whistleblowers. Intimidation in criminal proceedings has, in fact, pervasive and perverse effects. The risk of biased and untruthful testimonies is, for instance, potentially staggering and has often thrown serious doubts on the efficacy of these programs.[1] What are the costs and benefits of leniency in criminal proceedings where accomplices own insider information that is not perfectly verifiable? Do these people have the right incentives to disclose their private information? Is it really necessary to reward them with judicial leniency? Why do these benefits appear to be excessively generous?

The purpose of this paper is twofold. First, we identify the forces that lead informants to misbehave by releasing biased testimonies. Second, we characterize the instruments that the Legislator can use to limit such behavior. Our main conclusion is that the interplay between insider information and the risk of witness intimidation leads to a second-best policy that purposefully allows whistleblowers to hide part of their private information, but that at the same time imposes admission requirements into the program that are more demanding than the first-best.

To make this point, we study the optimal design of a leniency program in a simple game involving a hierarchical criminal organization and a Legislator. The criminal organization is formed by two mobsters: a principal (boss) and an agent (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

[1] There is much controversy concerning accomplice witnesses both on the efficiency and fairness grounds. In Germany, for instance, as underlined by Huber (2001), arguments against the use of accomplice witnesses are based on: "The principle of equal treatment and principles of proportionality and legality...Additionally, there have been doubts expressed about the level of truthfulness in the testimony of accomplice witnesses." Other countries, like those of Anglo-Saxon tradition, mainly underline the necessary role played by cooperating accomplices in criminal justice, especially when a state of emergency is justified because of organized crime.

boss and his involvement into the crime materializes, this evidence is observed only by the criminals but neither by prosecutors nor by the jury ruling the trial. The crime triggers an investigation and, at this stage, the agent can opt to whistle. The prize for cooperation entails an amnesty announced by the Legislator at the outset of the game. Moreover, the Legislator can also enforce restrictions on the selection process regulating the program's admission policy — i.e., only accomplices whose information satisfies minimal standards are eligible for the program.

In this set-up, we first emphasize the costs and benefits of leniency and then characterize the second-best policy shaped by these forces. We show that, as long as the relationship between the Legislator and the informants is plagued by asymmetric information, there is a positive (vertical) externality between the need to grant rents to whistleblowers in order to elicit truthful information and the monetary return from crime flowing to the boss. The point is that more precise and reliable testimonies (presumably) imply a higher conviction probability for the boss, whose intimidation and retaliation ability weakens when convicted and jailed. Hence, in the states of nature where the evidence that can be gathered against the boss is quite reliable regardless of whether the agent testifies, an accomplice might profit from hiding part of his private information. That is, pretending to face a high risk of reprisal, allows accomplices to ask for amnesties that are more lenient than what would be necessary. In equilibrium, this possibility generates an ex-post information rent for the agent that stifles the reservation wage he needs to be offered in order to accept the illegal deal. And, from an ex-ante perspective, the emergence of this rent spurs the boss' net gain from the crime to the detriment of society. We show that this externality is the main source of a marked difference between the second- and first-best policies. Under complete information the accomplice cannot distort the testimony because his information is the same as that available to the prosecutors (or to the jury ruling the trial). The first-best policy is then chosen so as to make the accomplice indifferent between talking and facing the trial, and it entails no entry restrictions to the program. By contrast, under asymmetric information, the second-best policy must award better deals to those who provide more productive information. Moreover, in order to minimize the rent that privately informed accomplices can grab, the Legislator is forced to restrict the access to the program (*rationing*) and to require distorted testimonies (*partial disclosure*).

Interestingly, the second-best policy entails an *excessively generous amnesty* relative to the efficient rule: in order to elicit truthful information, a bonus must be awarded to those accomplices that reveal 'good quality' information. Similarly, although it is always convenient to draw upon accomplices' testimonies to fight organized crime, rationing the access to the program is necessary insofar as it has a negative effect on the boss's expected profit and thus reduces the crime rate. This rationing rule can be implemented by means of a simple protocol: there exists an optimal *information floor* below which agents are sent to trial — i.e., their application to the program is rejected when they cannot deliver testimonies that meet the standard. Essentially, reducing the set of contingencies in which an accomplice can access the program stifles the uncertainty faced by the Legislator when announcing the policy, whereby making mimicking less profitable. Once again, this effect is welfare enhancing because lower information rents for the informant shift onto higher break-even wages and thus imply higher (employment) costs for the boss.

Finally, we extend the analysis to the case where the benefit of an amnesty can also be awarded to a *self-reporting* boss. We show that, when the agent's information is very productive, allowing the boss to whistle and cheat his organization may enhance efficiency, because it allows to save on the agent's information rent. More precisely, under the assumption that the whole organization is convicted with certainty when the boss self-reports, a domino effect in the spirit of Baccara and Baar-Isaac (2008) emerges. This effect reduces the set of contingencies where the agent whistles, hence it allows to reduce his rents, which are higher precisely in the states where testimonies are more productive. As a consequence, the second-best policy with self-reporting features a less selective admission policy and a lower distortion on the optimal disclosure. Of course, it is never optimal to let the boss talk in all contingencies and/or grant him a too lenient discount because this would have an adverse effect on deterrence by increasing (*ceteris paribus*) his return from the crime.

Our findings are consistent with a number of legal provisions characterizing accomplice-witnesses regulations across the world, and show that the benefits of those programs in terms of reduced crime may justify, at least from an efficiency point of view, the risk of biased testimonies and the recognition of pronounced legal benefits to cooperating accomplices.

The rest of the paper is organized as follows. Section 2 links our contribution to the existing literature. In Section 3 we set up the baseline model and determine first the efficient policy, then the characterization of the second-best policy. Section 4 extends the baseline model to the case where the benefit of an amnesty is also awarded to a self-reporting boss. Section 5 concludes. All proofs are in the Appendix.

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) — while more recently Jennings (1984), Polo (1995), Konrad and Skaperdas (1994, 1997) and Garoupa (2000) started to model criminal organizations as vertical structures where the principal has the necessity to control and discipline its members.[2] 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 byproduct of the crime but it is collected by criminals to be used as a threat to strengthen the sustainability of the organization itself. Our paper is also linked to Baccara and Bar-Isaac (2008): they analyze the link between the optimal design of criminal organizations and the information flow diffused through their hierarchies, by con-

[2] See also Fiorentini and Peltzman (1995), Kugler, Verdier and Zenou (2005) and Mansour et al. (2006).

sidering both vertical and horizontal structures. We focus only on the former type of organizations, but explore the link between leniency programs and insider information, an issue that is not addressed in their set-up. Hence, in this respect our models are complements. Recently, Acconcia et al. (2009) 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 also argue that the Italian accomplice-witness program introduced in 1991 did affect in a significative manner organized crime in those regions where the mafias have been historically more pervasive. More specifically, they identify the positive effect of the policy on prosecution and argue that it also strengthened deterrence.[3] Our analysis is motivated by this evidence and it extends the theoretical framework developed in Acconcia et al. (2009) in three main directions. First, in contrast to them, we consider an adverse selection setting where the accomplice's information is non-verifiable. Second, we enlarge the Legislator's set of instruments to include, besides the amnesty rate, an information floor below which an agent's testimony is not accepted. Third, to widen the scope of our conclusions, we also consider the possibility of awarding an amnesty to a self-reporting boss and show that this is sometimes necessary to fight organized crime. In this respect, our work also relates to the 'self-reporting' literature. 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 individuals who report their behavior bear certain rather than uncertain sanctions. In our model, instead, the welfare enhancing effect of self-reporting stems from the hierarchical nature of criminal organizations, and it becomes more relevant the more severe is the adverse selection problem between the Legislator and the cooperating accomplices.

Of course, our analysis relates, and builds upon the *antitrust* law enforcement literature, which begun with the pioneering paper of Motta and Polo (2003) and studies the effects of leniency programs on cartel formation in oligopolistic markets.[4] Here we will focus on the papers that elaborate on the role of information. Feess and Walz (2004) find that a more informed party that self reports providing more information should receive more generous benefits than a less informed party and use their findings to compare leniency programs in the US and the EU. Silbye (2010), Sauvagnat (2010) and Harrington (2011) all allow for some form of private information on the probability of conviction when no firm has applied for leniency. Specifically, while in Harrington (2011) each cartel member has private information on the likelihood that the authority will be able to convict them without a cooperating firm. Instead, Silbye (2010) assumes that the probability of conviction is common knowledge but each firm possesses evidence that it could submit to convict the other firm if it applied for leniency. Finally, Sauvagnat (2010) studies an informed principal problem since the authority has private information about the strength of its case and decides strategically whether to open an investigation or not. In contrast to them we take a mechanism design approach to leniency, where in order to minimize the rent that privately informed accomplices can grab, the Legislator restricts the access to the program

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

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

(*rationing*) and requires distorted testimonies (*partial disclosure*).

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 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 recent survey by Gazal-Ayal and Riza (2009). However, all these papers do not establish a link between internal cohesion of cartels and rewards, which is more specific to criminal organizations.

3. The Baseline Model

The criminal organization: Consider a game where a benevolent Legislator and two members of a criminal organization, the principal (boss) and his agent (fellow), interact sequentially. The Legislator, having forbidden welfare reducing criminal acts, designs an accomplice-witnesses program. Each member of the criminal organization owns specific skills: the boss plans the crime and delegates its execution to the fellow who materially commits the illegal act.

The crime yields a monetary return π which is stochastic and distributes over the compact support $\Pi \equiv [0, \overline{\pi}]$ according to the cumulative distribution function (cdf) $G(\pi)$. The boss hires the fellow after having observed the realization of the crime return π, he has full bargaining power and proposes a wage w to the agent. If accepted, the wage is paid after the crime is committed. If the agent refuses the offer, the game ends and both parties get a reservation utility $\underline{u}$. Committing the crime triggers an investigation with probability α. We normalize $\underline{u} = 0$ and $\alpha = 1$ with no loss of generality.

Information: After the crime has been committed and the wage w has been paid, some evidence about the boss and his involvement into the crime materializes. As we shall explain below, this evidence can be used against the boss and therefore affects the outcome of the investigative and judicial process. It is modeled as the realization of a random variable $\tilde{\theta}$ which distributes over the compact support $\Theta \equiv [0, \overline{\theta}]$ according to the twice continuously differentiable and atomless cdf $F(\theta)$, with density $f(\theta)$. As a convention, we assume that larger values of θ reflect better and more reliable evidence — i.e., higher values of θ mean that more evidence against the boss can be gathered by the judicial authority and brought at trial.

Judicial system and legal regimes: There are two legal regimes:

- *No leniency:* Under this regime, when prosecuted, the agent is sent to trial. He is convicted and bears a sanction S_a with probability p. The principal is convicted and bears the sanction S_p with probability $q(\theta)$, where $\dot{q}(\theta) \geq 0$.

The impact of θ on $q(.)$ can be interpreted as the outcome of the prosecutor's investigative activity (e.g., shadowing the agent or tapping his phone) that maps the potentially available evidence, as measured by θ, onto the trial's (stochastic) outcome.[5] In other words, one can think of the probability of conviction $q(.)$ as resulting from the interaction of the portion of evidence that the prosecutor is able to gather given the available 'traces', together with the preferences of judges and jury.

- *Leniency:* When a leniency program is in place, the agent can decide to whistle and cooperate with the justice. If so, he enjoys an amnesty $\phi(s)$ in exchange of a testimony s which, together with the state of nature θ, determines the probability $Q(s,\theta) \geq q(\theta)$ of convicting the boss.

