CSEF

Centre for Studies in Economics and Finance

WORKING PAPER NO. 503

Optimal Leniency and the Organization Design of Group Delinquency

Giovanni Immordino, Salvatore Piccolo and Paolo Roberti

June 2018

University of Naples Federico II   **University of Salerno**   **Bocconi University, Milan**

WORKING PAPER NO. 503

Optimal Leniency and the Organization Design of Group Delinquency

Giovanni Immordino[♣], Salvatore Piccolo[♦] and Paolo Roberti[♥]

Abstract

We study a simple law enforcement model in which the organizational structure of criminal organizations is endogenous and determined jointly with the amnesty granted to criminals who ip and blow the whistle (leniency program). We allow criminals to choose between a horizontal (partnership) and a vertical structure and study how this choice affects the optimal leniency chosen by a benevolent Legislator whose objective is to minimize crime. We show that when soldiers in vertical organizations have valuable information about the boss, the policy mainly targets vertical hierarchies, leaving horizontal structures proliferate in number. By contrast, when soldiers are poorly informed about their heads, the Legislator implements a policy that completely eradicates partnerships. When the two types of organization coexist, partnerships emerge only for intermediate levels of trust between criminals, while organizations take a vertical structure for low or high levels of trust among felons.

[♣] Università di Napoli Federico II and CSEF. E-mail: giovanni.immordino[at]unina.it

[♦] Università di Bergamo and CSEF. E-mail: salvapiccolo[at]gmail.com

[♥] Università di Bergamo. E-mail: paolo.roberti[at]unibg.it

Table of contents

1 Introduction

The introduction of laws intended to promote cooperation between members of criminal organizations and their prosecutors is the cornerstone of the modern fight against organized crime. Borrowing from the literature on antitrust law enforcement — see, e.g., Motta and Polo (2003), Spagnolo (2003), Harrington (2008) and Chen and Rey (2013) among many others — a few recent papers have started to investigate the optimal design of leniency programs that target criminal organizations and their members rather than cartels — see, e.g., Acconcia et al. (2014), Piccolo and Immordino (2017) and Gamba et al. (2018).

In this literature criminal organizations are modeled as vertical hierarchies whose leaders hardly get convicted because they push their own participation up to behind-the-scenes control and guidance. Convincing low-rank criminals to cooperate with justice and testify against their former heads (in exchange of lighter sanctions) is therefore crucial to counter organized crime effectively. However, determining the optimal amnesty in this environment is not an obvious task. Although the evidence disclosed by whistle-blowers helps prosecutors beheading these organizations (the bright side of leniency), the lighter sanctions that such cooperation requires reduce the cost that top criminals need to pay in order to recruit soldiers infringing the law on their behalf, whereby weakening deterrence (the dark side of leniency).[1]

Although the literature has modeled criminal organizations as vertical and centralized hierarchies, there is ample evidence that criminal organizations based on horizontal allocation of power and information, such as the Italian mafia syndicate Camorra and several terrorist groups, are in some circumstances a preferred choice (see evidence below). What drives the organizational choice of a criminal organization? How does the introduction of a leniency program impact this choice? What is the trade off that an optimal policy should reflect in this case? What type of organization is hurt more by such instruments?

Understanding more deeply how criminal organizations are structured and which factors determine this choice can have important implications for the design of effective public responses to organized crime. The existing papers focus on environments where criminal organizations cannot adapt their internal structure and decision making rules to the legal environment. Hence, what is missing is the understanding of how criminal organizations change their structure as an optimal response to these programs, and the effect of this change on the Legislators' behavior. The objective of our paper is to fill this gap.

We consider two alternative organizational forms: *partnerships,* whose members are in a symmetric position in the organization; and *vertical hierarchies* that are, instead, pyramidal organizations ruled by top criminals delegating the daily business to simple soldiers. Our key assumption is that soldiers in a vertical organization own less information about their heads compared to what partnership members know about each other — see, e.g., Baccara and

---

[1]The trade off between these two forces provides useful guidelines for the design and the assessment of leniency programs — see, e.g., Acconcia et al. (2014) for an empirical investigation.

Bar-Isaac (2008). Moreover, in order to capture the idea that the optimal policy depends on the extent to which criminals are loyal to one another, we also assume that criminals pay a personal cost (unknown to the Legislator) when they decide to flip and cheat on their partners. This cost reflects either (persistent) historical factors that determine a collective attitude towards a criminal culture, so called *omertà*, or the strength of these organizations in punishing disloyalty — e.g., Arlacchi and Ryle (1986), Hess (1988), and Hobsbawm (1959), among many others.

To gain insights on the basic trade-off that determines the optimal policy with an endogenous organization structure, we first analyze the policy that would emerge when the Legislator targets an exogenously given (horizontal or vertical) organization. Depending on the level of loyalty among felons and the amnesty chosen by the Legislator, in the equilibrium there are *weak* and *strong* organizations. Members of weak organizations choose to cooperate with the justice, while members of strong organizations do not blow the whistle. The probability of weak organizations is increasing with the amnesty granted by the Legislator. For each type of organizational structure, we show that the optimal amnesty is determined by the trade off between a bright and a dark side of leniency. The bright side is due to the fact that (other things being equal) the probability of facing a weak organization is larger when whistle-blowers are offered a relatively high amnesty. By contrast, the dark side emerges because criminals facing lower expected penalties are also more willing to commit a crime. Interestingly, the structure and magnitude of these two opposing forces depend on the organizational form. Hence, the optimal amnesty designed to fight partnerships is typically different than the one intended to counter vertical hierarchies. We show that the parameter that determines the ordering between these two amnesty levels is the accuracy of the information that soldiers own about their heads in vertical hierarchies. When soldiers are sufficiently informed, fighting pyramidal organizations requires a more generous amnesty than fighting partnerships; vice versa, when this information is not accurate enough, fighting horizontal organizations requires a more generous amnesty. This is because, while the boss operates behind the scenes and is (typically) very hard to convict (unless the soldier flips and cooperates with justice), a partnership can be dissolved with (relatively) low amnesties owing to a prisoner dilemma game played by its members. Hence, only when the information of the soldier is sufficiently helpful in convicting the boss, the Legislator is willing to implement such a large amnesty.

We then turn to characterize the optimal amnesty when criminals can adapt the organization's structure to the policy set by the Legislator. We show that criminals who are sufficiently loyal to one another always choose to form a vertical hierarchy. This is because in environments with an established and strong criminal culture soldiers will never blow the whistle, so that their heads can enjoy a larger (net) return from crime than in a partnership. By contrast, in environments with a weak criminal culture — i.e., when criminals are not very loyal to each other — the two types of organization coexist, with partnerships predom-

inating for (relatively) higher levels of *omertà* and lower crime profitability. Hence, when choosing the optimal policy, the Legislator must internalize the consequences of the amnesty on the criminals' organizational choice. Actually, the effect of the policy can be neutralized, or in principle even subverted by the choice of a suitable organization's structure.

However, the extent to which this new channel reduces the effectiveness of the policy is not obvious because now the bright and the dark side of leniency reflect the endogeneity of the organization structure. We show that when soldiers are sufficiently informed about their heads, the Legislator is willing to grant a large amnesty in order to exploit such insider information to disrupt vertical hierarchies, even though partnerships proliferate. By contrast, when soldiers are poorly informed about their heads, granting large amnesties in order to fight vertical hierarchies is less effective because top criminals are less likely to be convicted. The Legislator, therefore, prefers to grant a lower amnesty which completely eradicates partnerships, since they are always weak organizations and can be disrupted with a relatively less generous leniency program.

Hence, depending on the information flowing from the top to the bottom of vertical hierarchies, an optimal policy may induce an excessive proliferation of one or the other type of criminal organization (compared to the benchmark in which the policy targets only one type of organization). Finally, an interesting testable implication of our analysis is that while partnerships are likely to be formed in environments where the degree of *omertà* is neither too strong nor too weak, vertical hierarchies are either very resilient to leniency programs or extremely fragile.

These results are not only of theoretical interest, but they also contribute to understand more deeply the effects of leniency programs designed with the specific purpose of fighting criminal organizations. For example, they can shed new light on the debate about the recent decline in Sicilian Mafia activity and the increase of the presence of more horizontal organizations (e.g., the Camorra). On the same vein, they also provide policy recommendations for law enforcement against drug cartels in Central and South America, especially in countries where there is no leniency program in place for criminal organizations.

The rest of the paper is organized as follows. Below, we relate our analysis to existing evidence and highlight our contribution to the literature. In Section 2 we lay down the baseline model. In Section 3 we study the optimal policy targeting an exogenously given (horizontal or vertical) organization, compare the results and discuss some implications for the optimal policy when the organizational structure is exogenous. In Section 4 we study, instead, the optimal policy when criminals can adapt the organization's structure to the policy set by the Legislator. We extend the baseline model and check its robustness in Section 5. Section 6 concludes. Proofs are in the Appendix.

Motivating evidence. There is a large literature in economics that studies the costs and benefits of alternative organizational forms — see, e.g., Aoki (1986), Bolton and Dewatripont

4

([1994](#)) and Aghion and Tirole ([1997](#)) among many others. In these models firms can either be organized vertically or horizontally and the extent to which they prefer one option rather than the other depends (among other things) on the accuracy of their members' (private) information, as well as the allocation of authority among them. Criminologists have long realized that similar conclusions can be drawn for group context delinquency. Criminal organizations, indeed, are very likely to face the same decision making process of traditional firms, with aspects such as the level of trust and cohesion among their members being an important determinant of their organizational decisions and profitability — see, e.g., Best and Luckenbill ([1981](#)), Cressey ([1972](#)), Decker and Van Winkle ([1996](#)), Wilson and Donald ([1999](#)), and Reiss Jr ([1988](#)) among many others.

These theories have inspired an empirical literature trying to validate their conclusions. Catino ([2014](#)), for example, documents a significant heterogeneity in the type of organizational structure of the Italian main mafia groups. Mafias with a vertical internal structure — e.g., the Cosa Nostra in Sicily — feature higher levels of coordination, centralized power and decision making processes. By contrast, mafias with a horizontal structure — e.g., the Camorra in Campania — are characterized by the absence of higher levels of coordination and a more equal distribution of power and decision making rights — see, e.g., also Mallory ([2011](#)). He argues that vertical organizations are (on average) more resilient to State repression, although they are more visible and therefore their members can be targeted more easily by law enforcers. Similarly, in Latin America, drug cartels do not always feature a traditional pyramidal, top-down structure — see, e.g., Benson and Decker ([2010](#)) among others. While some cartels have a vertical structure (e.g., the Cali and the Medellin cartels), there is large evidence of cartels switching from a vertical to a horizontal structure after the war on drugs in Mexico (e.g., the Sinaloa cartel).[2] Terrorist groups and street gangs are other examples of illegal organizations whose internal structure is often not necessarily pyramidal — see, e.g., Baccara and Bar-Isaac ([2008](#)). Moreover, international terrorist organizations have been shown to adapt their organizational structure to law enforcement policies (see Kenney ([2003](#)) and Brinton Milward and Raab ([2006](#))).

Related literature. Our paper has obvious connections with the economic literature dealing with organized crime. In this literature Jennings ([1984](#)), Polo ([1995](#)), Konrad and Skaperdas ([1997](#)) and Garoupa ([2000](#)) were the first to model criminal organizations as vertical hierarchies whose heads need to discipline their subordinates, but cannot do so by relying on legally binding contracts. Hence, while these models focus on the enforcement costs of collective decision making in criminal organizations, they neglect the role of leniency programs as a tool for generating conflict within these organizations, which is instead the starting point of our analysis.

---

[2]See Morton ([2012](#)), Kenney ([2003](#)). See also: https://www.thecipherbrief.com/column_article/the-structure-and-psychology-of-drug-cartels http://www.businessinsider.com/colombia-criminal-cartel-world-changes-after-pablo-escobar-was-killed-2017-2?IR=T

As mentioned before, the idea of applying leniency programs to criminal organizations builds upon the antitrust law enforcement literature, which studies the effects of reduced sanctions on cartel formation in oligopolistic markets — see, e.g., Motta and Polo (2003) and Spagnolo (2003), Rey (2003), Spagnolo (2008), Aubert et al. (2006), Chen and Harrington Jr (2007), Chen and Rey (2013) and Harrington (2008) among many others.[3] The main difference between this literature and papers that deal with organized crime is that while cartels are horizontal institutions, criminal organizations are typically hierarchical. The optimal design of leniency programs meant to fight organized crime and collective delinquencies has recently been discussed in Acconcia et al. (2014), who also provide an empirical analysis of the phenomenon, Piccolo and Immordino (2017), who emphasize the benefits and the costs of these programs when whistle-blowers can hide their insider information, and Gamba et al. (2018) studying the effect of corruption on the optimal design of leniency programs. In all these papers criminal organizations are modeled exclusively as vertical hierarchies. Hence, their assessment of the effects of leniency programs does not capture the implications triggered by the endogenous choice of the organizational structure, which is the key point of our paper. The closest models are Buccirossi and Spagnolo (2006) and Baccara and Bar-Isaac (2008), which study different organizational aspects of organized crime. Buccirossi and Spagnolo (2006) focus on the relationship between leniency programs and the self-enforceability of the implicit agreements between criminal partners through repeated interaction. In this context the information that wrongdoers have on each other is used as a credible threat to govern the illegal exchange and punish failures to comply with the agreement. For simplicity we restrict attention to a static context in which this hold-up problem is absent; yet differently from them, our novelty is the comparison between different organizational structures. Baccara and Bar-Isaac (2008) instead explain the wide heterogeneity across the information structures of different criminal organizations, by showing that, depending on the nature and intensity of external threats, illegal organizations may strategically dole out the amount of information shared along their echelons to minimize the impact of different enforcement policies on their profitability. Our model is inspired by their work and builds on the idea that criminals might react to the legal environment by restructuring their internal organization and decision making rules. However, while Baccara and Bar-Isaac (2008) do not consider leniency programs, the objective of our paper is precisely to understand the interplay between amnesties and the optimal design of group delinquency.

