Endogenous Monitoring in a Partnership Game*

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Abstract

I consider a repeated game in which, due to imperfect monitoring, no collusion can be sustained. I add a self-interested monitor who commits to generating an imperfect private signal of firms' actions and sends a public message. The monitor makes an offer specifying the precision of the signal generated and the amount to be paid in return. I show that with low monitoring cost, collusive equilibria exist. In the monitor's favorite collusive equilibrium, firms' payoffs are decreasing in the discount factor. My model helps explain the cartel agreements between the mafia and firms in legal industries in Italy and America.

Keywords: Repeated games, mediation.
JEL codes: C73 (Repeated Games), K21 (Antitrust).

1 Introduction

Mafiosi appear to provide a genuine service to a number of cartels in legal industries in Italy and the United States, and sometimes enter these industries by invitation rather than on their own initiative – running counter to the widespread conception of mafias as

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ruthless extortionists imposing their presence upon firms. One of the services that the mafia offers to these cartels is monitoring. The little evidence we have suggests that the main beneficiaries in the agreements are firms themselves – the mafia is paid a relatively small fraction of total industry profits in return for their services. This is puzzling since firms in these industries are particularly "desperate" for the mafia's help in the sense that very little if any cooperation can be sustained without the help of a third party. As a result, one might expect the mafia to siphon a large fraction of firms' profits – at least, significantly more than they are actually charging. The aim of this paper is to offer an explanation for why the mafia makes such "modest" requests from industries that are so "desperate" for the mafia's help.

I develop a model of repeated interaction between two firms and a profit-maximizing monitor that resolves this puzzle. My repeated partnership game with imperfect public monitoring has the following features. Without a monitor, firms cannot sustain cooperation. The monitor makes a take-it-or-leave-it-offer to firms specifying the intensity of his monitoring and the per period fee to be paid. The monitor then decides which reports about his private signals to disclose publicly.

My paper has two main results. First, fully collusive equilibria (in which firms accept the monitor's offer) exist for sufficiently low costs of monitoring. The monitor's private signal and report imply that the cheater can be, at least statistically, identified and this enables cooperation. Second, my model delivers that for low degrees of patience, the monitor's share of the sum of payoffs is low. The monitor offers the terms of the agreement and attempts to appropriate the gains stemming from cooperation. His ability to do so depends on firms' incentive to deviate from cooperation. The benefit from deviating is high when patience is low. Fees decrease the benefit from sustaining cooperation. This means that the incentive to deviate is high when fees are high. Hence, when patience is low, high fees would compound the incentive problem. As a result, for low degrees of patience, the monitor's ability to siphon firms' payoffs is limited. I thereby offer an explanation why the mafia makes uncharacteristically modest requests from industries that are "desperate" for the mafia's help.

More generally, in my model, the benefit from deviating is decreasing with the discount factor. This delivers a number of auxiliary comparative statics results. Unlike what is commonly the case without a mediator (or a disinterested one), increased patience need not result in higher equilibrium payoffs among the firms. Focussing on fully collusive equilibria that maximize the monitor's payoff, I find that firms' payoffs are decreasing in the discount factor. Hence, the fact that collusion becomes "harder," the lower the discount factor works in firms' favor when a monitor is hired. When patience is high, the decreased incentive to deviate also implies that less monitoring is required to sustain cooperation. Thus, because monitoring is costly, the total sum of payoffs is increasing with the discount factor.

Beyond these results, I explore the relationship between the minimum intensity of monitoring and the maximum fee. Because the monitor sees the payments he receives, the maximum fee is independent of the intensity of monitoring. On the other hand, the minimum intensity of monitoring required to sustain cooperation is increasing in the fee. The probability that a deviation from cooperation with the other firm is detected (and therefore punished) is increasing in the intensity of monitoring. Hence, the incentive to deviate from cooperation with the other firm is decreasing in the intensity of monitoring. The incentive to deviate is increasing in the monitor's fee because the fee decreases the benefit from cooperation. As a result, the monitor faces a trade-off between increasing the intensity of monitoring and decreasing the fee.

My paper relates to the sociological and economic literature on the role of the mafia in cartel agreements. It draws on a number of case studies developed by Reuter (1984, 1987), Gambetta (1993), Gambetta and Reuter (1995), Alexander (1997) and Landesco (1968), to name a few. They present evidence on mafia involvement in customer allocation agreements in the garbage collection industry in the New York City up until the 1980s, in price-fixing and quota control in the wholesale fruit and vegetable market in Palermo up until the mid-1950s, in price-fixing in the bread and pasta production market in Chicago during the 1930s, and in market sharing agreements in the fish market in Palermo and in the construction industry in Sicily. However, the problem is by no means one of the past: in 2008, the Sicilian mafia, Cosa Nostra, was found to be involved in price fixing in the wholesale meat market in Palermo. It had ensured that prices were significantly above the competitive level. In return, firms paid a fee to the mafia. The case was revealed as part of a bigger investigation, when one of the traders complained to the Cosa Nostra that a competitor was not charging the agreed collusive price.

Alexander (1997), Reuter (1987) and Gambetta and Reuter (1995) argue that, among other things, the mafia acts as a monitor. The little evidence we have suggests that in return for this service, the mafia is paid modest fees relative to industry profits (Alexander 1997, Gambetta and Reuter 1995, Reuter 1987). At the same time, firms in these industries usually have no reserve equipment and very limited access to external finance (Reuter 1987). Put differently, the firms' discount factor is low.

