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Organized Crime, Corruption, and Punishment

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Abstract

We analyze an oligopoly model in which differentiated criminal organizations globally compete on criminal activities and engage in local corruption to avoid punishment. When law enforcers are sufficiently well-paid, difficult to bribe and corruption detection highly probable, we show that increasing policing or sanctions effectively deters crime. However, when bribing costs are low, that is badly-paid and dishonest law enforcers work in a weak governance environment, and the rents from criminal activity relative to legal activity are sufficiently high, we find that increasing policing and sanctions can generate higher crime rates. In particular, the relationship between the traditional instruments of deterrence, namely intensification of policing and sanctions, and the crime rate is nonmonotonic. Beyond a threshold, further increases in *intended* expected punishment create incentives for organized crime extending corruption rings, and ensuing impunity results in a fall of *actual* expected punishment that yields more rather than less crime.

JEL Classification: K42, L13, O17.

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1 Introduction

There are occasional examples of successful battles against the corruption perpetrated by criminal organizations to influence law enforcement and politics. For example, in 1931, right after prohibition of alcohol consumption ended in the United States, the conviction of the notorious gang leader Al Capone for tax evasion led to the break up of mobs and rackets built around the distribution of alcohol, and other complementary activities. Yet, failed attempts to curb the influence of organized crime are common place. Recently, in Italy, the investigation *mani pulite* (clean hands) initiated by a courageous group of judges disintegrated after disclosing pervasive corruption by the Mafia. This effort was halted by a string of assassinations inflicted upon law enforcers and their families. In general, organized crime syndicates are very difficult to eliminate. They are able to protect themselves by a combination of means: (*i*) corruption of law-enforcement officials; (*ii*) physical violence against informants and witnesses; (*iii*) violent threats against prosecutors, judges and members of juries; (*iv*) use of lawyers to manipulate the legal system; and (*v*) financial contributions to political campaigns.

The objective of this paper is to better understand the complex relationship between organized crime, corruption and the efficiency of the justice system. We will in fact focus on the evasion from conviction by criminal organizations through bribing law enforcers. However, the relevance of our findings is not confined to the influence on the operation of the legal system exerted through this channel. As long as organized crime can invest to manipulate the incentives faced by the actors involved in making prosecution possible, our results regarding the limited effectiveness of typical crime deterrents in weak governance environments hold.

Criminal gangs are active and strategic in their efforts to bribe policemen. Cooperative police officers are helpful to criminal gangs by passing information to them about police investigations and planned raids, and by making deliberate 'mistakes' in prosecutions. Such technical errors then ensure that the charges against the criminals will not result in guilty verdicts. Corruption of police officers is made easier by the fact that they are modestly paid and, therefore, are subject to temptation. Moreover, like prosecutors and members of juries, law enforcers can be coerced through violence. Also, once a few policemen have been corrupted, they will make strong efforts to ensure that their colleagues are also corrupted. An honest policeman who tries to inform on his corrupt colleagues will come under the most severe pressures from them.

The economics literature on crime has emphasized the deterrence capacity of the justice system (e.g. Becker 1968, Ehrlich, 1973, Levitt, 1998). Recent evidence for the United States tends to support the hypothesis that the expectations of potential criminals with respect to punishment determine crime rates (see e.g. Levitt, 1997). Yet, expected punishment depends not only on the severity of sentences but also on the probability of conviction once crime is perpetrated. The latter depends on detection by the police, prosecution by attorneys and the deliberation of judges and juries. As long as these three activities are conducted transparently and efficiently, tough sanctions will deliver deterrence of criminal activity.[1] However if, as described above, corruption is pervasive, then the deterrence capacity of rises in *intended* expected punishment can be very much reduced due to flawed law enforcement.

Since Becker and Stigler (1974) first acknowledged that malfeasance by enforcers can diminish the effectiveness of laws and sanctions in controlling crime, the literature on crime has considered the problem of bribed officials. Becker and Stigler propose the payment of efficiency wages to prevent bribe taking.[2] Besley and McLaren (1993) and Mookherjee and Png (1995) also propose wage regimes to mitigate the moral hazard problem when rent seekers attempt to co-opt law enforcers. Like Becker and Stigler (1974), Bowles and Garoupa (1997) consider a model in which bribery reduces punishment and thus deterrence. However, their focus is different since it is on the effects of bribery on the optimal allocation of resources (which incorporates the social costs of both crime and corruption) within the public enforcement agency. They show that the maximal fine may not be optimal. Chang et al. (2000) extend Bowles and Garoupa (1997) by introducing social stigma costs for caught corrupt officers. They show that, when corruption is widespread, social norms cannot generate a sufficient sanction to deter corrupt officers, and raising fines can in fact result

[1] It is also well-known that, when expected detection is itself endogenous and negatively depends on the number of criminals, multiple equilibria in crime and deterrence may emerge (see for instance Fender, 1999, or Sah, 1991).

[2] For a comprehensive survey on law enforcement, see Polinsky and Shavell (2000). Also, for a general survey on corruption and development, see Bardhan (1997).

in more crime. Another extension of Bowles and Garoupa (1997) is done by Garoupa and Jellal (2002). They consider the role of asymmetric information on the emergence of collusion between criminals and enforcers. They show that asymmetric information about the private costs of enforcers engaging in collusion might eventually deter corruption and bargaining between the two parties. Finally, Basu et al. (1992) argue that when the possibility of collusion between law enforcing agents and criminals is introduced, control of corruption becomes more difficult than is suggested by the standard Beckerian approach. Marjit and Shi (1998) extend this paper and show that controlling crime becomes difficult, if not impossible, because the probability of detection can be affected by the effort of a corrupt official. Finally, in a recent paper Polinsky and Shavell (2001) consider the dilution of deterrence caused by corruption not only due to bribing by criminals but also extortion of the innocent by crooked enforcers. They propose rewards for corruption reports to mitigate the breakdown of deterrence. Our approach contributes to the literature in that we focus on the relationship between organized crime,[3] corruption of law enforcers and punishment of criminals in the context of imperfect competition. Hence, we find not only a reduction in deterrence effectiveness due to corruption as in previous models but actually a potential reversal whereby policies usually identified as crime deterrents can instead become inducements as long as bribery remains unchecked.

To be more precise, in the present paper, *we analyze the role of corruption not only in diluting deterrence but also as a strategic complement to crime and therefore a catalyst to organized crime.* For that, we develop a simple oligopoly model in which n criminal organizations compete with each other on the levels of both criminal activities and corruption. We first show that when the cost of bribing judges or the number of criminal organizations increases, then both crime and corruption decrease whereas when the profitability of crime increases, then both crime and corruption increase. We then show our main results. If corruption is costly, due to law enforcers being well-paid, hard to bribe and easily detected when accepting side payments, relative to the profits from crime, then, as predicted by the standard literature on crime, it is always effective to reduce crime by intensifying policing or toughening sanc-

[3]There is a small theoretical literature on organized crime (without corruption). See in particular Fiorentini and Peltzman (1996), Garoupa (2000) and Mansour et al. (2000).

tions. However, in the reverse case of low-paid dishonest law enforcers under weak governance and sizable rents from illegal activity relative to the outside lawful options, increasing policing or sanctions may in some cases generate higher crime rates.