2 The baseline model

Environment. Consider a simple game played by two criminals (each denoted by $i = 1, 2$) and a benevolent Legislator.

---

[3]Related and more recent models are offered by Harrington (2013), Sauvagnat (2014, 2015) and Silbye (2010).

The Legislator, having forbidden welfare reducing acts, designs a leniency program with the goal of deterring crime. The two criminals must collaborate in order to commit the crime. Indeed, criminal organizations typically specialize in illegal activities that require large scale operations — e.g., drug and weapon trafficking, money laundering, extortions, control of prostitution, waste diversion etc. — which are too complex to be managed by a single offender.[4]

The organization structure can be of two types. The first option is a partnership where the two criminals are in a symmetric position in the organization — i.e., they jointly plan and commit the crime, they have the same decision rights and they equally split the monetary return from the crime. As mentioned above, some mafia syndicates show an horizontal structure. e.g., Camorra. Other smaller but very common examples of partnerships are street gangs, usually defined as self-formed associations of peers united by mutual interests, who act collectively to conduct illegal activities — see, e.g., Miller (1992). Criminal organizations with such a horizontal structure are characterized by the absence of higher levels of coordination, and the use of distributed power and clan-based decision-making processes — see, e.g., Catino (2014). The second option is a vertical hierarchy, in which the two criminals are in a principal-agent type of relationship. The head of the organization (the boss) operates behind the scenes, while the crime is materially committed by his fellow (the soldier). We assume, without loss of generality, that the boss has full bargaining power and makes a take-it or leave-it offer to the soldier.[5] The offer consists of a wage (w) to be paid after the crime is committed. Classical examples of criminal organizations based on the presence of higher levels of coordination, centralized power and decision-making are the Sicilian Mafia (Cosa Nostra) and the Japanese Yakuza.

Uncertainty. There are two sources of uncertainty in the model. The first reflects the stochastic monetary return from the crime, hereafter π, which distributes over the support $[0, \bar{\pi}]$ with cumulative distribution function $G(\pi)$ and density $g(\pi)$. The second captures the extent to which the two criminals are loyal one to another — i.e., their degree of cohesion or *omertà* — which can be either influenced by (persistent) cultural and historical factors (jointly determining the roots of organized crime in a society) or by the strength (ability) of these organizations in punishing betrayals.[6] Accordingly, in order to capture the idea that unilateral defections are costly to mafia members we assume that a criminal incurs a loss θ if he blows the whistle while the other does not. For simplicity, we assume that in a

---

[4]According to Warr (2002), offending groups tend to be relatively small, between two and four individuals, even though these groups of offenders are typically nested in larger groups of associates, many of whom are also involved in crime or delinquency.

[5]In Section (5.1) we show that the model's results do not depend on the bargaining power of the boss vis-à-vis the soldier.

[6]*Omertà* is, indeed, typically understood as a mix between the expression of social consensus surrounding the Mafia (i.e., a collective attitude towards the criminal culture) and a rational response to the fear of retribution.

vertical hierarchy the soldier always bears this cost by assumption (we relax this assumption in Section 5.4). The parameter θ is a common shock drawn from the support $\left[0, \bar{\theta}\right]$ with cumulative distribution function $F(\theta)$ and density $f(\theta)$.

Both criminals have the same reservation utility, which is normalized to zero. Moreover, as the two criminals are identical, for simplicity (and without loss of generality) we assume that the choice of organizational structure and the decision about whether committing the crime are taken by criminal 1. Notice however that our results would not change if these decisions were taken by one of the two criminals at random. As a result, criminal 2 is either hired as a soldier or as a partner depending on criminal 1's decision.

Conviction technology. Since both types of organization commit the same crime, to simplify exposition, we normalize sanctions to 1 regardless of the criminal's role in the organization. Let $\phi \geq 0$ be the amnesty granted by the Legislator to a criminal who blows the whistle. The conviction probabilities depend on the players' behavior, the type of criminal organization and the Legislator's amnesty choice.

- **Partnership**. Each criminal is convicted with probability $1 - p$ if nobody blows the whistle. Following the literature — e.g., Harrington (2013), and Chen and Rey (2013) — we assume that each criminal is granted an amnesty $\frac{\phi}{2}$ if both cooperate.[7] Finally, if only one criminal blows the whistle he is granted an amnesty ϕ, the criminal who does not confess is convicted with probability 1.

- **Vertical hierarchy.** Following the literature (e.g., Acconcia et al. (2014), Baccara and Bar-Isaac (2008), Piccolo and Immordino (2017), and Gamba et al. (2018)), we assume that the boss is never convicted if the soldier does not blow the whistle, while the soldier is convicted with probability $1 - p$. By contrast, if the soldier blows the whistle, the boss is convicted with probability $q \leq 1$. As a prize for his cooperation, the soldier (criminal 2 by assumption) is granted amnesty ϕ.

The information structure of the game builds on the idea that hierarchical organizations are arms length relationships (compared to horizontal ones). Soldiers operating at the bottom of the chain of command know less about their heads compared to partnership members who are in a closer relationship, and thus know more about each other. Therefore, the parameter q will be interpreted as a measure of the accuracy of the evidence that the soldier can disclose to prosecutors about the boss. For the moment we posit that the boss never blows the whistle. This assumption is consistent with the anecdotal evidence showing that these people hardly cooperate with justice, even after being convicted and jailed — e.g., because they have sufficiently high reputation costs that are not internalized by the fellow (we will relax this assumption in Section 5.4).

---

[7]Alternatively, one could imagine that full amnesty ϕ is granted to the first informant only, and that when both criminals blow the whistle each one of them wins with probability $\frac{1}{2}$.

It should be noted that the antitrust debate after Motta and Polo (2003) — see, e.g., Spagnolo (2003), and the recent experimental studies by Hinloopen and Soetevent (2008) and Bigoni et al. (2012) among others — clarified that there is a marked difference between ex-post and ex-ante leniency — i.e., amnesties offered to cartel members only after being caught by the police and leniency for 'spontaneous' self-reporting.[8] In our model these two instruments are equivalent since criminals are investigated with probability 1. This assumption is meant to capture the idea that the members of criminal organizations who materially infringe the law sooner or later are caught, as opposed to their heads acting behind the scenes. Moreover, while the possibility of spontaneous cooperation seems realistic for cartel and corruption cases, it appeals less to our organized crime framework. As a matter of fact, most of the informants cooperating with justice in criminal proceeding were first captured and sentenced and then eventually started to cooperate. This explains why we focus on a timing where criminals are first prosecuted and then choose whether to blow the whistle or not.

Timing. The timing of the game is as follows:

τ=0 The Legislator commits to an amnesty $\phi \geq 0$.[9]

τ=1 The random variables π and θ materialize. Criminals learn their realizations and decide whether to commit the crime and, if so, they also choose whether to set up a partnership or a vertical organization. In the latter case, criminal 1 offers a wage w to criminal 2. If the offer is rejected the game ends. Otherwise, once the illegal act is committed, the wage w is paid and the game proceeds to the next stage.

τ=2 A case against the organization opens. Criminals can opt to cooperate with justice.[10]

τ=3 The trial uncertainty resolves and sanctions are imposed.

The solution concept is Subgame Perfect Nash Equilibrium.

Payoffs. All players are risk neutral. Hence, sanctions are interpreted as the monetary equivalent of the imprisonment terms, fines, damages, and so forth, to which the criminals expose themselves. The payoffs of the criminals before the trial uncertainty is resolved are as follows.

---

[8] A serious concern in the Antitrust law enforcement (and more recently in the corruption literature, see, e.g., Dufwenberg and Spagnolo (2015)), is that focusing only on ex post leniency may weaken deterrence by providing extra insurance to criminals — i.e., the opportunity of obtaining lighter sanctions after committing the crime may drastically weaken deterrence. We would like to thank Giancarlo Spagnolo for pointing this out.

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

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

- **Partnership.** Conditional on the crime being committed, each member obtains a utility $\frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right)$ if both criminals blow the whistle. They obtain $\frac{\pi}{2} - (1 - p)$ if nobody blows the whistle. Finally, if only one criminal blows the whistle, he obtains $\frac{\pi}{2} - (1 - \phi) - \theta$ while the other criminal gets $\frac{\pi}{2} - 1$.

- **Vertical hierarchy.** Conditional on the crime being committed, the soldier's utility is $w - (1 - \phi) - \theta$ if he blows the whistle; otherwise, if he remains loyal to the boss, his utility is $w - (1 - p)$. The boss's utility is $\pi - w - q$, if the fellow blows the whistle, while he gets $\pi - w$ when the fellow does not flip.

The Legislator's objective function is to minimize the probability that the crime is committed.

Assumptions. We impose the following simplifying assumptions:

A1 *Tie-breaking*: Whenever indifferent between joining the program and facing the trial, criminals prefer the former option. Moreover, when indifferent between forming a partnership or a vertical organization, criminals prefer the former option.[11]

These are just two convenient tie-breaking conditions.

A2 *No rewards:* $\phi \in [0, 1]$.

This assumption implies that the fellow cannot enjoy (monetary) rewards from cooperating with justice, which may reflect legislative constraints due to political and ethical concerns.

To rule out uninteresting corner solutions we also assume that

A3 $\bar{\theta} > 1 - p$ and $p \geq \frac{1}{2}$.

Assuming that $\bar{\theta}$ is sufficiently large guarantees that criminals with a sufficiently large cost of betrayal remain loyal one another even when they are granted full amnesty. Assuming that p is not too small guarantees that, in a partnership, there exists an equilibrium of the reporting (sub)game in which the two partners do not cheat on each other.[12]

Finally, in order to guarantee that the Legislator's optimization problem is well behaved we impose the following (sufficient) conditions for optimality:

A4 $g(\cdot)$ and $f(\cdot)$ are non-increasing.

This assumption implies that the total amount of crime in the economy is always (i.e., regardless of the organization type) a convex function of the amnesty ϕ. Notice that **A4** also implies that the inverse hazard rates of $F(\cdot)$ and $G(\cdot)$ are increasing: a standard hypothesis in the literature.

---

[11]Of course, we also assume that when indifferent between committing the crime and being honest, criminals prefer the former option.

[12]We chose this restriction to simplify the presentation of the results. As we show in Section 5, the opposite case in which such a cooperative equilibrium does not exist and partnership members always blow the whistle ($p < \frac{1}{2}$) leads to the same results as in the baseline model.

3 Exogenous organization form

In order to gain intuition on the trade off that shapes the optimal amnesty when criminals can adapt the organization's structure to the policy set by the Legislator we first consider a simpler environment in which the organization structure is exogenous. Namely, we assume that criminals are either in a partnership or in a vertical relationship. For each case we characterize the crime minimizing amnesty and determine its bright and dark side. We will then compare results and study under which conditions fighting vertical organizations requires more (resp. less) leniency than fighting partnerships.

3.1 Partnerships

Suppose that criminals operate as a partnership. We first characterize the criminals' reporting behavior in the subgame following the announcement of a policy and then determine the amnesty that minimizes the probability that the partnership is formed — i.e., the optimal policy against horizontal mafias.

The payoff matrix of this simultaneous reporting game is as follows:

Criminal 2

		Talk	No talk
Criminal 1	Talk	$\frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right), \frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right)$	$\frac{\pi}{2} - \phi - \theta, \frac{\pi}{2} - 1$
	Not Talk	$\frac{\pi}{2} - 1, \frac{\pi}{2} - \phi - \theta$	$\frac{\pi}{2} - (1-p), \frac{\pi}{2} - (1-p)$

For any $\phi \geq 0$, it can be easily shown that there always exists an equilibrium in which both criminals blow the whistle. Indeed, a criminal's utility from self-reporting (given that the partner does so too) is always larger than the utility of not cooperating with justice and being sentenced with certainty — i.e.,

$$\frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right) \geq \frac{\pi}{2} - 1 \quad \Leftrightarrow \quad \phi \geq 0. \tag{1}$$

The intuition is simple. When a leniency program is in place each criminal has an incentive to blow the whistle if he expects the partner to do so. This echoes the so-called "rush to the courthouse" effect found in the antitrust enforcement literature: the ability to induce cartel members to self-report and betray their partners for fear of being otherwise betrayed by them.[13] This simple logic also implies that there cannot exist asymmetric equilibria in which only one criminal blows the whistle: a standard prisoner dilemma. Indeed, while the

---

[13]As stated by the Director of Criminal Enforcement at the Antitrust Division of the U.S. Department of Justice, Scott D. Hammond "The Amnesty Programme... sets up a race, and this dynamic leads to tension and mistrust among the cartel members" (United States Department of Justice website, http://www.justice.gov/atr/speech/when-calculating-costs-and-benefits-applying-corporate-amnesty-how-do-you-put-p rice-tag). See also Harrington (2008) and Kohn (2001).

criminal who (in equilibrium) is supposed to blow the whistle has no incentive to deviate when θ is not too large, the criminal who (in equilibrium) is expected not to blow the whistle always gains from deviating because he can enjoy an amnesty $\frac{\phi}{2}$ rather than being sentenced with certainty (as implied by condition (1)).

