Incomplete information as a deterrent to crime

Sugata Marjit [a,b,*], Meenakshi Rajeev [c], Diganta Mukherjee [d]

[a] *Center for Studies in Social Sciences, Jadunath Bhawan, 10 Lake Terrace, Calcutta 700029, India*
[b] *The Chinese University of Hong Kong, Shatin N.T., Hong Kong SAR, People's Republic of China*
[c] *Institute for Social and Economic Change, Nagarbhavi P.O., Bangalore 560072, India*
[d] *Economic Research Unit, Indian Statistical Institute, 203, B.T. Road, Calcutta 700035, India*

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Abstract

This paper presents an incomplete information model, where a supervisor is entrusted with supervising a number of potential criminals of different types. The supervisor may not know the type of an individual criminal. We show how lack of complete information available to the law-enforcing agent may help to prevent crime at least to a limited extent by making rewards and penalties more effective.

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1. Introduction

The literature dealing with the issue of corruption is indeed huge. One stream of literature, which concentrates on crime control in a corrupt regime, is also quite large.[1] In particular, this literature examines whether introducing a stiff penalty for

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* Corresponding author. Center for Studies in Social Sciences, Jadunath Bhawan, 10 Lake Terrace, Calcutta 700029, India. Fax: +91-33-466-6958.

E-mail address: marjit@csssc.emet.in (S. Marjit).

[1] Rose-Ackerman (1975), Lui (1985), Cadot (1987), Gangopadhyay et al. (1991), Basu et al. (1992), Chander and Wilde (1992), Mookherjee and Png (1992, 1994a,b), Besley and McLaren (1993), Bowles and Garoupa (1995), Marjit et al. (1998), etc.

crime or, alternatively, an incentive scheme for stricter enforcement can prevent corruption. It has been argued that control of corruption in general is not possible. For example, Mookherjee and Png (1994b) show that an increase in the penalty rate for violating regulation may raise the bribe (given by the factory owner to the inspector for not reporting the crime) rather than reduce the incidence of such activities. Marjit and Shi (1998), who extend the results of Basu et al. (1992), arrive at a similar conclusion that an increase in the penalty would reduce the monitoring effort on the part of the inspector, which in turn, continues to induce crime.

Given such a background, we consider a general and more realistic situation, where a supervisor is in charge of enforcing a law, on not just one agent or identical agents, but on a number of different types of agents. The agents who potentially engage in criminal activities are differentiated according to their abilities to avoid detection and the supervisor may or may not have information about the type(s) of the agents. We show that if the supervisor has complete information about the type of an agent, then he can choose his strategy accordingly and crime can never be prevented. Results derived by Mookherjee and Png (1994b) and Marjit and Shi (1998) turn out to be special cases of our complete information model. However, if the supervisor does not have complete information about the type of the agents (but he knows the distribution of the agents of different types), crime can be, at least partly, controlled, and an increase in the incentive to the supervisor for detecting crime can be effective. The latter situation, where a supervisor may not know the type of an agent, arises for example in the case of highway police checking, say, the pollution control device of the vehicles passing by, or a customs officer checking arriving passengers, etc.

Information usually has a positive role in economics. Better-informed agents are more likely to strike mutually profitable deals than less-informed ones. Tirole (1986) gives interesting examples of collusion in hierarchical organisations where supervisors and workers can inflict harm on the principal through collusion. Collusion between a law-enforcing agent and a criminal generates bribery in our model. However, our focus is basically on the question of whether crime can be prevented or not. In our set up, if a criminal is apprehended, the law-enforcing agent may not report and accept a bribe, or may report and receive a reward. But, in either case, the enforcing agent has an incentive to pamper crime. In a complete information case, such equilibrium is likely to be the outcome and crime cannot be controlled. We show that the law enforcer, having incomplete information about the type of a criminal, may take certain actions that will prevent crime to some extent. The starting point of our paper is related to Tirole (1986), but our focus is not on the issue of bribery as such, but on the possibility of prevention of crime. In our set up, the principal cannot directly verify the action of the potential criminals and appoints a law-enforcing official to prevent crime. We propose, via our model, that a relatively ‘less-informed’ law-enforcing official may better serve the purpose.