The interpretation of $Q(s,\theta)$ is as follows: while better (available) evidence — i.e., a higher θ — helps the prosecutor's investigative and proof-making activity, the testimony s delivers a public signal to the jury ruling the trial, whereby providing additional uncorroborated evidence that affects the trial's outcome.[6],[7]

Direct revelation mechanism: There is no loss of generality in invoking the Revelation Principle in this framework (see, e.g., Laffont and Martimort, 2002). Hence, we restrict attention to direct mechanisms: when launching a leniency program, the Legislator commits to a policy $\mathcal{L} = \left\{\phi(\hat{\theta}), s(\hat{\theta})\right\}_{\hat{\theta}\in\Theta}$ specifying an amnesty $\phi(.)$, with $\phi : \Theta \to \Re$, and a testimony $s(.)$, with $s : \Theta \to \Theta$, both contingent on the agent's report $\hat{\theta}$, which is interpreted as a private signal sent by the whistleblower to the prosecutor.[8] Essentially, cooperation is rewarded with a reduction $\phi(\hat{\theta})$ of the sanction S_a, but requires a public testimony $s(\hat{\theta})$ for every report $\hat{\theta}$.

In addition to the (direct) revelation mechanism, we also allow the Legislator to commit to an information floor $\underline{\theta}$: below this threshold a testimony is not accepted. Clearly, if $\underline{\theta} > \overline{\theta}$ the program is shut down and agents are always sent to trial.

Intimidation risk and retaliation: Criminal organizations seek to punish disloyalty and, when they succeed in doing so, a loss $R > 0$ is inflicted to whistleblowers. We normalize R to 1 without loss of generality[9] and assume that this loss materializes only if the boss is acquitted, which occurs with

[5] While the prosecutor's investigative activity is able to uncover some of the mobsters private information and more so the larger is θ ($\dot{q}(\theta) \geq 0$), at the same time the result of the trail remains uncertain. This is because the verdict depends not only on the available evidence but also on the preferences of judges and jury which are uncertain.

[6] The use of uncorroborated testimonies is an accepted instrument which helps convicting the heads of criminal organizations. In the U.S. federal courts defendants can be convicted solely on the basis of the uncorroborated testimony of the accomplices and also in Italy, the minimum requirements of evidence are lower in cases in which the defendant is accused of organized crime.

[7] The jury is a body of citizens and public officials summoned by law and sworn to hear and deliver a verdict upon a case presented in court. The prosecutor is the public official that institutes and conducts the legal proceedings against criminals. The final outcome of a trial is usually determined by the interaction of these independent parties, which we do not model here for the sake of simplicity.

[8] As explained in Cassidy (2004), the prosecutor is the public official in charge of proposing and motivating to the jury leniency for the whistleblower with whom he interacts.

[9] The historical evidence offers ample support to the idea that retaliation is an important source of deterrence for whistleblowers. Many accomplices in Italy have been murdered after their testimony in a mafia trial. The first member of the Sicilian mafia that publicly acknowledged its existence, Leonardo Vitale, was murdered after his testimony. He walked into a Palermo police station on the evening of March 29, 1973, and declared that he was a member of the Mafia and confessed to various acts of extortion, arson and two homicides. In front of dumbfounded police officers he explained how a Mafia family is organised and revealed the existence of the Mafia Commission, long before the pentito Tommaso

probability $1 - Q(s, \theta)$ in the state θ given the testimony s. This is with no loss of insights under the hypothesis that the retaliation ability of the boss weakens once he is convicted and jailed.

Timing: The timing of the game is as follows:

t=0 The Legislator decides whether to launch a leniency program and accordingly commits to a policy $\wp = (\mathcal{L}, \underline{\theta})$ that entails the mechanism $\mathcal{L}$ and the 'access' floor $\underline{\theta}$.

t=1 Uncertainty about π resolves and the boss decides whether to commit the crime. If so, he offers the wage w to the agent. 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.

t=2 A realization of $\tilde{\theta}$ materializes and only the criminals learn it.[10]

t=3 The investigation opens. If the leniency program is in place, the agent decides whether to whistle. If so, he sends a private message $\hat{\theta}$ to the prosecutor who then grants him an amnesty $\phi(\hat{\theta})$ in exchange of a testimony $s(\hat{\theta})$.

t=4 The trial uncertainty resolves and sanctions (including the retaliation loss) are imposed.

Actions and equilibrium concept: The boss decides whether to commit the crime and makes a wage offer w to the agent. The agent can accept or reject the offer and, if prosecuted, he also decides whether to confess and what report to make. The Legislator announces a policy $\wp$. The solution concept is Perfect Bayesian Equilibrium (PBE).

Technical assumptions: The analysis will be conducted under the following assumptions.

A1 The probability function $Q(s, \theta)$ is continuous and twice continuously differentiable. It is increasing and concave in θ, single peaked with respect to s and satisfies: $Q_s(s, \theta) = 0$ for $s = \theta$, $Q(s, \theta) > Q(0, \theta) \equiv q(\theta)$ for all θ and $s > 0$. Moreover, it also features increasing differences in θ and s — i.e., $Q_{s\theta}(.) > 0$ for all (θ, s).[11]

Assuming that $Q(.)$ is single peaked and has a unique maximum at $s = \theta$ implies that the closer is the informant's testimony to the true state of nature — i.e., the more precise is this testimony — the stronger is its effect on the boss' prosecution risk. Essentially, neither under-reporting nor making up false information can improve the probability of convicting the boss.

Buscetta exposed Mafia secrets to judges who were prepared to listen. According to judge Giovanni Falcone the Mafia understood the importance of Vitale's revelations much better than the Italian justice system at the time and killed him when the time was most opportune — see, e.g., Falcone (1991).

[10]This hypothesis captures the idea that cooperation between mobsters generates information. Only after interacting with the boss and executing its orders, the agent is able to learn some relevant information that, once released to prosecutors, can harm the crime instigator at the judicial stage.

[11]For instance, the quadratic specification $Q(s, \theta) = \sigma(\theta - \frac{1}{2}s)s + \gamma\sqrt{\theta}$, with $\sigma > 0$ and $\gamma > 0$, satisfies all these requirements.

Complementarity — i.e., $Q_{s\theta}(.) > 0$ — reflects the idea that the marginal impact of a better testimony on the probability of convicting the boss is stronger in states of nature where the available evidence is better — i.e., given $s' > s$ the difference $Q(s',\theta) - Q(s,\theta)$ is increasing in θ:

$$\frac{\partial \left(Q(s',\theta) - Q(s,\theta)\right)}{\partial\theta} = \int_s^{s'} Q_{s\theta}(x,\theta)\,dx > 0 \qquad \forall\theta\in\Theta.$$

The interpretation of this hypothesis is that more precise testimonies are relatively of little help when the evidence corroborating and supporting the informant's assertions is poor.[12]

A2 The inverse hazard rate associated to $F(.)$ is monotone and decreasing — i.e.,

$$\frac{\partial}{\partial\theta}\left[\frac{1-F(\theta)}{f(\theta)}\right] \le 0 \qquad \forall\theta\in\Theta.$$

This is a standard assumption in the screening literature. Moreover, to focus on separating equilibria it will be convenient to impose the following additional technical assumptions:

A3 $Q_{s\theta\theta}(.) \le 0$ and $Q_{ss\theta}(.) \ge 0$ for all s and θ.

We shall restrict attention to the class of continuous and almost everywhere differentiable mechanisms. As a *tie-breaking* condition we assume that whenever indifferent between joining the program and facing the trial, the agent whistles. All players are risk neutral. Moreover, following the literature, all sanctions will be interpreted as the monetary equivalent of the imprisonment terms, fines, damages, and so forth, to which the criminals expose themselves.

Social goal: For simplicity, we assume that the Legislator's objective is to minimize crimes.[13] Given the policy $\wp$, let $C(\wp)$ and $w(\wp)$ denote the boss' expected sanction and the agent's break-even wage, respectively. Then committing the crime yields a non negative expected utility to the boss if and only if the return π exceeds the (total) expected costs — i.e.,

$$\pi \ge C(\wp) + w(\wp) \equiv \underline{\pi}(\wp).$$

Hence, the Legislator's optimal policy $\wp$ will be chosen so as to minimize the (expected) crime rate

$$W(\wp) = 1 - \Pr\left(\pi \le \underline{\pi}(\wp)\right), \tag{3.1}$$

[12] The case of Leonardo Vitale is again emblematic to explain this point. Already in 1973 Vitale started to cooperate with the justice by indicating the names of many mafiosi and the roots of their main traffics, he also explained how a Mafia family is organized and revealed the existence of the Mafia Commission. In spite of this testimony, the evidence surrounding the trial that was opened on the basis of the mere Vitale's assertions was so tiny that all defendants were in the end acquitted. As pointed out by judge Falcone, this testimony turned out to be very important for the subsequent fights against organized crime in Italy, that is, when more evidence, gathered by Falcone and his investigative group, supported the testimonies of Vitale and the subsequent whistleblowers.

[13] Introducing trial and/or information gathering costs does not add new interesting trade-offs to our analysis. Hence, merely for the sake of crispiness, we rule them out.

subject to the relevant incentive and participation constraints.

3.1. First-best Policy

In this section we develop the benchmark where the realization of $\tilde{\theta}$ is common knowledge. Let

$$u(\theta) = -(1-\phi(\theta)) S_a - (1 - Q(s(\theta), \theta)),$$

be the utility of a type-θ agent who enters the program: he delivers a testimonies $s(\theta)$, enjoys an amnesty $\phi(\theta)$ and bears the retaliation loss $R = 1$ with probability $1 - Q(s(\theta), \theta)$ — i.e., in the event that the boss is acquitted. Moreover, let $u_0 = -pS_a$ be the expected utility that the agent obtains when facing the trial: a sanction S_a is imposed with probability p in this case.

Clearly, in each state θ where the agent can apply to the program — i.e., if $\theta \geq \underline{\theta}$ — the Legislator chooses the amnesty rate $\phi(\theta)$ and a testimony $s(\theta)$, so as to equalize $u(\theta)$ and u_0 — i.e.,

$$(1-\phi(\theta)) S_a + 1 - Q(s(\theta), \theta) = pS_a. \tag{3.2}$$

For any policy $\wp$ such that (3.2), the boss commits the crime if and only if the revenue π exceeds his expected costs — i.e., $\pi \geq C(\wp) + w(\wp) \equiv \underline{\pi}(\wp)$ — where the boss' expected sanction $C(\wp)$ is:

$$C(\wp) = S_p \int_0^{\underline{\theta}} q(\theta)\, dF(\theta) + S_p \int_{\underline{\theta}}^{\overline{\theta}} Q(s(\theta), \theta)\, dF(\theta), \tag{3.3}$$

and the agent's break even wage $w(\wp)$ solves the following participation constraint:

$$w(\wp) + \int_0^{\underline{\theta}} u_0 dF(\theta) + \int_{\underline{\theta}}^{\overline{\theta}} u(\theta)\, dF(\theta) = 0 \quad \Longrightarrow \quad w(\wp) = pS_a \qquad \forall \underline{\theta}. \tag{3.4}$$

Hence:

$$\underline{\pi}(\wp) \equiv pS_a + S_p \int_0^{\underline{\theta}} q(\theta)\, dF(\theta) + S_p \int_{\underline{\theta}}^{\overline{\theta}} Q(s(\theta), \theta)\, dF(\theta),$$

The Legislator's optimization program is then:

$$\max_{\wp} \Pr(\pi \leq \underline{\pi}(\wp)) \quad \Leftrightarrow \quad \max_{\underline{\theta},\ s(\theta)} \left\{ \int_0^{\underline{\theta}} q(\theta)\, dF(\theta) + \int_{\underline{\theta}}^{\overline{\theta}} Q(s(\theta), \theta)\, dF(\theta) \right\}, \tag{3.5}$$

whose solution determines the first-best policy described below:

Proposition 1. *Assume **A1**. The first-best policy $\wp^{fb}$ has the following properties:*

- ***(No rationing)*** *A whistleblower is always admitted into the program: $\underline{\theta}^{fb} = 0$.*
- ***(Full disclosure)*** *In every state there is full disclosure of information: $s^{fb}(\theta) = \theta$ for each θ.*
- ***(Zero-rent)*** *There are no rents left to the whistleblower: $u^{fb}(\theta) = u_0$ for each θ.*

Under complete information there is no reason to distort the agent's testimony: he fully reveals his private information in court. Moreover, it will be efficient not to ration the access to the program because the agent's information is always productive — i.e., $Q(\theta, \theta) > q(\theta)$ for all $\theta > 0$.