Next, consider an equilibrium in which nobody cooperates with justice. This equilibrium exists if and only if the members of the partnership are sufficiently loyal to one another — i.e.,

$$\frac{\pi}{2} - (1-p) > \frac{\pi}{2} - (1-\phi) - \theta \quad \Leftrightarrow \quad \theta > \underline{\theta}(\phi) \triangleq \max\{0, \phi - p\}. \tag{2}$$

As intuition suggests, condition (2) is more difficult to be satisfied the larger the amnesty (higher ϕ) and the lower the risk of conviction (higher p). Notice that in the region of parameters where (2) holds, the reporting game features multiple equilibria — i.e., one in which both criminals blow the whistle and the other in which they don't. How will they play in this case? In order to address this issue we use a refinement based on Pareto dominance (in Section 5.3 we show that using an alternative selection criterion based on risk dominance does not change the results of the analysis). Accordingly, it is easy to show that the selected equilibrium is the one in which the two criminals do not blow the whistle if and only if

$$\frac{\pi}{2} - (1-p) \geq \frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right) \quad \Leftrightarrow \quad \phi \leq 2p. \tag{3}$$

The intuition is straightforward. The two criminals are better off when nobody blows the whistle if the probability of not being sentenced p is higher than the amnesty $\frac{\phi}{2}$ that each one of them would be granted if both cooperate with justice. Notice that (3) is always true since $\phi \leq 1$ by assumption **A2** and $p \geq \frac{1}{2}$ by assumption **A3**. Hence, whenever the no-reporting equilibrium exists — i.e., for $\theta > \underline{\theta}(\phi)$ — it also Pareto dominates the equilibrium in which both criminals blow the whistle (in Section 5.2 we generalize the analysis to the case where $p < \frac{1}{2}$). Summing up, we can state the following:

Lemma 1 *When $\theta > \underline{\theta}(\phi)$ the partnership is strong — i.e., no criminal blows the whistle. By contrast, if $\theta \leq \underline{\theta}(\phi)$ the partnership is weak — i.e., both criminals blow the whistle.*

Obviously, when the amnesty is small enough ($\phi < p$) the policy is ineffective since criminals always coordinate on the no-reporting equilibrium. In this case the partnership is always strong, and the leniency program has no effect on deterrence. Consequently, the utility of each partner is equal to

$$u^P(\theta) \triangleq \begin{cases} \frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right) & \text{if } \theta \leq \underline{\theta}(\phi) \\ \frac{\pi}{2} - (1-p) & \text{if } \theta > \underline{\theta}(\phi) \end{cases}.$$

When the organization is weak both partners blow the whistle: the cost of committing the crime decreases with the amnesty granted by the Legislator. When the organization is strong

there is no reporting, and the cost of committing the crime decreases with the probability p of not being convicted.

Members of a partnership commit the crime if and only if $u^P(\theta) \geq 0$. Therefore the resulting harm for society — i.e., the crime rate — is equal to

$$\mathcal{H}^P(\phi) \triangleq \underbrace{\int_0^{\underline{\theta}(\phi)} \int_{2-\phi} dG(\pi)\,dF(\theta)}_{\text{Weak partnership}} + \underbrace{\int_{\underline{\theta}(\phi)} \int_{2(1-p)} dG(\pi)\,dF(\theta)}_{\text{Strong partnership}}.$$

Intuitively, by increasing ϕ the Legislator affects the crime rate via two different channels. First, it reduces the probability of facing a strong partnership since $\underline{\theta}(\phi)$ increases with ϕ: the bright side of leniency. Second, it also reduces the cost of crime for weak organizations: as ϕ grows large the criminals are more willing to commit the crime because they will be charged lighter sanctions, yielding the dark side of leniency.

The optimal policy solves the following minimization problem

$$\min_{\phi \in [0,1]} \mathcal{H}^P(\phi). \tag{4}$$

Differentiating with respect to $\phi \geq p$ and rearranging, we can easily identify the two effects discussed above:[14]

$$\mathcal{H}^P_\phi(\phi) = \underbrace{-f(\phi-p)\left[G(2-\phi) - G(2(1-p))\right]}_{\text{Bright side}} + \underbrace{\int_0^{\phi-p} g(2-\phi)\,dF(\theta)}_{\text{Dark side}}. \tag{5}$$

Interestingly, the bright side of leniency is a function of the difference between the probability of weak partnerships not being profitable $\Pr[\pi < 2-\phi] = G(2-\phi)$ and the probability of strong partnerships not being profitable $\Pr[\pi < 2(1-p)] = G(2(1-p))$. Increasing ϕ makes some organizations weaker, which negatively affects their choice to start a criminal venture when the crime return is larger than $2(1-p)$ and lower than $2-\phi$. This is because they would commit crimes if they were strong, but dont when they are weak. If these two terms were equal, the policy would only have a positive effect on the crime rate since, in terms of costs, weak and strong organizations would become too similar, which indeed makes the policy ineffective. When ϕ grows this difference drops, hence the bright side of leniency weakens.

We can thus show the following.

Proposition 2 *The solution of* (4), *hereafter* ϕ^P, *is always larger than* p. *Moreover,* ϕ^P *is*

---

[14]When $\phi < p$, the derivative is 0.

increasing in p and solves

$$\frac{G\left(2-\phi\right)-G\left(2\left(1-p\right)\right)}{g\left(2-\phi\right)}=\frac{F\left(\phi-p\right)}{f\left(\phi-p\right)},\tag{6}$$

if and only if $p\in\left[\frac{1}{2},\overline{p}\right)$, with $\overline{p}\in\left(\frac{1}{2},1\right)$ being the unique solution of

$$\frac{G\left(1\right)-G\left(2\left(1-p\right)\right)}{g\left(1\right)}=\frac{F\left(1-p\right)}{f\left(1-p\right)}.\tag{7}$$

Otherwise, $\phi^P=1$.

As intuition suggests, setting $\phi < p$ is never optimal because, in this case, the criminals would always coordinate on the bad equilibrium in which they never cooperate with justice. The optimal amnesty is increasing in p for two reasons. First, as p grows large it is less likely to face weak partnerships — i.e., $\underline{\theta}(\phi)$ decreases, so the dark side becomes relatively small. Second, for larger values of p the bright side amplifies because the expected cost of setting up vertical organizations decreases. Clearly, when p approaches 1, criminals are never convicted and the dark side vanishes, because the organization is always strong. The Legislator sets the possible largest amnesty, $\phi^P = 1$, in order to induce them to talk.

Example. To develop an example with a closed-form solution, suppose that π is uniformly drawn on the unit support $[0,1]$ and that θ is distributed on $[0,1]$ according to the beta distribution, which is $\theta \sim \text{Beta}\left[1,\lambda^{-1}\right]$, such that $F\left(\theta\right)=\theta^{\frac{1}{\lambda}}$ and $\frac{F(\theta)}{f(\theta)}=\lambda\theta$ and $\lambda \geq 0$ — see, e.g., Miravete (2002). Since $F\left(\theta\right)$ is increasing in λ, distributions parametrized by a lower value of λ first-order stochastically dominate those parametrized by higher values of λ.[15] This implies that, as λ increases, criminals are less likely to be loyal to each other. When $\lambda = 1$, the beta distribution converges to the uniform distribution. Conditions (6) and (7) then yield

$$\phi^P=\begin{cases} 1 & \text{if } p\geq\overline{p} \\ \frac{p}{\overline{p}} & \text{if } p<\overline{p} \end{cases},$$

where $\overline{p}\triangleq\frac{1+\lambda}{2+\lambda}$.

Notice that ϕ^P is (weakly) decreasing in λ and (weakly) increasing in p. As λ grows large the dark side of leniency magnifies — i.e., the inverse hazard rate $\frac{F(\theta)}{f(\theta)}=\lambda\theta$ grows large. In order to understand this effect suppose that λ is very large, so that it is very unlikely that the partnership is strong. In this case, there is no point for the Legislator to increase ϕ since this would have mainly the effect of reducing the criminals' expected sanction, whereby increasing the crime rate.

---

[15]This holds because $\frac{\partial F(\theta)}{\partial\lambda}=-\frac{\theta^{\frac{1}{\lambda}}}{\lambda^2}\ln\theta>0$ and $\theta\in[0,1]$.

3.2 Vertical hierarchies

Suppose now that criminals are organized as a vertical hierarchy. In this case, only the soldier has the option of blowing the whistle and he will do so when he is sufficiently disloyal — i.e., if and only if

$$w - (1 - \phi) - \theta \geq w - (1 - p) \quad \Leftrightarrow \quad \theta \leq \underline{\theta}(\phi).$$

Hence, once again, the organization is weak if θ is low enough to induce the soldier to cooperate with justice, and strong otherwise.

Moving backward to the boss' decision problem, the soldier's reservation wage — i.e., the wage level that makes him indifferent between accepting and rejecting the boss' offer — is equal to

$$\underline{w}(\theta) \triangleq \begin{cases} (1 - \phi) + \theta & \text{if } \theta \leq \underline{\theta}(\phi) \\ 1 - p & \text{if } \theta > \underline{\theta}(\phi) \end{cases},$$

while the boss' expected utility (substituting the soldier's reservation wage) is equal to

$$u^B(\theta) \triangleq \begin{cases} \pi - (1 - \phi) - \theta - q & \text{if } \theta \leq \underline{\theta}(\phi) \\ \pi - (1 - p) & \text{if } \theta > \underline{\theta}(\phi) \end{cases}.$$

Therefore, the boss decides to commit the crime if and only if $u^B(\theta) \geq 0$. The cost of crime for a weak organization is decreasing in ϕ, and increasing both in the accuracy q of the soldier's insider information and the degree of *omertà* θ. The comparative statics on ϕ and q are rather intuitive. If the soldier is granted a higher amnesty his reservation wage will be lower because the boss anticipates that he will blow the whistle and, by doing so, obtains a *rent* that can be extracted with a lower wage. By contrast, as the soldier becomes more informed about the boss, the latter's conviction risk increases making the crime less profitable. The parameter θ affects the boss' utility in two ways. First, there is a negative effect of θ on the profitability of crime for weak organizations: committing the crime is more costly when criminals become more loyal to each other. This is because a higher θ erodes the benefit in terms of amnesty that the boss can extract from the soldier via a lower wage which therefore makes the crime relatively more costly. Secondly, a higher θ can make the organization switch from weak to strong ($\theta > \phi - p$), which has a positive effect on the utility of the boss, as the costs of weak organizations are larger than the ones of strong ones — i.e.

$$(1 - \phi) + \theta + q > 1 - p \Leftrightarrow \theta > \phi - p - q.$$

The corresponding crime rate is

$$\mathcal{H}^V(\phi) \triangleq \underbrace{\int_0^{\overline{\theta}(\phi)} \int_{1-\phi+\theta+q} dG(\pi)\, dF(\theta)}_{\text{Weak hierarchy}} + \underbrace{\int_{\underline{\theta}(\phi)} \int_{1-p} dG(\pi)\, dF(\theta)}_{\text{Strong hierarchy}}.$$

As before, increasing ϕ has two effects on the crime rate. It determines the proportion of weak and strong organizations — hence the mass of whistle-blowers — but it also lowers the reservation wage that the soldier must be offered in order to enter a weak organization. The optimal policy trades off these two opposite forces solving the following minimization problem

$$\min_{\phi \in [0,1]} \mathcal{H}^V(\phi). \tag{8}$$

Differentiating with respect to $\phi \geq p$ we have the following expression:[16]

$$\mathcal{H}_\phi^V(\phi) = \underbrace{-f(\phi-p)\left[G(1-p+q) - G(1-p)\right]}_{\text{Bright side}} + \underbrace{\int_0^{\phi-p} g(1-\phi+\theta+q)\, dF(\theta)}_{\text{Dark side}}.$$

Again, leniency has a bright as well as a dark side. On the one hand, by increasing the probability that the soldier blows the whistle — i.e., by increasing the probability that the organization is weak — a higher amnesty increases the boss' expected sanction, whereby reducing his net return from crime. On the other hand, a higher amnesty also reduces the soldier's reservation wage when the organization is weak which in turn induces the boss to be more willing to commit the crime.

