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Hierarchies, Incentives and Collusion in a Model of Enforcement*

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Hierarchies, Incentives and Collusion in a Model of Enforcement

Abstract

This paper considers a model of enforcement with corruptible enforcers in an agency framework. We examine how supervisor's choice of effort and honesty are influenced by incentives (penalty and reward schemes) and organizational structure. We consider both vertical hierarchies (corrupt supervisor monitoring another) and horizontal structures where more than one corrupt supervisor monitor the agent. The latter tend to induce less corruption but need not welfare dominate the vertical hierarchies. The organizational structure matters most when there are constraints on rewards and penalties.

Key Words: corruption, hierarchies, monitoring

JEL Classification Numbers:D72, D73, K42

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I. INTRODUCTION

Many agency relationships (government-tax payer, regulator-firm) rely on intermediate agents (supervisors/officers) to seek agent-related information, which is essential to the implementation of the incentive scheme. The possibility that these supervisors can collude with the agents and distort or hide relevant information to further their own interest has a lot of significance for design of optimal policies in these settings. Recently, this issue has been addressed by a number of authors[1]. At a broad level one can think of three different approaches to overcome this problem. One way is to get rid of the supervisors- that is to design incentive schemes such that agent's compliance is voluntary. But in all the examples mentioned above it is unlikely that such a policy can work and intermediate supervisors are an integral part of the enforcement mechanism. The other end of the spectrum is privatization or more appropriately transfer of the principal-ship to the supervisor. In that case the supervisor is expected to carry out necessary enforcement in his own interest. The middle ground is covered by design of various incentive schemes in the form of reward and punishment for both the agents and the supervisors. In this paper, we shall be focussing on issues related to these schemes.

It would be a relatively simple matter if the principal could directly monitor supervisor's *effort and honesty* while enforcing the contract. But, in many cases this is not feasible. Moreover, given the information and other constraints faced by the principal he may not be able to design incentive compatible contracts to induce optimal effort and honest behavior by the supervisor. It is in these contexts that issues of hierarchies and organizational structure assume importance. One could appoint a higher level supervisor to monitor the original supervisor. Or else, one could have parallel supervision by more than one supervisor. But the higher level supervisor can be corrupt as well. Despite the fact that the higher level supervisor is corrupt, such a hierarchy (hiring a thief to catch a thief) can be optimal in certain cases. We study such structures and characterize the optimal policy in such situations.

The paper shows that organizational structure and incentive systems are related. The optimality (or otherwise) of a particular organizational design depends on the kind of incentive schemes that are feasible. However, we are not suggesting a theory of organizational structure as such. In many cases a particular organizational structure might exist for reasons which have nothing to do with corruptibility of the supervisors[2]. Moreover, the optimal structure depends on the particular objective of the principal or the planner. For example, whether corruption *per se* has any social cost or not can be an important factor in determining the optimal organizational structure in the present model context.

Section II introduces a simple model of enforcement. This can be adapted to various situations like tax evasion, pollution control and other regulatory compliance problems. In section IIA we focus only on the corruption aspect and consider various organizational structures. It also contains a brief discussion of the related literature on corruption in hierarchies. Section IIB introduces effort of the supervisor. This effort can also be interpreted in a broader way so that it affects various factors like quality of information, likelihood of error and probability of detection. Since effort is costly for the supervisor, right incentives have to be provided. Section III compares various organizational structures. The comparative analysis is not quite complete, as it is not possible to characterize the entire set of outcomes under different structures. The analysis in sections II-III can be viewed as input based schemes, where supervisor's effort and honesty can be viewed as inputs to the final goal of agent's compliance. A supervisor is rewarded if he reports a crime. Section IV contains a brief discussion of what we call output based schemes. Here the supervisor is held responsible for the over all crime levels (final goal) and is compensated accordingly.

II. A MODEL OF ENFORCEMENT

IIA: CORRUPTION

Consider an individual Z contemplating an illegal activity worth B to him. If he is caught having committed the crime and reported by the officer then he has to pay a penalty f, $f > B$. If p is the probability that he would be caught and punished then he would commit the crime iff

(1) $B - pf > 0$.