An example of a cartel, where the mafia acted as a monitor, is the bread and pasta production market in Chicago in the 1930s. The cartel was set up at a time of rapid decline in demand, and when around 40% of Chicago's labor force was unemployed. While also providing a number of other services such as providing credible threats of punishment and a barrier to entry, Alexander (1997) suggests that the mafioso Calabrese acted "as a cartel ringmaster whose primary duties are to monitor and control members' output levels." Calabrese collected a "sales tax" by selling package labels. The labels were akin to tax stamps. Manufacturers were required to put the labels on each package of pasta sold within a 50-mile radius of Chicago – this enabled Calabrese to monitor firms' outputs.[1]

Evidence that the mafia is paid modest fees relative to industry profits comes from cartels in New York City, Long Island and Chicago. In the Long Island garbage collection industry in the mid-1980s, the mafia was paid around $400,000 annually – estimated profits on the other hand were over $10 million. In the New York City concrete cartel, the mafia charged 2% of the contract price in return for price fixing (Gambetta and Reuter 1995). In the bread and pasta production cartel in Chicago in the 1930s, the mafia charged 0.25 cents per pound of pasta (plus a fee for every "macaroni press" owned), where pasta was sold for $7.5-9$ cent per pound – whereas in areas outside Chicago pasta was sold for around 6.5 cent per pound (Alexander 1997). More evidence that the main beneficiaries of these cartel agreements with the mafia were firms themselves comes from the fact that customers in customer allocation agreements in the garbage collection industry in New York City were "sold" at very high prices – sometimes a single truck garbage collector was able to sell his customers for up to $400,000 (Reuter 1987).

A typical example illustrating the difficulty of firms to sustain collusion without a third party is the commercial garbage collection industry in New York City. In the 1980s, the industry in New York City consisted of over 300 small, often family-run firms, and on Long Island of at least 200 firms, with the largest four sharing less than 25% of the market. Most of these firms had no reserve equipment and very limited access to external finance (Reuter 1987). These adverse credit conditions mean firms are not sufficiently patient for the Folk Theorem to apply. The mafia organized this cartel through local

[1]While there are examples of the mafia providing services other than monitoring, I abstract from them for the purposes of this paper. As I argue in Section 5, the key insights of the paper generalize to services other than monitoring.

labour unions which it used to police the agreements. While the exact nature of these agreements remains unclear, there is little evidence of actual violence. It is clear that the mafia was involved in allocating new customers, determining who had (allegedly) broken the agreement and resolving such conflicts (Gambetta and Reuter 1995, Reuter 1987).

My paper also relates to the literature on monitoring in repeated games. This literature has mainly focused on information acquisition without a third party. Miyagawa, Miyahara and Segikuchi (2008), Ben-Porath and Kahneman (2003) and Kandori and Obara (2004) analyze models with costly, perfect monitoring. In these papers, players monitor one another. In contrast to Miyagawa, Miyahara and Sekiguchi (2008), Ben-Porath and Kahneman (2003), and this paper, Kandori and Obara (2004) assume players observe signals about the other player's monitoring activity (at a cost). One common assumption of those papers is that the monitoring decision is binary; each player simply decides whether to obtain (almost) perfect information at a cost or not to obtain additional information at all. In my model, like in Miyagawa, Miyahara and Sekiguchi (2009), there is flexibility in the quality of information obtained, at varying cost levels. Another difference between these papers and my work is that I consider equilibria for a fixed discount factor, whereas most of them consider asymptotic equilibria and derive folk theorems.

The literature has considered third parties as a means to improve efficiency – for instance, Tomala (2009) in a repeated games setting, and Rahman and Obara (2010) in a one shot setting. Both papers look at a mediator in the spirit of Myerson (1982, 1986). My model differs from the traditional way of modeling a mediator in the spirit of Myerson in three ways. First, in my model the monitor is a profit-maximizing agent with vested interests as opposed to a disinterested agent. Second, my monitor is an integral part of the game with the same problems of commitment with respect to the messages he sends as other strategic players. Finally, the monitor generates new information, rather than relaying existing information.

In the following, I will first describe the set-up, starting with the stage game without the mafia as a self-interested monitor, followed by a description of the stage game with the monitor. Then I present the main results. I first show that fully collusive equilibria exist for sufficiently low monitoring costs. I then turn to comparative statics results. I show that the payoffs for firms in the monitor's favorite fully collusive equilibria are decreasing in the discount factor. Moreover, I show that the minimum intensity of monitoring is increasing in the monitor's fee. I conclude with a discussion of open problems.

2 Model

Let me start with an overview of the model. There are two firms, and a monitor (the mafia).[2] In the beginning, the monitor offers a contract, specifying an intensity of monitoring and a fee to be paid by firms. Whether this contract is accepted or rejected by firms determines the status of the monitor. If the contract is rejected, the monitor is passive in the sense that his actions are trivial, and his payoff is always 0. I call this the baseline game. In the baseline game, firms play an infinitely repeated Prisoner's Dilemma with imperfect public monitoring. Firms' actions are private; only a public signal is observable at the end of each period. If instead the monitor is active, in addition to playing the Prisoner's Dilemma, firms also choose whether to (privately) pay the fee to the monitor. The monitor observes firms' action choices imperfectly, and sends a public message to firms.

	C	D
C	$1, 1$	$-\ell, 1+g$
D	$1+g, -\ell$	$0, 0$

Figure 1: Expected stage game payoffs.

To be precise, the game is as follows. There are three players – two firms, $i = 1, 2$, and a monitor. Time is discrete, and the horizon is infinite. The horizon can be divided into two stages. The first stage is period 0 only; and the second stage is from period 1 onwards. It is most convenient to think of the first stage as defining the repeated game $\Gamma(k, F, a_0)$ that follows. In period 0, the monitor offers a contract $(k, F) \in [0, 1] \times \mathbb{R}$, where k specifies the constant intensity of monitoring and F a fee payable by each firm in each period. Firms observe this contract, and then simultaneously choose to accept or reject it (so $A_0 = \{accept, reject\} \times \{accept, reject\}$, and $a_0 \in A_0$). This ends the first stage.