3.2. Second-best Policy

We now turn to analyze the case where the realized state of nature θ is private information. In this scenario the game is one of imperfect information and the privately informed agent can gain from mimicking. More precisely, depending on the shape of the mechanism $\mathcal{L}$, in state θ the whistleblower might gain from providing an untruthful report $\hat{\theta}$ in order to enjoy a lighter sanction. These mimicking opportunities force the Legislator to distort the optimal policy for rent extraction reasons.

To characterize the incentive feasible allocations, let

$$u(\hat{\theta}, \theta) = -(1 - \phi(\hat{\theta}))S_a - (1 - Q(s(\hat{\theta}), \theta)),$$

be the agent's utility in state θ given his report $\hat{\theta}$. An incentive feasible allocation must induce truthful information revelation by those agents that are admitted into the program and, if the floor $\underline{\theta}$ exceeds the lower-bound 0, it must also be such that rationed accomplices do not find it profitable to lie in order to join the program.

The second-best policy must satisfy the following first- and second- order local conditions for truth-telling:

$$u_{\hat{\theta}}(\hat{\theta}, \theta)\Big|_{\hat{\theta}=\theta} = 0 \qquad \Leftrightarrow \qquad \dot{\phi}(\theta)S_a + Q_s(s(\theta), \theta)\,\dot{s}(\theta) = 0 \qquad \forall \theta \geq \underline{\theta}, \tag{3.6}$$

$$u_{\hat{\theta}\theta}(\hat{\theta}, \theta)\Big|_{\hat{\theta}=\theta} \geq 0 \qquad \Leftrightarrow \qquad \dot{s}(\theta)\, Q_{s\theta}(\theta, \theta) \geq 0 \qquad \forall \theta \geq \underline{\theta}, \tag{3.7}$$

in addition to the participation constraint:

$$u(\theta) \geq u_0 \qquad \forall \theta \geq \underline{\theta}. \tag{3.8}$$

These conditions ensure that (locally) the cooperating accomplice has no incentive to manipulate his information and that he prefers to join the program rather than being sent to trial.[14] As standard, an envelope argument allows to rewrite the first-order incentive compatibility constraint as:

$$\dot{u}(\theta) = Q_\theta(s(\theta), \theta) \qquad \forall \theta \geq \underline{\theta}. \tag{3.9}$$

Hence, under **A1** the information rent $u(\theta)$ is increasing — i.e., $\dot{u}(\theta) > 0$. Agents with better information have an incentive to mimic downward because the risk of retaliation is higher in worst states of nature — i.e., the probability $1 - Q(s(\theta), \theta)$ is decreasing in θ — and thus they request a more generous amnesty in exchange of a testimony. This induces the agent to under-report in order

[14] We shall verify in the Appendix that, when these conditions hold, mimicking is unprofitable also globally.

to enjoy lighter (expected) sanctions than it would be necessary from the Legislator's point of view.

Integrating equation (3.9) we have:

$$u(\theta) = u(\underline{\theta}) + \int_{\underline{\theta}}^{\theta} Q_\theta(s(x), x)\, dx \qquad \forall \theta \geq \underline{\theta}. \tag{3.10}$$

An important point to note is that the rent increases with the testimony $s(x)$. A more precise testimony amplifies the incentive to mimic downward for the same reasons of an higher θ. Moreover, a tighter information floor — i.e., a larger $\underline{\theta}$ — also stifles the information rent: when the access to the program is rationed there are fewer mimicking possibilities.

Finally, for all types that are excluded from the program the following rationing constraint must hold:

$$u_0 \geq \max_{\hat{\theta} \geq \underline{\theta}} u(\hat{\theta}, \theta) \qquad \forall \theta < \underline{\theta}, \tag{3.11}$$

that is, rationed types must prefer facing the trial rather than mimicking those who can access the program.

We can now turn to solve the boss' and Legislator's optimization problems. As before, the crime is committed if and only if its return exceeds the expected cost— i.e., if

$$\pi \geq \underline{\pi}(\wp) \equiv \int_0^{\underline{\theta}} (q(\theta) S_p - u_0) dF(\theta) + \int_{\underline{\theta}}^{\overline{\theta}} (Q(s(\theta), \theta) S_p - u(\theta))\, dF(\theta).$$

Hence, the Legislator's program can be rewritten as:

$$\begin{cases} \max\limits_{\underline{\theta},\ s(.),\ u(.)} \Pr(\pi \leq \underline{\pi}(\wp)) \\ \text{s.t.,} \\ (3.7),\ (3.8),\ (3.10),\ (3.11). \end{cases}$$

Neglecting the second-order local incentive constraint (3.7) and the rationing constraint (3.11), which will be verified ex-post, inserting (3.10) into the maximand and integrating by parts, we have:

$$\mathcal{P}: \quad \max_{\underline{\theta},\ s(.)} \left\{ \int_0^{\underline{\theta}} (q(\theta) S_p - u_0) dF(\theta) + \int_{\underline{\theta}}^{\overline{\theta}} \left[Q(s(\theta), \theta) S_p - u_0 - Q_\theta(s(\theta), \theta) \frac{1 - F(\theta)}{f(\theta)} \right] dF(\theta) \right\}.$$

What are the trade-offs at stake when the inability to verify the agent's insider information creates scope for manipulation? How does the second-best policy change with respect to the first-best? The key difference between the cases of complete and asymmetric information rests upon a simple idea. In order to elicit truthful information revelation the Legislator needs to give up an information rent to a whistleblower and this rent generates a positive externality on the boss' expected profit: rents granted by the Legislator ex post, translate onto lower wages that the boss has to pay to the agent ex ante, thus making the crime more profitable (other things being kept equal). By the same token, limiting the subset of types eligible for the program — i.e., a tighter floor $\underline{\theta}$ — also stifles the boss' crime return. This restriction, however, comes at a cost: excluding agents from the program generates a positive externalities on the boss's expected utility as long as the information of these excluded types is very productive — i.e., if the difference $Q\left(s\left(\theta\right),\theta\right)-q\left(\theta\right)$ is not negligible.

The next proposition shows that, taken together, these effects force the Legislator to: (i) distort the testimony required to whistleblowers, and (ii) ration the access to the program in the attempt to minimize the information rent and its positive externality on the boss's expected profit.

Proposition 2. *Assume **A1-A3**. The second-best policy $\wp^{sb}$ has the following properties:*

- **(*Rationing*)** *There exists a lower bound $\underline{\theta}^{sb}>0$ such that all types θ above $\underline{\theta}^{sb}$ are admitted into the program and prefer to talk in equilibrium, all types below $\underline{\theta}^{sb}$ prefer to opt-out and face the trial. The bound $\underline{\theta}^{sb}$ is determined by the following condition:*

$$(Q(s^{sb}(\underline{\theta}^{sb}),\underline{\theta}^{sb})-q(\underline{\theta}^{sb}))S_p-Q_\theta(s^{sb}(\underline{\theta}^{sb}),\underline{\theta}^{sb})\frac{1-F(\underline{\theta}^{sb})}{f(\underline{\theta}^{sb})}=0, \tag{3.12}$$

- **(*Partial disclosure*)** *All agents admitted into the program provide a downward distorted testimony — i.e., $s^{sb}(\theta)\leq\theta$ with equality only at $\theta=\overline{\theta}$ and $s^{sb}(\theta)$ being solution of:*

$$Q_s(s^{sb}(\theta),\theta)S_p-\frac{1-F(\theta)}{f(\theta)}Q_{s\theta}(s^{sb}(\theta),\theta)=0, \tag{3.13}$$

  with $\dot{s}^{sb}(\theta)>0$.

- **(*Excessive amnesty*)** *The second-best amnesty $\phi^{sb}(\theta)$ is larger than the first-best for every θ — i.e.,*

$$\phi^{sb}(\theta)=\underbrace{1-p+(1-Q(s^{sb}(\theta),\theta)\frac{1}{S_a}}_{\textbf{\textit{Zero Rent Amnesty}}}+\underbrace{\frac{1}{S_a}\int_{\underline{\theta}^{sb}}^{\theta}Q_\theta(s^{sb}(x),x)dx}_{\textbf{\textit{Bonus }}B^{sb}(\theta)\geq 0}>\phi^{fb}\left(\theta\right), \tag{3.14}$$

  with $\dot{\phi}^{sb}(\theta)<0$ and $\dot{B}^{sb}(\theta)>0$.

The second-best policy trades off the social costs and benefits of a leniency program. The information floor $\underline{\theta}^{sb}$ is determined so as to account for the rent-effect that asymmetric information adds to the entry process into the program. A smaller support of types admitted into the program — i.e., a higher $\underline{\theta}^{sb}$ — stifles the agent's mimicking possibilities, whereby reducing his ex post information rent. This rent-reduction effect due to rationing translates onto the boss' expected utility: lower ex post rents for the agent imply higher expected wages and thus higher costs for the boss. On the other side, however, a smaller support of types also stifles the boss' risk of prosecution whereby reducing his expected profits. On the balance, the second-best policy calls for stricter eligibility criteria relative to the first-best one. Interestingly, by creating less conflict between the boss and the agent, stricter eligibility criteria increase the wage that the former has to pay to the latter, whereby stifling the equilibrium crime rate. The same type of intuition also explains why the second-best policy does not feature full disclosure: to limit mimicking opportunities, and the implied information rents, the Legislator is forced to require downward distorted testimonies.

Finally, note that the amnesty rate will be set so as to satisfy the local incentive compatibility constraint (3.6) and to make the marginal type $\underline{\theta}^{sb}$ indifferent between talking or facing the trial. This leads to a second-best amnesty that, besides the zero utility level characterizing the complete information benchmark, also grants a bonus increasing with the quality of information provided by the agent — i.e., increasing in θ. Overall, however, the second-best amnesty is decreasing in θ because a cooperating accomplice with worse information faces a higher likelihood of retaliation and need to get compensated for such extra risk.

4. Self-reporting by the Boss

Up to now, we have considered a policy that grants an amnesty only to the agent. What would happen if this benefit is extended to a self-reporting boss as well? Would such a policy be optimal?

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'.[15] In this section we modify the baseline model to encompass this possibility. The objective is to show that dealing directly with a self-confessing boss might be necessary to efficiently fight organized crime.

Suppose that the Legislator grants an amnesty, hereafter Φ, to the self-reporting boss as a reward for his cooperation. The structure of the game is similar to that analyzed before with the following modifications:

- **t=0:** the Legislator commits to a policy $\wp_\Phi = (\mathcal{L}, \underline{\theta}, \Phi)$ that, as before, includes the (direct) mechanism $\mathcal{L}$ together with the access floor $\underline{\theta}$, and in addition the discount Φ granted to the self-reporting boss.
- **t=2**: after the random variable $\tilde{\theta}$ has realized, the boss can self-report. If he does so, the sanction S_p gets reduced by Φ, while the agent is convicted with probability 1.
- **t=3:** the agent can whistle and enters the program if and only if: (*i*) the boss has not already self-reported at stage **t=2**; (*ii*) his information meets the standard $\underline{\theta}$.