But the corrupt officer can always take a bribe and let him off (do not report). Assuming bribes are determined by Nash bargaining solution[3], Z would have to pay a bribe of f/2. He would now commit the crime if

(2) $B - pf/2 > 0$.

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[1] See Bardhan (1997) for a recent survey.
[2] There are various approaches to the study of organization design, i.e. Radner (92), Sah & Stiglitz (86).
[3] The bribe determination and the basic model setup follows Basu, Bhattacharya and Mishra (92).

So enforcement is diluted to the extent the officer is corruptible. So long as bribes are some increasing function of the penalty, enforcement is diluted but not eliminated altogether. In that case one can argue that by raising the penalty f beyond 2B/p one could achieve compliance.

Suppose fines can not be raised indefinitely (e.g. Limited liability reasons). Say, $B/p < f < 2B/p$. Then the only way to ensure compliance by Z is to induce honest reporting by the officer. The officer, to that effect, can be given a reward r for honest reporting. Since the officer can always collect the reward by reporting after the bribe negotiation with Z has failed; it is proper to take r as the disagreement payoff of the officer[4]. Now the bribe to be paid by Z to the officer is $(f+r)/2$. A higher r would mean a higher bribe for Z. So even if honesty is not guaranteed by introduction of reward, the bribe negotiation becomes more costly. Suppose, $r < f$, then it can be checked that the officer will never report honestly. But the individual Z will now commit a crime only if,

(3) $\quad B- p\,(r+f)/2> 0$

Even if $f > B/p$, if r is substantially less than B/p, then the above inequality can still hold and Z would benefit from committing the crime. For example, let $f = B/p + \alpha$ and $r = B/p - 2\alpha$ then (3) would imply that Z still finds it profitable to commit the crime. But comparing the inequalities 1-3, one can see that some deterrence can be achieved.

As seen in the previous paragraph, if $r < f$ then honest reporting does not take place. In that case, one can hire another officer to monitor the first officer. Officer 2 can detect with some probability q any bribe taking by officer 1. Now, officer 1 can be subject to a penalty of g for bribery. This threat of punishment can work to some extent to prevent corruption by officer 1. However, there is nothing to guarantee that officer 2 will honestly report. Officer 2 can also take bribe from officer 1 and decide not to report. The Nash bargaining solution to the bribe negotiation between the officers will simply be g/2, assuming there is no reward for officer 2. But this has also important implications for the bribe negotiations between officer 1 and Z. We assume that Z can not be tried again after being let off by officer 1 even if the latter is caught. Bribe to be paid by Z is now given by t* where t* maximizes $(f-t)\,(t- qg/2 - r)$ or,

(4) $\quad t^* = (f+r)/2 + qg/4$

The officer's net expected payoff from taking a bribe will be given by $(f+r)/2 - qg/4$. Hence even if $r < f$, the officer would choose to be honest if $r > f - qg/2$. So the introduction of another layer of

[4] An earlier version of the paper treated r as an outside option. As has been pointed out by a referee, the disagreement interpretation is more appropriate. The details are different but the main results do not change.

supervision has made bribe taking less attractive even when the second officer is corrupt. Given that $f > B/p$, honest reporting would imply compliance by Z.

Instead of having a higher level of monitoring, one can add another layer horizontally. In many organizations these kind of overlapping jurisdictions is observed. For example, a license or permit might have to be cleared by several bureaucrats in different ministries. The exact nature of this overlap depends on the context and can vary. In our setting, both the officers are supposed to detect illegal activity by Z. If one of them catches Z and reports truthfully, then Z pays the penalty and the second officer's action does not matter any more. However, if the first officer were to take a bribe and let Z off, then officer 2 could also catch Z and demand a bribe or report truthfully. Unlike the previous case, when officer 2 is honest and Z is penalized, nothing happens to officer 1 who had taken a bribe earlier. The second officer does not monitor the first officer. We rule out collusion between the officers although this can have interesting implications.