As in the case of partnerships, the bright side depends on the difference between the probability of weak organizations not being profitable $G(1-p+q)$ and the probability of a strong partnership not being profitable $G(1-p)$. Indeed, a larger leniency makes organizations with the marginal type $\theta = \phi - p$ become weak, whereby negatively affecting their choice of starting a criminal activity, when their returns from crime are higher than $1-p$ and lower than $1-p+q$ (the costs of committing a crime for strong and weak organizations respectively). Notice that, in contrast to the case of a partnership, with a vertical organization this difference does not depend on ϕ because criminals with the marginal type $\theta = \phi - p$ completely internalize the amnesty through a higher personal cost of disloyalty. Moreover the bright side depends on the amount of information q that the soldier has on the boss. Clearly, the higher q, the less profitable a weak organization is compared to a strong one, and this magnifies the bright side of leniency. At the limit when $q \to 0$ the bright side of leniency collapses: increasing ϕ for the Legislator has no value since the two types of organization have the same costs.

We can show the following result.

---

[16]For $\phi < p$, the derivative is equal to 0.

Proposition 3 *The solution of* (8), *hereafter* ϕ^V, *is always larger than* p. *Moreover,* $\phi^V < 1$ *if and only if*

$$G\left(1-p+q\right)-G\left(1-p\right) < \int_0^{1-p} \frac{g\left(\theta+q\right)}{f\left(1-p\right)} dF\left(\theta\right). \tag{9}$$

In this region of parameters ϕ^V *solves*

$$G\left(1-p+q\right)-G\left(1-p\right) = \int_0^{\phi-p} \frac{g\left(1-\phi+\theta+q\right)}{f\left(\phi-p\right)} dF\left(\theta\right), \tag{10}$$

and is increasing in q *and* p. *Otherwise,* $\phi^V = 1$.

As already discussed the bright side of leniency is increasing in the accuracy (q) of the soldier's insider information and vanishes when $q \to 0$ since, in this limiting case, the soldier's testimony in trial is useless. However, also the dark side is affected by q since this probability affects the profit that the boss obtains in a weak organization: the higher the probability of being sentenced if the fellow blows the whistle, the lower his willingness to start the business. Hence, the optimal amnesty with only vertical hierarchies is increasing in q.

Example. To obtain a closed-form solution, suppose again that π is uniformly drawn on the unit support $[0,1]$ and that θ is distributed on $[0,1]$ according to the beta distribution $\theta \sim \text{Beta}\left[1, \lambda^{-1}\right]$. Then, solving (10) we have

$$\phi^V = p + \frac{q}{\lambda},$$

which is lower than 1 if and only if $\lambda > q$ and $p < \frac{\lambda-q}{\lambda}$.

Moreover, the optimal amnesty is (weakly) decreasing in λ and (weakly) increasing in p and q. The intuition is the same as before.

3.3 Comparison

We now compare the outcomes characterized above. Specifically, we study the following question: other things being equal, which type of criminal organization induces the Legislator to grant a more generous amnesty? In order to tackle this issue it is useful to start the analysis by comparing the bright sides of leniency in the case of a vertical hierarchy and a partnership. To this purpose, we study the sign of the following difference:

$$\Delta B\left(\phi\right) \triangleq G\left(1-p+q\right)-G\left(1-p\right)-\left(G\left(2-\phi\right)-G\left(2\left(1-p\right)\right)\right).$$

We can state the following:

Proposition 4 *For any* $\phi \in [0,1]$, *there exists a threshold* $q^B \in (0,1)$ *such that* $\Delta B\left(\cdot\right) \geq 0$

if and only if

$$q \geq q^B \triangleq \Phi \left(G(2 - \phi) - \int_{1-p}^{2(1-p)} g(\pi) \, d\pi \right) - (1 - p),$$

with $\Phi(\cdot) \triangleq G^{-1}(\cdot)$.

The intuition is straightforward. A leniency program meant to fight vertical hierarchies is relatively less effective when the soldier's information about the boss is not too accurate. To understand why, consider q close to 0 — i.e.,

$$\lim_{q \to 0} G(1 - p + q) - G(1 - p) = 0 < G(2 - \phi) - G(2(1 - p)).$$

In this case, the soldier's reporting decision has no impact on the boss' conviction risk, meaning that (other things being equal) the boss is not harmed by the soldier's decision to cooperate with justice. Hence, for q relatively small a leniency program is more effective when it is meant to disrupt a partnership rather than a vertical hierarchy.

By contrast, the bright side of leniency is higher with a vertical organization when q is close to 1 — i.e.,

$$\lim_{q \to 1} G(1 - p + q) - G(1 - p) > G(2 - \phi) - G(2(1 - p)).$$

Intuitively, this is because while the boss operates behind the scenes and is (typically) very hard to convict (unless the soldier flips and cooperates with justice), a partnership can be dissolved with (relatively) low amnesties owing to the prisoner dilemma game played by its members.

Next, consider the dark side of leniency. We are interested in studying the sign of the following difference:

$$\Delta D(\phi) \triangleq \int_0^{\phi - p} g(1 - \phi + \theta + q) \, dF(\theta) - \int_0^{\phi - p} g(2 - \phi) \, dF(\theta).$$

Recall that, regardless of the organization form, the dark side of leniency stems from the fact that, ceteris paribus, a larger ϕ reduces the criminals' expected sanctions, which in turn increases their profit from the crime. Clearly, the magnitude of this effect depends on the probability of the organizations being weak — i.e., the probability of at least one criminal blowing the whistle. As discussed above, the higher this probability, the lower the Legislator's incentive to grant a generous amnesty because of its negative effect on the cost of crime.

We can thus show the following.

Proposition 5 *For any $\phi \in [0, 1]$, there exists a threshold $q^D \in (0, 1)$ such that $\Delta D(\cdot) \geq 0$*

if and only if $q \leq q^D$. The threshold q^D is the unique solution of

$$\int_0^{\phi-p} \frac{g\left(1 - \phi + \theta + q\right)}{g\left(2 - \phi\right)} dF\left(\theta\right) = F\left(\phi - p\right).$$

The logic of this result is based on the simple idea that when q is small a weak vertical hierarchy is always more profitable than a weak partnership because the boss faces a relatively lower risk of conviction and, moreover, he can always internalize (via a lower wage) the benefits of a more generous policy on the soldier's sanction. Hence, other things being equal, it is relatively more costly for the Legislator to grant an amnesty when she faces a vertical hierarchy than a partnership.

Summing up, comparing the optimal leniency with a partnership and with a vertical hierarchy we can state the following result.

Proposition 6 $\phi^V > \phi^P$ *for* $q > \max\{q^B, q^D\}$. *By contrast,* $\phi^V < \phi^P$ *for* $q < \min\{q^B, q^D\}$.

To gain a clear intuition of this result it is useful to consider the extreme cases in which q is sufficiently small (resp. large). First, it should be clear that $\phi^P > \phi^V$ if $q \to 0$, since in this case the introduction of a leniency program with a vertical hierarchy has a negligible bright side, while it also has a higher dark side compared to the case of a partnership. By contrast, it should also be clear that $\phi^P < \phi^V$ as $q \to 1$; in this case, the introduction of a leniency program with a vertical hierarchy has a higher bright side and a lower dark side compared to the case of a partnership.

Clearly, it is hard to draw more precise implications when q takes intermediate values since we cannot compare q^D and q^B. However, there is an interesting limiting case that delivers clear cut predictions.

Lemma 7 *Assume that* $g'\left(\cdot\right) \approx 0$, *then* $\phi^V > \phi^P$ *if and only if* $q > q^B$.

Example. The condition stated in the lemma holds, for instance, when $G\left(\cdot\right)$ is uniform. To perform simple comparative statics on the difference between ϕ^V and ϕ^P, assume also that $\theta \sim \text{Beta}\left[1, \lambda^{-1}\right]$. As shown in Lemma (7) with this specification, only the bright side of leniency matters — i.e., $\Delta D\left(\phi\right) = 0$ for any given ϕ. Hence, assuming interior solutions we have

$$\phi^V - \phi^P > 0 \quad \Leftrightarrow \quad q > \overline{q} \triangleq \frac{\lambda}{1 + \lambda} p. \tag{11}$$

In Figure 1 we compare ϕ^V with ϕ^P in the space $(p, q) \in [0, 1]^2$.

The figure has a simple interpretation. When the accuracy of the soldier's information is sufficiently large, fighting a vertical organization requires a more generous amnesty than fighting a partnership. The reason has been discussed before: other things being equal, attracting better informed soldiers is more effective for the Legislator than attracting partners, who would be stuck in a prisoner dilemma game anyway. Interestingly, condition (11)

Figure 1: COMPARISON
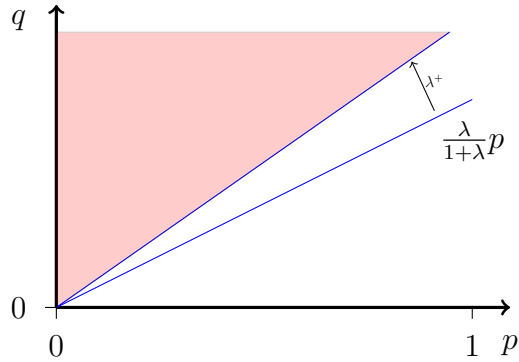
is harder to satisfy when both p and λ grow large. Indeed, as p grows, fighting a partnership becomes relatively more profitable for the Legislator because the bright side of leniency for vertical organizations does not depend on p — i.e.,

$$G\left(1 - p + q\right) - G\left(1 - p\right) = q.$$

By contrast, the bright side of leniency against partnerships increases with p — i.e.,

$$G\left(2 - \phi\right) - G\left(2\left(1 - p\right)\right) = 2p - \phi.$$

Finally, as λ grows large, criminals are more likely to be loyal to each other. Hence, while the soldier requests a large amnesty in order to be willing to flip, a lower amnesty is requested to trigger a courthouse race game between the partnership members.

4 Endogenous structure and optimal leniency

We now turn to study the amnesty that minimizes the total amount of crime in an economy where the organization structure of the criminals is endogenous and responsive to the policy. Notice that differently from the existing literature in which criminal organizations cannot adapt their internal structure to the intensity of the leniency policy — e.g., Gamba et al. (2018), Acconcia et al. (2014) and Piccolo and Immordino (2017) — in our environment the effect of the policy can be neutralized, or even subverted by the choice of a suitable organization structure (as briefly explained after Figure 1) weakening the Legislator's first-mover advantage. The extent to which this new channel reduces the effectiveness of the policy depends on the interplay between the following effects. First, the impact of the amnesty on the probability of weak organizations — i.e., the bright side of leniency. Second, its impact on (lowering) the costs of the criminal organizations that emerge in equilibrium — i.e., the dark side of leniency. Third, the criminals' ability to bypass the policy by choosing the

organization structure as a best reply to the amnesty announced by the Legislator.

The game is solved by backward induction. Without loss of generality, from now on, we focus on $\phi \geq p$ otherwise the policy would not induce criminals to blow the whistle in either type of organization.

The utility of each member in a partnership is

$$u^P(\theta) \triangleq \begin{cases} \frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right) & \text{if } \theta \leq \underline{\theta}(\phi) \\ \frac{\pi}{2} - (1 - p) & \text{if } \theta > \underline{\theta}(\phi) \end{cases}.$$

The utility of the boss ruling a vertical hierarchy is

$$u^V(\theta) \triangleq \begin{cases} \pi - (1 - \phi) - q - \theta & \text{if } \theta \leq \underline{\theta}(\phi) \\ \pi - (1 - p) & \text{if } \theta > \underline{\theta}(\phi) \end{cases}.$$

Comparing these two expressions we obtain the following immediate result.

Lemma 8 *Strong organizations — i.e., such that $\theta \geq \underline{\theta}(\phi)$ — are always organized as vertical hierarchies.*

The intuition is straightforward. Recall that the boss is never convicted when he rules a strong vertical hierarchy, whereas with a partnership both criminals face the same (positive) risk of conviction $1 - p$. Hence, a vertical hierarchy creates a higher total surplus (net of the expected sanctions) for the two criminals. As a result, keeping the soldier at his reservation wage, the boss heading a strong vertical hierarchy is always better off than in a partnership.

If a partnership is chosen, it must be a weak organization. Below we study the conditions under which this happens. Recall that a weak partnership is profitable if and only if

$$u^P(\theta) \geq 0 \quad \Leftrightarrow \quad \pi \geq \pi^P(\phi) \triangleq \underbrace{2 - \phi,}_{\text{Cost of crime}} \tag{12}$$

which is decreasing in ϕ as discussed before.

By contrast, a weak vertical hierarchy is profitable if and only if

$$u^V(\theta) \geq 0 \quad \Leftrightarrow \quad \pi \geq \pi^V(\phi, \theta) \triangleq \underbrace{1 - \phi + q + \theta.}_{\text{Cost of Crime}} \tag{13}$$

Comparing the utility of a partnership member with that of the boss ruling a weak vertical hierarchy, we have

$$u^V(\theta) \leq u^P(\theta) \quad \Leftrightarrow \quad \pi \leq \pi^*(\phi, \theta) \triangleq 2(q + \theta) - \phi. \tag{14}$$

This condition has a few interesting implications. First, it suggests that when the crime is not too profitable, the best organization is the partnership. The reason is as follows:

while the boss fully internalizes the crime return, in a partnership this return has to be equally split among its members. Second, the region of parameters in which the partnership is preferred to a vertical hierarchy expands as q and θ grow large, whereas it shrinks as ϕ gets bigger. Obviously, when the soldier is more informed (q high), the boss bears a higher conviction risk that makes, ceteris paribus, a partnership relatively more appealing than a vertical hierarchy. When instead criminals become more loyal to each other (higher θ) the cost of crime for a weak vertical hierarchy increases, which makes a partnership relatively more appealing. Finally, when the amnesty increases, a vertical hierarchy is more likely to be optimal because the cost reduction that this higher amnesty implies is fully internalized by the boss, while it is only partly internalized in a partnership.[17]

Combining conditions (12) and (14) it follows that, in equilibrium, a necessary condition for the criminals to be organized as a partnership is

$$\pi^{P}\left(\phi\right) \leq \pi^{*}\left(\phi,\theta\right) \quad \Leftrightarrow \quad \theta \geq 1 - q. \tag{15}$$

Clearly, this inequality must be compatible with both organizations being weak — i.e., $\theta \leq \underline{\theta}\left(\phi\right)$. Otherwise, the region of parameters in which a partnership is profitable and, at the same time, preferred to a vertical hierarchy would be empty.