We assume that the agent is convicted with certainty when the boss self-reports: the information provided by a self-confessing boss is more reliable than the agent's imperfect testimony.[16] Moreover, to capture the idea that the boss might be more reluctant to talk than the agent, we denote by $\delta \geq 0$

[15] For instance, in 1996 Giovanni Brusca, one of the most powerful leaders of the corleonesi family and self-confessed multiple murderer (e.g., he was convicted for the bombings that killed judges Chinnici and Falcone), started his cooperation with the justice by releasing relevant information that turned out to be crucial for the capture and conviction of many of his former partners, among which the powerful 'Godfather' Bernardo Provenzano whose hiding lasted for over forty years.

[16] While we believe that the boss possess better information than the agent, the assumption that this information leads to conviction with probability 1 is made only for simplicity.

the additional cost that he bears when cheating his fellow. This parameter reflects those psychological costs incurred by a mobster that gives up a 'command position' and reneges his criminal 'culture'.

Throughout we will make the following additional technical hypothesis:

A4 δ is large enough relative to the boss' expected sanction in the absence of leniency — i.e.,

$$\delta > q(\overline{\theta}) S_p. \tag{4.1}$$

Equation (4.1) rules out the uninteresting case where the boss whistle when the agent is not allowed to talk, which would be at odds with the available historical evidence.[17]

Before characterizing formally the optimal policy it is worthwhile discussing how the equilibrium of the game looks like in this new setting. To make the problem interesting, we will focus on equilibria where, to improve efficiency, the Legislator grants a positive amnesty to the boss. Then, two extra features characterize the equilibrium strategies under self-reporting. First, since the boss decides to self-report upon observing the realization of the state of nature θ, the equilibrium description must specify the subset of states of nature where this contingency occurs. Second, the 'off-equilibrium' actions and policy matter to sustain equilibria with self-reporting. To understand this point, suppose that (in equilibrium) the boss is expected to talk in state θ, and assume that he deviates by not talking. Then, what happens in the continuation game following such an unexpected action? What would the agent do in this contingency?

Under **A4** this deviation is unprofitable if the agent talks in state θ — i.e., (3.8) holds — and:

$$Q\left(s\left(\theta\right),\theta\right) S_p \geq \left(1-\Phi\right) S_p + \delta, \tag{4.2}$$

implying that the boss' expected sanction in the deviation exceeds the utility from self-reporting.[18]

We shall look for a cutoff equilibrium where in some states neither the agent nor the boss talk, in some other states only the agent whistles, while in the rest of the states the boss self-reports. In order to describe such equilibrium two relevant thresholds need to be characterized: (i) $\underline{\theta} > 0$ below which no agent is admitted into the program (precisely as before), and (ii) $\underline{\theta}\left(\Phi\right)$ above which the boss self-reports.

Given a policy $\wp_{\Phi}=(\mathcal{L},\underline{\theta},\Phi)$ and a state $\theta > \underline{\theta}$, the boss decides to self-report if and only if inequality (4.2) holds. Consider any incentive compatible policy specifying a disclosure rule $s\left(\theta\right)$, such that $s\left(\theta\right) \leq \theta$ and $\dot{s}\left(\theta\right) \geq 0$. Denote by $\underline{\theta}\left(\Phi\right)$ the solution with respect to θ of (4.2) taken as an equality, then in all states above this cutoff — i.e., $\theta \geq \underline{\theta}\left(\Phi\right)$ — the boss gains from self-reporting.

[17] In Italy, for instance, the earliest whistleblowers were simple soldiers, even Buscetta (the first important 'pentito') never reached the status of leader within the organization, it was only a few years after the introduction of the accomplice-witnesses program that the first important bosses started their cooperation — e.g., Giovanni Brusca and Giuseppe Di Cristina in Sicily, Carmine Alfieri and Domenico Bidognetti in Campania and Francesco Fonti in Calabria (Falcone, 1991).

[18] Also in this case we assume that the boss self-reports whenever indifferent between cooperating and facing the uncertainty of the trial.

Of course, if δ is large enough, the boss never self-reports and the optimal policy is the same as that characterized in the baseline model.[19] This applies, for instance, to organizations such as the 'Ndrangheta, where leadership is inherited on a 'blood relationship' basis. However, the Mafia and the Camorra feature a different pattern: command positions in these organizations do not necessarily follow the bloodline and are usually the outcome of interior fights. Hence, to make the problem interesting for our purpose, from now on we will impose the following assumption:

A5 The cost of self-reporting δ is such that the boss self-reports at least in some states:

$$Q(\overline{\theta},\overline{\theta})S_p > \delta. \tag{4.3}$$

Intuitively, **A5** implies that for Φ sufficiently close to 1 the boss is going to self-report in state $\overline{\theta}$ and in its neighborhood.[20] Finally, to guarantee uniqueness of the optimal policy we also make the next additional technical requirement:

A6 The function $Q(\theta,\theta)$ is strictly concave in θ and satisfies the Inada condition $Q_\theta(0,0) = +\infty$.[21]

Assuming that, when the agent tells the truth, the conviction probability $Q(\theta,\theta)$ exhibits 'decreasing marginal returns' seems a mild and reasonable requirement.

We now begin the analysis with the following preliminary result.

Lemma 1. *Assume **A4-A5**. For any disclosure rule $s(\theta)$, such that (i) $0 \leq s(\theta) \leq \theta$, (ii) $s(0) = 0$ and $s(\overline{\theta}) = \overline{\theta}$, and (iii) $\dot{s}(\theta) \geq 0$, there exits an upper-bound $\overline{\Phi} < 1$ and a lower-bound $\underline{\Phi} < \overline{\Phi}$ such that:*

- *for all $\Phi < \underline{\Phi}$ the boss never self-reports;*
- *for all $\Phi > \overline{\Phi}$ the boss always self-reports;*
- *for every $\Phi \in (\underline{\Phi},\overline{\Phi})$ there exists a cutoff $\underline{\theta}(\Phi) > 0$ such that the boss self-reports for $\theta \geq \underline{\theta}(\Phi)$, while he does not talk for $\theta < \underline{\theta}(\Phi)$.*

The intuition for this result is straightforward. Under **A5** a too generous amnesty — i.e., Φ larger than $\overline{\Phi}$ — leads the boss to plea guilty and cheat his fellow, while a too restrictive policy — i.e., Φ smaller than $\underline{\Phi}$ — discourages self-reporting. For intermediate values of Φ there is a non-empty region of Θ where the boss does not self-report, while in the complementary region he self-reports.

First-best policy: Let us briefly illustrate the first-best policy with self-reporting.

[19] Suppose that there exists some exogenous limit $\bar{\Phi} > 0$ to the amnesty that can be granted to the self-reporting boss. Then, for every finite $\bar{\Phi}$, there exists a finite $\underline{\delta}$ such that for $\delta > \underline{\delta}$ the boss never self-reports — i.e., $\delta > \underline{\delta} \equiv \left[Q\left(\overline{\theta},\overline{\theta}\right) + \left(\bar{\Phi}-1\right)\right] S_p$.

[20] Of course, this is only a sufficient condition and is made only for simplicity. More generally, for any given δ, there exists a Φ sufficiently large such that the equivalent of (4.3) holds.

[21] The Inada condition above allows to safely focus on interior solutions, and can be easily relaxed by $Q_\theta(0,0) = K$ with K finite but large enough.

Proposition 3. *Assume **A1-A6**. The first-best policy $\wp_{\Phi}^{fb}$ features the same properties as in Proposition 1 — i.e., no rationing and full disclosure. Moreover, the boss self-reports for all $\theta \geq \underline{\theta}(\Phi^{fb})$, where $\underline{\theta}(\Phi^{fb})$ and $\Phi^{fb} \in (0,1)$ solve:*

$$Q(\underline{\theta}(\Phi^{fb}), \underline{\theta}(\Phi^{fb}))S_p = (1 - \Phi^{fb})S_p + \delta, \tag{4.4}$$

$$\underbrace{\frac{(1-p)S_a}{Q_\theta(\underline{\theta}(\Phi^{fb}), \underline{\theta}(\Phi^{fb}))}}_{\textbf{\textit{Domino effect}}} = \underbrace{\frac{1 - F(\underline{\theta}(\Phi^{fb}))}{f(\underline{\theta}(\Phi^{fb}))}S_p}_{\textbf{\textit{Crime-enhancing effect}}} \quad , \tag{4.5}$$

where $0 < \underline{\theta}(\Phi^{fb}) < \overline{\theta}$, so that the agent whistles only if $\theta \leq \underline{\theta}(\Phi^{fb})$.

Hence, allowing the boss to self-report is socially beneficial even under complete information. However, this is for reasons that are completely different from those emphasized in Kaplow and Shavell (1994). In their model self-reporting is unambiguously good for welfare since it saves enforcement resources (individuals who report their harmful acts need not be detected) and reduces risk (self-reporting criminals bear certain rather than uncertain sanctions). In our hierarchical set-up, instead, self-reporting entails benefits but also costs. First, when the boss self-reports, the agent is convicted with certainty. This reflects a vertical externality, hereafter *domino effect*, that spurs the agent's conviction risk and translates onto a higher reservation wage that, in turn, reduces the crime rate.[22] Second, the simple fact that in all states larger than $\underline{\theta}(\Phi^{fb})$ the self-reporting boss enjoys a lighter sanction, weakens deterrence, and therefore reduces welfare by increasing the crime rate: a *crime enhancing* effect.

Second-best policy: We can now turn to study the case of asymmetric information where the choice of the boss' amnesty will be also affected by the rent that the agent obtains in equilibrium. As a first step we define the set of incentive feasible allocations. It is easy to verify that the participation, rationing and (local) incentive compatibility constraints are as before.

We assume and verify ex post that $\overline{\theta} > \underline{\theta}(\Phi) > \underline{\theta}$, where as before $\underline{\theta}(\Phi)$ solves (4.2) taken as an equality. Under this conjecture the boss' expected sanction is:

$$C(\wp_\Phi) \equiv \int_0^{\underline{\theta}} q(\theta) S_p dF(\theta) + \int_{\underline{\theta}}^{\underline{\theta}(\Phi)} Q(s(\theta), \theta) S_p dF(\theta) + \int_{\underline{\theta}(\Phi)}^{\overline{\theta}} ((1-\Phi) S_p + \delta) dF(\theta).$$

By the same token, the agent's break-even wage is defined by the participation constraint:

$$w(\wp_\Phi) + \int_0^{\underline{\theta}} u_0 dF(\theta) + \int_{\underline{\theta}}^{\underline{\theta}(\Phi)} u(\theta) dF(\theta) + \int_{\underline{\theta}(\Phi)}^{\overline{\theta}} S_a dF(\theta) = 0,$$

[22] This domino effect echoes Baccara and Bar-Isaac (2005).