Whoever is the second officer can get a bribe if Z has not been reported already. Assuming the same kind of rewards r for honest reporting, the second officer will take bribe of $(r+f)/2$ whenever $r < f$. This means the first officer's bribe is always going to be less. While negotiating with him, Z knows that an agreement with him does not guarantee complete let off. If p is the probability that the second officer can catch Z (after having been caught by officer 1), bribe would be given by argmax $\{ f - t - p(f+r)/2\} \{t - r\}$ or,

(5) $t^* = (f+r)(2-p)/4$

This is less than the earlier bribe of $(f+r)/2$ when $p > 0$. This bribe amount is going to be still less when officer 2 is expected to report truthfully. Like before, bribe taking is less attractive to the officer. It is possible to induce honesty even if $r < f$.

The previous discussion makes it clear that different organizational structures affect the corruptibility of the officers in different ways. However, it must be pointed out that we are looking only at the corruption issue and other efficiency issues can be important determinants of the organization. For example, in the overlapping jurisdiction case, if screening of the project requires specialized knowledge then such a hierarchy might be optimal, as it would reduce the number of undesirable projects. On the other hand there might be efficiency loss due to delays and un-coordinated actions[5].

The issue of hierarchies has received some attention in studies on corruption. Basu et al (92) and Gangopadhaya et al (93) have considered hierarchies of auditors where the higher level monitors the lower level. Carillo (95) also considers a similar vertical hierarchy with penalty for corruption being endogenized by an internal promotion scheme (which is enforced by an honest super principal). In all these models probabilities of detection are given from outside. However, these detection probabilities ought to depend, in addition to ratio of criminal-officer population, on the state of information technology and effort exerted by the officers. Mookherjee and Png (95) consider a similar model in the context of pollution control, where both effort and honesty decisions of the inspectors are endogenously determined. But in their model, the principal can always detect corruption with some probability. In our model language it would mean that the second officer is always honest and detects bribery with some exogenous probability. Bac (96), Bag (97) and D'Souza and Klein(99) consider hierarchies where both monitoring effort and corruption are endogenously determined, but they restrict attention to vertical case and its variants. Unlike the vertical hierarchy case, the horizontal case has not received much attention[6]. Kofman and Lawarree (93) examine a case similar to the horizontal case. In their model, the principal hires an external auditor (in addition to the internal one) and makes inference about the honesty of the internal auditor based on both reports. But again, the external auditor is supposed to be always honest. In our model, both effort and honesty of both the officers are endogenously determined. This makes the model somewhat more complicated and necessitates the use of simpler specifications. The next section introduces effort into the model.

IIB. EFFORT CHOICE

Let p_1 be the probability that officer would catch Z. It depends on the amount of effort e_1 exerted by the officer 1 as given by the simple function

(6) $P_1 = e_1 / E$, $P_1 \in [0 \quad 1]$ and $e_1 \in [0 \quad E]$

where E is the maximum effort that an officer can exert.

We assume that utility functions are linear and additively separable. So the officer's payoff is given by

(7) $\Pi = y - e$, where y is expected net income and includes bribe and rewards.

The officer can truthfully report and collect the reward r or take a bribe t from individual Z. Bribe t will depend on the penalties and reward. Officer's choice of honesty is denoted by h, $h \in \{0 \; 1\}$. It will be assumed that h = 0 refer to honest reporting and h = 1 for bribe taking. When indifferent

[5] In a different context, Bardhan and Mookherjee (2000) have looked at the issue of corruption and institutional structures like centralized and decentralized modes of delivery of public services.

between these two options, the officer can randomize. Likewise, Z's decision to commit the crime is denoted by c, $c \in \{0\ 1\}$ and c =0 refers to no crime. We shall suppose that c and h stand for these randomization probabilities as well and interpret these as levels of crime and corruption respectively. We shall begin with the no-hierarchy case as a benchmark.

In the no-hierarchy case, officer 1 chooses p_1 and h to maximize his expected payoff. Individual chooses c to maximize his payoff. We look for Nash equilibrium which is simply a vector (c*, e*, h*), so that given the individual's choice the officer's payoff is maximized and vice-versa. The payoffs (Πz and Π_1) in the no-hierarchy case can be given as follows

$$\Pi_z = B - p_1\left[h\left(\frac{f+r}{2}\right) + (1-h)f\right]$$

$$\Pi_1 = c.\max\left[\left(\frac{f+r}{2}\right), r\right]p_1 - p_1 E \tag{8}$$

It can be verified that when r < f, the officer always take a bribe and in equilibrium h = 0. To avoid cases where the officer puts no effort in equilibrium we also assume that E is not too large. More specifically, E < f/2. The officer will put in positive effort irrespective of the value of the reward.