Section 2 describes the framework under consideration and discusses the situation where there is complete information. Section 3 takes up the incomplete information model. Section 4 sums up the findings.

2. The framework

The framework under consideration comprises a supervisor who is entrusted with the task of supervising a large number of agents of different types. These agents have the opportunity to engage in criminal activities. Criminal activity in our paper leads to an illegally acquired sum of x and corrupt activity refers to the acceptance of a bribe. The acquired sum x can be described as embezzlement of funds, amount of tax evasion, net value of smuggled goods, and any other type of illegal gains. If an agent chooses to engage in activities that generate x, we define him or her to be a criminal. Fewer are the people who acquire x, lesser is the extent of crime committed. Agents are different from each other with respect to their abilities to avoid detection by the supervisor, particularly, the agents who have the lowest ability or synonymously having the least experience in the field would be notified as the type 1 agents. Thus, a type t agent has lesser ability to avoid detection than a type $t+1$ agent. Finally, type T agent(s) form the upper bound by being the one(s) with the highest ability. To capture this phenomenon, we would index the agents of different types through the elements θ (a real number) in the interval $[\theta_T, 1]$, where type T agents would be indexed by θ_T and type 1 agents would be indexed by 1. In general, if θ_t is the index for a type t agent and θ_{t+1} for a type $t+1$ agent, and if the latter is more experienced then $\theta_{t+1} < \theta_t$.

Thus, the supervisor's chance of detecting a crime depends on the type of the agent. We assume that this chance or probability is also influenced positively by a second factor, viz. the effort e made by the supervisor for detecting the crime. Thus, if the supervisor puts an effort e into catching an agent whose type is indexed by θ, the chance of the former being successful is denoted by $\theta p(e)$, which clearly decreases for the agents with lower type index (or, equivalently, higher ability to avoid detection). In particular, the probability of detecting a type T agent is $\theta_T p(e)$ and that of a type 1 agent is $p(e)$. This exertion or effort produces disutility to the supervisor, which we denote by $d(e)$ (>0), and we make the following reasonable assumptions:

$$p'(e) > 0, \quad p''(e) < 0, \quad d'(e) > 0, \quad d''(e) > 0.$$

If a criminal is brought to the court of law, he has to pay a penalty αx, $\alpha > 1$, where x is the net pay-off for the agent due to his criminal activities. As a consequence, the supervisor earns a reward $\lambda \alpha x$, $1 > \lambda > 0$. Alternatively, however, a supervisor can be paid an amount B (as a bribe) by a corrupt agent for not reporting the crime.

We will pose this problem in a principal–agent set-up, where we assume that the supervisor commits a certain effort level and the agents react accordingly. This assumption has been made under the supposition that a supervisor is in charge of a locality for a period of time during which he builds up a reputation regarding his strictness (characterized by his effort level) in monitoring crime. Under this assumption, we consider two possible situations, which basically relate to the supervisor's knowledge about the type of an agent. In the first case (and this will be the focus of this section), we assume that the supervisor has full information about the type of an agent. This is a possibility when a supervisor has been in charge of a particular locality for quite a long period, supervising a fixed set of agents, and, as a result, is experienced enough to gather personalized knowledge about the type of each agent. The agents, in turn, act according to their personalized experience regarding the efforts (or, strictness) of the supervisor. In Section 3, we look at the effect of relaxing this assumption by introducing an incomplete information model.

Given this basic environment, let us now look at the strategies available to the supervisor and the agents. Sequence of moves:

1. Supervisor commits an effort level for detection.
2. The agent decides to be honest (H) or dishonest (D) and then the supervisor chooses to report (R) or not to report (NR).

An agent can be honest (H), i.e., is not involved in any criminal activity, or can be dishonest (D), i.e., can commit a crime and ready to pay a bribe when required. The supervisor's strategies are either to report (R) or not to report the crime (NR), and a corresponding effort level e. If the agent chooses to remain honest, he receives a pay-off of zero. Since e is precommitted, the supervisor obtains $-d(e)$ whether the 'honest' action of the agent is reported or not. We naturally focus on the pay-off to both players for the strategy sets (D, R) and (D, NR) (see Fig. 1).