Unless $a_0 = (accept, accept)$, the game $\Gamma(k, F, a_0)$ is defined as follows.[3] The action

[2]The model and the results naturally extend to n firms.

[3]Throughout I will refer to the game $\Gamma(k, F, a_0)$ with $a_0 \neq (accept, accept)$ as the "baseline game."

set of the monitor in $\Gamma(k, F, a_0)$ is trivial, and his payoff is always 0. In each period $t = 1, 2, \ldots$, firms simultaneously and privately choose whether to cooperate (action C) or defect (action D). Let $Y = \{y_L, y_H\}$ denote the set of public signals, observable at the end of any period $t \geq 1$. The probability distribution of signals conditional on effort profiles is given by: $\pi_Y : E \to \triangle(Y)$, where $E = E_i \times E_j = \{C, D\} \times \{C, D\}$. I denote:

$$\pi_Y(y_H|e) = \begin{cases} p & \text{if } e = (C, C), \\ q & \text{if } e = (C, D) \text{ or } e = (D, C), \\ r & \text{if } e = (D, D). \end{cases}$$

Note that the probability of y_H only depends on the number of firms choosing C. Throughout I maintain the assumption that $1 > p > q > r > 0$. The expected stage game payoffs for firms in the baseline game are as in a Prisoner's Dilemma – they are summarized in Figure 1 with $g, \ell > 0$, $g - \ell < 1$.

Note that we have two actions per firm, and two public signals. This means that the standard sufficient conditions for the Folk Theorem fail. Throughout this paper, I make an even stronger assumption. In particular, I assume that

$$q - r \leq p - q \leq \frac{g}{1+g}(1-q),$$

$$1 + \frac{g}{1+\ell} \geq \frac{p(p - 2q + r)}{pr - q^2} \geq 0.$$

It then follows from Sanktjohanser (2016) that there is a unique equilibrium payoff (in public strategies) of 0 for all players. The first condition says that the marginal increase in the probability of a high signal from (C, D) to (C, C) is larger than the marginal increase from (D, D) to (C, D). Moreover, it requires that the marginal increases are sufficiently small, i.e., the signals are sufficiently noisy. The second condition says that firm i's maximal payoff within the set of individually rational and feasible payoffs, $1+\frac{g}{1+\ell}$, must be large enough. Note that fixing p, q, and r (in a way that satisfies the first inequality), the conditions are fulfilled if g is large enough, i.e., the benefit of deviating needs to be sufficiently high.[4]

If $a_0 = (accept, accept)$, then $\Gamma(k, F, a_0)$ is as follows. In every period $t = 1, 2 \ldots$, firms move first, and the monitor moves second. An action of firm i is a pair

[4]With this restriction on parameters, there is no need to make a necessarily arbitrary choice of equilibrium payoffs in the baseline game. However, my results hold so long as this choice is independent of the specific (k, F) that was rejected.

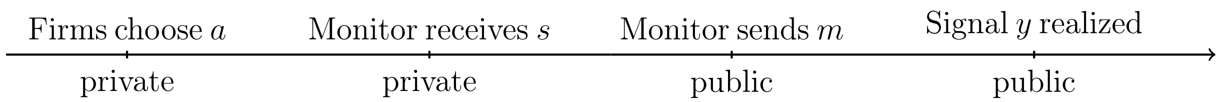

Figure 2: Sequence of events within any period $t \geq 1$.

$$a_i = (e_i, f_i) \in A_i \equiv E_i \times \mathcal{F}_i = \{C, D\} \times \{0, F\}.$$

The first element e_i is the effort choice, where $e_i = C$ represents "cooperate", and $e_i = D$ represents "defect." The second element f_i is the payment choice, where $f_i = F$ represents "pay the monitor the specified fee," and $f_i = 0$ represents "not pay the monitor." An action for the monitor is a public message $m \in M \equiv \{c, d\}$.

As in the baseline game, there is a binary public signal, either *high (y_H)* or *low (y_L),* at the end of period t. In addition, the monitor receives the following private information. First, he perfectly and costlessly observes firms' payment choices $(f_1, f_2) \in \{0, F\} \times \{0, F\}$. Second, the monitor receives a pair of private signals about firms' effort choices. Those signals are independent. The set of private signals is given by $S \equiv \{c, d\} \times \{c, d\}$. The monitoring technology of the monitor is a map

$$\pi_S : E \rightarrow \triangle(S),$$

where $\pi_S(e'|e)$ is the probability that $e' \in S$ is observed when e is played, and, with some abuse of notation, $\pi_S(e'_i|e)$ is the marginal probability that e'_i is observed when e is played. Specifically, I assume:

$$\pi_S(e_i|e) = \begin{cases} k & \text{if } e = (D, e_j), \\ 1 & \text{if } e = (C, e_j). \end{cases}$$

For instance, the probability that (c, d) is observed when (D, D) is played is given by:

$$\pi_S((c, d)|(D, D)) = k(1 - k).$$

Hence, the quality of monitoring is measured by k: When $k = 0$, then the monitor receives the same signal regardless of firms' effort choices. When $k = 1$, the monitor observes firms' effort choices perfectly. Therefore, bad news are informative. The sequence of events within a period is described in Figure 2.

Given some action profile a, firm i's expected stage game payoff is

$$u_i(a) \equiv \sum_{y \in Y} g_i(a_i, y)\pi_Y(y|e).$$

Expected stage game payoffs are given in Figure 3. The expected stage game payoffs are the expectations of the realized payoffs which firms do privately observe but carry no further information.[5] The monitor's stage game payoff is

$$g_m : \mathcal{F}_i \times \mathcal{F}_j \times [0,1] \to \mathbb{R},$$

where g_m is additively separable in f and k:

$$g_m(f,k) = g'_m(f) - \gamma_m(k) = f_1 + f_2 - \gamma k.$$

Players aim to maximize their payoff, which is the average discounted sum of stage game payoffs, denoted $v_i(a)$ for firm i and $v_m(k)$ for the monitor. Note that the min-max payoff in $\Gamma\left(k, F, (\mathit{accept}, \mathit{accept})\right)$ is $-\gamma k$ for the monitor and 0 for the firms.