We can have two kinds of equilibria. If penalty f is small compared to the gain B, then it is possible that there is an equilibrium with c* = 1, p^*_1= 1 and h* = 0. But for large penalties, there is an interior equilibrium with c* = 2E/ (f + r) and, p^*_1 = 2B / (f+r) and h* = 0. The equilibrium crime level decreases in f.

Notice that in no case c* = 0, except in the limit when f tends to infinity. This is not surprising, since in the absence of any crime the officer is deprived of any reward or bribe income and hence puts no effort[7]. So long as officer's payoff depend on equilibrium crime level in this fashion such a result will always hold. However, there might be lower bounds on p or e because of several other reasons. But the general point being made here is that if bribery is sought to be discouraged this way then the incentive scheme may not be very effective in eliminating crime altogether.

Before we proceed to analyze different hierarchies, we need to specify some means of evaluating social welfare. Many different formulations are possible. A minimal version would be to take welfare as simply dependent on the crime level and the effort costs. According to this,

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[6] Rose-Ackerman (78) contains an early discussion of this and other hierarchies.
[7] Similar to the result by Marjit and Shi (98) who consider more general functions.

corruption *per se* does not affect welfare. Let x be the net social cost associated with the criminal activity. Then welfare is given by

(9) $W = - cx - p_1 E$

One can also argue that corruption is a major determinant of welfare and should not be treated simply as a transfer. Then one can include the relevant cost associated with h in this function.

The third approach would be to bring in revenue considerations as well[8]. Penalty f and g can be treated as fines and these constitute revenue to the government. Likewise rewards are payments made by the government. One can introduce this net revenue of the government (suitably weighted) in the welfare function.

(10) $W = -cx - p_1 E + \theta(f-r)cp_1h$

Where θ is the weight associated with revenue considerations. Corruption also enters the welfare function because penalty is imposed only when there is honest reporting. This formulation can also explain why rewards are not raised arbitrarily in many real enforcement situations. We shall primarily consider the first version of welfare in making comparisons but also point out how these comparisons would be affected by introducing revenue constraints.

The social optimum in the no-hierarchy case is easy to see. Welfare is maximized when f is set at its maximal level. This corresponds to the standard Beckerian maximal fine hypothesis. Such a result is true as bribes are increasing functions of the fine level. One need not have to induce honesty, as it would mean setting r above f. Neither welfare criteria discussed above would prescribe this.

III. HIERARCHY

IIIA. VERTICAL LAYERS

Let us introduce a second officer who will monitor the first one. As mentioned earlier, we shall consider a hierarchy where the second officer is only interested in finding out whether the first officer has taken a bribe or not[9]. Depending on the effort by the second officer; the first officer can be caught and pays a penalty g if reported. But the second officer can take a bribe as well and let him off. In fact in our model the second officer is always dishonest. One can consider the more general case, but since there is no one to monitor the second officer and rewards are less

[8] I am grateful a referee for pointing this out. This has the added implication of making bounds on rewards endogenous.

[9] Throughout the model it is taken that bribery can be detected. Normally however detection of bribery follows the detection of the initial crime. This aspect has not been modeled. Later in the paper we discuss this issue in more detail.

than the penalties, the second officer will always choose to take a bribe. Hence we abstract from issues like rewards to the second officer for honest reporting.