To solve the game backwards, we look at the pay-off to an agent of type t who chooses between D and H given that the supervisor has chosen a particular level of e. When choosing D, his profit is

$$x(1-\theta_t p(e)) + (x-\alpha x)\theta_t p(e) = x(1-\theta_t p(e)) - x(\alpha-1)\theta_t p(e)$$
$$= x(1-\theta_t p(e)) - x\beta\theta_t p(e) \qquad (1)$$

where $\theta_t \in [\theta_T, 1]$ is the index for the type t agents (as mentioned above) and $\beta = \alpha - 1$. We define $p(e_t)$ as $\theta_t p(e)$. The supervisor's pay-off is:

$$\lambda\alpha x\theta_t p(e) - d(e) \qquad (2)$$

Note that the agent would play D if his expected pay-off derived in Eq. (1) above is positive. This is the case if

$$\theta_t p(e) \le \frac{1}{1+\beta} = \frac{1}{\alpha}.$$

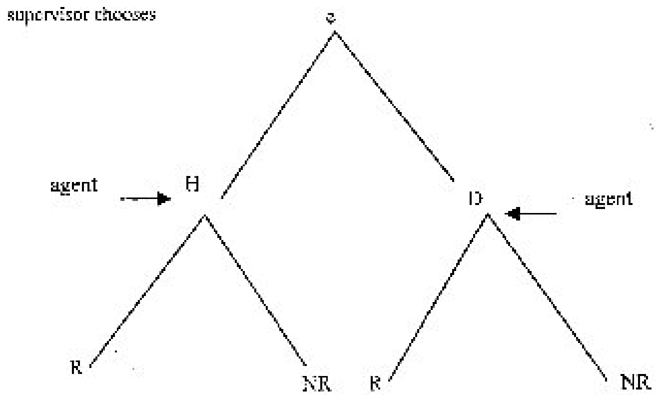

Fig. 1. Sequence of moves.

Since the supervisor wants to maximize his pay-off in his confrontation with a type t agent, his optimal effort would be

$$Z(e) = \max_e\{\lambda \alpha x \theta_t p(e) - d(e)\} = \lambda \alpha x \theta_t p(e^*) - d(e^*)$$

and $p(e_t^*) = \theta_t p(e^*)$.

On the other hand, if the agent plays D and the supervisor opts for NR, the possibility of a bribe emerges. Computing the agents' pay-off in a fashion similar to that of Eq. (1), we arrive at the following condition for an arbitrary type t agent to play D,

$$\theta_t p(e) \leq \frac{x}{B}.$$

We further assume that there is a probability q, such that the corrupt supervisor is successfully penalized for taking a bribe, in which case he incurs a loss L. Both q and L are exogeneously determined by the social consciousness of the people as well as the alertness and honesty of the reporting and judiciary system. This possibility, coupled with an expected bribe B, induces the supervisor to maximize the following pay-off function:

$$G(e) = \max_e\{B\theta_t p(e) - d(e)\} - qL$$
$$= B\theta_t p(e^{**}) - d(e^{**}) - qL, \text{ say.}$$

We assume a general form for B as $B = \delta \alpha x$, $\delta < 1$. Lemma 1 clearly follows:

Lemma 1. *In the above framework, there exists a* λ, $0 < \lambda < 1$, *such that the supervisor will always find it optimal to report.*

Proof. Case 1: If L is large enough such that $B - qL = \delta \alpha x - qL < 0$, $\forall \delta$, then, for any λ, $0 \leq \lambda < 1$, $Z(e) > G(e)$, $\forall e$.
Case 2: If $\delta \alpha x - qL > 0$. Then comparing $G(e)$ and $Z(e)$, we see that there exists a $\lambda > \delta - (qL/\alpha x)$ (< 1) s.t. $0 < \lambda < 1$, which ensures $Z(e) > G(e)$, $\forall e$.

Hence, it is possible to find a λ s.t. "reporting" is an optimal choice for the supervisor.

Note that the optimal λ depends very much on the amount of B that the supervisor can get as a bribe.

Proposition 1. *In the circumstances described above, it is not possible to prevent crime on the part of the agents.*[2]

Proof. From Lemma 1, it is clear that $\exists$ a λ s.t. $0 < \lambda < 1$, which ensures $Z(e) > G(e)\ \forall e$. Hence, it is possible to fix a λ such that the supervisor would prefer to charge a fine rather than taking a bribe whenever a criminal has been caught.