Combining conditions (12)-(15), we can show the following result.

Lemma 9 *If $q \geq p$, in equilibrium, the group of criminals will be organized as a partnership only if*

$$\phi \geq \underline{\phi} \triangleq 1 + p - q.$$

In this case, a partnership emerges in the following (non-empty) space of parameters

$$\pi \in \left[\pi^{P}\left(\phi\right), \pi^{V}\left(\phi,\theta\right)\right] \wedge \theta \in \left[1 - q, \phi - p\right].$$

Otherwise, if $q < p$, there can only exist an equilibrium in which the organization is a vertical hierarchy.

This lemma provides a few testable implications. First, it shows that partnerships coexist with vertical hierarchies only if potential informants own sufficiently accurate information about their heads, which clearly makes the choice of a weak vertical organization less appealing (from the boss' perspective) compared to a partnership. Second, it implies that while a partnership is formed for intermediate values of *omertà* (θ), a vertical hierarchy emerges for very high and very low values of this parameter — i.e., vertical hierarchies are either very resilient to leniency programs or extremely fragile. Indeed, when the cost of betrayal is sufficiently low, the boss has to compensate the soldier who talks with a low wage, making the choice of a vertical hierarchy more appealing. When the cost of betrayal is very large, the

---

[17]For example, because each criminal enjoys it with probability $\frac{1}{2}$ when both blow the whistle.

Figure 2: ORGANIZATION CHOICE
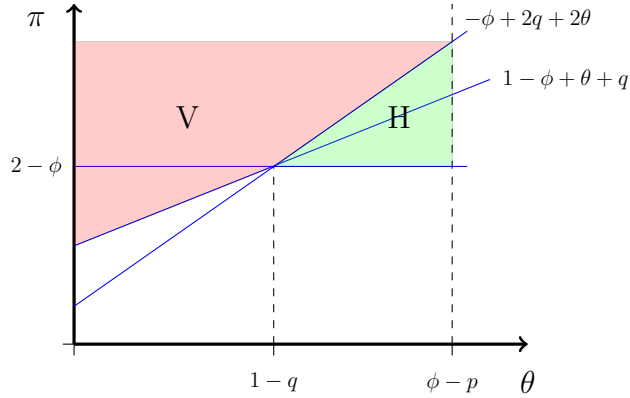
soldier does not blow the whistle, making again the choice of a vertical organization optimal. Third, the lemma suggests that, provided q is sufficiently large, a partnership can emerge in equilibrium only if the Legislator grants a sufficiently generous amnesty. This is not obvious, as looking at inequality (14) one would be induced to think that larger amnesties favor vertical hierarchies. However, partnerships are chosen for relatively high levels of *omertà*: $1 - q \leq \theta \leq \phi - p$. When ϕ is too small, only criminals with a very low cost of betrayal blow the whistle which, as just discussed, favors the choice of vertical hierarchies. This also implies the following corollary.

Corollary 10 *If there is no leniency program in place, i.e. $\phi = 0$, criminals always choose to form vertical hierarchies.*

The corollary follows directly from Lemma (9).

Figure 2 illustrates in the space (θ, π) the optimal organization form for a given ϕ.

Notice that, when the crime is profitable for a weak partnership (for $\theta \in [0, \phi - p]$) it is not necessarily profitable for a weak vertical hierarchy as well, and vice-versa. For example, for π slightly above $2 - \phi$, the partnership commits the crime while a vertical hierarchy does not. On a similar vein, when $\theta \leq 1 - q$ and π is slightly below $2 - \phi$ a partnership is not profitable while a vertical hierarchy still is. This shows that (taking as a given the Legislator's behavior) the amount of crime necessarily increases when criminals can optimally react to the policy by changing their organizational structure. An optimal policy must cope with this new force.

To focus on the most interesting case for our purposes, from now on we assume that $q \geq p$ so that $\underline{\phi} \leq 1$; otherwise, the optimal policy would always be equal to ϕ^V and, by assumption, the equilibrium of the game would not feature partnerships. Therefore, depending on the

amnesty ϕ, the overall amount of crime in the economy is

$$\mathcal{H}^*(\phi) \triangleq \int_{\underline{\theta}(\phi)} \int_{1-p} dG(\pi) dF(\theta) +$$

$$+ \begin{cases} \int_0^{\underline{\theta}(\phi)} \int_{\pi^V(\phi,\theta)} dG(\pi) dF(\theta) & \text{if } \phi < \underline{\phi} \\ \int_0^{1-q} \int_{\pi^V(\phi,\theta)} dG(\pi) dF(\theta) + \int_{1-q}^{\underline{\theta}(\phi)} \int_{\pi^P(\phi)} dG(\pi) dF(\theta) & \text{if } \phi \geq \underline{\phi} \end{cases}.$$

Essentially, the Legislator may either set $\phi < \underline{\phi}$ and have only vertical hierarchies in equilibrium or, alternatively, she may set $\phi \geq \underline{\phi}$ so to have some partnerships as well. The optimal policy solves the following minimization problem

$$\min_{\phi \in [0,1]} \mathcal{H}^*(\phi). \tag{16}$$

We can show the following result.

Proposition 11 *Suppose that $q \geq p$. The solution of* (16)*, hereafter ϕ^*, is always larger than p and features the following properties:*

- *$\phi^* \geq \underline{\phi}$ if and only if*

$$\int_0^{1-q} \frac{g(2q-p+\theta)}{f(1-q)} dF(\theta) \leq G(1-p+q) - G(1-p), \tag{17}$$

In this region of parameters an interior solution is identified by the following first-order condition:

$$\underbrace{G(2-\phi) - G(1-p)}_{Bright\ Side} = \underbrace{\frac{\int_0^{1-q} g(1-\phi+\theta+q)dF(\theta) + \int_{1-q}^{\phi-p} g(2-\phi)dF(\theta)}{f(\phi-p)}}_{Dark\ Side}. \tag{18}$$

The optimal amnesty is increasing in q and p, and strong and weak vertical hierarchies coexist with weak partnerships.

- *$\phi^* < \underline{\phi}$ if and only if* (17) *does not hold. In this region of parameters, $\phi^* = \phi^V$ and there are only vertical hierarchies in equilibrium.*

By inspecting equation (18) we can highlight a few salient properties of the optimal amnesty.

First, the bright side of the amnesty is larger than the one prevailing when the only existing organization form is the partnership, while it is lower than the bright side prevailing when there are only vertical hierarchies:

$$G(2-\phi) - G(2(1-p)) < G(2-\phi) - G(1-p) \leq G(1-p+q) - G(1-p). \tag{19}$$

The second inequality is verified if $\phi^* \geq \underline{\phi}$ because

$$2 - \phi \leq 1 - p + q \quad \Leftrightarrow \quad \phi \geq 1 + p - q.$$

Essentially, by increasing the amnesty ϕ the Legislator magnifies the probability of the criminal organization being weak, which is beneficial for society since it implies a higher conviction risk and, other things being equal, a lower crime rate. Such benefit depends on the difference between the costs of the weak partnership $(2 - \phi)$ and of the strong vertical hierarchy $(1 - p)$, that is the organizational change triggered by an increase of ϕ. Hence, when criminals optimally adapt the organizational structure, the bright side is affected in a non obvious way: with respect to a world where only horizontal organizations are present, there is a reduction in the cost of strong organizations which are now always vertical. With respect to an economy completely populated by vertical organizations, there is a decrease in the cost of weak organizations which at the margin $\theta = \phi - p$, are now horizontal.

Second, as expected, the dark side when criminals can adapt the organization's structure to the policy set by the Legislator is a convex combination of the dark sides prevailing when the organization is exogenously given. Moreover, if condition (17) holds, and $G(\cdot)$ is not uniform, the dark side in the endogenous case is larger than the dark side when only partnerships are present — i.e.,

$$\int_0^{1-q} g(1 - \phi + \theta + q)dF(\theta) + \int_{1-q}^{\underline{\theta}(\phi)} g(2 - \phi)dF(\theta) > \int_0^{\underline{\theta}(\phi)} g(2 - \phi)dF(\theta), \qquad (20)$$

because of Assumption **A4** and

$$2 - \phi < 1 - \phi + \theta + q \quad \Leftrightarrow \quad \theta > 1 - q.$$

For the same reason, in the endogenous case the dark side is also larger than the one where there are only vertical hierarchies — i.e.,

$$\int_0^{1-q} g(1 - \phi + \theta + q)dF(\theta) + \int_{1-q}^{\underline{\theta}(\phi)} g(2 - \phi)dF(\theta) > \int_0^{\underline{\theta}(\phi)} g(1 - \phi + \theta + q)dF(\theta). \quad (21)$$

Indeed, as criminals optimally adapt the organizational structure to the legal environment, the Legislator's first mover advantage weakens, and this translates into a larger dark side of leniency, as compared to both organizational scenarios.

The relationship between the bright and dark sides, as just described, implies the following result.

Proposition 12 *When condition* (17) *is satisfied,* $\phi^* < \phi^V$.

The relationship between the bright and dark sides makes instead the ordering of ϕ^* and

ϕ^P ambiguous. However, in the case in which $G(\cdot)$ is uniform, differences in the dark sides vanish, and we have the following result.

Lemma 13 *Assume that $g'(\cdot) \approx 0$, then $\phi^P < \phi^*$ if and only if condition (17) holds.*

A point to highlight is that when condition (17) does not hold, in the endogenous case the optimal policy completely eradicates partnerships. This happens when the bright side of leniency with partnerships is too low, conditional on a partnership being profitable — i.e., when $G(2 - \underline{\phi})$ is relatively small. The next proposition provides an interesting testable implication along this line.

Proposition 14 *Condition (17) is always satisfied for $q = 1$. Moreover, the region of parameters in which this condition holds expands as q grows large.*

Hence, when soldiers are sufficiently informed, the Legislator is willing to bear the cost of letting partnerships proliferate in order to exploit such insider information to disrupt vertical hierarchies. By contrast, when soldiers are poorly informed about their heads, the Legislator has a lower return from large amnesties. Therefore the optimal leniency decreases, making partnerships always the worse choice for criminals even when the organization is weak, i.e. inequality (14) is never satisfied for $\theta < \phi - p$. In this case, the Legislator optimally prefers to deal with vertical organizations only and chooses, accordingly, a policy that completely shuts down partnerships.[18]

Interestingly, this result is consistent with what has been observed in Italy in the last decades. After a series of violent terroristic attacks from Sicilian mafia in the early nineties, the Italian Legislator decided to grant full or partial amnesty to whistle-blowers who provide information leading to further Mafia prosecutions: the Italian accomplice-witness program (D.L. 13/05/1991 n.152).[19] While this strategy partially succeeded at the same time the Camorra flourished and is now among the most active organizations in Europe and the US for the traffic of drugs, illegal waste, and money laundering.

Example. Once more, to obtain a closed-form example of the optimal policy in the endogenous case we assume that $\pi \sim U[0, 1]$ and $\theta \sim \text{Beta}[1, \lambda^{-1}]$. Then, solving condition (17) we have

$$q > \frac{\lambda}{\lambda + 1}.$$

In this region of parameters, an interior solution yields

$$\phi^P = p\frac{2 + \lambda}{1 + \lambda} < \phi^* = p + \frac{1}{1 + \lambda} < \phi^V = p + \frac{q}{\lambda}.$$

---

[18]Notice that this result is consistent with Proposition (12). Indeed, when q is low, ϕ^* is equal to ϕ^V, when q is large ϕ^* (which increases with q) is lower than ϕ^V, due to the fact that also ϕ^V increases with q.

[19]See Acconcia et al. (2014) for an empirical investigation of the effects of the Italian accomplice-witnesses program).

As discussed, partnerships will emerge in equilibrium if the soldier has valuable information to exchange with prosecutors. Moreover, as λ grows large, it is less likely that the optimal policy will induce partnerships to emerge in equilibrium — i.e., when criminals are (on average) less likely to be loyal to each other horizontal organizations should proliferate less in the endogenous case.