This last result is fairly intuitive. As long as the return to legal economic activity is sufficiently low relative to rents from crime, gangs continue pursing crime. When sanctions and policing are toughened, the cost of hiring criminals rises as there is a wage premium to compensate for the risk of conviction if apprehended. This will discourage crime but only up to a point. In particular, if bribing costs are small relative to the rents from crime, there is a level of expected punishment beyond which further *intended* deterrence will induce increasingly higher levels of corruption, and of *actual* crime. Indeed, when governance is weak, harsher punishment can be a catalyst for organized crime and may lead to concentration of criminal rents and higher rates of return ex post. For example, in the 1920's during alcohol prohibition in the United States, mob activities were so profitable that organized crime could afford to keep in its payroll government officials at various levels, including elected politicians and law enforcers, to influence the legal system in its favor. With imperfect competition, the potential effectiveness of traditional deterrence policies to stop organized crime and other subsidiary illegal activities is limited. This does not imply that tough sanctioning of crime and policing should be abandoned altogether when institutional checks and balances are underdeveloped. But, rather that unless corruption is curbed, traditional deterrence measures can have the perverse effect of making crime and corruption strategic complements.

After this introduction, Section 2 sets up the model by describing the problem of the criminal organization. Section 3 characterizes the corruption market. In Section 4, the interaction between crime and corruption is analyzed and the main propositions are presented. Section 5 analyzes the free-entry equilibrium. Finally, Section 6 concludes the paper by discussing some implications of the results obtained.

2 The model

There are n criminal organizations in the economy. These organizations compete with each other on crime but are local monopsonies in the corruption market. On the crime market (think for example of illicit drug cartels), there is a pie to be shared and Cournot competition takes place. On the corruption market, there is a continuum of judges to bribe for each of the n criminal organizations. As this will become clear below, crime is global whereas corruption is local.

Let us first describe the profit function. For each criminal organization, the revenue from criminal activities depends on the number of crimes and the size of the booty per crime. The cost is given by the wage bill accruing the criminals and the bribes paid to avoid conviction when crimes are detected. For the criminal organization $i = 1, ..., n$, profits are given by:

$$\pi(C, C_i, \alpha) = B(C)\, C_i - w_i L_i - T_i \tag{1}$$

where

$$C = \sum_{j=1}^{j=n} C_j$$

is the total number of crimes perpetrated in the economy, C_i denotes the number of crimes committed by organization i, $B(C)$ is the booty per crime for all criminal organizations, with $B'(C) < 0$ (the booty per crime $B(C)$ is assumed to decrease as the number of crimes increases), w_i, which is determined below, denotes the wage paid by each criminal organization i to their L_i employed criminals, and T_i are the total costs to bribe judges borne by the criminal organization i, also to be explicitly determined below. For simplicity, we assume linear crime profitability and technology, with $B(C) = B - C$ and $C_i = L_i$.

Let us determine the wage w_i. Those supplying labor are risk neutral. The participation constraint for a given criminal working for organization i is given by:

$$\phi\left[w_i - (\alpha_i.0 + (1-\alpha_i)S)\right] + (1-\phi)w_i \geq w_0 \tag{2}$$

where $0 < \phi < 1$ is the probability of detection of a crime, α_i denotes the probability that a judge is corrupted by organization i, $S > 0$ is the sanction when punishment of detected crime is enforced and $w_0 > 0$ is the outside legal wage for individuals not engaged in criminal activities. In equation (2), the left hand side gives the expected gain of a criminal. Indeed, if he/she is not caught (with probability $1 - \phi$), he/she gets w_i. If he/she is caught (with probability ϕ), he/she still obtains w_i (we assume that criminals get their wage even when they are caught) but might be convicted and punished. In particular, if the judge is bribed by organization i (with probability α_i), the criminal is not sanctioned whereas if the judge is not bribed by organization i (with probability $1 - \alpha_i$), the criminal faces sanction S (this represents, for example, the number of years in prison). This is a key incentive for a criminal to join organized crime. Apart from getting w_i independently of detection, he/she benefits from not being punished by sanction S even if caught when assigned to a judge in the payroll of organization i.

In equilibrium, this constraint is binding since there is no incentive for the criminal group to pay more than the outside wage. Therefore, the reservation wage for which workers accept to commit crime for organization i is equal to:

$$w_i = \phi S(1 - \alpha_i) + w_0 \tag{3}$$

Interestingly, in equilibrium, this wage will be determined by the level of corruption α_i in each organization since the higher the level of corruption, the lower is the risk premium commanded by criminals. Indeed, if the risk of conviction for a criminal is low, then, as long as w_i is greater than w_0 (which is always the case; see (3)), there is no need to pay a much higher wage.

3 Corruption

The interaction between criminal organizations and judges is modeled here by means of a monopsonistic competitive market inspired by Salop (1979). For that, we consider n local markets (for example regions or local areas); each of them is described by the circumference of a circle which has length 1. In each local market, there is one criminal organization and a continuum of judges uniformly distributed on the circumference of the circle; the density is constant and equal to 1. Without loss of generality, organization i's ($= 1, ...n$) location is normalized to 0. The space in which each criminal organization and judges are located is interpreted as the "transaction cost" space. As a result, criminal organizations compete with each other on crime, i.e. *crime is global*, whereas they only bribe judges locally, i.e. *corruption is local.* This means that, if a criminal belonging to organization i is caught, he/she will be prosecuted by a judge located in market i. In other words, all criminals commit crime in a common market but criminals belonging to different organizations are prosecuted in distinct markets. For example, for crimes related to narcotics distribution, drug cartels deal illicit substances across many different geographic markets but criminals are prosecuted in the jurisdiction where their cartel operations originate.

Contrary to the standard spatial model (Salop, 1979), the horizontal differentiation of judges takes place from the point of view of criminal organizations. In other words, the latter are paying all the transaction costs needed to bribe a judge (i.e. "delivery costs" accrue to the buyer). From the judge's point of view, there is no differentiation since they will accept a bribe if and only if their expected gain is greater than their current wage. As a result, the "distance" of a judge to a criminal organization reflects the transaction cost necessary to agree on a bribe. As social network formation may be based on regional, ethnic or religious affinity, closeness between gang leaders and law enforcers along any of these dimensions facilitates bribing. If we take the geographic example of Italy, it is easier for a criminal organization originating in Sicily to bribe a judge located in Palermo than in Milan because it has more contacts with locals who speak the same dialect. In the model, judges' location types are denoted by x. The more distant, the higher the transaction cost to bribe a judge. The transaction cost function between a criminal organization located in 0 and a judge x is $t\,|x|$, where t expresses the transaction cost per unit of distance in the location space. We assume that the outside option for judges is their current wage w_b, as corrupt law enforcers caught accepting bribes lose their jobs.

In this paper, we focus on non-covered corruption markets, i.e. markets in which some of the judges do not accept bribes and are thus not corrupted. We believe it is much more realistic than a covered market in which all judges will be corrupted in equilibrium. This means that each criminal organization acts as a local monopsony on the corruption market whereas they will compete a la Cournot on the crime market. Denote by $\overline{x}_i$ the boundary of the segment corresponding to each monopsonist i. This implies that each criminal organization will bribe $2\overline{x}_i$ judges in equilibrium. Since each criminal organization is alone in its corruption market, we have to check that $\overline{x}_i < 1/2$, $\forall i = 1, ..., n$, so that, in equilibrium, the corruption market is not covered. Observe that, even if the prosecution and thus the corruption are local, the probability to be prosecuted by a corrupted judge is never 1. Indeed, when a criminal belonging to organization i is caught, one knows that he/she will be judged in local market i but does not know the judge to which the case is to be assigned. This is why the probability to be prosecuted by a corrupted judge in region i is $2\overline{x}_i$, which is by assumption strictly less than 1.