Suppose the supervisor meets a type t agent.

Case 1: If $p(e_t^*) \leq (1/\alpha)$.

Recall that this is the condition for an agent to play D. Thus, the supervisor would exert effort, and the crime would be committed by the agent.

Case 2: If $p(e_t^*) > (1/\alpha)$.

In this case, the supervisor would naturally commit effort e_t, such that $p(e_t)$ is slightly less than $1/\alpha$, in order to ensure that crime occurs and he secures a reward, otherwise, the supervisor's pay-off would reduce to zero. Thus, crime on the part of the agent cannot be controlled by raising α or λ. Though by raising λ, corruption can be controlled, we show here that (D, R) is a subgame-perfect equilibrium with an appropriate λ.

3. Incomplete information

Suppose now that the supervisor knows only the distribution of the agents according to their types, which we denote by $f(\theta)$ (θ as define above) and $\int_{\theta_T}^1 f(\theta)\mathrm{d}\theta = 1$, but he does not know individually the type of an agent. This will constrain him to choose a uniform effort level for all the agents. Thus, the supervisor chooses his optimal effort level by maximizing his expected pay-off function:

$$F(e) = \lambda\alpha x\int_{\theta_T}^{\theta(e)}(\theta p(e))f(\theta)\mathrm{d}\theta - d(e)\int_{\theta_T}^{1} f(\theta)\mathrm{d}\theta$$

$$= Kp(e)\int_{\theta_T}^{\theta(e)}\theta f(\theta)\mathrm{d}\theta - d(e),$$

where $K = \lambda\alpha x$ and $\theta(e)$ is the largest index of the agents playing D. In other words, it is the index of the agents who would be just indifferent between playing

[2] In this case a negative λ might also serve our purpose. We are, however, not concerned with this possibility as λ here stands for reward.

H and D at an effort level e. The supervisor can expect to obtain a reward $\lambda \alpha x$ with probability $\theta p(e)$ only from the agents who play D at an effort level e. Hence, the range of integration for the first term involves $\theta(e)$, a function of e where $\theta(e) \geq \theta_T$. However, since this effort of monitoring needs to be given for each and every agent, the range of the integration for the second term, where the supervisor takes account of his disutility is from θ_T to 1. While taking a decision on the effect level, the official takes into account λ. But one should note from the earlier section that such λ depends very much on the alternative pay-off received through a bribe (δ), which is clearly the informational rent the supervisor enjoys. δ is the outcome of potential collusion, and therefore, λ very much depends on the alternative collusive equilibrium. Incomplete information as such does not determine the bribery equilibrium as in Tirole (1986). The second-stage of the game generates the equilibrium (D, R) for those who commit crime and is based on the condition that the first-stage is resolved.

In this set-up, the supervisor's optimal effort would be

$$\max_e F(e) = F(\tilde{e}), \text{ say.}$$

This $\tilde{e}$ would give us a measure of the extent of corruption. Using Eq. (1), we find that all the agents for whom

$$x(1-\theta p(\tilde{e})) - \beta x \theta p(\tilde{e}) < 0$$

would not commit crime and for whom

$$x(1-\theta p(\tilde{e})) - \beta x \theta p(\tilde{e}) \geq 0$$

would commit crime.

Thus, the supervisor's optimal exercise now pools these different types of agents into two classes. The supervisor would commit an effort level $\tilde{e}$ which gives rise to a pooling equilibrium because of his lack of information about the individual agents. At first glance, this result appears to be intuitive and encouraging. However, a detailed exercise reveals that this pooling equilibrium can effectively reduce corruption only in a limited number of cases. More precisely, in the above set-up, it is possible to prevent crime only when there is a proportionately larger share of experienced people in the population. This tends to make the uniform effort level high enough to discourage crime by a subset of agents. Proposition 2 shows that if there are equal number of people belonging to each type, such that $f(\theta)$ is uniformly distributed, it is not possible to reduce crime even under incomplete information.