Following the same procedure as before, we have:

$$\underline{\pi}\left(\wp_{\Phi}\right)\equiv\int_{0}^{\underline{\theta}}(q\left(\theta\right)S_{p}-u_{0})dF\left(\theta\right)+\int_{\underline{\theta}}^{\underline{\theta}(\Phi)}\left(Q\left(s\left(\theta\right),\theta\right)S_{p}-u\left(\theta\right)\right)dF\left(\theta\right)+$$
$$+\int_{\underline{\theta}(\Phi)}^{\overline{\theta}}\left(S_{a}+(1-\Phi)S_{p}+\delta\right)dF\left(\theta\right).$$

Hence, the Legislator's program is:

$$\begin{cases}\max\limits_{\underline{\theta},\ s(.),\ u(.),\ \Phi} \Pr\left(\pi\leq\underline{\pi}\left(\wp_{\Phi}\right)\right)\\ \text{s.t.,}\\ (3.7),\ (3.8),\ (3.10),\ (3.11).\end{cases}$$

Neglecting (3.7) and (3.11), which will be verified ex-post, inserting (3.10) into the maximand and integrating by parts, we have the following relaxed program:

$$\mathcal{P}_{\Phi}:\quad\max_{\underline{\theta},\ s(.),\ \Phi}\left\{\int_{0}^{\underline{\theta}}(q\left(\theta\right)S_{p}-u_{0})dF\left(\theta\right)+\int_{\underline{\theta}(\Phi)}^{\overline{\theta}}\left(S_{a}+(1-\Phi)S_{p}+\delta\right)dF\left(\theta\right)+\right.$$
$$\left.+\int_{\underline{\theta}}^{\underline{\theta}(\Phi)}\left[Q\left(s\left(\theta\right),\theta\right)S_{p}-u_{0}-Q_{\theta}\left(s\left(\theta\right),\theta\right)\frac{F(\underline{\theta}\left(\Phi\right))-F(\theta)}{f(\theta)}\right]dF\left(\theta\right)\right\}.$$

The next proposition characterizes the solution of this program and defines the second-best policy:

Proposition 4. *Assume **A1-A6**. There exists a PBE of the game with self-reporting such that* $\overline{\theta}>\underline{\theta}(\Phi^{sb})>\underline{\theta}_{\Phi}^{sb}>0$ *and:*

- *for* $\theta<\underline{\theta}_{\Phi}^{sb}$ *the boss does not self-report and there is no leniency for the agent;*
- *for* $\theta\in[\underline{\theta}_{\Phi}^{sb},\underline{\theta}(\Phi^{sb})]$ *the agent whistles but the boss does not self-report;*
- *for* $\theta>\underline{\theta}(\Phi^{sb})$ *the boss-self reports.*

This equilibrium behavior is supported by a policy $\wp_{\Phi}^{sb}$ *with the following properties:*

- **(*Rationing*)** *The cutoff* $\underline{\theta}_{\Phi}^{sb}$ *is determined by the first-order condition:*

$$(Q(s_{\Phi}^{sb}(\underline{\theta}_{\Phi}^{sb}),\underline{\theta}_{\Phi}^{sb})-q(\underline{\theta}_{\Phi}^{sb}))S_{p}-Q_{\theta}(s_{\Phi}^{sb}(\underline{\theta}_{\Phi}^{sb}),\underline{\theta}_{\Phi}^{sb})\frac{F(\underline{\theta}(\Phi^{sb}))-F(\underline{\theta}_{\Phi}^{sb})}{f(\underline{\theta}_{\Phi}^{sb})}=0,\tag{4.6}$$

- **(*Partial disclosure*)** *For* $\theta\in[\underline{\theta}_{\Phi}^{sb},\underline{\theta}(\Phi^{sb})]$ *an agent who whistles is required to deliver a testimony* $s_{\Phi}^{sb}(\theta)$ *solving the following first-order condition:*

$$Q_{s}(s_{\Phi}^{sb}\left(\theta\right),\theta)S_{p}-Q_{s\theta}(s_{\Phi}^{sb}\left(\theta\right),\theta)\frac{F(\underline{\theta}(\Phi^{sb}))-F\left(\theta\right)}{f\left(\theta\right)}=0,\tag{4.7}$$

where $s_{\Phi}^{sb}(\theta) \leq \theta$*, with equality only at* $\theta = \underline{\theta}(\Phi^{sb})$*, and* $\dot{s}_{\Phi}^{sb}(\theta) > 0$*. For* $\theta \geq \underline{\theta}(\Phi^{sb})$*, the policy entails a disclosure rule* $s_{\Phi}^{sb}(\theta) = \theta$ *and an amnesty equal to* $\phi_{\Phi}^{sb}(\underline{\theta}(\Phi^{sb}))$*.*

- ***(Excessive self-reporting)*** *The cutoff* $\underline{\theta}(\Phi^{sb})$ *and the discount* Φ^{sb} *solve:*

$$Q(\underline{\theta}(\Phi^{sb}), \underline{\theta}(\Phi^{sb}))S_p = (1-\Phi^{sb})S_p + \delta, \tag{4.8}$$

$$\underbrace{\frac{(1-p)S_a}{Q_\theta(\underline{\theta}(\Phi^{sb}), \underline{\theta}(\Phi^{sb}))}}_{\textbf{Domino effect}} + \underbrace{\frac{\int_{\underline{\theta}_{\Phi}^{sb}}^{\underline{\theta}(\Phi^{sb})} Q_\theta(s_{\Phi}^{sb}(\theta), \theta)d\theta}{Q_\theta(\underline{\theta}(\Phi^{sb}), \underline{\theta}(\Phi^{sb}))}}_{\textbf{Rent Saving effect}} = \underbrace{\frac{1-F(\underline{\theta}(\Phi^{sb}))}{f(\underline{\theta}(\Phi^{sb}))}S_p}_{\textbf{Crime Enhancing effect}}, \tag{4.9}$$

with $\underline{\theta}_{\Phi}^{sb} < \underline{\theta}(\Phi^{sb}) < \underline{\theta}(\Phi^{fb}) < \overline{\theta}$ *and* $\Phi^{sb} > \Phi^{fb}$*.*

- ***(Excessive amnesty)*** *The amnesty* $\phi_{\Phi}^{sb}(\theta)$ *is larger than the first-best level — i.e.,* $\phi_{\Phi}^{sb}(\theta) \geq \phi_{\Phi}^{fb}(\theta)$*. Moreover, for* $\theta \in [\underline{\theta}_{\Phi}^{sb}, \underline{\theta}(\Phi^{sb})]$*, the second-best amnesty with self-reporting is:*

$$\phi_{\Phi}^{sb}(\theta) = \underbrace{1-p+(1-Q(s_{\Phi}^{sb}(\theta), \theta))\frac{1}{S_a}}_{\textbf{Zero Rent Amnesty}} + \underbrace{\frac{1}{S_a}\int_{\underline{\theta}_{\Phi}^{sb}}^{\theta} Q_\theta(s_{\Phi}^{sb}(x), x)dx}_{\textbf{Bonus } B_{\Phi}^{sb}(\theta) \geq 0} \tag{4.10}$$

with $\dot{\phi}_{\Phi}^{sb}(\theta) < 0$ *and* $\dot{B}_{\Phi}^{sb}(\theta) > 0$*. While* $\phi_{\Phi}^{sb}(\theta) = \phi_{\Phi}^{sb}(\underline{\theta}(\Phi^{sb}))$ *for* $\theta \geq \underline{\theta}(\Phi^{sb})$*.*

There is one novel force shaping the second best amnesty Φ^{sb} in addition to the *domino* and the *crime enhancing* effects emphasized in Proposition 3. Essentially, granting an amnesty to the self-reporting boss has a beneficial *rent saving effect* that goes through the incentive constraints. The logic is similar to that explaining the rationing result. An higher amnesty Φ expands the subset of states where the boss self-reports, this diminishes the measure of agents admitted into the program, which in turn makes mimicking less profitable. This rent-reduction effect reinforces the domino effect, whereby leading the boss to self-report more often than in the complete information case. The second-best policy under self-reporting also differs from the policy characterized in Proposition 2. This is because asymmetric information introduces mimicking opportunities that lead the Legislator to require biased testimonies, and these distortions are positively linked with the measure of agents that whistle in equilibrium. Hence, granting an amnesty to the self-reporting boss allows to mitigate the basic rent-efficiency trade-off:

Corollary 1. *Assume **A1-A7**. Then* $s_{\Phi}^{sb}(\theta) > s^{sb}(\theta)$ *for all* $\theta \in [\underline{\theta}_{\Phi}^{sb}, \underline{\theta}(\Phi^{sb})]$ *and* $\underline{\theta}_{\Phi}^{sb} < \underline{\theta}^{sb}$*. The effect of self-reporting on the amnesty is ambiguous.*

When the boss can self-report there is less need to distort the agent's testimony simply because in equilibrium there will be a lower fraction of agents that whistle. This effect is formally captured by the modified distortion in equation (4.7). Hence, the Legislator needs to waste less rents to elicit truthful information revelation, and this allows to request more precise testimonies. Precisely the same reasoning can also explain why self-reporting also implies less need for rationing.

The reason why the effect of self-reporting on the amnesty is ambiguous is due to the presence of two countervailing effects. On the one hand, the amnesty granted to the agent when the boss is allowed to self-report increases because of both better testimonies (higher s) and less rationing (lower $\underline{\theta}$). On the other hand, however, better testimonies also reduce the retaliation risk faced by an agent entering the program, which in turn decreases the need for compensating this higher risk.

5. Concluding Remarks

The use of insider information in criminal proceeding is widely recognized as one of the main pillars of the 'modern' fight against organized crime. Nevertheless, the implementation of these rules is often undermined by ethical and political concerns. This skepticism calls for a better theoretical understanding of the right responses of the judicial and legal system to the growing organizational complexity and economic influence of criminal groups. Keeping this goal in mind, in this paper we have studied the problem of a policy maker designing immunity for privately informed accomplice-witnesses. We focused on a hierarchical criminal organization to capture the basic trade-offs emerging when the efficacy of an accomplice-witnesses program is undermined by an asymmetry of information between the judicial system and its actors, and criminals willing to testify against their partners in exchange of lighter sanctions. We have identified the main economic forces that may induce informants to release distorted testimonies and, building on the interplay between these effects, we have characterized the second-best policy preventing untruthful information revelation. Our conclusions are consistent with a number of widespread legislative provisions requiring that accomplices must fulfill minimal information requirements to be admitted into the program and that a bonus should be granted to those who provide more valuable information. These insights have been extended to the case where the privilege of an amnesty is also awarded to a self-reporting boss.