All judges are risk neutral. The participation constraint for a judge who is bribed by a criminal organization i located at a distance x_i is thus given by

$$(1-q)(f+w_b) \geq w_b$$

where q is the probability that corruption is caught (quite naturally, we assume that if a judge is caught, he/she loses his/her wage w_b) and f is the bribe given to the judge. Observe that f is not indexed by i since on the corruption market each criminal organization has total monopsony power and thus fixes a bribe that just binds the judge's participation constraint. The latter only depends on q and w_b. Once again, the left hand side gives the expected benefit from corruption whereas the right hand side describes the opportunity cost. The sanction for corruption is the loss of the job and the bribe. As a result, for each organization $i = 1, ..., n$ the bribe necessary to corrupt a judge is given by

$$f = \frac{q}{1-q} w_b \tag{4}$$

As stated above, all judges are identical so that at f they will always accept a bribe. We could have assumed that the bribe is $f + \varepsilon$, where ε is very small but positive; this would obviously not change our results so whenever judges are indifferent they accept to be bribed. However, from the criminal organization's point of view each judge is not located at the same "distance" so that the transaction cost to bribe a judge is different from one judge to another. Since $\overline{x}_i$ is the maximum "distance" acceptable for each criminal organization i (i.e. beyond $\overline{x}_i$ the transaction cost of bribing a judge is too high), then the total transaction costs for each criminal organization i is given by:[4]

$$T_i = 2\int_0^{\overline{x}_i} (f+t)x\,dx = (f+t)\overline{x}_i^2$$

In this context, since the length of the circumference of the circle is normalized to 1, the probability α_i (the fraction of law enforcers that will be bribed in equilibrium by paying to each of them a bribe f) is given by $\alpha_i = 2\overline{x}_i/1 = 2\overline{x}_i$.

Taking into account all the elements (in particular the participation constraint of each criminal (3) and the participation constraint of each judge), and using (1), the profit function of a criminal organization can be written as:

$$\pi(C, C_i, f) = \left(B - \sum_{j=1}^{j=n} C_j\right) C_i - \left[\phi S\left(1 - 2\overline{x}_i\right) + w_0\right] C_i - (f+t)\overline{x}_i^2 \qquad (5)$$

This profit function of each criminal organization is divided in three parts. The first one is the proceeds from crime, which depends on the competition in the crime market between the different crime organizations. The second corresponds to the salary costs of hiring criminals while the third part denotes the costs of bribing judges. From this reduced form, the link between crime and corruption can be seen. While the marginal cost of bribing is increasing, corruption reduces the unit cost per crime as the wage risk premium paid to criminals falls.

4 Crime and corruption

As stated above, criminal organizations compete on both crime and corruption. On the crime market, each criminal organization i competes a la Cournot by determining the optimal C_i. On the corruption market, each acts as local monopsonist by determining the optimal $\overline{x}_i$ (indeed, they have to determine

[4] If we take a geographical interpretation, then the total cost $(f+t)x$ of bribing a judge located at a distance x from a criminal organization is as follows. The criminal organization has to "travel" a distance x, at a cost t per unit of distance, to see the judge and then has to bribe him/her, at a cost f per unit of distance, i.e. the cost of bribing a judge depends on the physical distance between this judge and the criminal organization. In fact, we assume that there is a perfect correlation between the physical distance and the bribe distance between a criminal organization and a judge, even though the cost per unit of distance is different, i.e. $t \neq f$.

the maximum distance $\overline{x}_i$ beyond which it is not profitable corrupting a judge). Because, in this model, judges are basically belong to the payroll of criminal organizations, the choices of C_i and $\overline{x}_i$ are simultaneous. Thus, choosing simultaneously C_i and $\overline{x}_i$ (observe that there is a one-to-one relationship between $\overline{x}_i$ and α_i) that maximize the profit (5) yields the following first order conditions:

$$B - \sum_{j=1}^{j=n} C_j - C_i - [\phi S (1 - 2\overline{x}_i) + w_0] = 0 \tag{6}$$

$$2\phi S C_i - 2(f + t)\overline{x}_i = 0 \tag{7}$$

Using the Hessian matrix, it is easy to verify that the profit function (5) is strictly concave (implying a unique maximum) if and only if:

$$f + t > 2(\phi S)^2 \tag{8}$$

Let us now focus on a symmetric equilibrium in which $C_i = C_j = C^*$ and $\overline{x}_i = \overline{x}_j = \overline{x}^*$ for all $i \neq j$ with $1 \leq i \leq n$ and $1 \leq j \leq n$. The first order conditions are now given by:

$$B - (n + 1)C^* = \phi S (1 - 2\overline{x}^*) + w_0 \tag{9}$$

$$\phi S C^* = (f + t)\overline{x}^* \tag{10}$$

Now, from (9) we obtain

$$C^* = \frac{B - w_0 - \phi S (1 - 2\overline{x}^*)}{n + 1} \tag{11}$$

Plugging (11) into (10) yields

$$\overline{x}^* = \frac{\phi S (B - w_0 - \phi S)}{(f + t)(n + 1) - 2(\phi S)^2} \tag{12}$$

Then, by plugging (12) into (11), we have

$$C^* = \frac{(f + t) (B - w_0 - \phi S)}{(f + t)(n + 1) - 2(\phi S)^2} \tag{13}$$

We have finally the following result.

Proposition 1 *Assume*

$$\phi S < \min\left[\sqrt{(f+t)/2}, B - w_0, \frac{(f+t)(n+1)}{2(B-w_0)}\right] \tag{14}$$

Then, there is a unique equilibrium C^* and $\alpha^* = 2\overline{x}^*$, where the number of crimes per criminal organization C^* is given by (13) and the measure of corrupted judges per criminal organization $\alpha^* = 2\overline{x}^*$ by (12). Both of them are strictly positive and $(1-\alpha^*)\,n$ judges are not corrupted in equilibrium. Moreover, the equilibrium profit of each criminal organization is given by

$$\pi^*(n) = \frac{(f+t)(B-w_0-\phi S)^2 (f+t-(\phi S)^2)}{[(f+t)(n+1)-2(\phi S)^2]^2} > 0 \tag{15}$$

and the wage paid to each criminal is equal to

$$w^*(n) = \phi S \frac{(f+t)(n+1) - 2\phi S\,(B-w_0)}{(f+t)(n+1)-2(\phi S)^2} + w_0 > w_0 \tag{16}$$

Proof. See the Appendix.

The following comments are in order. First, condition (14) guarantees that both C^* and $\overline{x}^*$ are strictly positive and that the solution of the maximization problem is unique. Condition (14) also ensures that, in equilibrium, some judges are not corrupted (i.e. $\overline{x}^* < 1/2$). Indeed, the difference between the booty B and the wage of an individual having a regular job (i.e. working in the "legal" sector) has to be large enough to induce criminal organizations to hire criminals and to bribe judges. At the same time, this difference has to be bounded above otherwise all judges will be corrupted because the profitability per crime would be so large to yield a corner solution in bribing. Second, when choosing C^* the optimal number of criminals to hire, each criminal organization faces two opposite effects. When it increases C, the proceeds from crime are higher (*positive loot effect*) but the competition will be fiercer (*negative competition effect*) and the wage bill higher (*negative salary effect*). As a result, choosing the optimal C^* results from a trade-off between the first positive effect and the second and third negative effects. This trade-off is reflected in the first order condition (9). Finally, when choosing $\overline{x}^*$ the level of corruption, each criminal organization only faces two effects (there is no competition since each criminal organization acts as a monopsonist in its corruption market). Indeed, when it increases $\overline{x}$, lower payments to criminals increase profits by saving in wages (*positive salary effect*) since criminals have less risk to be sentenced but the costs of bribing judges rise (*negative bribe effect*). This trade-off is reflected in the first order condition (10).