The reason why $\phi^* < \phi^V$ is as follows: as seen in Figure 2, there is a region of parameters in which the crime is profitable when the organization switches from a weak vertical hierarchy to a partnership — i.e., when θ and π take intermediate values. Hence, anticipating this switch, the Legislator tends to use the policy less intensively compared to the case in which there are only vertical hierarchies. The same argument explains why $\phi^* > \phi^P$ — i.e., when criminals can only be organized as a partnership, depending on the value of θ it can only switch from being a strong to a weak partnership. In the endogenous case, instead, criminals can also decide to be organized as a vertical hierarchy, whereby inducing the Legislator to use the policy more intensively.

5 Extensions

In this section we check the robustness of the previous results by considering various extensions of the baseline model.

5.1 Power *vs* information

So far in our baseline model we have implicitly assumed that while in a partnership both agents have identical power and information, a vertical hierarchy is asymmetric in both dimensions. Specifically, the boss has both the power — since he decides to commit the crime and has all the bargaining power when splitting the return from crime — and more sensible information than the soldier. In order to show that our results only depend on the second dimension — i.e. the asymmetry in the compromising information held by criminals in vertical and horizontal hierarchies respectively — we now assume that the key decisions on whether or not to commit the crime and the choice of the organization structure are the outcome of an efficient bargaining between the two criminals, with parameter k identifying the bargaining power of one criminal over the other.

Let us consider first a vertical exogenous organization form. Notice that the decision to blow the whistle in the reporting subgame does not depend on how the return from crime is shared among the two criminals. Assume for now that the equilibrium of the reporting subgame is such that the soldier talks, $\theta < \underline{\theta}(\phi)$. The two criminals share the return from crime π according to a Nash bargaining with ρ identifying the share going to the boss.[20] The

---

[20]Binmore et al. (1986) provide theoretical foundations for the application of the axiomatic Nash bargaining solution to non cooperative games.

outside option of the bargaining is not to start the criminal business. Therefore, the status quo utilities are both equal to 0. The optimal share is the solution to the following problem:

$$\max_{\rho \in [0,1]} k \log\left(\rho\pi - q\right) + (1-k)\log\left[(1-\rho)\pi - (1-\phi) - \theta\right],$$

such that $\rho\pi - q \geq 0$ and $(1-\rho)\pi - (1-\phi) - \theta \geq 0$. The first order condition yields

$$\rho^* = \frac{k\pi - k[(1-\phi) + \theta] + (1-k)q}{\pi}.$$

If $k = 1$ the solution is equal to the one in the main analysis, where the boss has all the bargaining power and has utility $\pi - q - (1-\phi) - \theta$, while the soldier receives a payoff equal to 0.[21] The solution ρ^* must be compatible with both criminals enjoying positive utility from the bargaining: $\rho^*\pi - q \geq 0$ and $(1-\rho^*)\pi - (1-\phi) - \theta \geq 0$. As it is always the case in bargaining games with transferable utility — see e.g., Myerson (2013, p. 385) — the status quo (not starting the criminal business) is not chosen as long as there is a positive total surplus from the criminal activity:

$$\pi \geq (1-\phi) + q + \theta.$$

This is equal to condition (13) in the main analysis and does not depend on the boss' bargaining power k. In a similar fashion when the organization is strong, $\theta \geq \underline{\theta}(\phi)$, it can be proven that the crime is committed as long it yields a positive total surplus $\pi \geq 1 - p$. Thus, when the structure of the organization is exogenous and vertical, the analysis is equal to the one in the main body of the paper, independently from the bargaining power inside the organization.

Let us now turn to the case of an endogenous organization structure. We assume that the return from crime in a vertical organization is shared according to a Nash bargaining game, where the outside option of the bargaining for each criminal is the best outcome between not committing the crime or choosing an horizontal organization and committing the crime.[22] As in the case of an exogenous structure, the vertical organization is chosen as long as it yields a positive total surplus with respect to the outside option. For weak organizations this implies

$$\pi - (1-\phi) - q - \theta > \max\left\{0, 1 - \frac{\phi}{2}\right\}.$$

This condition gives the result in Lemma (9). Similarly, when organizations are strong the vertical organization is chosen if

$$\pi - (1-p) \geq \max\left\{0, \frac{\pi}{2} - (1-p)\right\} \quad \Rightarrow \quad \pi \geq 1 - p.$$

---

[21]k therefore parameterizes the distribution of the surplus obtained by committing the crime.

[22]Notice that in each of these scenarios the payoffs for the two criminals are the same.

Therefore, as shown in Lemma (8), strong organizations can only be vertical. To sum up, our analysis does not depend on the bargaining power that the boss has vis-à-vis the soldier, but on the vertical organizations' information asymmetry which is due to the fact that the boss operates behind the scenes while the soldier is more likely to be targeted by law enforcers.

5.2   Strong enforcement

So far, we have only considered the case in which $p \geq \frac{1}{2}$. As argued before, this restriction guarantees that, with a partnership, there always exists a Pareto dominant equilibrium of the reporting (sub)game in which the two partners do not cheat on each other, even if they are granted full amnesty (i.e., $\phi = 1$). By contrast, when $p < \frac{1}{2}$, there exists a sufficiently high amnesty (larger than $2p$) such that the Pareto dominant equilibrium is the one in which both partners blow the whistle. Hence, if there are only partnerships, when $\phi \geq 2p$ the Legislator's decision making problem is

$$\min_{\phi \geq 2p} \int_{2-\phi} dG(\pi).$$

It can be shown that this problem always features a corner solution at $\phi = 2p$ under Assumption **A4**. Hence, the optimal amnesty must lie in the support $\phi \in [0, 2p]$, which is either found solving the first order condition (6) or it is $\phi = 2p$. Notice, however, that at $\phi = 2p$, the bright side of leniency in (5) vanishes. Therefore, the solution is always interior and solves equation (6). Hence, Proposition (2) still applies.

We can now study whether, in the region of parameters under consideration, the long-run policy changes or is unaltered. Specifically, we show that the choice of the optimal organizational form, when enforcement is strong, is the same as in the case in which enforcement is weak. Hence, the analysis of the optimal leniency in the endogenous case is equal to the one carried out in the baseline model. The optimal organization form, for a given ϕ, is the same as in the main analysis when $\theta \leq \underline{\theta}(\phi)$, because under this condition horizontal organizations feature the reporting equilibrium both when there is weak enforcement: $p \geq \frac{1}{2}$ (the baseline model), and when enforcement is strong: $p < \frac{1}{2}$. When $\theta \geq \underline{\theta}(\phi)$, we separately consider two cases: $\phi < 2p$ and $\phi \geq 2p$. When $\phi < 2p$, partnerships feature the no-reporting equilibrium. As in the baseline model, the optimal organizational form is therefore vertical. When leniency ϕ is larger than $2p$, criminals in a partnership play the reporting equilibrium. In this case, a partnership is preferred to a vertical hierarchy if and only if

$$\pi - (1 - p) \leq \frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right) \quad \Leftrightarrow \quad \pi \leq \phi - 2p.$$

Notice that $2 - \phi > 1 - p > \phi - 2p$. Hence, both organizations are only active when vertical organizations are preferred to partnerships. Moreover, the cost of a vertical organization is

lower than a partnership's. As a result, like in the baseline model, when $\theta > \underline{\theta}(\phi)$, criminal organizations take a vertical structure, and they commit crime if $\phi \geq 1 - p$.

5.3 Risk dominance

In the partnership game we selected equilibria by considering a Pareto dominance criterion. In order to check the robustness of our results, we now assume that equilibrium selection follows a risk dominance argument — see, e.g., Harsanyi et al. (1988). Specifically, instead of choosing the equilibrium yielding higher payoffs, we posit that the partners select the equilibrium that minimizes the loss from miscoordination. This assumption is coherent with a recent strand of experimental literature (Bigoni et al., 2015) studying the channels through which different law enforcement strategies deter cartel formation. In this literature deterrence appears to be mainly driven by distrust among cartel members — i.e., the fear of partners deviating and reporting. Although this is a serious concern in dynamic games (Blonski et al., 2011) we will show that this is less problematic in our static game: the implications of the baseline model continue to hold even if equilibria are selected with a risk based rather than a Pareto dominance criterion.

Let us solve the game by backward induction. The equilibrium in which both partners do not blow the whistle risk dominates the equilibrium in which they both talk when

$$\frac{\pi}{2} - (1 - p) + \frac{\pi}{2} - 1 \geq \frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right) + \frac{\pi}{2} - (1 - \phi) - \theta,$$

which implies

$$\theta \geq \underline{\theta}^P(\phi) \triangleq \frac{3}{2}\phi - p > \underline{\theta}(\phi).$$

As intuition suggests, when the equilibrium of the reporting game is selected according to risk dominance, the partnership is less likely to be strong compared to the case in which the equilibrium is selected by Pareto dominance. Hence, with risk dominance the equilibrium in which nobody blows the whistle is relatively more fragile compared to the baseline model — i.e., $\underline{\theta}^P(\phi) > \underline{\theta}(\phi)$.

Assuming that criminals are always organized as a partnership, the amount of crime in the economy is

$$\mathcal{H}^P(\phi) \triangleq \underbrace{\int_0^{\underline{\theta}^P(\phi)} \int_{2-\phi} dG(\pi)\, dF(\theta)}_{\text{Weak partnership}} + \underbrace{\int_{\underline{\theta}^P(\phi)} \int_{2(1-p)} dG(\pi)\, dF(\theta)}_{\text{Strong partnership}},$$

which , as before, is the function that the Legislator minimizes. Differentiating with respect

to ϕ yields

$$\mathcal{H}_\phi^P(\phi) = -\underbrace{\frac{3}{2}f\left(\underline{\theta}^P(\phi)\right)[G(2-\phi) - G(2(1-p))]}_{\text{Bright side}} + \underbrace{\int_0^{\underline{\theta}^P(\phi)} g(2-\phi)\,dF(\theta)}_{\text{Dark side}},$$

which is similar to (6). Hence, Proposition (2) still holds qualitatively.

When the organization is chosen endogenously, the optimal organization form, for a given leniency program ϕ, is the same as in the main analysis, when $\theta \leq \underline{\theta}(\phi)$ or $\theta \geq \underline{\theta}^P(\phi)$. When $\underline{\theta}(\phi) < \theta < \underline{\theta}^P(\phi)$, a vertical hierarchy is strong while a partnership is weak. In this interval, vertical organizations are chosen over partnerships if

$$\pi - (1-p) > \frac{\pi}{2} - \left(1 - \frac{\phi}{2}\right) \quad \Leftrightarrow \quad \pi > \phi - 2p.$$

Recalling that $2 - \phi > 1 - p > \phi - 2p$, then (as in the strong enforcement extension (5.2)) both organizations are active only when vertical organizations are preferred to partnerships. Moreover the cost of a vertical organization is lower than a partnership's. Hence, if $\theta > \underline{\theta}(\phi)$, criminal organizations take a vertical structure, and they commit crime if $\pi \geq 1 - p$: the analysis of the optimal leniency in the endogenous case is equal to the one in the baseline.

5.4 When the boss can blow the whistle

In the previous analysis we assumed that a boss never self reports. This assumption is consistent with the anecdotal evidence showing that these people hardly cooperate with the justice, even after being convicted and jailed. Nevertheless, in order to complete the analysis we now allow also the boss to self report, so to capture the case in which the boss is strategic enough to preempt the soldier's betrayal.

As before, we assume that the amnesty is not contingent on the criminal's role in the organization. When the case against the organization opens, the boss and the soldier can simultaneously opt to cooperate with the justice. Independently from the choice of the soldier, if the boss blows the whistle, he is the only one receiving the amnesty. This is because the boss has more information about the organization compared to the soldier: when he self reports the soldier falls too, a sort of domino effect that echoes Baccara and Bar-Isaac (2008).

Let us again use a backward induction argument. When the boss and the soldier choose

whether or not to blow the whistle, the payoff matrix is

		Soldier	
		Talk	No talk
Boss	Talk	$\pi - w - (1 - \phi), \ w - 1$	$\pi - w - (1 - \phi) - \theta, \ w - 1$
	Not Talk	$\pi - w - q, \ w - \theta - (1 - \phi)$	$\pi - w, \ w - (1 - p)$

There are three cases to be analyzed. First, if $\theta > \underline{\theta}(\phi)$ there is an equilibrium of the reporting game in which no one blows the whistle. In the same subset of parameters there could also exist an equilibrium in which both boss and soldier blow the whistle. Notice, however, that this is a fragile equilibrium in the sense that it is Pareto and risk dominated by the equilibrium in which nobody talks. Accordingly, we select the equilibrium in which no one blows the whistle. In this case the salary is $w = 1 - p$ and the payoff of the boss is $\pi - (1 - p)$. Second, if $\theta \leq \underline{\theta}(\phi)$ and $\phi < 1 - q$ the boss does not self report while the soldier blows the whistle. In this case the salary is $w = 1 - \theta - \phi$ and the payoff of the boss is $\pi - (1 - \phi) - \theta - q$. Third, when $\theta \leq \underline{\theta}(\phi)$ and $\phi \geq 1 - q$ the boss and the soldier blow the whistle.[23] In this case the soldier's reservation wage is $w = 1$ and the payoff of the boss is $\pi - (1 - \phi) - 1$.