6. Appendix

Proof of Proposition 1: Differentiating the objective function of the first-best program with respect to $s(.)$ and $\underline{\theta}$ we have:

$$\frac{\partial \pi(\wp)}{\partial s(\theta)} = Q_s(s(\theta), \theta),$$

$$\frac{\partial \pi(\wp)}{\partial \underline{\theta}} = (Q(\underline{\theta}^{fb}, \underline{\theta}^{fb}) - q(\underline{\theta}^{fb}))S_p.$$

Under **A1** these equations immediately imply $s^{fb}(\theta) = \theta$ and $\underline{\theta}^{fb} = 0$ — i.e., full disclosure and no rationing. Moreover, the Legislator will induce agents to apply to the program by granting the reservation amnesty $\phi(.)$ that satisfies the participation constraint as equality — i.e.,

$$(1 - \phi^{fb}(\theta))S_a + (1 - Q(\theta, \theta)) = pS_a \quad \forall \theta \in \Theta. \blacksquare$$

Incentive feasible allocations: The characterization of the incentive compatibility constraints is standard, see for instance Laffont and Martimort (2002, Ch., 3). Equation (3.6) is standard, while (3.7) comes from the usual total differentiation technique which implies $u_{\hat{\theta}\hat{\theta}}(\theta, \theta) \leq 0$ and thus $u_{\hat{\theta}\theta}(\theta, \theta) \geq 0$. Finally, the expression for $\dot{u}(\theta)$ follows immediately from (3.6) together with an application of the Envelope Theorem. Note that **A1** implies that this rent is positive. $\blacksquare$

Proof of Proposition 2: Optimizing pointwisely the objective function in $\mathcal{P}$ with respect to $s(\theta)$ one gets immediately the first-order condition (3.13), which directly implies $s^{sb}(\theta) \leq \theta$ for all θ with equality only at $\overline{\theta}$ by **A1**. Moreover, optimizing with respect to $\underline{\theta}$ one has the first-order condition (3.12). Given the pair $(s^{sb}(\theta), \underline{\theta}^{sb})$, the second-best amnesty schedule $\phi^{sb}(\theta)$ has to satisfy two requirements: (i) it has to ensure that the agent's incentive compatibility constraint is met — i.e., it must satisfy (3.6) evaluated at $s^{sb}(\theta)$; (ii) it must be such that the cutoff type $\underline{\theta}^{sb}$ is indifferent between entering the program and facing the trial — i.e., $u(\underline{\theta}^{sb}) = u_0$. From (3.10) one has:

$$-(1 - \phi^{sb}(\theta))S_a - (1 - Q(s^{sb}(\theta), \theta)) = u_0 + \int_{\underline{\theta}^{sb}}^{\theta} Q_\theta(s^{sb}(x), x)dx,$$

using $u_0 = -pS_a$:

$$\phi^{sb}(\theta) = 1 - p + (1 - Q(s^{sb}(\theta), \theta))\frac{1}{S_a} + \frac{1}{S_a}\int_{\underline{\theta}^{sb}}^{\theta} Q_\theta(s^{sb}(x), x)dx,$$

which immediately implies (ii). Next, differentiating with resepct to θ we have:

$$\dot{\phi}^{sb}(\theta)S_a = -Q_s(s^{sb}(\theta), \theta))\dot{s}^{sb}(\theta),$$

which directly implies (i) and that $\dot{\phi}^{sb}(\theta) < 0$ provided that $\dot{s}^{sb}(\theta) > 0$ (which is shown below). Moreover, $\phi^{sb}(\theta) > \phi^{fb}(\theta)$ for all $\theta \geq \underline{\theta}^{sb}$ follows from the fact that $Q(.)$ is concave in s and has a maximum at $s = \theta$:

$$\phi^{sb}(\theta) \geq 1 - p + (1 - Q(\theta, \theta))\frac{1}{S_a} + \frac{1}{S_a}\int_{\underline{\theta}^{sb}}^{\theta} Q_\theta(s^{sb}(x), x)dx > 1 - p + (1 - Q(\theta, \theta))\frac{1}{S_a} = \phi^{fb}(\theta).$$

Finally, the fact that $B^{sb}(\theta) \geq 0$ is immediate, while

$$\dot{B}^{sb}(\theta) = Q_\theta(s^{sb}(x), x) > 0.$$

We now prove that the first-order necessary conditions (3.12) and (3.13) are also sufficient for an optimum by showing that the objective of the Legislator's relaxed program $\mathcal{P}$ is strictly concave under **A1-A3**. To begin with, observe that for any given $\underline{\theta}$ the objective of $\mathcal{P}$ (hereafter $W(.)$ with a little abuse of notation) is strictly concave in $s(.)$ — i.e.,

$$\frac{\partial^2 W(.)}{\partial s(.)^2} = Q_{ss}(s^{sb}(\theta), \theta)S_p - Q_{ss\theta}(s^{sb}(\theta), \theta)\frac{1-F(\theta)}{f(\theta)} < 0.$$

Differentiating twice with respect to $\underline{\theta}$ the objective $W(.)$ evaluated at the disclosure rule $s^{sb}(\theta)$ that solves (3.13) one has:

$$\frac{\partial^2 W(.)}{\partial \underline{\theta}^2} = \Bigg\{ -Q_\theta(.) - \dot{s}^{sb}(.)\left(Q_s(.)S_p - Q_{\theta s}(.)\frac{1-F(\theta)}{f(\theta)}\right) + \\ + \left(Q_{\theta\theta}(.)\frac{1-F(\theta)}{f(\theta)} + Q_\theta(.)\frac{\partial}{\partial\theta}\left(\frac{1-F(\theta)}{f(\theta)}\right)\right)\frac{1}{S_p}\Bigg\}_{\theta=\underline{\theta}^{sb}},$$

which by (3.13) implies:

$$\frac{\partial^2 W(.)}{\partial \underline{\theta}^2} = \left\{ -Q_\theta(.) + \left(Q_{\theta\theta}(.)\frac{1-F(\theta)}{f(\theta)} + Q_\theta(.)\frac{\partial}{\partial\theta}\left(\frac{1-F(\theta)}{f(\theta)}\right)\right)\frac{1}{S_p}\right\}_{\theta=\underline{\theta}^{sb}}.$$

Assumption **A2** then implies that $\frac{\partial^2 W(.)}{\partial \underline{\theta}^2} < 0$ since $Q_\theta(.) > 0$ and $Q_{\theta\theta}(.) \leq 0$. Moreover, in order to show that $\underline{\theta}^{sb}$ is in the interior of Θ, observe that, under **A1,** the left-hand side of (3.12) is positive, increasing and nil at $\theta = 0$. In order to establish the optimality of setting a floor $\underline{\theta}^{sb} \in (0, \overline{\theta})$ it is then enough to verify that the right-hand side of (3.12), i.e.,

$$\Omega(\underline{\theta}^{sb}) \equiv Q_\theta(s^{sb}(\underline{\theta}^{sb}), \underline{\theta}^{sb})\frac{1-F(\underline{\theta}^{sb})}{f(\underline{\theta}^{sb})S_p},$$

satisfies the following conditions: (i) $\Omega(0) > 0$, (ii) $\Omega\left(\overline{\theta}\right) < Q\left(\overline{\theta}, \overline{\theta}\right) - q\left(\overline{\theta}\right)$, and (iii) $\Omega(\theta)$ is continuous. Showing that $\Omega(0) > 0$ is immediate since $\frac{1-F(0)}{f(0)} = 1/f(0) > 0$. Moreover, showing that $\Omega(\overline{\theta}) < Q(\overline{\theta}, \overline{\theta}) - q(\overline{\theta})$ is simple since $\frac{1-F(\overline{\theta})}{f(\overline{\theta})} = 0$ implies $s^{sb}(\overline{\theta}) = \overline{\theta}$ from (3.13). Continuity of $\Omega(\theta)$ follows from the hypothesis that the functions $Q(.)$, $q(.)$ and $F(.)$ are twice continuously differentiable.

Finally, to conclude the proof we have to verify that the policy characterized by (3.12), (3.13) and (3.14) satisfies the second-order local incentive compatibility constraint (3.7), the global incentive compatibility constraint and the rationing constraint (3.11).

We first show that (3.7) is met under **A1-A3**. Since $Q_{s\theta}(.) > 0$ by **A1,** we only need to show that

$\dot{s}^{sb}(\theta) \geq 0$. This is straightforward, using (3.13) the Implicit Function Theorem implies:

$$\dot{s}^{sb}(\theta) = \frac{Q_{s\theta}(.)\left(S_p - \frac{\partial}{\partial\theta}\left(\frac{1-F(\theta)}{f(\theta)}\right)\right) - Q_{s\theta\theta}(.)\frac{1-F(\theta)}{f(\theta)}}{-Q_{ss}(.)S_p + Q_{ss\theta}(.)\frac{1-F(\theta)}{f(\theta)}},$$

where **A2** and **A3** imply $\dot{s}^{sb}(\theta) > 0$.

Second, in order to show that the global incentive compatibility constraint holds we need to verify that there is no state $\theta \geq \underline{\theta}^{sb}$ where the agent can profit by by announcing $\theta' \geq \underline{\theta}^{sb}$ with $\theta \neq \theta'$ — i.e.,

$$u(\theta,\theta) - u(\theta',\theta) \geq 0 \quad \forall (\theta,\theta') \in [\underline{\theta}^{sb},\overline{\theta}]^2,$$

which by definition of $u(\theta',\theta)$ implies:

$$(1-\phi^{sb}(\theta'))S_a + (1-Q(s^{sb}(\theta'),\theta)) \geq (1-\phi^{sb}(\theta))S_a + (1-Q(s^{sb}(\theta),\theta)). \tag{A1}$$

Assume $\theta' > \theta$, with no loss of generality, then (A1) yields:

$$-\int_{\theta}^{\theta'}\left\{\dot{\phi}^{sb}(x)S_a + \dot{s}^{sb}(x)\,Q_s(s^{sb}(x),\theta)\right\}dx \geq 0,$$

using (3.6) and substituting for $\dot{\phi}^{sb}(x)S_a = -\dot{s}^{sb}(x)\,Q_s(s^{sb}(x),x)$ for $x \geq \theta$ we have:

$$0 \leq -\int_{\theta}^{\theta'}\left\{\dot{s}^{sb}(x)\,Q_s(s^{sb}(x),\theta) - \dot{s}^{sb}(x)\,Q_s(s^{sb}(x),x)\right\}dx =$$

$$= -\int_{\theta}^{\theta'}\left\{\dot{s}^{sb}(x)\int_{x}^{\theta}Q_{s\theta}(s^{sb}(x),y)dy\right\}dx. \tag{A2}$$

which immediately implies the result since $\dot{s}^{sb}(x) \geq 0$, $x \geq \theta$ and $Q_{s\theta}(.) \geq 0$.

Showing that no type $\theta \geq \underline{\theta}^{sb}$ can profit by mimicking a type $\theta' < \underline{\theta}^{sb}$ is obvious given the fact that $\dot{u}(\theta) > 0$. Finally, we show that the rationing constraint is satisfied — i.e., there is no state $\theta < \underline{\theta}^{sb}$ where the agent can profit by announcing $\theta' \geq \underline{\theta}^{sb}$. Formally:

$$u_0 = -pS_a \geq u(\theta',\theta) \quad \forall\theta < \underline{\theta}^{sb} \quad \text{and} \quad \forall\theta' \geq \underline{\theta}^{sb}. \tag{A3}$$

First, observe that by definition of the marginal type $\underline{\theta}^{sb}$ equation (A3) can be rewritten as:

$$u(\underline{\theta}^{sb}) \geq u(\theta',\theta), \tag{A4}$$

moreover, since $Q_\theta(.) > 0$ and $\underline{\theta}^{sb} > \theta$ it must be $u(\theta',\underline{\theta}^{sb}) > u(\theta',\theta)$. Inequality (A4) must then hold as long as the following is true:

$$u(\underline{\theta}^{sb}) \geq u(\theta',\underline{\theta}^{sb}) \quad \forall\theta' > \underline{\theta}^{sb},$$

which is true precisely by the same argument used to show that the global incentive compatibility constraint holds for all types $(\theta,\theta') \in [\underline{\theta}^{sb},\theta)^2$. This concludes the proof. ■

Proof of Lemma 1: Take any continuously differentiable disclosure rule $s(\theta)$ such that: (i) $s(\theta) \leq \theta$, (ii) $s(\overline{\theta}) = \overline{\theta}$ and $s(0) = 0$, (iii) $\dot{s}(\theta) \geq 0$. Then, for given $s(\theta)$, let $\underline{\theta}(\Phi)$ be the solution with respect to θ of:

$$Q(s(\theta), \theta) S_p = (1 - \Phi) S_p + \delta. \tag{A5}$$

By assumption $\underline{\theta}(\Phi)$ exists for some $\Phi > 0$ because $Q(s(\theta), \theta)$ is increasing in θ. Moreover, $\underline{\theta}(\Phi)$ is decreasing in Φ — i.e.,

$$\frac{\partial \underline{\theta}(\Phi)}{\partial \Phi} = -\frac{1}{Q_s(s(\theta), \theta)\dot{s}(\theta) + Q_\theta(s(\theta), \theta)} < 0.$$