Proposition 2. *In the above set-up, if $f(\theta) = c$, $\forall \theta$, it is not possible to even partially control crime.*

Proof. The supervisor optimizes F w.r.t. e where

$$F = Kp(e) \int_{\theta_T}^{\theta(e)} \theta f(\theta) \mathrm{d}\theta - d(e).$$

As mentioned above, the agents with index θ would be just indifferent between playing H and D. Hence, using Eq. (1), we obtain:

$$x(1-\theta p(e)) - \beta x \theta p(e) = 0.$$

Thus, $\theta(e) = 1/\alpha p(e)$. Hence,

$$F = Kp(e)c\int_{\theta_T}^{\frac{1}{\alpha p(e)}} \theta \mathrm{d}\theta - d(e).$$

After integrating, we obtain,

$$F = \frac{Kc}{2\alpha^2 p(e)} - \frac{Kcp(e)\theta_T^2}{2} - d(e).$$

Thus,

$$F' = -\frac{Kc}{2\alpha^2}\frac{p'(e)}{p^2(e)} - \frac{Kc\theta_T^2}{2}p'(e) - d'(e),$$

which is negative, and, thus, F is a decreasing function of e. Therefore, optimal effort for the supervisor will be the minimum possible, which in turn would ensure that all agents would choose to be dishonest.

Exerting effort is costly. It only makes sense if there are quite a few experienced people and the corrupt official can gain by taking the extra pain. With $f(\theta) = c$ and $d'' > 0$, marginal gain from marginal exertion is less than the marginal loss.

This conclusion would hold even strongly when proportionately more agents are inexperienced. In other words, $f(\theta)$ is an increasing function of θ.

Suppose, on the contrary, that $f(\theta)$ is a decreasing function of θ. We note that, as θ increases, the experience level of the agents decreases. In particular, let us assume that $f(\theta) = A/\theta^3$, where A is s.t. $\int_{\theta_1}^{1} f(\theta)\mathrm{d}\theta = 1$. We then have the following results:

Proposition 3. *In the above set-up, if $f(\theta) = (A/\theta^3)$, it may be possible to (i) reduce the extent of criminal activities, and (ii) raise the effort level of the supervisor by providing better incentive.*

Proof. (i) Clearly, the supervisor would try to maximize $F(e)$ w.r.t. e where,

$$\begin{aligned} F(e) &= Kp(e)\int_{\theta_T}^{\frac{1}{\alpha p(e)}} \theta\frac{A}{\theta^3}\mathrm{d}\theta - d(e) \\ &= KAp(e)\left[\frac{1}{\theta_T} - \alpha p(e)\right] - d(e) \\ &= \frac{KAp(e)}{\theta_T} - KA\alpha p^2(e) - d(e). \end{aligned}$$

Hence,

$$F' = KAp'(e)\left[\frac{1}{\theta_T} - 2\alpha p(e)\right] - d'(e).$$

Thus, F' can be positive and, hence, F can be an increasing function of e if the quantity within brackets is positive and the second term (viz., $d'(e)$) does not dominate the first one. For sufficiently small values of e (or, not large values of θ_T), the quantity within brackets can be positive. If for initial values of e, $d(e)$ increases slower than $p(e)$ (which is indeed reasonable to assume), F' can be positive, and hence, a strictly positive value of e can be optimal, giving rise to a partially pooling equilibrium as mentioned above. Computing $F''(e)$ we see that

$$F''(e) = KAp''(e)\left[\frac{1}{\theta_T} - 2\alpha p(e)\right] - 2KA\alpha(p'(e))^2 - d''(e)$$

Given the properties of $p(e)$ and $d(e)$, $F''(e)$ will be negative if the same quantity $(1/\theta_T) - 2\alpha p(e)$ is positive. Therefore, for the initial (smaller) values of e, F can be an increasing concave function. Thus, a maximum with $e > 0$ can exist, which makes partial control of crime possible.

(ii) To show that the optimal e increases with K $(= \lambda\alpha x)$, we look at the first order maximization condition $F' = 0$. This gives us

$$KAp'(e)\left[\frac{1}{\theta_T} - 2\alpha p(e)\right] = d'(e).$$

Now, as K increases to $K + \varepsilon$ (through an increase of incentive, say λ), the L.H.S. of the above equation becomes greater than the R.H.S. Given the assumptions on $p(e)$ and $d(e)$, equality can be restored only by raising e.