Let us consider first the case of exogenous organizations. In this case the Legislator chooses the optimal amnesty, minimizing a piecewise objective function. When $\phi \leq 1 - q$, the first order conditions are given by equation (10). When $\phi > 1 - q$, the first order condition (for an interior solution) is

$$G(2 - \phi) - G(1 - p) = \int_0^{\underline{\theta}(\phi)} \frac{g(2 - \phi)}{f(\underline{\theta}(\phi))} dF(\theta). \tag{22}$$

The problem solved by the Legislator has a kink in $\phi = 1 - q$ which makes the analysis less straightforward. In general the following holds.

Proposition 15 *When the criminal organization can only be vertical, the optimal leniency* ϕ^V *solves equation* (22) *if*

$$f(1 - q - p)\left[G(1 + q - p) - G(1 - p)\right] > \int_0^{1-q-p} g(2q + \theta) dF(\theta); \tag{23}$$

The leniency program is such that, when the organization is weak, the boss self-reports. If instead

$$f(1 - q - p)\left[G(1 + q) - G(1 - p)\right] < \int_0^{1-q-p} g(1 + q) \, dF(\theta), \tag{24}$$

---

[23]This is also a very weak equilibrium, because the soldier is indifferent between talking and not talking. However, in the region of parameters under consideration, this is the only existing equilibrium. Indeed, there is no equilibrium in which the boss blows the whistle and the soldier does not: the boss would rather deviate, because if he does not talk he would not be prosecuted.

the Legislator chooses ϕ^V solving equation (10): the leniency program is such that, when the organization is weak, only the soldier talks.[24]

In general, when the boss can blow the whistle and the information that the soldier has on the boss is sufficiently valuable, $q > 1 - \phi$, vertical organizations become more similar to partnerships, because now also in vertical hierarchies there is a "rush to the courthouse" effect, which would push for a lower amnesty, as in partnerships. At the same time, when the boss blows the whistle, he needs to pay a higher wage to the soldier, as the latter is convicted and receives no leniency. This can create an incentive for a higher amnesty in order to induce the boss to self-report. The comparison between leniency ϕ^V in this extension and in the baseline is not straightforward.

Let us make this comparison in our running example, where G is uniform and F is a Beta distribution. Condition (23) becomes

$$q > \frac{\lambda}{1 + \lambda}(1 - p).$$

In this case ϕ^V solves first order condition (22): $\phi^V = \frac{1}{1+\lambda} + p$, which is larger than the optimal leniency $p + \frac{q}{\lambda}$ in the baseline, if $q < \frac{\lambda}{1+\lambda}$. Instead, inequality (24) is satisfied, if $q < \frac{\lambda}{1+\lambda} - p$. In this case the optimal leniency in this extension and the one in the baseline are the same. Hence we can conclude that, when $\frac{\lambda}{1+\lambda}(1-p) < q < \frac{\lambda}{1+\lambda}$, the optimal leniency for vertical organizations, when the boss can blow the whistle, is larger than the optimal leniency in the baseline model. If $q > \frac{\lambda}{1+\lambda}$ or $q < \frac{\lambda}{1+\lambda} - p$, the optimal leniency in this extension is lower than or equal to the one set in the baseline model.

Let us turn to the endogenous case. When the organization choice is endogenous, criminals always set up vertical organizations. Indeed, when the organization is strong, no one blows the whistle and the analysis is equal to the one carried out in the main body of the paper. When the organization is weak, we have to analyze two cases: $\phi \geq 1 - q$ and $\phi < 1 - q$. Let us consider first $\phi \geq 1 - q$: in vertical organizations the boss self-reports. The payoff from setting up a vertical organization, $\pi - 1 - (1 - \phi)$, is larger than the payoff from setting up a partnership, $\pi/2 - (1 - \phi/2)$ if $\pi \geq 2 - \phi$. However, both types of organization are active if $\pi \geq 2 - \phi$. This implies that even weak organizations always choose to be vertical. When $\phi < 1 - q$, the choice of the organizational structure is the same as in the baseline model, where for some values of θ and π, organizations take a horizontal structure. Notice however that, in the baseline model, horizontal organizations exist in the endogenous case only if $\phi \geq 1 - q + p$. This condition is incompatible with $\phi < 1 - q$. Therefore, in the endogenous case organizations always take a vertical structure and the optimal leniency is $\phi^* = \phi^V$.

---

[24]When equations (23) and (24) are not satisfied, the are two local minima, one that solves equation (10) and one that solves equation (22). In this case the solution is found comparing the Legislator's objective function for these two levels of leniency.

6   Conclusions

Starting from the simple observation that criminal groups face organizational problems similar to those of firms and inspired by a substantial empirical evidence collected by criminologists, we studied a simple law enforcement model in which the internal structure of a criminal organization is endogenous and is jointly determined with the amnesty that the Legislator grants to criminals who flip and blow the whistle. The insider information owned by soldiers in vertical criminal organizations is a key parameter to understand the shape and the consequences of an optimal leniency policy that takes into account the organizational changes that co-offenders may undertake in order to shield against these laws. When the organization structure is endogenous and soldiers are sufficiently informed about their heads, the optimal amnesty is lower than the one set for vertical organizations and larger than the one set for horizontal organizations; while the opposite occurs when soldiers are poorly informed. Moreover, when the leniency program is designed to target vertical organizations, without considering its effects on horizontal organizations, the latter proliferate in number.

On the positive side, our results contribute to explain some Italian stylized facts — i.e., the rise of criminal organizations based on a horizontal structure and street gangs after an intense period of fight against the Sicilian Mafia widely recognized a pyramidal and top-down organization. On the normative ground, the analysis may help designing policies taking into account that criminals can adapt the organization's structure to the policy set by the Legislator and gain a better understanding of the consequences of short term policies that target specific criminal groups particularly active at a given date.

References

Acconcia, A., Immordino, G., Piccolo, S., and Rey, P. (2014). Accomplice witnesses and organized crime: Theory and evidence from Italy. *The Scandinavian Journal of Economics*, 116(4):1116–1159.

Aghion, P. and Tirole, J. (1997). Formal and real authority in organizations. *Journal of political economy*, 105(1):1–29.

Aoki, M. (1986). Horizontal vs. vertical information structure of the firm. *The American Economic Review*, pages 971–983.

Arlacchi, P. and Ryle, M. (1986). *Mafia business: The mafia ethic and the spirit of capitalism*, volume 3. Verso London.

Aubert, C., Rey, P., and Kovacic, W. E. (2006). The impact of leniency and whistle-blowing programs on cartels. *International Journal of Industrial Organization*, 24(6):1241–1266.

Baccara, M. and Bar-Isaac, H. (2008). How to organize crime. *The Review of Economic Studies*, 75(4):1039–1067.

Benson, J. S. and Decker, S. H. (2010). The organizational structure of international drug smuggling. *Journal of Criminal Justice*, 38(2):130–138.

Best, J. and Luckenbill, D. (1981). *Organizing deviance*. Prentice Hall, Upper Saddle River.

Bigoni, M., Fridolfsson, S.-O., Le Coq, C., and Spagnolo, G. (2012). Fines, leniency, and rewards in antitrust. *The RAND Journal of Economics*, 43(2):368–390.

Bigoni, M., Fridolfsson, S.-O., Le Coq, C., and Spagnolo, G. (2015). Trust, leniency, and deterrence. *The Journal of Law, Economics, and Organization*, 31(4):663–689.

Binmore, K., Rubinstein, A., and Wolinsky, A. (1986). The Nash bargaining solution in economic modelling. *The RAND Journal of Economics*, pages 176–188.

Blonski, M., Ockenfels, P., and Spagnolo, G. (2011). Equilibrium selection in the repeated prisoner's dilemma: Axiomatic approach and experimental evidence. *American Economic Journal: Microeconomics*, 3(3):164–92.

Bolton, P. and Dewatripont, M. (1994). The firm as a communication network. *The Quarterly Journal of Economics*, 109(4):809–839.

Brinton Milward, H. and Raab, J. (2006). Dark networks as organizational problems: Elements of a theory. *International Public Management Journal*, 9(3):333–360.

Buccirossi, P. and Spagnolo, G. (2006). Leniency policies and illegal transactions. *Journal of Public Economics*, 90(6-7):1281–1297.

Catino, M. (2014). How do mafias organize? conflict and violence in three mafia organizations. *European Journal of Sociology/Archives Européennes de Sociologie*, 55(2):177–220.

Chen, J. and Harrington Jr, J. E. (2007). The impact of the corporate leniency program on cartel formation and the cartel price path. *Contributions to Economic Analysis*, 282:59–80.

Chen, Z. and Rey, P. (2013). On the design of leniency programs. *The Journal of Law and Economics*, 56(4):917–957.

Cressey, D. R. (1972). *Criminal organization: its elementary forms*. Harper & Row New York.

Decker, S. H. and Van Winkle, B. (1996). *Life in the gang: Family, friends, and violence*. Cambridge University Press, Cambridge.

Dufwenberg, M. and Spagnolo, G. (2015). Legalizing bribe giving. *Economic Inquiry*, 53(2):836–853.

Gamba, A., Immordino, G., and Piccolo, S. (2018). Organized crime and the bright side of subversion of law. *Journal of Public Economics, forthcoming.*

Garoupa, N. (2000). The economics of organized crime and optimal law enforcement. *Economic Inquiry*, 38(2):278–288.

Hammond, S. D. (2004). Cornerstones of an effective leniency program. In *ICN Workshop on Leniency Programs, Sydney*, pages 22–23.

Harrington, J. E. (2008). Optimal corporate leniency programs. *The Journal of Industrial Economics*, 56(2):215–246.

Harrington, J. E. (2013). Corporate leniency programs when firms have private information: The push of prosecution and the pull of pre-emption. *The Journal of Industrial Economics*, 61(1):1–27.

Harsanyi, J. C., Selten, R., et al. (1988). *A general theory of equilibrium selection in games*, volume 1. The MIT Press, Cambridge.

Hess, H. (1988). *Mafia: zentrale Herrschaft und lokale Gegenmacht*, volume 8. Mohr Siebrek Ek, Tubingen.

Hinloopen, J. and Soetevent, A. R. (2008). Laboratory evidence on the effectiveness of corporate leniency programs. *The RAND Journal of Economics*, 39(2):607–616.

Hobsbawm, E. J. (1959). *Primitive rebels: Studies in archaic forms of social movements in the 19th and 20th centuries.* Manchester, Manchester University Press.

Jennings, W. P. (1984). A note on the economics of organized crime. *Eastern Economic Journal*, 10(3):315–321.

Kenney, M. (2003). From Pablo to Osama: Counter-terrorism lessons from the war on drugs. *Survival*, 45(3):187–206.

Kohn, S. M. (2001). *Concepts and procedures in whistleblower law.* Quorum Books, Westport.

Konrad, K. A. and Skaperdas, S. (1997). Credible threats in extortion. *Journal of Economic Behavior & Organization*, 33(1):23–39.

Mallory, S. (2011). *Understanding organized crime.* Jones & Bartlett Publishers, Burlington.

Miller, W. B. (1992). *Crime by youth gangs and groups in the United States.* US Department of Justice, Office of Justice Programs, Office of Juvenile Justice and Delinquency Prevention Washington, DC.

Miravete, E. J. (2002). Estimating demand for local telephone service with asymmetric information and optional calling plans. *The Review of Economic Studies*, 69(4):943–971.

Morton, A. D. (2012). The war on drugs in Mexico: A failed state? *Third World Quarterly*, 33(9):1631–1645.

Motta, M. and Polo, M. (2003). Leniency programs and cartel prosecution. *International journal of industrial organization*, 21(3):347–379.

Myerson, R. B. (2013). *Game theory.* Harvard University Press, Cambridge.

Piccolo, S. and Immordino, G. (2017). Organised crime, insider information and optimal leniency. *The Economic Journal*, 127(606):2504–2524.

Polo, M. (1995). Internal cohesion and competition among criminal organizations. *The economics of organised crime*, pages 87–115.

Reiss Jr, A. J. (1988). Co-offending and criminal careers. *Crime and justice*, 10:117–170.

Rey, P. (2003). *Advances in Economics and Econometrics: Theory and Applications, Eighth World Congress*, volume 36, chapter Toward a theory of Competition Policy, pages 82–132. Cambridge University Press, Cambridge.

Sauvagnat, J. (2014). Are leniency programs too generous? *Economics Letters*, 123(3):323–326.

Sauvagnat, J. (2015). Prosecution and leniency programs: The role of bluffing in opening investigations. *The Journal of Industrial Economics*, 63(2):313–338.

Silbye, F. (2010). Asymmetric evidence and optimal leniency programs. *Topics in Competition Policy*, page 41.

Spagnolo, G. (2003). Divide et impera: Optimal deterrence mechanisms against cartels and organized crime. *mimeo*.

Spagnolo, G. (2008). *Handbook of Antitrust Economics*, chapter : Leniency and whistleblowers in antitrust, pages 259–303. MIT Press, Cambridge.

Warr, M. (2002). *Companions in crime: The social aspects of criminal conduct*. Cambridge University Press, Cambridge.

Wilson, A. and Donald, I. (1999). *The Social Psychology of Crime: Groups, teams and networks*, chapter Ram Raiding: Criminals Working in Groups. Routledge, New York.