We then need to show that there exists a $\Phi \in (0, 1)$ such that $\underline{\theta}(\Phi) \in (0, \overline{\theta})$. This simply follows from the fact that at $\Phi = 1$ one has $\underline{\theta}(\Phi) < \overline{\theta}$ by **A5** — i.e., the boss self-reports for θ large enough. Moreover, **A4** implies that at $\Phi = 1$ equation (A5) cannot hold for θ close to 0 and therefore the boss does not self-report in these states. Hence, $\underline{\theta}(\Phi) > 0$. By continuity, this implies that there must exist a non-empty open set $(\underline{\Phi}, \overline{\Phi})$ such that $\underline{\theta}(\Phi) \in (0, \overline{\theta})$ for all $\underline{\Phi} < \Phi < \overline{\Phi}$. ■

Proof of Proposition 3: To begin with, note that in an equilibrium where the boss self-reports — i.e., $\underline{\theta}(\Phi) < \overline{\theta}$ — and the agent whistles but is rationed in some states — i.e., $0 < \underline{\theta} < \underline{\theta}(\Phi)$ — the first-best policy must solve the following (relaxed) program:

$$\max_{\underline{\theta},\ s(.),\ \Phi} \left\{ \int_0^{\underline{\theta}} (q(\theta) S_p - u_0) dF(\theta) + \int_{\underline{\theta}(\Phi)}^{\overline{\theta}} (S_a + (1-\Phi) S_p + \delta) dF(\theta) + \right.$$
$$\left. + \int_{\underline{\theta}}^{\underline{\theta}(\Phi)} (Q(s(\theta), \theta) S_p + pS_a) dF(\theta) \right\}.$$

Differentiating the above objective function with respect to $s(.)$ and $\underline{\theta}$ it is immediate to show that, in an interior solution, the first-best policy with self-reporting features full disclosure and no rationing — i.e., $s_\Phi^{fb}(\theta) = \theta$ for all θ and $\underline{\theta}_\Phi^{fb} = 0$. Differentiating with respect to Φ one obtains the first-order condition:

$$-(S_a + (1-\Phi^{fb}) S_p + \delta) \frac{\partial \underline{\theta}(\Phi^{fb})}{\partial \Phi} - \frac{\int_{\underline{\theta}(\Phi^{fb})}^{\overline{\theta}} S_p dF(\theta)}{f(\underline{\theta}(\Phi^{fb}))} + \frac{\partial \underline{\theta}(\Phi^{fb})}{\partial \Phi} (Q(\underline{\theta}(\Phi^{fb}), \underline{\theta}(\Phi^{fb})) S_p + pS_a) = 0.$$

Using the fact that if $\underline{\theta}(\Phi^{fb}) \in \mathrm{int}\Theta$ then (4.4) must hold by definition — i.e.,

$$Q(\underline{\theta}(\Phi^{fb}), \underline{\theta}(\Phi^{fb})) S_p = (1 - \Phi^{fb}) S_p + \delta.$$

From **A1** and the implicit Function Function Theorem, one gets

$$\frac{\partial \underline{\theta}(\Phi^{fb})}{\partial \Phi} = -\frac{1}{Q_\theta(\underline{\theta}(\Phi^{fb}), \underline{\theta}(\Phi^{fb}))} < 0.$$

The first-order condition above then boils down to (4.5).

Now, in order to show that $\underline{\theta}(\Phi^{fb}) < \overline{\theta}$ note that as long as Φ^{fb} is such that $\underline{\theta}(\Phi^{fb}) = \overline{\theta}$ equation

(4.5) implies

$$\frac{(1-p)\,S_a}{Q_\theta(\overline{\theta},\overline{\theta})}>0,$$

hence $\underline{\theta}(\Phi^{fb})<\overline{\theta}$. Moreover, to show that $\underline{\theta}(\Phi^{fb})>0$ note that for $\underline{\theta}(\Phi^{fb})=0$ equation (4.5) together with **A6** implies immediately:

$$\frac{(1-p)\,S_a}{Q_\theta\,(0,0)}-\frac{S_p}{f\,(0)}<0.$$

Uniqueness of the optimal policy follows from the fact that under **A6** the left hand side of (4.5) is decreasing in Φ and $\frac{\partial\underline{\theta}(\Phi^{fb})}{\partial\Phi}<0$, while **A2** together with $\frac{\partial\underline{\theta}(\Phi^{fb})}{\partial\Phi}<0$ imply that the right hand side of (4.5) is decreasing in Φ. ■

Proof of Proposition 4: Differentiating the objective function of $\mathcal{P}_\Phi$ with respect to $\underline{\theta}$ and $s\,(.)$ yields immediately the first-order conditions (4.6) and (4.7). Using the same techniques developed in the proof of Proposition 2 it follows immediately that: (i) $\underline{\theta}_\Phi^{sb}\in$int$\Theta$, (ii) $s_\Phi^{sb}\,(\theta)\leq\theta$ with equality only at $\theta=\underline{\theta}(\Phi^{sb})$ and $\dot{s}_\Phi^{sb}\,(\theta)\geq 0$, and (iii) that (4.10) yields the agent's state contingent amnesty.

Next, we must show that (4.9) identifies the optimal amnesty for the self-reporting boss, and that $\underline{\theta}_\Phi^{sb}<\underline{\theta}(\Phi^{sb})<\overline{\theta}$. First, differentiating the objective of $\mathcal{P}_\Phi$ with respect to Φ and using the fact that $s_\Phi^{sb}(\underline{\theta}\left(\Phi^{sb}\right))=\underline{\theta}\left(\Phi^{sb}\right)$ one gets:

$$-(S_a+(1-\Phi^{sb})S_p)+\delta\frac{\partial\underline{\theta}(\Phi^{sb})}{\partial\Phi}-\frac{\int_{\underline{\theta}(\Phi^{sb})}^{\overline{\theta}}S_p dF\,(\theta)}{f(\underline{\theta}(\Phi^{sb}))}+$$
$$+(Q(\underline{\theta}(\Phi^{sb}),\underline{\theta}(\Phi^{fb}))S_p+pS_a)\frac{\partial\underline{\theta}(\Phi^{sb})}{\partial\Phi}-\frac{\partial\underline{\theta}(\Phi^{sb})}{\partial\Phi}\int_{\underline{\theta}_\Phi^{sb}}^{\underline{\theta}(\Phi^{sb})}Q_\theta(s_\Phi^{sb}(\theta),\theta)d\theta=0.$$

Using the fact that when $\underline{\theta}(\Phi^{sb})\in$int$\Theta$ condition (4.8) must hold by definition — i.e.,

$$Q(\underline{\theta}(\Phi^{sb}),\underline{\theta}(\Phi^{sb}))S_p=(1-\Phi^{sb})S_p+\delta,$$

the first-order condition above boils down to:

$$(1-p)\,S_a\frac{\partial\underline{\theta}(\Phi^{sb})}{\partial\Phi}+\frac{\int_{\underline{\theta}(\Phi^{sb})}^{\overline{\theta}}S_p dF\,(\theta)}{f(\underline{\theta}(\Phi^{sb}))}+\frac{\partial\underline{\theta}(\Phi^{sb})}{\partial\Phi}\int_{\underline{\theta}_\Phi^{sb}}^{\underline{\theta}(\Phi^{sb})}Q_\theta(s_\Phi^{sb}\,(\theta)\,,\theta)d\theta=0. \tag{A6}$$

Differentiating (4.8) and using the fact that $s_\Phi^{sb}(\underline{\theta}\left(\Phi^{sb}\right))=\underline{\theta}(\Phi^{sb})$ by (4.7), which by **A1** implies $Q_s(\underline{\theta}(\Phi^{sb}),\underline{\theta}(\Phi^{sb}))=0$, we have:

$$\frac{\partial\underline{\theta}(\Phi^{sb})}{\partial\Phi}=-\frac{1}{Q_\theta(\underline{\theta}(\Phi^{sb}),\underline{\theta}(\Phi^{sb}))}<0. \tag{A7}$$

Implying that the first-order condition (A6) rewrites as:

$$\frac{(1-p)\,S_a+\int_{\underline{\theta}_\Phi^{sb}}^{\underline{\theta}(\Phi^{sb})}Q_\theta(s_\Phi^{sb}\,(\theta)\,,\theta)d\theta}{Q_\theta(\underline{\theta}(\Phi^{sb}),\underline{\theta}(\Phi^{sb}))}=\frac{1-F\left(\underline{\theta}(\Phi^{sb})\right)}{f(\underline{\theta}(\Phi^{sb}))}S_p, \tag{A8}$$

which is (4.9).

Now, to show that $\underline{\theta}(\Phi^{sb}) < \overline{\theta}$ note that for $\underline{\theta}(\Phi^{sb}) = \overline{\theta}$ the first-order condition (A8) yields:

$$\frac{(1-p)\,S_a + \int_{\underline{\theta}_\Phi^{sb}}^{\overline{\theta}} Q_\theta(s_\Phi^{sb}(\theta),\theta)d\theta}{Q_\theta(\overline{\theta},\overline{\theta})} > 0,$$

hence $\underline{\theta}(\Phi^{sb}) < \overline{\theta}$. We then need to show that $\underline{\theta}(\Phi^{sb}) > \underline{\theta}_\Phi^{sb} > 0$. First, suppose that $\underline{\theta}(\Phi^{sb}) = \underline{\theta}_\Phi^{sb}$, then (A8) rewrites as

$$\frac{(1-p)\,S_a}{Q_\theta(\underline{\theta}_\Phi^{sb},\underline{\theta}_\Phi^{sb})} = \frac{1-F(\underline{\theta}_\Phi^{sb})}{f(\underline{\theta}_\Phi^{sb})} S_p. \tag{A9}$$

Substituting $\underline{\theta}(\Phi^{sb}) = \underline{\theta}_\Phi^{sb}$ into the first-order condition (3.12) one has $\underline{\theta}_\Phi^{sb} = 0$. Then **A6** implies that (A9) cannot hold, and therefore $\underline{\theta}(\Phi^{sb}) \neq \underline{\theta}_\Phi^{sb}$. Second, showing that $\underline{\theta}(\Phi^{sb}) < \underline{\theta}_\Phi^{sb}$ follows from a revealed preference argument. Suppose that there exists an equilibrium where only the boss self-reports, and denote by $\hat{\Phi}^{sb}$ the optimal amnesty such that $0 < \underline{\theta}(\hat{\Phi}^{sb}) < \underline{\hat{\theta}}_\Phi^{sb}$. Then in such equilibrium there will be a subset of states of nature where the trial takes place — i.e., for all $\theta \in [0, \underline{\theta}(\hat{\Phi}^{sb}))$. But, for any given $\underline{\theta}(\hat{\Phi}^{sb})$, Proposition 2 implies that the Legislator can strictly reduce the crime rate by letting the agent talk in some states $\theta < \underline{\theta}(\hat{\Phi}^{sb})$ — i.e.,

$$\int_0^{\underline{\theta}(\hat{\Phi}^{sb})} (q\,(\theta)\,S_p - u_0)dF\,(\theta) < \max_{\underline{\theta},\ s(\theta)} \left\{ \int_0^{\underline{\theta}} (q\,(\theta)\,S_p - u_0)dF\,(\theta) + \right.$$

$$\left. + \int_{\underline{\theta}}^{\underline{\theta}(\hat{\Phi}^{sb})} \left[Q\,(s\,(\theta)\,,\theta)\,S_p - u_0 - Q_\theta\,(s\,(\theta)\,,\theta)\,\frac{F(\underline{\theta}(\hat{\Phi}^{sb})) - F\,(\theta)}{f\,(\theta)} \right] dF\,(\theta) \right\}.$$

It then follows that $\underline{\theta}(\Phi^{sb}) > \underline{\theta}_\Phi^{sb}$ and that (4.9) is a necessary condition to identify an internal optimum.