	C	D
C	$1 - f_1, 1 - f_2$	$-\ell - f_1, 1 + g - f_2$
D	$1 + g - f_1, -\ell - f_2$	$0 - f_1, 0 - f_2$

Figure 3: Firms' expected stage game payoffs with $f_i \in \{0, F\}$.

A few comments about modeling choices are in order. First, the monitoring technology is particularly simple: the monitor detects defection with probability k, where k is the intensity of monitoring. It is constant and independent across periods, and identical

[5]The actual, realized stage game payoff for firm i is

$$g_i : A_i \times Y \to \mathbb{R},$$

where $g_i(a_i, y) = y - \gamma_i(e_i)$ with

$$\gamma_i(e_i) = \begin{cases} 1 + g + \ell & \text{if } e_i = C, \\ 0 & \text{if } e_i = D. \end{cases}$$

Hence, if the good signal, y_H, is realized and firm i has played (C, F) the stage game payoff for firm i is given by:

$$g_i((C,F), y_H) = y_H - (1 + g + \ell) - F.$$

for both firms. This assumption is made to keep the model parsimonious, and the main insights do not rely on it. Second, the monitor commits to the level of k. The monitor specifies in advance the level of payment expected from the firms, yet each firm may privately renege on paying the monitor even after having consented to the contract. Note that the information obtained by the monitor is not verifiable — the monitor may conceal defection, or claim that firm i has cheated even if i has played C but, for example, refused to pay them F. In the motivating application, we can think of the level of k as the time that mafiosi spend at the fruit and vegetable market they monitor (which is observable to the sellers in the market). The outcome of the monitoring on the other hand is less readily observable by firms: the mafia may simply have seen a firm undercutting the agreed price but it cannot provide hard evidence in the form of receipts etc. Third, the precise cost structure of the monitoring technology is not crucial for my results – it is sufficient that the cost of monitoring is monotone in k. Finally, I abstract from any enforcement role that the monitor (mafia) can play in these cartels. It is straightforward to enrich the model in this way and the results do not change qualitatively. Limitations of the modeling assumptions are discussed in more detail in Section 5.

In the game $\Gamma(k, F, (accept, accept))$, a public history of length t corresponds to the public signals observed, and the public messages sent by the monitor:

$$h_t = ((y_1, m_1), ..., (y_{t-1}, m_{t-1})).$$

The set of public histories is denoted by $H_t \equiv (Y \times M)^{t-1}$. I set $H_0 \equiv \{\emptyset\}$. A private history for the monitor is the public history, plus the history of private signals and payments if any received (including this period's):

$$h_{mt} = ((y_1, m_1, s_1, f_1), ..., (y_{t-1}, m_{t-1}, s_{t-1}, f_{t-1}), (s_t, f_t)).$$

I denote the set of private histories by $H_{mt} \equiv (S \times \mathcal{F})^t \times (Y \times M)^{t-1}$. A reporting strategy for the monitor is

$$\mu : H_{mt} \to \triangle(M).$$

It selects message m with probability $\mu(m|h_{mt})$ conditional on private history h_{mt}. Firm i's public strategy is a mapping from all t-period public histories h_t to A_i with $h_t \in H_t$:

$$\sigma_i : H_t \to \triangle(A_i).$$

The analysis in $\Gamma(k, F, a_0)$ is restricted to perfect public equilibria modified in the following way. A perfect public equilibrium is a profile of public strategies such that, given any period t and public history h_t, the strategy profile is a Nash equilibrium from that period on. I restrict the firms to public strategies, but the monitor is permitted to make use of his private histories as just described, in particular the private signals and payments received. This is the only modification to the solution concept of PPE. I am fully aware that perfect public equilibrium is a restrictive equilibrium concept, but it has the advantage of tractability. In addition, (k, F, a_0) must form a sub-game perfect equilibrium (SPE) in the first stage taking as given the selection of PPE payoffs in $\Gamma(\cdot, \cdot, \cdot)$. I refer to an equilibrium as a pair of a sub-game perfect equilibrium in the first stage, and (a selection of) PPE for every $\Gamma(k, F, a_0)$.

Let $E(\delta)$ denote the (compact) set of equilibrium payoff vectors for any given discount factor $\delta < 1$. I am interested in characterizing fully collusive equilibria for fixed δ, where I interpret "fully collusive" as $e = (C, C)$ being chosen on the equilibrium path in every period $t > 0$. In particular, I focus on the set of fully collusive equilibria which maximize the monitor's payoff. While one of the reasons for doing so is analytical tractability, I believe I can motivate my restrictions as follows: (1) Prices and hence, profits in these cartels were significantly above the competitive level (Alexander 1997, Gambetta and Reuter 1995, Reuter 1987). This suggests that "full collusion" may accurately describe the cartels under consideration. (2) Taking into account the kind of organization the mafia is, it is interesting to consider how firms might benefit from working with the mafia even though the mafia in some ways "dictates" the terms of the agreement. By restricting attention to the "best equilibria" for the mafia, I exclude certain kinds of off-equilibrium beliefs. For instance, I am not considering equilibria where firms believe the monitor will not report deviations from $f_i = F$ but will report report deviations from $e_i = C$. In my motivating example this seems a plausible restriction. However, it may not be fully satisfactory in other contexts.