Let p_2 be the probability that the first officer is caught having taken a bribe. Given the penalty g, he would have to pay a bribe of g/2 if caught. As shown earlier, the bribe he receives from Z would be (f+r) /2 + p_2g/4. Assuming that p_2 is determined the same way as p_1 in (6), the payoffs in the vertical hierarchy case are given by

$$\Pi_z = B - p_1\left[h\left(\frac{f + r + p_2 \, g/2}{2}\right) + (1-h)f\right]$$

$$(11) \qquad \Pi_1 = c.\max\left[\left(\frac{f + r + p_2 \, g/2}{2} - p_2 \, g/2\right), r\right]p_1 - p_1 E$$

$$\Pi_2 = cp_1hp_2\left(g/2\right) - p_2 E$$

Like the previous case an equilibrium is given by (c*, h*, p^*_1 and p^*_2). The only difference in the present case is the choice of effort by the second officer who optimally chooses his effort level to maximize his expected income. Clearly, officer 1's decision depends on 2's choice. Since the bribe that individual Z has to pay in the event of getting caught by officer 1 depends on officer 2's choice, individual Z's decision also depends on officer 2' choice.

Like before, we assume that E is not so high as to make the officers choose zero effort. Instead of characterizing all the equilibria we shall focus on the interior equilibrium.

Proposition 1:

(a) An equilibrium with positive level of corruption is always dominated by another equilibrium with a lower level of corruption.

(b) A zero corruption level, however, need not be optimal when r is constrained to be small.

Proof: (a) For r > f, corruption is always zero, hence the claim can be verified only when r < f. It can be shown that when $r < f$ and E is not too high there exists[10] an interior equilibrium where

$$(12) \qquad c = E/r \,,\; p_1 = B/f \,,\; p_2 = 2(f-r)/g \,,\; h = 2rf/gB$$

[10] The detailed characterizations of all the equilibria under different parameter specifications have been omitted and can be obtained from the author.

There are two cases to be considered.

Case 1- g can be increased. Recall that the g is the fine that the first officer pays if he is caught taking a bribe. Consider an equilibrium with h = h*. Now, keeping everything else same raise g. In the new equilibrium $h^{/}$ is lower and so is p_2 . But c and p_1 remain same. The variable h does not affect the crime level but a lower p certainly would raise welfare according to either of the welfare criteria as given by (9) and (10).

Case 2 - But in some cases it may not be possible to raise g. For example when the only fine possible is that of firing, g will refer to the future wage income. In that case g is fixed for our purpose.

Now corruption can be reduced (h lowered) by either reducing r or f. Reducing r is clearly not the solution as it raises c and raises p_2 as well. So a reduction in r will certainly mean lower welfare according to the first welfare criterion. But one can raise r and lower f by a slightly bigger amount so that rf falls. This means c falls, p_2 falls, but p_1 rises. It can be shown that the fall in p_2 will compensate for the rise in p_1. This would mean such a change would lead to higher welfare. To see this more formally, consider any equilibrium with $h^* > 0$. Now consider a change in r and f, $dr > 0$ and $df < 0$ and in addition $dr = - df$. Using this once can show that in the new equilibrium, c is lower, $h = h^*$ and $(p_1 + p_2)$ is also lower (unless $f < g/4$)[11]. So this equilibrium clearly dominates the other one. By continuity, one can consider another pair of r and f with $|dr| < |df|$ such that welfare is higher in the new equilibrium. Clearly for the new equilibrium $h < h^*$.

This completes the proof of the fact that there always exists an equilibrium with higher welfare and lower corruption[12]. If we were to use the welfare criterion with revenue consideration, the proof needs to consider the possible trade off between reduction in crime and reduction in revenue. For example, if r is lowered crime level is higher but so is payments made by the government. It is difficult to say which direction welfare will go without further information on x and θ. Note that this does not imply that any lower corruption equilibrium will welfare dominate an equilibrium with higher level of corruption. As part B shows if one is constrained in the choice of the incentive instruments a target of zero corruption is not optimal.

(b) Elimination of corruption would mean $h = 0$. This is possible only if, $r > f$. When $r > f$, we have $h = 0$, $p_2 = 0$, $c = E/r$, $p_1 = B/f$. Since $r < R$, where R is some upper limit for r, $f < R$.

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[11] By differentiating $(p_1 + p_2)$ and using the fact that $df = -dr$ we can get, $d(p_1 + p_2) = df\,(4f^2 g - Bg^2) / (fg)^2$. Since $f > B$, $4f > g$ would imply the term on the right hand side is positive.