A   Appendix

Proof of Proposition (2)**.** Let us first prove the convexity of the minimization problem solved by the Legislator, conditional on $\phi \geq p$. The second derivative of the Legislator's objective function is

$$\mathcal{H}^P_{\phi\phi}(\cdot) = -f'(\phi - p)[G(2 - \phi) - G(2(1 - p))]+$$
$$+ f(\phi - p)g(2 - \phi) + g(2 - \phi)f(\phi - p) - g'(2 - \phi)F(\phi - p),$$

which is positive by Assumption **A4**. Consider now the first order condition (5). When $\phi \in [0, p)$, the derivative is zero. When $p = \phi$, the derivative is negative, therefore the solution ϕ^P must be larger than p. When $\phi = 1$, the first order condition reduces to equation (7). Note that, when $p = 1$, the right hand side of equation (7) is 0 and the left hand side is positive. When $p = \frac{1}{2}$, the right hand side is positive, the left hand side is 0. Therefore there exists $\overline{p} \in (\frac{1}{2}, 1)$ which solves equation (7). When $p \in [\frac{1}{2}, \overline{p})$, in $\phi = 1$, the derivative is positive, which implies that the first order condition (5) has a solution $\phi^* \in (p, 1)$. In order to show the relationship between ϕ^P and p, the Implicit Function Theorem yields

$$\frac{\partial \phi^P}{\partial p} = -\frac{f'(\phi^P - p)[G(2 - \phi^P) - G(2(1 - p))] - 2f(\phi^P - p)g(2(1 - p)) - g(2 - \phi^P)f(\phi^P - p)}{\mathcal{H}^P_{\phi\phi}(\phi^P)}.$$

As shown before $\mathcal{H}^P_{\phi\phi}(\cdot)$ is positive, $f'(\cdot)$ is non-positive by Assumption **A4**, hence the result. ∎

Proof of Proposition (3)**.** Let us first prove the convexity of the problem solved by the Legislator, conditional on $\phi \geq p$. by computing the second derivative of the objective

function

$$\mathcal{H}_{\phi\phi}^{V}(\cdot) = -f'(\phi-p)[G(1-p+q)-G(1-p)]+g(1-p+q)F(\phi-p)-\int_{0}^{\phi-p}g'(1-\phi+\theta+q)dF(\theta),$$

which is positive by Assumption **A4**.

For $\phi < p$, the derivative $\mathcal{H}_{\phi}^{V}(\phi)$ is zero. For $\phi = p$, the derivative is negative. Hence ϕ^{V} must be larger than p. When $\phi = 1$, the derivative is positive if and only if inequality (9) is satisfied. In this case the solution $\phi^{V} \in [p,1]$ is found solving first order condition (10). In order to show the relationship between ϕ^{V} and q, the Implicit Function Theorem yields

$$\frac{\partial \phi^{V}}{\partial q} = -\frac{-g(1-p+q)+\int_{0}^{\phi^{V}-p}g'(1-\phi^{V}+\theta+q)dF/f(\phi^{V}-p)}{\mathcal{H}_{\phi\phi}^{V}(\phi^{V})}.$$

As shown before $\mathcal{H}_{\phi\phi}^{V}(\cdot)$ is positive, $g'(\cdot)$ is non-positive by Assumption **A4**, hence the result. In order to show the relationship between ϕ^{V} and p, the Implicit Function Theorem yields

$$\frac{\partial \phi^{V}}{\partial p} = -\frac{f'(\phi^{V}-p)[G(1-p+q)-G(1-p)]}{\mathcal{H}_{\phi\phi}^{V}(\phi^{V})} -$$
$$\frac{-f(\phi^{V}-p)[g(1-p)-g(1-p+q)]-g(1-p+q)f(\phi^{V}-p)}{\mathcal{H}_{\phi\phi}^{V}(\phi^{V})}.$$

$\mathcal{H}_{\phi\phi}^{V}(\cdot)$ is positive, $f'(\cdot)$ and $g'(\cdot)$ are non-positive by Assumption **A4**, hence the result. ∎

Proof of Proposition (4). To begin with, notice that $\Delta B(\phi)$ increases with q — i.e.,

$$\frac{\partial \Delta B(\phi)}{\partial q} = g(1-p+q) > 0.$$

Moreover $\Delta B(\phi)$ is negative at $q=0$ — i.e.,

$$\lim_{q\to 0}\Delta B(\phi) = -[G(2-\phi)-G(2(1-p))] < 0,$$

and it is positive at $q=1$ — i.e.,

$$\lim_{q\to 1}\Delta B(\phi) = G(2-p)-G(2-\phi)+G(2(1-p))-G(1-p) > 0,$$

because $\phi > p$ in the relevant region of parameters. Therefore there exists a unique threshold $q^{B} \in (0,1)$, defined in Proposition (4), such that $\Delta B(\phi) \geq 0$ if and only if $q \geq q^{B}$ for any given $\phi \in [0,1]$. ∎

Proof of Proposition (5). To begin with, notice that $\Delta D(\phi)$ decreases with q — i.e.,

$$\frac{\partial \Delta D(\phi)}{\partial q} = \int_{0}^{\underline{\theta}(\phi)}\frac{g'(1-\phi+\theta+q)}{f(\underline{\theta}(\phi))}dF(\theta) < 0.$$

Moreover, $\Delta D(\phi)$ is positive at $q = 0$ — i.e.,

$$\lim_{q \to 0} \Delta D(\phi) = \int_0^{\bar{\theta}} [g(1 - \phi + \theta) - g(2 - \phi)]\, dF(\theta) > 0,$$

because $1 - \phi + \theta < 2 - \phi$, and $g'(\cdot) < 0$. On the other hand ΔD is negative at $q = 1$ — i.e.,

$$\lim_{q \to 1} \Delta D(\phi) = \int_0^{\bar{\theta}} [g(2 - \phi + \theta) - g(2 - \phi)]\, dF(\theta) < 0.$$

Hence, there exists a unique threshold $q^D \in (0, 1)$, defined in Proposition (5), such that $\Delta D(\phi) \geq 0$ if and only if $q \leq q^D$ for any $\phi \in [0, 1]$. ∎

Proof of Proposition (6). Fix a given $\phi \in [0, 1]$. Then, for $q > \max\{q^B, q^D\}$ it follows that $\Delta B(\phi) > 0$ and $\Delta D(\phi) < 0$. This implies $\mathcal{H}_\phi^V(\phi) < \mathcal{H}_\phi^P(\phi)$. Hence, it follows immediately that $\phi^V > \phi^P$ in the region of parameters under consideration. The converse can be shown with a similar logic. ∎

Proof of Lemma (9). A necessary condition for gangs to be organized as partnerships is $1 - q \leq \theta \leq \phi - p$. This interval for θ is not empty if $1 + p - q \leq \phi \leq 1$, which is possible only if $q \geq p$. Finally, the return from crime must be larger than its cost, $\pi \geq \pi^P(\phi)$, and lower than the threshold for which gangs choose to be organized as vertical organizations, $\pi \leq \pi^*(\phi, \theta)$. ∎

Proof of Proposition (11). Let us first show the convexity of the problem faced by the Legislator in the long run when $\phi > p$. When $\phi \leq \underline{\phi}$, the objective function of the Legislator is equal to the one analyzed in the case where only vertical organizations are present, for which we have already proven convexity. When $\phi \geq \underline{\phi}$, the derivative of the objective function of the Legislator is

$$\mathcal{H}_\phi^*(\phi) = \int_0^{1-q} g(1 - \phi + q + \theta) dF(\theta) + \int_{1-q}^{\phi-p} g(2 - \phi) dF(\theta) - f(\phi - p) [G(2 - \phi) - G(1 - p)],$$

while the second order derivative is

$$\mathcal{H}_{\phi\phi}^*(\phi) = -\int_0^{1-q} g'(1 - \phi + q + \theta) dF(\theta) - \int_{1-q}^{\phi-p} g'(2 - \phi) dF(\theta) +$$
$$g(2 - \phi) f(\phi - p) - f'(\underline{\theta}(\phi)) [G(2 - \phi) - G(1 - p)] + f(\phi - p) g(2 - \phi).$$

The latter derivative is positive by Assumption **A4**. Hence, the objective function is convex also for $\phi \geq \underline{\phi}$. Moreover the objective function is differentiable in $\phi = \underline{\phi}$, because

$$\lim_{\phi \to \underline{\phi}^-} \mathcal{H}_\phi^*(\phi) = \lim_{\phi \to \underline{\phi}^+} \mathcal{H}_\phi^*(\phi) =$$
$$= \int_0^{1-q} g(2q - p + \theta) dF(\theta) - f(1 - q) [G(1 - p + q) - G(1 - p)].$$

Hence the objective function is convex in the whole interval $\phi \in [0, 1]$. Moreover the differentiability in $\phi = \underline{\phi}$ implies that, if $\mathcal{H}_\phi(\underline{\phi})$ is negative — i.e. when condition (17) holds — the

solution to the Legislator problem is on the right of $\underline{\phi}$, that is $\phi^* > \underline{\phi}$, and solves equation (18). Otherwise the solution is in the interval $\phi^* \in [0, \underline{\phi}]$, and it is equal to ϕ^V. Finally, when $\phi < p$ the derivative of the Legislator's objective function is 0 because $\underline{\theta}(\phi) = 0$, while for $\phi = p$, derivative $\mathcal{H}^*_\phi(\phi)$ is negative, hence the solution ϕ^* must be larger than p.

In order to show the relationship between ϕ^* and q, by the Implicit Function Theorem we have

$$\frac{\partial \phi^*}{\partial q} = -\frac{-g(2-\phi^*)f(1-q) + \int_0^{1-q} g'(2-\phi^*)\,dF(\theta) + g(2-\phi^*)f(1-q)}{\mathcal{H}^*_{\phi\phi}(\phi^*)}.$$

As shown before $\mathcal{H}^*_{\phi\phi}(\cdot)$ is positive, $g'(\cdot)$ is non-positive by Assumption **A4**, hence the result. In order to show the relationship between ϕ^* and p, by the Implicit Function Theorem we have

$$\frac{\partial \phi^*}{\partial p} = -\frac{f'(\phi - p)[G(2-\phi^*) - G(1-p)] - f(\phi^* - p)g(1-p) - g(2-\phi^*)f(\phi^* - p)}{\mathcal{H}^*_{\phi\phi}(\phi^*)}.$$

As shown before $\mathcal{H}^*_{\phi\phi}(\cdot)$ is positive, $g'(\cdot)$ is non-positive by Assumption **A4**, hence the result. ∎

Proof of Proposition (12). If condition (17) is satisfied, the bright side, when only vertical hierarchies are present, is larger than the bright side in the long run, as shown by inequalities (19). Conversely, the dark side, when only vertical hierarchies are present, is lower than the bright side in the long run, as shown by inequalities (21). Therefore it must be that $\phi^V > \phi^*$. ∎

Proof of Lemma (13). When $G(\cdot)$ is uniform, there is no difference in the dark sides, i.e. the left hand sides and right sides of inequalities (20) and (21) are equal. Therefore, the Lemma follows immediately from the chain of inequalities (19). ∎

Proof of Proposition (14). Showing that the area for which condition (17) holds increases with q is equivalent to showing that the following expression decreases with q:

$$\int_0^{1-q} g(2q - p + \theta)\,dF(\theta) - f(1-q)\left[G(1-p+q) - G(1-p)\right].$$

Let us compute the derivative with respect to q of the latter expression. Differentiating we have

$$-g(1-p+q)f(1-q) + \int_0^{1-q} 2g'(2q - p + \theta)\,dF(\theta) +$$
$$f'(1-q)\left[G(1-p+q) - G(1-p)\right] - f(1-q)g(1-p+q).$$

This derivative is negative by Assumption **45**. Hence, the result follows immediately. ∎

Proof of Proposition (15)
The problem solved by the Legislator has a kink in $\phi = 1 - q$. Therefore, in order to find the solution we must compare the derivative at $\phi = (1-q)^-$ and $\phi = (1-q)^+$. If, for example, the two derivatives are negative, the solution ϕ^V solves equation (22). When $\phi = (1-q)^-$,

the derivative is negative if

$$f(1 - q - p)\left[G(1 + q - p) - G(1 - p)\right] > \int_0^{1-q-p} g(2q + \theta)dF(\theta)$$

When $\phi = (1 - q)^+$ the derivative is negative if

$$f(1 - q - p)\left[G(1 + q) - G(1 - p)\right] > \int_0^{1-q-p} g(1 + q)\, dF(\theta). \qquad \text{(A1)}$$

At the threshold $\phi = (1 - q)$ the bright side is larger at $\phi = (1 - q)^+$; while the dark side is lower for $\phi = (1 - q)^+$ if $g(2q + \theta) > g(1 + q)$ which implies $2q + \theta < 1 + q$, $\theta < 1 - q$. This is always true in the interval of integration, $\theta \in [0, 1 - q - p]$. Therefore, condition (23) implies (A1), and when condition (A1) is not satisfied, also inequality (23) is not satisfied. If inequality (23) is satisfied, the Legislator best choice is ϕ^V, which solves equation (22). Hence, ϕ^V is such that, when the organization is weak, the boss self-reports. If, instead, condition (A1) is not satisfied, the Legislator chooses ϕ^V solving equation (10): ϕ^V is such that, when the organization is weak, only the soldier talks. ∎