3 Equilibrium with a monitor

In this section, I introduce the main result of the paper, showing how the incentives of firms determine the maximum fee and the minimum amount of monitoring that the monitor offers in the first stage. Formally, define

$$F^* = 1 - (1-\delta)(1+g),$$

and

$$k^* = \frac{(1-\delta)g}{\delta(1-F^*)}.$$

Proposition 1. *There exist $\overline{\gamma} > 0$, such that for every $\gamma < \overline{\gamma}$ and $\delta > \frac{g}{1+g}$, there exist equilibria such that, on the equilibrium path,*

(i) the monitor offers (k^*, F^*),

(ii) both firms accept the offer, and

(iii) both firms play C and pay F^*.

Moreover, these equilibria guarantee the monitor the highest payoff within the set of fully collusive equilibria.

The following strategies sustain cooperation in the game $\Gamma\left(k^*, F^*, (accept, accept)\right)$ as specified in Proposition 1. Players start out in the collusive phase. In the collusive phase, each firm i sets $e_i = C$ and $f_i = F^*$. Firms remain in the collusive phase so long as the monitor reports $m = c$. When the monitor reports $m = d$, firms switch to a punishment phase. In the punishment phase, each firm i sets $e_i = D$ and $f_i = F^*$. Firms remain in the punishment phase so long as the monitor reports $m = d$, and they switch back to the collusive phase when $m = c$.

In the collusive phase, the monitor truthfully reports $m = c$. If a firm unilaterally deviates from (C, F^*) and the monitor detects this, he reports $m = d$. If the monitor reported $m = d$ in the previous period, and firms stick to their prescribed strategies (play (D, F^*)), then he reports $m = d$ with probability z and $m = c$ with probability $1 - z$, where z is chosen such that firms' continuation payoff following a deviation is equal to their min-max payoff (i.e., 0). If either firm deviates during the punishment phase, the monitor sends $m = d$ with probability 1.

More formally, the entire strategy profile that supports Proposition 1 is as follows. The monitor's strategy in the first stage is to offer:

$$a_{m0} = \left(k^*, F^*\right).$$

Firm i's strategy in the first stage is:

$$a_{i0} = \begin{cases} accept & \text{if } \ F \leq F^* \text{ and } k \geq k^*, \\ reject & \text{otherwise.} \end{cases}$$

The choice of actions in this first stage define the repeated game $\Gamma(k, F, a_0)$. When $k \geq k^*$, $F \leq F^*$, and $a_0 = (accept, accept)$, then players' strategies are as follows. For any period $t \geq 1$, firm i sets

$$a_{it} = \begin{cases} (D, F) & \text{if } m_{t-1} = d, \\ (C, F) & \text{if } m_{t-1} = c. \end{cases}$$

The monitor's reporting strategy in $t \geq 1$ depends on m_{t-1}:

$$\mu_t (c \mid m_{t-1} = c) = \begin{cases} 1 & \text{if } f_t = (F, F) \text{ and } s_t = (c, c), \\ 0 & \text{otherwise,} \end{cases}$$

$$\mu_t (c \mid m_{t-1} = d) = \begin{cases} 1 - z & \text{if } f_t = (F, F), \\ 0 & \text{otherwise.} \end{cases}$$

When

$$(k, F, a_0) \neq (k \geq k^*, F \leq F^*, (accept, accept)),$$

then players' strategies are as follows. For any period $t \geq 1$, firm i sets

$$a_{it} = (D, 0),$$

and the monitor's reporting strategy (unless he is passive) is

$$\mu_t (c) = 0.$$

Denote this strategy profile by $(\sigma_1^*, \sigma_2^*, \mu^*)$.

Proof. In the following, I show that the strategy profile $(\sigma_1^*, \sigma_2^*, \mu^*)$ constitutes an equilibrium. By the one-shot deviation principle, it is sufficient to check that no player has an incentive to deviate for exactly one period (then immediately returning to the proposed equilibrium strategy), after every possible public history of the game. I distinguish histories by the following partitions. First, I distinguish histories by the game

$\Gamma(k, F, a_0)$ induced in the first stage. Second, I partition histories by the message sent in the previous period, m_{t-1}.

Consider the strategy profile $(\sigma_1^*, \sigma_2^*, \mu^*)$. Assume

$$(k, F, a_0) \neq (k \geq k^*, F \leq F^*, (accept, accept)).$$

The proposed equilibrium strategy for firm i is to play $a_{it} = (D, 0)$ indefinitely and unconditionally. This is simply the static Nash equilibrium play. Hence, there is no profitable unilateral deviation for firm i. Firms' strategies are independent of the monitor's report. As a result, the monitor cannot affect payoffs through his report. Hence, there is no incentive to deviate from the proposed equilibrium strategy for the monitor.

Assume $(k \geq k^*, F \leq F^*, (accept, accept))$. If there is no unilateral profitable deviation for firm i in $\Gamma(k^*, F^*, (accept, accept))$, then there is no unilateral profitable deviation for firm i in any $\Gamma(k, F, (accept, accept))$ with $k \geq k^*$ and $F \leq F^*$. Hence, it is sufficient to check all unilateral deviations for firms in $\Gamma(k^*, F^*, (accept, accept))$. Assume that firm 2 and the monitor play the proposed equilibrium strategies. Firm 1's payoff from playing the proposed strategy is $v_1 = 1 - F$. Firm 1's payoff following a detected deviation is:

$$v_1^p = z(1-\delta)(0-F) + \delta z v_1^p + (1-z)(1-F),$$

where the monitor chooses z such that $v_1^p = 0$, i.e., firms are min-maxed following a detected deviation.[6] This is the case when

$$z = \frac{1-F}{1-F+(1-\delta)F}.$$

Consider a one-shot deviation in period t when $m_{t-1} = c$. Firm 1 may set

$$(e_{1t}', f_{1t}') \in \{(C, 0), (D, 0), (D, F)\},$$

[6] We can derive z by setting $v_1^p = 0$, i.e.,

$$z(1-\delta)(0-F) + (1-z)(1-F) = 0.$$

When $F = F^* = 1 - (1-\delta)(1+g)$, then:

$$z = \frac{1+g}{\delta(1+g)+1}.$$

Clearly, $z \in [0,1]$ since $\delta > \frac{g}{1+g}$.