At this stage, it is important to question the timing of the model in which the choices of C_i and $\overline{x}_i$ are simultaneous, implying that some judges are basically permanent employees of criminal organizations. Another possibility would have been that criminal organizations commit crimes first, and then, when detected, invest resources to bribe the judge to which the case has been assigned. In that case, the timing would have been that C_i is chosen first and then $\overline{x}_i$ is decided. It is easy to verify that using this timing, we would have obtained exactly the same results as using the simultaneous choice timing, i.e. C^* and $\overline{x}^*$ will still be given by (13) and (12). This is because in both cases crime does not have strategic effects on corruption, i.e. C_{-i} (crimes committed by all other competing organizations but i) has no effect on $\overline{x}_i$ (see equation (7)). However, if the timing was to choose first $\overline{x}_i$ and then C_i, it is easy to verify that C_i would depend both on $\overline{x}_i$ and $\overline{x}_{-i}$, and, in this case, the results would drastically change. But, with this timing, the economic interpretation does not make very much sense since it implies that criminal organizations would decide on corruption before even committing crime.

It is now interesting to analyze the properties of the equilibrium. We have a first simple result.

Proposition 2 *Assume (14). Then,*

(*i*) *When f the cost of bribing judges, t the unit transaction cost of bribing judges or n the number of criminal organizations increases, then both crime and corruption decrease.*

(*ii*) *When the maximum net proceeds per crime $B - w_0$ increases, then both crime and corruption increase.*

Proof. Straightforward from calculations.

Not surprisingly, both increasing the direct and transaction costs of bribing judges (f and t) lead to less crime and to less corruption. Moreover, raising the number of criminal organizations n also decreases crime and corruption because competition in the crime market becomes fiercer and lower profitability feeds back to the corruption market. In particular, the incentives to bribe fall with competition and when the profitability per crime increases independently of n, then obviously crime and corruption increase.

Let us go further in the analysis. Define

$$(\phi S)_1^{CSX} \equiv \frac{(f+t)(n+1) - \sqrt{(f+t)(n+1)}\sqrt{(f+t)(n+1) - 2(B-w_0)^2}}{2(B-w_0)}$$

and

$$(\phi S)_1^{CSC} \equiv B - w_0 - \sqrt{(B-w_0)^2 - (f+t)(n+1)/2}$$

The following proposition gives our main results.[5]

Proposition 3 *Assume (14). Then,*

(i) If $(B-w_0)^2 \leq 2(f+t)(n+1)^2/(n+2)^2$, increasing sanctions always reduces crime. However, for small values of ϕS, increasing sanctions increases corruption. But for values of ϕS larger than $(\phi S)_1^{CSX}$, increasing sanctions decreases corruption.

(ii) If $2(f+t)(n+1)^2/(n+2)^2 < (B-w_0)^2 \leq (f+t)(n+2)^2/8$, increasing sanctions monotonically reduces crime and increases corruption.

(iii) If $(B-w_0)^2 > (f+t)(n+2)^2/8$, increasing sanctions always increases corruption. However, for small values of ϕS, increasing sanctions reduces crime. But for values of ϕS larger than $(\phi S)_1^{CSC}$, increasing sanctions increases crime. This implies that, above a threshold value of ϕS, rising sanctions increase both crime and corruption.

Proof. See Kugler, Verdier and Zenou (2003).

Using Figures 1a, 1b and 1c that illustrate Proposition 3, we can give the intuition of the main results. When $(B-w_0)^2 \leq 2(f+t)(n+1)^2/(n+2)^2$, in relative terms, we have that the labor productivity w_0 is high, the proceeds per crime B are low, the probability for a corrupted judge of getting caught q as well as his/her wage w_b are high (see (4)), and the transaction costs per distance unit t to bribe judges are large. From Figure 1a, in this case,

[5] The technical counterpart of Proposition 3 is Proposition 7, which is given in the Appendix.

increasing ϕ the probability that a criminal is caught (e.g. enhancing frequency of crime detection by policemen in the region) and S the sanctions (e.g. tougher punishment upon conviction) always reduce crime.

Yet, corruption can in fact increase for low values of ϕS and decrease for high values of ϕS. The intuition runs as follows. When $B - w_0$ is quite low compared to f and t, productivity in the legal sector is high, implying the need of high payoffs to compensate criminals, and the revenue per crime are low compared to the high costs of bribing judges. Moreover, it is easy to see that the *negative competition effect and the positive loot effect* are not affected by a variation of ϕS whereas the *negative salary effect* is affected since it becomes even more costly to hire criminals, as they have a higher risk of being caught. So, when ϕS increases, each criminal organization finds it optimal to reduce crime, or more exactly the number of criminals hired, because the costs of hiring criminals relatively rise. In the corruption market, when ϕS increases, the *positive salary effect* yields incentives to intensify corruption since it becomes more costly to hire criminals whereas the *negative bribe effect* is not affected since the cost of bribing law enforcers is independent of ϕS. This can easily be seen in (10) since the left hand side corresponds to the salary effect (which depends on ϕS) and the right hand side to the bribe effect (which does not depends on ϕS). In fact, differentiating the left hand side of (10) with respect to ϕS yields: $C^* + (\phi S)\partial C^*/\partial(\phi S)$. The first effect C^* is positive (i.e. for a given level of crime, as ϕS rises, each criminal organization increases the level of corruption to induce people to become criminal) whereas the second one $(\phi S)\partial C^*/\partial(\phi S)$ is negative (i.e. as ϕS rises, there is less crime and thus there is less incentive to bribe so that corruption decreases). As a result for low values of ϕS, with profit-maximizing crime C^* relatively high, if ϕS increases, the first effect dominates the second effect leading to increased bribing. For high values of ϕS, with profit-maximizing crime C^* relatively low, if ϕS increases, the second effect dominates the first one because the crime level C^* is relatively low and it is optimal for criminal organizations to bribe less.

When $2(f+t)(n+1)^2/(n+2)^2 < (B-w_0)^2 \leq (f+t)(n+2)^2/8$, sanctions affect *monotonically* both crime and corruption. In this intermediate case, the maximum profits per crime also bounded above but are higher. As n rises the lower bound depends only on the costs of bribing while the upper bound is a term increasing both with bribing costs and the number of competing criminal organizations. In this case, when ϕS increases, profit-maximizing crime falls while corruption rises. This is an example of a situation in which bribing dilutes deterrence but does not offset it (see e.g., Polinsky and Shavell, 2001). In the previous case, corruption also mitigated deterrence but only for relatively small ϕ and S. With both sufficiently intense policing and tough sanctions, bribery has not diluting effect on deterrence policies. Figure 1b illustrates this case.

Let us now interpret the case when $(B - w_0)^2 > (f + t)(n + 2)^2/8$. In this case, revenue per crime is sufficiently high relative to productivity in the legal sector so that the squared difference exceeds the upper bound of the previous case. In this case, when ϕS increases, it is always optimal for criminal organizations to increase corruption because the resulting gain from the reduction of the criminal wage always is greater than the rise in cost of bribing law enforcers, which is not affected by ϕS. In contrast, the profit-maximizing level of crime this is nonmonotonic with respect to ϕS. Indeed, as stated above, only the salary effects for both crime and corruption are affected by ϕS. From equation (11), we verify that the sign of $\partial C^*/\partial(\phi S)$ depends on $-(1-2\overline{x}^*)+2\phi S\partial\overline{x}^*/\partial(\phi S)$. As we assume non-covered corruption markets where $\overline{x}^* < 1/2$, the first term $-(1 - 2\overline{x}^*)$ is always negative (i.e. for a given level of corruption, when ϕS increases, it becomes more costly to hire criminals). The second term $2(\phi S)\partial\overline{x}^*/\partial(\phi S)$ is positive and increasing on ϕS (i.e. when ϕS increases, there is more bribing and it becomes less costly to hire criminals since their wage risk premium is lower). For low values of ϕS, the first effect dominates the second one. This is because at low levels of corruption intensifying policing and sanctions deters crime by increasing its expected cost. However, for high values of ϕS, the second effect dominates the first one since the level corruption is quite high and thus neither policing nor sanctioning deter crime. Profit-maximizing bribing is an increasing function of ϕS. In fact, beyond a threshold ϕS, further corruption reduces the criminal wage enough to elicit a rise in profit-maximizing crime.