[12] Mookherjee and Png (95) also have a similar claim. The present one can be considered a generalization as officer 2's effort and honesty are also being determined in equilibrium.

Hence welfare is bounded above by (E/R) x + BE/R. But we can construct another equilibrium with r = R but f > r, so that there is some corruption. The value of c remains same. The enforcement effort now is E(B/f + 2(f-r)/g). One can raise f and g such that this term is less than E(B/R). Hence by stipulating large fines one can achieve another equilibrium which yields greater welfare despite positive level of corruption. []

This shows that one need not insist on elimination of corruption all the time and at any cost. We can use the previous analysis to ask whether an additional layer of supervision is desirable. The following Proposition shows when it is desirable.

Proposition 2:

A two layered hierarchy is better in welfare terms only when r and f are constrained to be small and the cost associated with the crime x is large.

Proof: Suppose, r and f are constrained to be such that r + f < 2B. Note that c = 1 irrespective of whether r > f or r < f. So it is optimal to have no enforcement at all and W = -x.

Now by introducing a second layer, one can achieve some compliance c <1, but there is effort cost as well. Assuming r < f, we have an equilibrium c = E/r, p_1 = B/f and p_2 = 2(f-r)/g. Now there is welfare gain of (1-E/r) x due to a reduction of criminal activity but there is welfare loss as well of the order of (p_1 + p_2)E. When g can be raised, the second term p_2E can be made very small and one can find a value of x = x* such that for x > x*, (1-E/r) x > (p_1 + p_2)E. But when g can not be made large, there still exists x** > x*, such that for x> x** we still have (1-E/r) x > (p_1 + p_2) E. In this case, only if the cost of the criminal activity is very large, it is worth having a second layer.[]

Intuitively, this makes sense. When the first officer can be punished severely (g large), limited enforcement can be achieved at a lower cost (p_2 is low) and one is more likely to see a hierarchy. But when the first officer can not be punished severely (g is small), there is need for greater monitoring (p_2 is large) and hence the cost of enforcement is greater. So unless the criminal activity is a serious one, there is no need for a hierarchical monitoring and hence no enforcement activity at all.

IIIB: OVERLAPPING JURISDICTION OR HORIZONTAL LAYERS

When more than one officer are supposed to monitor individual Z, the sequence in which Z is apprehended matters. In many organizations, this sequence might be given from outside. We simplify our analysis by assuming that both officers have equal probabilities of being the first one to catch Z. Since we shall focus on the symmetric case, where both the officers put in same effort, it is not such a restrictive assumption. The penalty f, the reward r and the effort-probability functions are the same. As mentioned earlier, if the first officer reports Z then apprehension by the second officer does not add anything to the picture.

Let p be the probability that officer I (I = 1,2) will catch Z. The probability that Z will be caught is simply p + (1-p)p and the probability that he will be caught by both is p^2 . The probability that officer I is the first one to catch is p – $p^2/2$. This is because he is the only one to catch Z with probability (p - p^2) and he has equal probability of being the first one when Z is caught by both.

The analysis is straightforward if r > f. Now both of them are honest. However, only one can get the reward. The payoffs are given by

(13)
$$\Pi_i = c(p - p^2/2)r - pE$$
$$\Pi_Z = B - (p + p(1-p))f$$

Since f > B, the only equilibrium possible is where c* = 2E/r(2-p) and p is given by the function 2p- p^2 = B/f. If we compare this with the vertical hierarchy case, note that if r >f then one does not need a second layer or second officer's effort is always zero. So in equilibrium c* = E/r and p = B/f. It can be shown that both the crime level and the effort costs are higher in the horizontal case. Since p > 0, 2E/r(2-p) > E/r. Moreover, $2\{1-(1-B/f)^{1/2}\} > B/f$. The main reason behind this is the duplication of effort by officers in the horizontal case.