i.e., cooperate but not pay, or defect and not pay, or defect yet pay. Since the first two types of deviation are both surely detected, but $(C, 0)$ yields a lower one-shot gain than $(D, 0)$ does, the former is dominated by the latter. Firm 1 does not want to deviate to $(e'_{1t}, f'_{1t}) = (D, 0)$ if the payoff from doing so is weakly less than $v_1 = 1 - F$, that is,

$$1 - F \geq (1 + g)(1 - \delta) + \delta v_1^p.$$

This yields an upper bound on F, call it F^*:

$$F \leq F^* = 1 - (1 - \delta)(1 + g).$$

A deviation to $(e'_{1t}, f'_{1t}) = (D, F)$ is only detected with probability k. If it is detected, then the continuation payoff for firm 1 is v_1^p as above. If firm 1 is not detected, collusion continues. Firm 1 does not want to deviate to $(e'_{1t}, f'_{1t}) = (D, F)$ if the payoff from doing so is no more than $v_1 = 1 - F$:

$$v_1 \geq (1 + g - F)(1 - \delta) + \delta k v_1^p + \delta(1 - k)(1 - F).$$

After substitution of v_1^p and v_1 and simplification we obtain a lower bound on k, call it $k^*(F)$:

$$k \geq k^*(F) = \frac{(1 - \delta)g}{\delta(1 - F)}.$$

This implies $k^*(F^*) = k^*$. Hence, in $\Gamma(k^*, F^*, (accept, accept))$, neither firm has an incentive to deviate on path.

Now consider a one-shot deviation in t when $m_{t-1} = d$. A firm's payoff from playing the proposed equilibrium strategy v_1^p. Firm 1 may set

$$(e'_{1t}, f'_{1t}) \in \{(C, 0), (D, 0), (C, F)\}.$$

For the same reason as above, $(C, 0)$ is dominated by $(D, 0)$. Clearly, (C, F) is dominated by (D, F). Firm 1 does not want to deviate to $(e'_{1t}, f'_{1t}) = (D, 0)$ if the payoff from doing so is weakly less than v_1^p:

$$v_1^p \geq 0(1 - \delta) + \delta v_1^p.$$

This holds by construction.

Assume both firms use the proposed equilibrium strategy. The monitor's payoff from playing the proposed strategy is $v_m^* = 2F^* - \gamma k^*$. Since the monitor's payoff does not depend on his report, there is no incentive to deviate from the proposed equilibrium strategy.[7]

Hence, the strategy profile $(\sigma_1^*, \sigma_2^*, \mu^*)$ constitutes a PPE in any $\Gamma(k, F, a_0)$. It remains to be checked that the game $\Gamma(k^*, F^*, (accept, accept))$ arises from equilibrium behavior in stage 1 of the game taking as given the PPE in $\Gamma(k, F, a_0)$ as specified.

Suppose the monitor offers $(k \geq k^*, F \leq F^*)$, and that firm 2 accepts the offer. Firm 1's payoff from accepting the offer and using the proposed equilibrium strategy is $v_1^* = 1 - F$, whereas its payoff from rejecting the offer is 0. Firm 1 has no incentive to reject the offer if:

$$1 - F \geq 0,$$

which yields $F \leq 1$. Hence, neither firm has an incentive to reject an offer $(k \geq k^*, F \leq F^*)$.

By choice of strategy, both firms accept an offer iff $F \leq F^*$and $k \geq k^*$. The monitor will choose the contract offer so as to maximize his own payoff v_m given by

$$v_m(F, k) = \begin{cases} 2F - \gamma k & \text{if } (k \geq k^*, F \leq F^*, (accept, accept)), \\ -\gamma k & \text{if } (k, F, (accept, accept)) \neq (k \geq k^*, F \leq F^*, (accept, accept)), \\ 0 & \text{otherwise.} \end{cases}$$

subject to $k \geq k^*$ and $F \leq F^*$. Denote by F^{FB} the $\arg\max_F v_m(F, k)$ conditional on (i) $a_0 = (accept, accept)$, and (ii) $k = \frac{1-\delta g}{\delta(1-F)}$. It is straightforward to show that

$$F^{FB} = 1 - \sqrt{\frac{\gamma(1-\delta)g}{2\delta}}.$$

F^{FB} is decreasing in γ. Hence, for monitoring costs sufficiently low, the constraints $k \geq k^*$ and $F \leq F^*$ bind. In particular, $F^{FB} > F^*$, and hence, offering (k^*, F^*) is optimal if

$$\gamma \leq \bar{\gamma} = \frac{2(1-\delta)\delta(1+g)^2}{g}.$$

Therefore, I have shown that the proposed strategies form an equilibrium. In this equilibrium, (k^*, F^*) is offered and accepted in the first stage. In the repeated game that

[7] In fact, by choice of strategies, the monitor's payoff is independent of his report in any $\Gamma(k, F, a_0)$.

follows, firms play C and pay F^* on path as specified in Proposition 1.[8]

Finally, note that any offer (F, k) with either $F \geq F^*$ or $k \leq k^*$ would not support (C, C) in every period. This implies that the strategy profile $(\sigma_1^*, \sigma_2^*, \mu^*)$ with $(k^*, F^*, (accept, accept))$ guarantees the monitor the highest equilibrium payoff within the set of fully collusive equilibria.[9]

□

4 Comparative statics

In this section, I present comparative statics for $\Gamma(k^*, F^*, (accept, accept))$, showing that firms' payoffs are decreasing in the discount factor and that the minimum intensity of monitoring is increasing in the monitor's fee.