This is our main result. In a jurisdiction where crime is profitable relative to legal economic opportunities, judges are badly-paid and easy to corrupt, we find that for crimes subject to intense policing and severe punishments, further increasing the crime detection probability or the severity of the sanctions results in more rather than less crime. In particular, when the expected cost of crime rises due to increases in the detection probability and statutory punishment, the optimal response of criminal organizations to counteract deterrence policy is to increase bribing to lower the conviction probability. If law enforcers can be co-opted into the payroll of criminal organizations, pervasive bribing induced by *intended* deterrence policies can be catalyst to a rise in crime. This implies that, in jurisdictions with weak governance, the policy implications of the standard crime model may not hold and instead, as our model suggests, crime deterrence policy can only be effective ensuing a substantial cut down in corruption. In this case, a rise in ϕS beyond a threshold can take the model into a region of the parameter space where crime and corruption are strategic complements, as long as the equilibrium bribe is bounded.

It is interesting to compare our result with that of Malik's (1990). In his model, individuals engage in socially costly activities that reduce their probability of being caught and fined. This is comparable to corruption in our model. His main finding is to show that it is not necessarily optimal to set fines for offenses as high as possible. This has the same flavor as our result (*iii*) in Proposition 3. There are however important differences between the two models. First, contrary to us, Malik (1990) adopts a normative perspective. He focuses on an enforcement agency that aims at reducing the social costs of avoidance activities by increasing fines. In our analysis, there is no such an agency. There is instead competition between criminal organizations. In our model, we can conduct positive analyses but cannot make statements about efficiency. Our results are comparative statics results. If one compares two equilibria with different levels of sanctions, then the one with the highest level of sanctions is not necessarily the one with the lowest levels of crime and corruption. Second, his main result is driven by the fact that individuals are heterogeneous ex ante in their earning abilities. In our model, all agents are identical ex ante and our main result is driven by the imperfect competition in the crime and corruption markets, and the fact that crime and corruption are strategic complements. The mechanism that leads to the results, and their nature, is thus quite different in the two models.

$[Insert\ Figures\ 1a, 1b\ and\ 1c\ here]$

We can analyze further the potentially counterproductive effect of intended deterrence policies by investigating case (*iii*) in Proposition 3. We have the following result:

Proposition 4 *Assume* $(B - w_0)^2 > (f + t)(n + 2)^2/8$ *and (14). Then* (*i*) *the lower the labor productivity* w_0 *in the legal sector,* (*ii*) *the higher the booty* B *per crime,* (*iii*) *the easier it is to bribe law enforcers (i.e. the lower the reservation bribe* f *and associated transaction cost* t*), and/or* (*iv*) *the weaker is the competition between criminal organizations (i.e. the lower is* n*), the lower is the threshold of* ϕS *above which crime and corruption become strategic complements, i.e. the more likely that an increase in policing or sanctions leads to an increase in crime.*

Proof. Straightforward from calculations.

This proposition complements our previous results. It helps explain why in some countries deterrence works, even if diluted by corruption, while in others it can have perverse effects. The proposition establishes that in jurisdictions where productivity is quite low in the legal sector, bribing is pervasive, and criminal organizations have high market power, then increasing policing and sanctions is *more likely to trigger* strategic complementarity among corruption and crime resulting in a perverse effect of deterrence.

This result contrasts with the literature that has posited optimal maximal sanctions. First, Polinsky and Shavell (1979) show that if fine collection is costless and monitoring of criminal activity is costly, the optimal magnitude of fines corresponds to the maximum payable by criminals. When this maximum falls well short of the booty from crime, nonmonetary sanctions are required for deterrence. Since it is not only costly to apprehend criminals but also to punish them, Shavell (1987) proves that it is optimal for sanctions to be imposed with low frequency. Hence, in the case that the courts' information is imperfect, deterrence requires sufficiently large sanctions. The standard result is that under risk neutrality fines should be maximal. But, if criminals are risk averse, maximal fines are not best for deterrence.[6] The presence of

[6] Polinsky and Shavell (2000) present the standard case with risk neutrality (p.50) and then discuss other reasons why maximal fines may not be optimal (pp. 62-64). First, marginal deterrence may dictate heterogenous fines across criminal acts socially harmful in different degrees. Second, the potential for general enforcement investments yields economies

corruption in Polinsky and Shavell (2001) always dictates higher sanctions to counter the deterrence-diluting effects of corruption. To the extent that there is perfect competition in criminal activities, rises in expected costs always act as deterrents. In contrast, in our model with imperfect competition, until bribery can be eradicated, the intensifying policing and punishment beyond a threshold worsens the corruption and crime problems.

5 Free entry

It is natural to ask what happens to main results derived so far with the model if we allow for free entry. In our model, this entails that we investigate the formation of criminal organizations, given that each of them creates their own "local" corruption market. We would thus like characterize the number of criminal organizations that will be created in a given country.

Each criminal organization that enters the crime and corruption markets must pay a positive fixed cost G. To determine the number of criminal organizations n^e we have to solve: $\pi^*(n^e) - G = 0$, where $\pi^*(n)$ is given by (15). We easily obtain:[7]

Proposition 5 *If*

$$\phi S < \min\left[\sqrt{(f+t)/2}, B - w_0\right] \tag{17}$$

and

$$\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}} < \min\left[\frac{B-w_0-\phi S}{f+t-2(\phi S)^2}, \frac{1}{2\phi S}\right] \tag{18}$$

Then, under free entry, the equilibrium number of criminal organizations is given by:

$$n^e = \frac{1}{f+t}\left[(B-w_0-\phi S)\sqrt{\frac{(f+t)\left[f+t-(\phi S)^2\right]}{G}} - \left[(f+t)-2(\phi S)^2\right]\right] \tag{19}$$

of scope in monitoring inducing apprehension probabilities consistent with deterrence for sanction magnitudes below the maximal level.

[7] The superscript e indicates equilibrium variables under free entry.

The equilibrium number of criminals and corruption are respectively equal to:

$$C^e = \sqrt{\frac{G(f+t)}{f+t-(\phi S)^2}} \tag{20}$$

$$\overline{x}^e = \phi S \sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}} \tag{21}$$

In this case, increasing sanctions always increases the crime and corruption level per organization, i.e.

$$\frac{\partial C^e}{\partial(\phi S)} > 0 \text{ and } \frac{\partial \overline{x}^e}{\partial(\phi S)} > 0$$

Proof. See the Appendix.

The following comments are in order. First, as in the case with a fixed number of criminal organizations, condition (17) guarantees that C^e and $\overline{x}^e$ are strictly positive and unique. Condition (18) guarantees that n^e is strictly positive and that, at the free entry equilibrium, the market is not covered, i.e. some judges are not corrupted. In order for a free-entry crime market to remain consistent with non-covered corruption markets, it has to be that the free-entry fixed cost G is bounded above. The intuition runs as follows. When the fixed cost G increases, there are less criminal organizations in the economy so less competition for crime. This implies that crime, corruption and profits per criminal organization increase. As a result, for the corruption market not to be covered, i.e. $\overline{x}^e < 1/2$, it has to be that G is sufficiently low to rule out a corner solution with maximal bribing. Similarly, for n^e to be positive, whereby entry takes place in equilibrium, it has to be that G is sufficiently low. These two conditions are expressed in (18). Second, when there is free entry, the number of criminal organizations n^e, the crime and corruption level per criminal organization, C^e and $\overline{x}^e$, are respectively given by (19), (20) and (21). It is easy to verify that both C^e and $\overline{x}^e$ increase with sanctions ϕS. Indeed, when sanctions increase, the competition in the crime market is reduced and thus C^e and $\overline{x}^e$ increase. However, this is does not necessarily increase the total level of crime $n^e C^e$ and corruption $2n^e\overline{x}^e$ in the economy. We would like now to verify when our previous result established in Proposition 3 (*iii*), both higher crime and corruption in the wake of rises in policing and/or sanctions, is still valid with entry. The following proposition shows that it is still true under some conditions on parameters.