A more interesting case emerges when r < f. Now the second officer is always taking a bribe if the first officer has not already reported. This affects the bribe negotiation between Z and the first officer. The bribe will be given by

(14)
$$\underset{t}{\operatorname{argmax}}[f - t - p(f+r)/2][t - r]$$
$$t^* = (f+r)/2 - p(f+r)/4$$

This means that even if r < f, for certain values of r > r*, the first officer will prefer to report truthfully and collect reward rather than accept a bribe. This implies that officer's optimal strategy regarding truthful reporting depends on whether he is the first one to catch Z or not. Given that both officers follow the same strategy this would mean in equilibrium Z is always reported honestly and there is no bribe taking by any officer. The equilibrium outcome is same as the previous case with r>f. So even with r < f, one can see complete honest reporting in the horizontal case as opposed to the vertical case where some bribe taking always takes place. Even though corruption does not per se affect welfare, lower corruption lead to smaller enforcement effort and possibly higher welfare in this case.

PROPOSITION 3: There exists an equilibrium where Z is reported honestly even when rewards are less than the penalty. The equilibrium level of crime is always greater than the level under the vertical hierarchy (whenever the latter has an interior equilibrium). But the horizontal case welfare dominates the vertical hierarchy when the cost associated with crime and officer's penalty g is not too large.

PROOF: We shall first show that there exists a r^*, given B and f such that for $f > r > r^*$, an equilibrium with truthful reporting exists. As discussed earlier, if such an equilibrium exists then the detection probability p will be given by

(14) $p = 1-(1-B/f)^{1/2}$

Given this p, the expected bribe t to the first officer will be given by

(15) $t = (2-p)(f+r)/4$

It can be shown that total expected bribe income will be less than rewards iff

(16) $$r \geq f\left(\frac{1+\sqrt{1-B/f}}{3-\sqrt{1-B/f}} \right) = r^*$$

For r ≥ r*, the first officer will always choose to report in equilibrium. Since this equilibrium is same as the one where both are honest the crime level and effort will be given by

(17) $c^* = 2E/r(2-p)$ and $e = E\{ 1-(1-B/f)^{1/2}\}$

Comparing this with the vertical case (12), note that since p>0, $2E/r(2-p) > E/r$. Hence crime level is higher. But if g is not too large then the vertical case has higher enforcement cost compared to the horizontal case. So there is a trade off between enforcement effort and crime control. The horizontal case dominates the vertical case if the cost savings are greater. We illustrate this point using an example.

Let B= 15, f = 16, r = 8 and g = 20. Now the critical value of r will be 80/11. So any r ≥8 would mean there would be an honest equilibrium under the horizontal case. Detection probability p = 3/4. Using (12) and the parameter values, it can be shown that the total effort cost under the vertical case is E(139/80) and total effort cost under the horizontal case is E(6/4). There is a saving of E(19/80) in the horizontal case. But on the other hand crime level under the horizontal case is higher by an amount 3E/40. Using the first welfare function in (9) it is easy to see that the horizontal case welfare dominates if x < 3. The same would also hold true with (10), because under the horizontal case there is more honest reporting and hence greater revenue collection.[]

Note that as g increases the effort cost decreases under the vertical case and the claim would not hold anymore for sufficiently large g. Likewise, if g is so small that the second layer of policing is defunct, the horizontal case may again welfare dominate but for exactly opposite reasons. Now the horizontal case would have lower crime level but higher enforcement cost. To see this let $g = 8$, $r = 7.5$ and $E = 4$.B and f are same as in the previous example. So reward is still large enough to ensure truthful reporting in the horizontal case. But now, since g is very low, there is no interior equilibrium under the vertical case. In fact for the parameter values it can be verified that $c = 1 = h = p_1$, $p_2 = 0$. So there is no deterrence of crime. In that case it is better to have no enforcement at all under the vertical case. But, the horizontal case does succeed in reducing the crime level for the same parameter values. If the gain from crime reduction outweighs the enforcement cost, then the horizontal case is better. It is better in terms of both welfare criteria, because it achieves positive enforcement as well as honest reporting. This suggests the following corollary.

Corollary: When the reward and penalty for the officer are small so that no enforcement is possible under the vertical case, the horizontal case can achieve positive enforcement. If the cost associated with crime is substantial then it may be the preferred organizational structure.