Proposition 2. *Consider the game $\Gamma(k^*, F^*, (accept, accept))$. In any PPE, where firms cooperate on path, firms' payoffs are (strictly) decreasing in δ and sum of payoffs (including the monitor's) is (strictly) increasing in δ.*

Proof. Firm i's payoff is given by

$$v_i^* = 1 - F^* = (1-\delta)(1+g),$$

and the first part of the proposition immediately follows. Since F^* is simply a transfer from firms to the monitor, F^* does not directly affect the sum of payoffs. The sum of payoffs is increasing in δ because the amount of monitoring required

$$k^* = \frac{(1-\delta)g}{\delta(1-F^*)} = \frac{g}{\delta(1+g)}$$

is decreasing in δ. □

Proposition 2 follows from the fact that the monitor offers the terms of the agreement and attempts to appropriate the gains stemming from cooperation. His ability to do so depends on firms' incentive to deviate from cooperation. The benefit from deviating is

[8] When $\tilde{\gamma} > \gamma > \bar{\gamma}$, fully collusive equilibria still exist, where $\tilde{\gamma}$ is the monitoring cost that guarantees the monitor a payoff of 0. All results in this paper continue to hold. When the cost of monitoring is very high, specifically when $\tilde{\gamma} < \gamma$, fully collusive equilibria do not exist.

[9] However, that is not to say that $\Gamma(k, F, (accept, accept))$ with $k \leq k^*$ and $F \geq F^*$ cannot arise from equilibrium behavior in the first stage of the game.

decreasing in δ. Hence, when δ is high, the monitor can exploit this decreased incentive to deviate. Note that this implies that firms' share in payoffs is strictly decreasing in δ.

The decreased incentive to deviate also implies that the monitor sets k lower when δ is high. When δ is high, less monitoring is required to sustain cooperation. Since monitoring is costly, the sum of payoffs is strictly increasing in δ.

My results may seem surprising in light of Abreu, Pearce and Stacchetti's monotonicity result. Abreu, Pearce and Stacchetti (1990) show that if the set of equilibrium payoffs is convex, it is non-decreasing in the discount factor. The set of equilibrium payoffs is necessarily convex when players have access to a public randomization device. While I do not assume a public randomization device, this is not relevant for my results.[10] Instead, note that Proposition 2 makes a statement about the distribution of payoffs between the different parties, rather than the sum of payoffs. The sum of all payoffs in my model is non-decreasing in the discount factor. Only the distribution of payoffs between the different parties is changing such that firms' payoffs are decreasing in the discount factor. As an aside, also note that I have not analyzed the full set of equilibrium payoffs. Given that I focus on fully collusive equilibria, it is not clear whether the result would extend to the maximum payoff in the set of all equilibrium payoffs.

On a related point, note that my result hinges on the first mover advantage of the monitor: while there are good reasons for assuming the mafia to move first in my motivating example, this may not be plausible in other applications. If instead we assume that firms may make a proposal to the monitor, firms' payoffs are increasing in the discount factor.

According to this model, we should expect industries with mafia cartels to be characterized by bleak business prospects. We should not expect the mafia to be present in flourishing industries – not because they can sustain cooperation themselves, but because the mafia is becoming too "greedy" when the discount factor is high leaving firms hardly better off than without the mafia. Looking at the empirical evidence, we do indeed find that industries in which the mafia monitors cartels are characterized by having very limited or no access to external credit, and no access to reserve equipment (Reuter 1987). In some mafia cartels, for instance in the garment manufacturing industry in Sicily in the 1930s, firms were so credit and capacity constrained they struggled to even afford the equipment needed to operate and many of them would not have survived if

[10] Yamamoto (2010) shows that for pure strategies the set of payoffs may not be monotonic if a public randomization device is not available.

it were not for the mafia granting them credit (see Gambetta 1993, Gosch and Hammer 1975). Note also, that because firms' credit constraints limit the monitor's ability to siphon payoffs, granting firms' credit is exactly what we would expect the mafia to do in order to increase their share in collusive payoffs. With this model we can explain why firms' desperation (in terms of a low discount factor) protects the gains from collusion from the mafia rather than enables it to appropriate it. Hence, I can offer a solution to the puzzle why the share of profits that the mafia takes in return for its services is "modest" (see Alexander 1997, Gambetta and Reuter 1995, Reuter 1987).

Proposition 3. *Consider the game $\Gamma\left(k^*, F^*, (accept, accept)\right)$. In any PPE, where firms cooperate on path, the lower bound on the intensity of monitoring required, $k^*(F)$, is increasing in the fee F. The upper bound on the fee, F^*, is independent of k.*

Proof. The intensity of monitoring required and the fee are given by

$$\begin{aligned} k^*(F) &= \frac{(1-\delta))\, g}{\delta\,(1-F)}, \\ F^* &= (1-\delta)\,(1+g)\,, \end{aligned}$$

and the proposition immediately follows. □

There are two main ways in which a firm can deviate in a collusive phase, by not paying the monitor (i.e., by playing $(D, 0)$), or by defecting on the other firm (i.e., by playing (D, F)). The first type of deviation pins down an upper bound on the fee F:

$$1 - F \geq (1+g)(1-\delta) + \delta v_1^p.$$

The upper bound on F is independent of the intensity of monitoring k because deviations involving not paying the monitor are detected with probability 1, regardless of k. The second type of deviation pins down a lower bound on the intensity of monitoring k:

$$1 - F \geq (1+g-F)(1-\delta) + \delta k v_1^p + \delta(1-k)(1-F).$$

A deviation to (D, F) is detected with probability k. If it is detected, the firm receives $v_1^p = 0$, which is independent of F. This implies that holding k fixed, a higher fee F increases the benefit from deviating to (D, F). As a result, the lower bound on the intensity of monitoring, k^*, is increasing in F. This means that the monitor faces a trade-off between increasing the intensity of monitoring and decreasing the fee. When the cost of monitoring is sufficiently high, i.e., when

$$\gamma \geq \bar{\gamma} = \frac{2(1-\delta)\,\delta\,(1+g)^2}{g},$$

this trade-off will induce the monitor to offer a fee which is below the maximum fee.[11]