Proposition 6 *If*

$$\max\left[\frac{1}{2}\sqrt{f+t}, \frac{f+t}{B-w_0}\right] < \phi S < \sqrt{(f+t)/2} \tag{22}$$

and

$$\frac{f+t-(\phi S)^2}{\phi S\left[3(f+t)-2(\phi S)^2\right]} < \sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}} < \min\left[\frac{B-w_0-\phi S}{f+t-2(\phi S)^2}, \frac{1}{2(\phi S)}\right] \tag{23}$$

then, under free entry, increasing sanctions increase the total levels of both crime and corruption in the economy, i.e.

$$\frac{\partial(n^e C^e)}{\partial(\phi S)} > 0 \text{ and } \frac{\partial(2n^e \overline{x}^e)}{\partial(\phi S)} > 0$$

Proof. See the Appendix.

This proposition shows that increasing sanctions can increase both the total levels of crime and corruption in the economy if (23) holds, i.e. the fixed cost G has to be bounded above and below. Indeed, as in Proposition 5, the fixed cost has to be sufficiently low for the market not to be covered and for criminal organizations to enter the market. But, a higher fixed cost G generates market power for incumbent criminal organizations thereby increasing the profit-maximizing levels of crime and corruption C^e and $\overline{x}^e$. Hence, with free entry, only for a sufficiently high G is it possible that rises policing and sanctions exacerbate corruption and crime. Indeed, a low fixed cost G implies stiff competition and a relatively high n^e, and an increase in ϕS would reduce n^e. In this case, each criminal organization raises its level of corruption $\overline{x}^e$ and hires more criminals but the global effect can be lower total crime $n^e C^e$ because there are less criminal organizations in the economy. If, on the contrary, G is not too low, competition in the crime market is limited. Prevailing competition mitigates the rise in crime per organization to offset the fall in the number of organizations. Then, the exit effect that reduces aggregate crime in the wake of introducing deterrence policies is dominated by the rise in crime per organization as bribing takes off. In such case, *intended* deterrence policies can become catalysts to increase crime.

6 Conclusion

This paper has spelled out the role of corruption and imperfect competition in preventing the justice system to work efficiently. Indeed, in a model where criminal organizations compete a la Cournot on the crime market and act as local monopsonists on the corruption market, we have showed that when bribing costs are small relative to crime profitability, beyond a threshold further policing and sanctions lead to higher rather than lower crime.

We agree with Becker (1968), Ehrlich (1973), Polinsky and Shavell (1979) and Levitt (1998) that enhancing enforcement efficiency and sanction severity in order to increase expected punishment, thereby reducing criminal activity, is important. However, when dealing with organized crime that engages in corruption to manipulate conviction probabilities, complementary measures, such as crack down on corruption or the institutionalization of checks and balances, are warranted to control the problem.[8] Our model delivers stark conclusions with respect to the relationship between crime and corruption and as to why the standard "crime and punishment" framework may fail for some countries. When corruption is pervasive, further efforts to inflict tougher sentences on criminals will just raise the rents to organized crime. More generally the enforcement of property rights at large can break down once the police force and courts stop functioning properly. Beyond a threshold further policing and sanctions can be a catalyst to corruption in the justice system. As crime and corruption become strategic complements, increasing returns in various types of crimes may take off. This observation may explain crime dynamics in some countries (e.g. Colombia and Russia) or regions within countries (e.g. Sicily in Italy). Once this process starts, the best policy may be to contain diffusion of corruption by organized crime to neighboring jurisdictions. Before it starts, the best policy may be to try to suppress organized crime rents. In terms of policy formulation, this insight is related to the Lucas (1976) critique. To evaluate the effect of a policy change, we need to incorporate in the analysis potential adjustments in the behavior of agents in response to the new policy. The intended outcome from crime deterrence measures may not materialize if

[8]See e.g., Kugler and Rosenthal (2004) for an analysis about separation of powers in Colombia on the importance of checks and balances to buttress the legal system in an environment with weak governance.

the policy regime change leads criminals to intensify corruption.

Given the complementarity between crime and corruption, and since building the required institutions for a transparent legal system can take a long time to achieve, tolerating some degree of illegality (or of a socially harmful activity which is legalized) can be desirable if it helps to destroy the rents of organized crime. It is interesting to observe that, in the 1920's, after prohibition was introduced in the United States, organized crime did have police, judges and politicians in its payroll. In this period of time, increased police monitoring and investigation of alcohol distribution, as well as further laws against it, only increased the rents of the business for both traffickers and corrupt "enforcers". On the one hand, in some sense, severe sanctions on alcohol consumption sowed the seeds for very powerful cartels. On the other hand, the destruction of rents through legalization had a lasting effect in weakening the influence of organized crime on the legal system, which had facilitated all kinds of illegal subsidiary operations by the Mafia, including the intense use violence for establishing new turfs and racketeering rings.

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APPENDIX

Proof of Proposition 1

First, by assuming that $f + t > 2(\phi S)^2$ (see (14)), we guarantee that: (i) the second order condition (8) is always true, (ii) $(f+t)(n+1) > 2(\phi S)^2$. As a result, (ii) implies that the denominator of C^* and $\overline{x}^*$ are both strictly positive and that the equilibrium profit $\pi^*(n)$ given by (15) and the equilibrium wage $w^*(n)$ given by (16) are both strictly positive.

Second, using (12) and (13), it is easy to see that $C^* > 0$ and $\overline{x}^* > 0$ are equivalent to $B - w_0 > \phi S$. This is guaranteed by (14).

Third, because we consider the case of local monopsonists, we have to check that in equilibrium some judges will not be corrupted (i.e. the market is not covered). The market is not covered iff $\overline{x}^* < 1/2$. Using (12), this writes:

$$\frac{\phi S\,(B - w_0 - \phi S)}{(f+t)(n+1) - 2(\phi S)^2} < \frac{1}{2}$$

which is equivalent to

$$\phi S < \frac{(f+t)\,(n+1)}{2\,(B - w_0)}$$

This is the third part in the bracket in (14).

Finally, to calculate the equilibrium profit and the equilibrium criminal's wage, it suffices to plug (12) and (13) into (5) and (3). ■

Proposition 7

(i) *When* $(B - w_0)^2 \leq (f+t)/2$,

$$\frac{\partial C^*}{\partial\,(\phi S)} < 0 \;,\; \forall \phi S < B - w_0$$

$$\frac{\partial \overline{x}^*}{\partial\,(\phi S)} > 0 \;,\; \textit{if}\ \phi S < (\phi S)_1^{CSX} < B - w_0$$

$$\frac{\partial \overline{x}^*}{\partial\,(\phi S)} < 0 \;,\; \textit{if}\ (\phi S)_1^{CSX} < \phi S < B - w_0$$

(ii) When $(f+t)/2 < (B-w_0)^2 \leq 2(f+t)(n+1)^2/(n+2)^2$,

$$\frac{\partial C^*}{\partial(\phi S)} < 0 \ , \ \forall \phi S < \sqrt{(f+t)/2}$$

$$\frac{\partial \overline{x}^*}{\partial(\phi S)} > 0 \ , \ \textit{if } \phi S < (\phi S)_1^{CSX} < \sqrt{(f+t)/2}$$

$$\frac{\partial \overline{x}^*}{\partial(\phi S)} < 0 \ , \ \textit{if } (\phi S)_1^{CSX} < \phi S < \sqrt{(f+t)/2}$$