Finally, we show that $\underline{\theta}(\Phi^{sb}) < \underline{\theta}(\Phi^{fb})$, and therefore $\Phi^{sb} > \Phi^{fb}$. In doing so let us rewrite the first-order necessary conditions identifying Φ^{fb} and Φ^{sb} respectively, as:

$$(1-p)S_a = \frac{1-F(\underline{\theta}(\Phi^{fb}))}{f(\underline{\theta}(\Phi^{fb}))} S_p Q_\theta(\underline{\theta}(\Phi^{fb}), \underline{\theta}(\Phi^{fb})), \tag{A10}$$

and

$$(1-p)S_a + \int_{\underline{\theta}_\Phi^{sb}}^{\underline{\theta}(\Phi^{sb})} Q_\theta(s_\Phi^{sb}\,(\theta)\,,\theta)d\theta = \frac{1-F(\underline{\theta}(\Phi^{sb}))}{f(\underline{\theta}(\Phi^{sb}))} S_p Q_\theta(\underline{\theta}(\Phi^{sb}), \underline{\theta}(\Phi^{sb})). \tag{A11}$$

Note that the left-hand side of (A11) is larger than the left-hand side of (A10) because $\underline{\theta}(\Phi^{sb}) > \underline{\theta}_\Phi^{sb}$ and $Q_\theta\,(.) > 0$. Moreover, note that for any given Φ under **A2** the right-hand of both equations is increasing in Φ — i.e.,

$$\frac{\partial}{\partial \Phi}\left[\frac{1-F(\underline{\theta}(\Phi))}{f(\underline{\theta}(\Phi))} Q_\theta(\underline{\theta}(\Phi), \underline{\theta}(\Phi))\right] > 0.$$

Hence, $\underline{\theta}(\Phi^{sb}) < \underline{\theta}(\Phi^{fb})$ and $\Phi^{sb} > \Phi^{fb}$. Finally, showing that $\phi_\Phi^{sb}\,(\theta) > \phi_\Phi^{fb}\,(\theta)$ for all $\theta \geq \underline{\theta}_\Phi^{sb}$ and that the first-order necessary conditions (4.6)-(4.9) are also sufficient for an optimum follows the same arguments used in the proof of Proposition 2.

In order to complete the proof we must verify that, given the policy described in the statement of the proposition, neither the agent nor the boss can profitably deviate from the equilibrium where the agent talks in states $\theta < \underline{\theta}(\Phi^{sb})$ and the boss self-reports only if $\theta \geq \underline{\theta}(\Phi^{sb})$.

Consider first the boss. Showing that he cannot gain by self-reporting in states $\theta < \underline{\theta}(\Phi^{sb})$ is straightforward and it immediately follows from equation (4.8) and **A1**. Next, suppose that he does not talk in a state $\theta > \underline{\theta}(\Phi^{sb})$, we must show that in this 'off equilibrium' history the following happens: (i) the agent will cooperate and, (ii) his testimony is such that the boss' deviation is not profitable. In order to do so, consider the allocation $\tilde{s}(\hat{\theta}) = \hat{\theta}$ and $\tilde{\phi} = \phi_{\Phi}^{sb}\left(\underline{\theta}(\Phi^{sb})\right)$. Suppose for now that such allocation is incentive compatible, that is $\hat{\theta} = \theta$ for all $\theta \geq \underline{\theta}(\Phi^{sb})$ (a conjecture that will be checked ex post). By construction the boss will not find it profitable to deviate because under **A1** the following is true:

$$Q\left(\theta, \theta\right) S_p > (1 - \Phi^{sb}) S_p + \delta \quad \forall \theta > \underline{\theta}(\Phi^{sb}).$$

We can now show that $\tilde{s}(\hat{\theta}) = \hat{\theta}$ and $\tilde{\phi} = \phi_{\Phi}^{sb}\left(\underline{\theta}(\Phi^{sb})\right)$ is indeed incentive compatible for type $\theta > \underline{\theta}(\Phi^{sb})$ provided that the boss has (unexpectedly) not self-reported. To do so, we need to check that the agent cannot profitably deviate neither from mimicking a type $\hat{\theta} > \underline{\theta}(\Phi^{sb})$ nor a type $\hat{\theta} < \underline{\theta}(\Phi^{sb})$. Given the 'off-equilibrium' policy $(\tilde{s}(\hat{\theta}), \tilde{\phi})$, it is immediate to show that mimicking a type $\hat{\theta} > \underline{\theta}(\Phi^{sb})$ is not convenient because both the first- and second-order local incentive constraints are satisfied (which by standard arguments also implies that the global incentive constraint holds). Suppose now that the agent lies by claiming that the state is $\hat{\theta} \leq \underline{\theta}(\Phi^{sb})$, his utility would then be:

$$u(\hat{\theta}, \theta) = -(1 - \phi_{\Phi}^{sb}(\hat{\theta})) S_a - (1 - Q(s_{\Phi}^{sb}(\hat{\theta}), \theta)), \tag{A12}$$

implying that

$$\frac{\partial u(\hat{\theta}, \theta)}{\partial \hat{\theta}} = \dot{\phi}_{\Phi}^{sb}(\hat{\theta}) S_a + Q_s(s_{\Phi}^{sb}(\hat{\theta}), \theta) \dot{s}_{\Phi}^{sb}(\hat{\theta}).$$

Note that $Q_{s\theta}\left(.\right) > 0$ and $\dot{s}_{\Phi}^{sb}(\hat{\theta}) > 0$ together with the local incentive constraint (3.6) yield:

$$\dot{\phi}_{\Phi}^{sb}(\hat{\theta}) S_a + Q_s(s_{\Phi}^{sb}(\hat{\theta}), \theta) \dot{s}_{\Phi}^{sb}(\hat{\theta}) > \dot{\phi}_{\Phi}^{sb}(\hat{\theta}) S_a + Q_s(s_{\Phi}^{sb}(\hat{\theta}), \hat{\theta}) \dot{s}_{\Phi}^{sb}(\hat{\theta}) = 0 \quad \forall \hat{\theta} \leq \underline{\theta}(\Phi^{sb}) < \theta.$$

Hence,

$$\frac{\partial u(\hat{\theta}, \theta)}{\partial \hat{\theta}} = \dot{\phi}_{\Phi}^{sb}(\hat{\theta}) S_a + Q_s(s_{\Phi}^{sb}(\hat{\theta}), \theta) \dot{s}_{\Phi}^{sb}(\hat{\theta}) > 0 \quad \forall \hat{\theta} \leq \underline{\theta}(\Phi^{sb}) < \theta.$$

This implies that if the agent mimics in state $\theta > \underline{\theta}(\Phi^{sb})$ by pretending that the state is $\hat{\theta} \leq \underline{\theta}(\Phi^{sb})$ he will always pretend to be in state $\underline{\theta}(\Phi^{sb})$ — i.e., where the information rent that he gets by reporting a state $\theta' \leq \underline{\theta}(\Phi^{sb})$ is maximal. But then, he could do strictly better from telling the truth and obtain the allocation $\tilde{s}(\theta) = \theta$ and $\tilde{\phi} = \phi_{\Phi}^{sb}\left(\underline{\theta}(\Phi^{sb})\right)$. This can be easily verified by using equation (A12). In fact, in this case the agent's expected utility would be:

$$\tilde{u}\left(\theta\right) = -(1 - \phi_{\Phi}^{sb}(\underline{\theta}(\Phi^{sb}))) S_a - (1 - Q(\theta, \theta)),$$

which immediately yields

$$\tilde{u}\left(\theta\right) > u(\underline{\theta}(\Phi^{sb}), \theta) = -(1 - \phi_{\Phi}^{sb}(\underline{\theta}(\Phi^{sb}))) S_a - (1 - Q(\underline{\theta}(\Phi^{sb}), \theta)),$$

since $\theta > \underline{\theta}(\Phi^{sb})$. It then follows that, given the policy described in the statement of the proposition, in an 'off-equilibrium' history where the boss has not self-reported in state $\theta > \underline{\theta}(\Phi^{sb})$ the agent truthfully reveals his type. Hence, the boss' expected sanction in this continuation game would be $Q(\theta, \theta)S_p$, which is clearly above the costs from self-reporting $(1 - \Phi^{sb})S_p + \delta$ by (4.8) and **A1.**

We are left to show that no agent can profitably deviate when the boss self-reports. But this is trivial as in this case they are convicted with certainty and their information is worthless to the prosecutor. Finally, showing that the rationing and global incentive constraints hold for all types $\theta \in [\underline{\theta}^{sb}, \underline{\theta}(\Phi^{sb}))$ follows exactly the same steps as those developed in the proof of Proposition 2. ■

Proof of Corollary 1: Showing that $s_{\Phi}^{sb}(\theta) > s^{sb}(\theta)$ for all $\theta \in [\underline{\theta}_{\Phi}^{sb}, \underline{\theta}(\Phi^{sb})]$ follows immediately from comparing equation (3.13) with (4.7) and $F(\underline{\theta}(\Phi^{sb})) < 1$ since $\underline{\theta}(\Phi^{sb}) < \bar{\theta}$. To show that $\underline{\theta}_{\Phi}^{sb} < \underline{\theta}^{sb}$ consider equations (3.12) and (4.6). Note that $\underline{\theta}_{\Phi}^{sb} = \underline{\theta}^{sb}$ for $\Phi^{sb} = 0$. Moreover, for any given Φ let

$$\mathcal{F}(\underline{\theta}_{\Phi}^{sb}, \Phi) \equiv (Q(s_{\Phi}^{sb}(\underline{\theta}_{\Phi}^{sb}), \underline{\theta}_{\Phi}^{sb}) - q(\underline{\theta}_{\Phi}^{sb}))S_p - Q_{\theta}(s_{\Phi}^{sb}(\underline{\theta}_{\Phi}^{sb}), \underline{\theta}_{\Phi}^{sb}) \frac{F(\underline{\theta}(\Phi)) - F(\underline{\theta}_{\Phi}^{sb})}{f(\underline{\theta}_{\Phi}^{sb})} = 0,$$

note that the Envelope Theorem applied to equation (4.6) implies:

$$\frac{\partial \underline{\theta}_{\Phi}^{sb}}{\partial \Phi} = -\frac{\mathcal{F}_{\Phi}(\underline{\theta}_{\Phi}^{sb}, \Phi)}{\mathcal{F}_{\underline{\theta}}(\underline{\theta}_{\Phi}^{sb}, \Phi)} = \frac{1}{\mathcal{F}_{\underline{\theta}}(\underline{\theta}_{\Phi}^{sb}, \Phi)} \frac{\partial \underline{\theta}(\Phi^{sb})}{\partial \Phi},$$

where $\mathcal{F}_{\underline{\theta}}(\underline{\theta}_{\Phi}^{sb}, \Phi) > 0$ by concavity of the objective function with respect to $\underline{\theta}$ and $\frac{\partial \underline{\theta}(\Phi^{sb})}{\partial \Phi} < 0$ by (A7). Hence, it follows that $\frac{\partial \underline{\theta}_{\Phi}^{sb}}{\partial \Phi} < 0$ implying immediately that $\underline{\theta}_{\Phi}^{sb} < \underline{\theta}^{sb}$. ■

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