5 Discussion

I have made a series of restrictive assumptions regarding the environment and the equilibrium concept. With respect to the environment, both the message and the monitoring structure are particularly simple. The message space I have assumed throughout is: $M = \{c, d\}$ – a subset of the monitor's private signals. It is easy to show that enlarging the message space to $M = \{c, d\} \times \{c, d\}$ (i.e., the set of the monitor's private signals) does not affect the monitor's maximum equilibrium payoff from fully collusive equilibria. However, with the larger message set, this maximum payoff can be supported by other strategies, due to the possibility of asymmetric (i.e., targeted) punishment strategies. As is known (see Bester and Strausz 2001), the larger message set need not be without loss either: direct mechanisms under which the monitor's message set is the set of his possible private signals need not suffice when there is no commitment. If we allow the monitor to send messages both about the effort and the firms' payment choices (i.e., $M = \{c, d\} \times \{f, 0\} \times \{c, d\} \times \{f, 0\}$), the strategies supporting Proposition 1 remain an equilibrium. However, in that case I don't know whether it is the monitor's favorite equilibrium within the set of fully collusive equilibria.

I assume that messages are public. If the monitor can send private messages to firms, the outcome of Proposition 1 remains an equilibrium outcome. However, private messages enlarge the set of fully collusive equilibria. For instance, private messages imply that targeted punishment strategies are feasible, even when messages are binary.

With regards to the monitoring structure, I have assumed throughout that bad news are informative. Consider the following modification regarding the monitoring technology. In particular, assume:

[11] For a derivation of this cut-off, see the proof of the existence of collusive equilibria in the previous section.

$$\pi_S(e_i|e) = \begin{cases} 1 & \text{if } e = (D, e_j), \\ k & \text{if } e = (C, e_j). \end{cases}$$

This implies, for instance, $\pi_S((c,d)|(C,C)) = k(1-k)$. Hence, good news are informative. It is straightforward to show that fully collusive equilibria exist. In the best fully collusive equilibria for the monitor, the monitor offers (F^{**}, k^{**}), where $F^{**} = 1-(1-\delta)(1+g)$, and $k^{**} = 1$ in the first stage. This is accepted by both firms. In the repeated game that follows, firms play C and pay F^{**}. Payoffs to firms are identical to the bad news case, but the monitor's payoff is lower due to the higher intensity of monitoring k^{**}. Note that $k^{**} = 1$ implies that even in the good news case punishment does not happen on path. Moreover, firms' payoffs (and their share in the sum of payoffs) are decreasing in δ as before. However, in contrast to the bad news set-up, the sum of payoffs is independent of δ because the amount of monitoring required is independent of δ. I have chosen a bad news technology because I believe it more accurately reflects the situation in the motivating example. A good news monitoring technology would imply that no case of cheating would remain undetected.

My results are restrictive in the sense that I only look at the subset of equilibria which are optimal for the monitor within the set of fully collusive equilibria. I neither look at the full set of equilibria, nor the full set of fully collusive equilibria. It might be interesting to consider equilibria which are not fully collusive. From the monitor's perspective, I strongly suspect that he cannot do better in any other equilibrium than in the "best" fully collusive equilibria.

Regarding the equilibrium concept, I restrict the monitor to offer a stationary contract – both the intensity of monitoring and the fee are constant across periods. A natural question is whether (and if so, which) results are affected by allowing for non-stationary contracts. Assuming fully collusive equilibria, the intensity of monitoring should be as low as possible in the monitor's favorite equilibrium. Hence, it is pinned down by the (possibly, history-dependent) fee. As a result, the problem simplifies to a Markovian decision problem with constraints (i.e., maximizing the monitor's payoff subject to incentive compatibility constraints that bind). Such problems have solutions that are known to be Markovian, and hence, stationary. However, given that the focus on fully collusive equilibria is possibly with loss, I do not explore this further.

Moreover, for reasons of analytical tractability, I restrict firms to use public strategies – firms cannot condition their strategy on their own past actions. This assumption is made for the sake of realism in the motivating application. It is an open question how my results would be affected by allowing firms the use of private strategies.

However, despite these restrictions, the key insight of my paper holds in more general settings. Fix any model, where the benefit from deviating is decreasing in the discount factor. Then the fee a third party can charge in equilibrium is increasing in the discount factor resulting in lower payoffs for the firms. This insight generalizes to services other than monitoring. Other examples might include providing a barrier to entry, enabling players to communicate or coordinate etc.

6 Conclusion

This paper shows how the puzzling nature of the mafia's involvement in cartels in legal industries can be captured by a repeated game with two firms and a profit-maximizing monitor (the mafia), who tries to appropriate the gains stemming from cooperation. While I focussed on the mafia's role as a monitor, we can use the framework in this paper to analyze and understand the effects of organized crime providing quasi-governmental services more generally. Agents engaging in illegal activities cannot rely on law enforcement and other state institutions to induce compliance or resolve conflicts. As a result, the use of a self-interested third party is particularly relevant in the economics of crime. For instance, one might consider the role of local mediators and brokers in the underground economy in neighborhoods in Southside Chicago (Venkatesh 2008). Examples for such mediators who carry a brokerage fee are local store managers, gang leaders but also local preachers who depend on the underground economy for their own livelihood. The role of the local mediators is diverse – ranging from establishing a fair price for a car wash, stolen goods or prostitution, to finding clients for people who use their cars as gypsy cabs, to settling gun-related conflicts.

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