(iii) When $2(f+t)(n+1)^2/(n+2)^2 < (B-w_0)^2 \leq (f+t)(n+2)^2/8$,

$$\frac{\partial C^*}{\partial(\phi S)} < 0 \ \textit{and} \ \frac{\partial \overline{x}^*}{\partial(\phi S)} > 0 \ , \ \forall \phi S < \sqrt{(f+t)/2}$$

(iv) When $(f+t)(n+2)^2/8 < (B-w_0)^2 \leq (f+t)(n+1)^2/2$,

$$\frac{\partial C^*}{\partial(\phi S)} < 0 \ , \ \textit{if } \phi S < (\phi S)_1^{CSC} < \sqrt{(f+t)/2}$$

$$\frac{\partial C^*}{\partial(\phi S)} > 0 \ , \ \textit{if } (\phi S)_1^{CSC} < \phi S < \sqrt{(f+t)/2}$$

$$\frac{\partial \overline{x}^*}{\partial(\phi S)} > 0 \ , \ \forall \phi S < \sqrt{(f+t)/2}$$

(v) When $(B-w_0)^2 > (f+t)(n+1)^2/2$,

$$\frac{\partial C^*}{\partial(\phi S)} < 0 \ , \ \textit{if } \phi S < (\phi S)_1^{CSC} < \frac{(f+t)(n+1)}{2(B-w_0)}$$

$$\frac{\partial C^*}{\partial(\phi S)} > 0 \ , \ \textit{if } (\phi S)_1^{CSC} < \phi S < \frac{(f+t)(n+1)}{2(B-w_0)}$$

$$\frac{\partial \overline{x}^*}{\partial(\phi S)} > 0 \ , \ \forall \phi S < \frac{(f+t)(n+1)}{2(B-w_0)}$$

Proof. See Kugler, Verdier and Zenou (2003).

Proof of Proposition 5

To calculate n^*, it suffices to solve $\pi^*(n) - G = 0$, where $\pi^*(n)$ is given by (15). We easily obtain (19).

We have then to study the sign of n^*. Because of (14), $2(\phi S)^2 - (f+t) < 0$. Thus, $n^* > 0$ if and only if

$$(B - w_0 - \phi S)\sqrt{\frac{(f+t)(f+t-(\phi S)^2)}{G}} > (f+t) - 2(\phi S)^2$$

which is equivalent to

$$\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}} < \frac{B - w_0 - \phi S}{f+t-2(\phi S)^2}$$

which is the first part of (18).

To calculate the equilibrium values of C^e and $\overline{x}^e$, it suffices to plug n^*, which is given by (19) in (13) and (12) respectively.

We also have to check that, at the free-entry equilibrium, the market is not covered, i.e. $\overline{x}^e < 1/2$. Using (21), we easily obtain

$$\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}} < \frac{1}{2(\phi S)}$$

which is the second part of (18).

Finally, by differentiating (20) and (21), we easily obtain:

$$\frac{\partial C^e}{\partial(\phi S)} = \phi S\sqrt{\frac{(f+t)G}{\left[f+t-(\phi S)^2\right]^3}} > 0$$

$$\frac{\partial \overline{x}^e}{\partial(\phi S)} = \sqrt{\frac{(f+t)G}{(f+t)\left[f+t-(\phi S)^2\right]^3}} > 0$$

■

Proof of Proposition 6

First, by differentiating (19), (20) and (21), we obtain:

$$(f+t)\frac{\partial n^*}{\partial(\phi S)} = 4(\phi S) - \sqrt{\frac{(f+t)\left[f+t-(\phi S)^2\right]}{G}}\left[1 + \frac{\phi S(B - w_0 - \phi S)}{f+t-(\phi S)^2}\right]$$

$$\frac{\partial C^e}{\partial\left(\phi S\right)}=\frac{(f+t)\phi S}{\left[f+t-(\phi S)^2\right]}\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}}$$

$$\frac{\partial \overline{x}^e}{\partial\left(\phi S\right)}=\frac{(f+t)}{\left[f+t-(\phi S)^2\right]}\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}}$$

Second, we would like to see how the total level of crime n^*C^* and corruption $2n^*\overline{x}^*$ are affected by ϕS. We have:

$$\frac{\partial\left(n^eC^e\right)}{\partial\left(\phi S\right)}=n^e\frac{\partial C^e}{\partial(\phi S)}+C^e\frac{\partial n^e}{\partial(\phi S)}$$

$$=\sqrt{\frac{G}{\left[f+t-(\phi S)^2\right](f+t)}}\left[4(\phi S)-\frac{\phi S\left[(f+t)-2(\phi S)^2\right]}{\left[f+t-(\phi S)^2\right]}-\sqrt{\frac{(f+t)\left[f+t-(\phi S)^2\right]}{G}}\right]$$

Thus the sign of $\frac{\partial(n^eC^e)}{\partial(\phi S)}$ is the same as

$$4(\phi S)-\frac{\phi S\left[(f+t)-2(\phi S)^2\right]}{\left[f+t-(\phi S)^2\right]}-\sqrt{\frac{(f+t)\left[f+t-(\phi S)^2\right]}{G}}$$

Thus

$$\frac{\partial\left(n^eC^e\right)}{\partial\left(\phi S\right)}\gtrless 0\Leftrightarrow\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}}\gtrless\frac{f+t-(\phi S)^2}{4(\phi S)\left[f+t-(\phi S)^2\right]-\phi S\left[f+t-2(\phi S)^2\right]}$$

or equivalently

$$\frac{\partial\left(n^eC^e\right)}{\partial\left(\phi S\right)}\gtrless 0\Leftrightarrow\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}}\gtrless\frac{f+t-(\phi S)^2}{\phi S\left[3\left(f+t\right)-2\left(\phi S\right)^2\right]}$$

As a result,

$$\frac{\partial\left(n^eC^e\right)}{\partial\left(\phi S\right)}>0\Leftrightarrow\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}}>\frac{f+t-(\phi S)^2}{\phi S\left[3\left(f+t\right)-2\left(\phi S\right)^2\right]}$$

Similarly, we have:

$$\frac{\partial\left(2n^e\overline{x}^e\right)}{\partial\left(\phi S\right)} = 2\left[n^e\frac{\partial\overline{x}^e}{\partial(\phi S)} + \overline{x}^e\frac{\partial n^e}{\partial(\phi S)}\right]$$

$$= \frac{2}{f+t}\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}}$$

$$\left[(B-w_0-2\phi S)\sqrt{\frac{(f+t)\left[f+t-(\phi S)^2\right]}{G}}\right.$$

$$\left.+\frac{\left[f+t-(\phi S)^2\right]\left[4(\phi S)^2-(f+t)\right]+(\phi S)^2(f+t)}{\left[f+t-(\phi S)^2\right]}\right]$$

Thus the sign of $\frac{\partial(n^e\overline{x}^e)}{\partial(\phi S)}$ is the same as the sign of

$$(B-w_0-2\phi S)\sqrt{\frac{(f+t)\left[f+t-(\phi S)^2\right]}{G}}$$
$$+\frac{\left[f+t-(\phi S)^2\right]\left[4(\phi S)^2-(f+t)\right]+(\phi S)^2(f+t)}{\left[f+t-(\phi S)^2\right]}$$

which is always positive using (22). Thus,

$$\frac{\partial\left(n^e\overline{x}^e\right)}{\partial\left(\phi S\right)} > 0$$

We need that this result holds under conditions (17) and (18), which are given by:

$$\phi S < \min\left[\sqrt{(f+t)/2}, B-w_0\right]$$

and

$$\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^2\right]}} < \min\left[\frac{B-w_0-\phi S}{f+t-2(\phi S)^2}, \frac{1}{2\phi S}\right]$$

Let us start with condition (18). Denote by

$$A \equiv \frac{B-w_0-\phi S}{f+t-2(\phi S)^2} \text{ and } E \equiv \frac{1}{2\phi S}$$