IV: OTHER INCENTIVE SCHEMES

Recall that in the vertical hierarchy model, officer 2 is simply supposed to monitor officer 1 to detect bribery. This is unsatisfactory on two accounts. First, it assumes that there is a simple and direct way to detect bribery- a feature shared by most of the literature. Second, given that bribery *per se* is not the target variable, a natural case to consider would be to have the second officer monitor Z as well. Once Z's illegal act is detected, then both Z and the officer 1 are penalized. Detection of Z's illegal activities by officer 2 (but not reported by officer1) could be taken as evidence of bribery by officer 1. As has been noted by Mookherjee and Png (95), this would strengthen officer 1's incentive to put higher effort. This arrangement has features of both the vertical and horizontal cases. This however has serious implications when the monitoring technology is not prefect because officer 1 can get penalized despite best efforts and honesty simply because of his failure to detect Z's activities.

A logical extension of this argument would be to compensate the officer solely in terms of the final outcome – the extent of criminal activities. This would also take care of the problem and an unpleasant feature of all these models that reward income vanishes when there is no illegal activities. To fix ideas, consider an example of pollution by two firms. The regulator can observe the aggregate level of pollution but can not regulate individual firm's behavior based on aggregate information. Hence a pollution inspector is hired to monitor the firms. In the case of identical firms, the inspector will report truthfully to the regulator if both firms choose c = 0 or c = 1. But for all other intermediate cases, scope for bribery exists. The inspector can take a bribe from the polluting firm to misreport or take a bribe from the non-polluting firm to file a true report. This kind of extortion or harassment would be a major problem[13]. If suitable institutional and incentive schemes could be put in place to overcome the problem of extortion, then the inspector will always report truthfully. One such case is when firms can present hard evidence to prove non-pollution and the inspector can then be penalized for false reports.

These kind of schemes can be viewed as output based as compensation depends on the outcome of monitoring. This has interesting implications for the effort choice of the officers. If all agents were to choose c = 0, then the officer is getting maximum rewards possible and there is no need to put any effort. But without any effort detection probabilities would be low and agents might be induced to choose c> 0 again. In fact in multi-stage settings, the officer would have an incentive to put high effort and maintain the reputation of high effort and honesty. This reputation can deter agents from choosing high c and consequently lowering officer's income. Notice that in all the input based models studied earlier, the reputation effect is exactly the opposite. The officer would like the agents to believe that he is a low effort and corrupt person so that more agents would be induced to choose c = 1 and the officer can get a high bribe or reward income. Hence, the incentive scheme in use can have dramatic implications for the officer's effort-honesty choice. In the paper, we focussed on only one kind of scheme and its various instruments and how they affect the officer's choices. The study of the output based schemes is left for future research.

V: CONCLUSIONS

We have shown that organizational design and the optimal policy towards corruption matter most when there are constraints on penalties and rewards. The desirability of a particular organizational structure (no hierarchy, vertical hierarchy or overlapping jurisdiction) is context specific and depends on the nature of the crime (its cost x), the bounds on rewards and penalties (f, g) and the weight of corruption in social welfare. In general, the horizontal structure leads to less

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[13] Hindriks, Keen and Muthoo (99) study the problem in a tax evasion and audit context.

corruption. In the vertical case, there is greater amount of corruption in equilibrium though the overall level of illegal activities (c) might be lower.

The effort choice of the officer has been one of the main focuses of our analysis. The monitoring effort is but only one component of the enforcement process. One can consider other factors like investment in human capital, learning and information gathering on the part of the officer. Jointly, these factors determine how efficient the enforcement process is. Greater efficiency would imply fewer criminals going undetected and unpunished; and fewer innocent individuals being wrongly apprehended and bearing avoidable costs. The second aspect of efficiency has not been dealt in the paper as it would require a separate treatment on its own[14].

Moreover, given the static nature of the model many interesting issues like reputation building, optimal length of agent-supervisor relationships can not be addressed here. Incentive schemes of the types discussed in section IV also need further investigation

[14] Mishra (97) show how this could lead to multiple equilibria. Efficient officer and small criminal population on one hand and inefficient officer and large criminal population oon the other arise as equilibria in a model with the same parameter values.

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