This shows that by raising the level of reward (λ), or, alternatively, the penalty (α), it is possible to raise the effort level of the supervisor and, thereby, to reduce the extent of crime. This observation justifies the transfer policy of the government, which ensures that a person would not stay in one place long enough to gather individual information about the agents concerned. Whenever he (the government official) can gather complete information, Proposition 1 tells us that crime can never be controlled. However, Propositions 2 and 3 also reveal that a transfer policy would be effective only in the situations where there are comparatively larger number of experienced individuals, who need greater effort on the part of the supervisor to be detected with a reasonable probability. It is important to note that in the set-up of incomplete information — unlike Mookherjee and Png (1994a,b) or Marjit and Shi (1998) — one can justify a stiff penalty or better incentives as positive steps.

4. Conclusions

This paper had examined the possibility of controlling crime through an incentive scheme or a supervisor to undertake strict monitoring, where the potential criminals have different abilities to avoid detection. An incentive scheme may be effective when the supervisor does not have complete information about the agents' ability to avoid detection. The main purpose of the paper is to argue that law enforcement is easier when a potentially corrupt law-enforcing official has incomplete information regarding the potential violators of law. When the official knows the exact type of the criminal, he can make sure that crime is committed and can benefit either by a bribe or by a reward. Rewards in general will lead to greater incidence of crime. But, with incomplete information, the official may commit a fairly high level of detection effort and 'weaker' criminals may not commit crime. We have derived exact conditions under which this would be feasible.

One extension of this framework is to introduce a learning process for the supervisor. When a supervisor has been in charge of a particular locality for too long, he would start gathering individual information about the type(s) of the agents. The learning process for the supervisor in this framework has some interesting features. If the supervisor does not detect an agent as corrupt, he cannot distinguish between whether the agent is playing honest or dishonest and, hence, cannot find the type of the agent. However, if the game has been played a sufficiently large number of times, the supervisor is expected to be able to detect all the agents playing D. Once the supervisor completes his learning process, we are back to Proposition 1.

One can also examine, as a next step, whether a positive role of information can be set into a model of corruption, especially when some of the supervisors in the system are intrinsically honest. It is possible that more information provided to the supervisor helps him to do his duties more efficiently. We have ignored such a positive role of information to highlight its counter-productive role.

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References

Basu, K., Bhattacharya, S., Misra, A., 1992. Notes on bribery and the control of corruption. Journal of Public Economics 48, 349–359.

Besley, T., Mclaren, J., 1993. Taxes and bribery: the role of wage incentives. The Economic Journal 103, 119–141.

Bowles, R., Garoupa, N., 1995. Casual police, corruption and the economics of crime. Discussion Paper II/95, University of Bath, Center for Fiscal Studies.

Cadot, O., 1987. Corruption as gamble. Journal of Public Economics 33, 223–244.

Chander, P., Wilde, L., 1992. Corruption in tax administration. Journal of Public Economics 49, 333–349.

Gangopadhyay, S., Goswami, O., Sanyal, A., 1991. Tax enforcements with hierarchy of corrupt auditors. Mimeo, ISI Delhi.

Lui, F.T., 1985. An equilibrium queuing model of bribery. Journal of Political Economy 93, 760–781.

Marjit, S., Mukherjee, A., Mukherjee, V., 1998. Harassment, corruption and tax policy. European Journal of Political Economy 16.

Marjit, S., Shi, H., 1998. On controlling crime with corrupt officials. Journal of Economic Behaviour and Organization 34, 163–172.

Mookherjee, D., Png, I.P.L., 1992. Monitoring vis-à-vis investigation in enforcement of law. American Economic Review 82, 556–565.

Mookherjee, D., Png, I.P.L., 1994a. Marginal deterrences in enforcement of law. Journal of Political Economy 102, 1039–1066.

Mookherjee, D., Png, I.P.L., 1994b. Corruptible law enforcers: how should they be compensated? The Economic Journal 105, 145–159.

Rose-Ackarman, S., 1975. The economics of corruption. Journal of Public Economics 4, 187–203.

Tirole, J., 1986. Hierarchies and bureaucracies. Journal of Law, Economics and Organization 2, 181–214.