We have that

$$\frac{\partial\left(n^{e}C^{e}\right)}{\partial\left(\phi S\right)}>0 \text{ and } \frac{\partial\left(n^{e}\overline{x}^{e}\right)}{\partial\left(\phi S\right)}>0$$

if

$$\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^{2}\right]}}>\frac{f+t-(\phi S)^{2}}{\phi S\left[3\left(f+t\right)-2\left(\phi S\right)^{2}\right]}\equiv D$$

which, using (18), implies that

$$\frac{f+t-(\phi S)^{2}}{\phi S\left[3\left(f+t\right)-2\left(\phi S\right)^{2}\right]}<\sqrt{\frac{G}{(f+t)\left[f+t-(\phi S)^{2}\right]}}<\min\left[\frac{B-w_{0}-\phi S}{f+t-2(\phi S)^{2}},\frac{1}{2\left(\phi S\right)}\right]$$

This is (23). We thus need to check that $D<\min\left[A,E\right]$. We have:

$D<E\Leftrightarrow\dfrac{f+t-(\phi S)^{2}}{\phi S\left[3\left(f+t\right)-2\left(\phi S\right)^{2}\right]}<\dfrac{1}{2\left(\phi S\right)}\Leftrightarrow 2<3$. Thus $D<E$ is always true

$$D<A\Leftrightarrow\frac{f+t-(\phi S)^{2}}{\phi S\left[3\left(f+t\right)-2\left(\phi S\right)^{2}\right]}<\frac{B-w_{0}-\phi S}{f+t-2(\phi S)^{2}}$$

$$\Leftrightarrow\frac{f+t-(\phi S)^{2}}{\phi S}\frac{1}{3\left(f+t\right)-2\left(\phi S\right)^{2}}<\frac{1}{f+t-2(\phi S)^{2}}\left(B-w_{0}-\phi S\right)$$

Since

$$\frac{1}{3\left(f+t\right)-2\left(\phi S\right)^{2}}<\frac{1}{f+t-2(\phi S)^{2}}$$

we need to show that

$$\frac{f+t-(\phi S)^{2}}{\phi S}<B-w_{0}-\phi S$$

which is equivalent to

$$B-w_{0}>\frac{f+t}{\phi S}$$

This is part of condition (22). Observe that $B - w_0 > (f + t) / (\phi S)$ implies that $B - w_0 > \phi S$ since $f + t > 2 (\phi S)^2$.

Let us now check if condition (17) holds. Because $B - w_0 > (f + t) / (\phi S)$ implies that $B - w_0 > \phi S$, it is easy to see that condition (17) is included in (22). ■

Figure 1a: Case when $(B-w_0)^2 \leq 2(f+t)\dfrac{(n+1)^2}{(n+2)^2}$

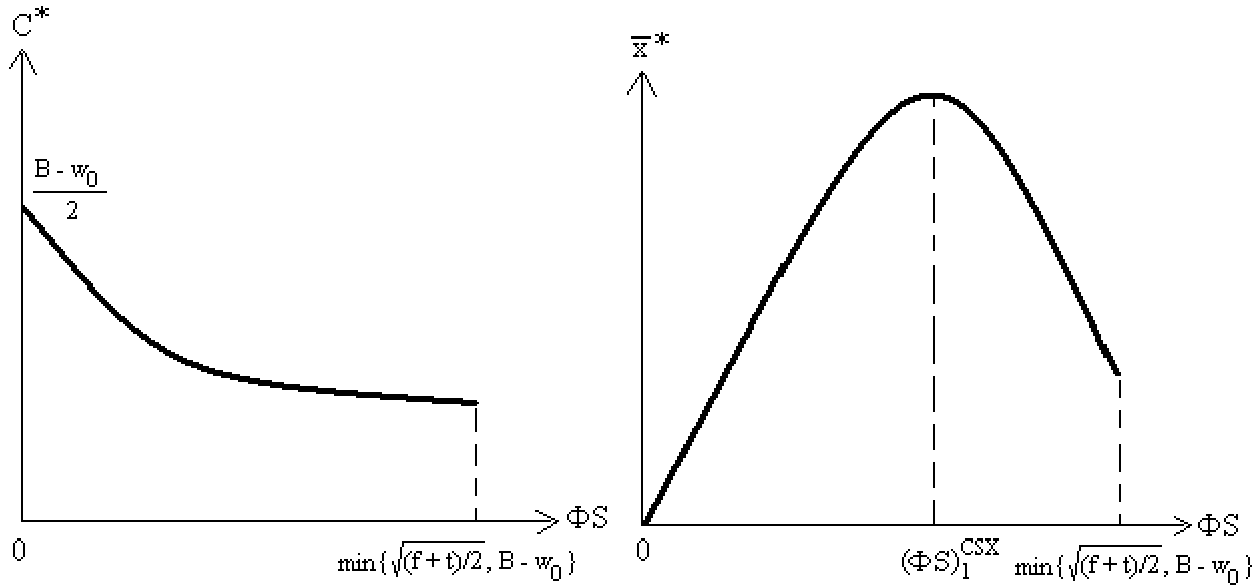

Figure 1b: Case when $2(f+t)\frac{(n+1)^2}{(n+2)^2} < (B-w_0)^2 \leq (f+t)\frac{(n+2)^2}{8}$

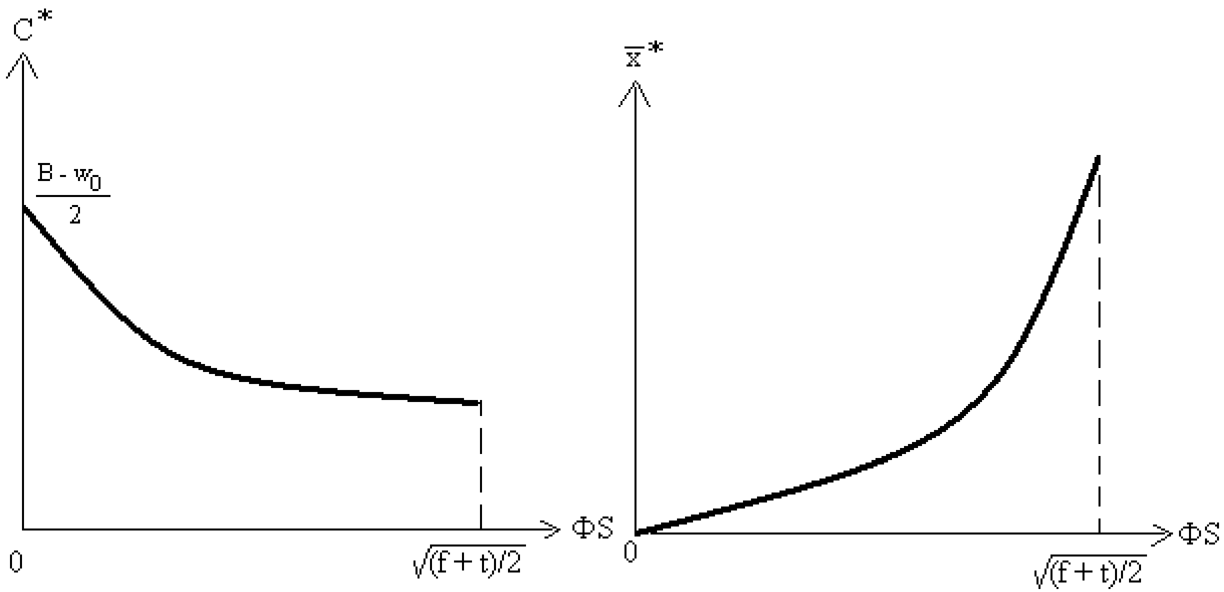

Figure 1c: Case when $(B - w_0)^2 > (f + t)\frac{(n+2)^2}{8}$