CORRUPTION AND ADVERSE SELECTION

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Abstract: It is well known that in the presence of asymmetric information, adverse selection has detrimental effects on possible exchanges. We go a step further, and present a game-theoretic setup in which under such adverse selection effects there are uncertain benefits for bribing unknown players' types (e.g., individuals, committees, or companies). A policy maker may then want to design indirect anti-corruption policies based on triggering failures for bribery attempts. In our stylized framework, we get a complete unraveling of bribes. This result can be extended to more complex environments under fairly mild conditions on players' payoff functions.

Keywords: Corruption, bribe, adverse selection.

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[*]University of Manchester, School of Social Sciences, Oxford Rd, Manchester M13 9PL, UK. E-mail: leonidas@manchester.ac.uk.

[†]University of Miami, School of Business Administration, Coral Gables, FL 33124-6550, USA. E-mail: m.santos2@miami.edu

1. INTRODUCTION

Corruption continues to be a central issue in the governance of institutions (public, private or mixed) -a phenomenon that costs the European economy around 120 billion euros per year. The World Bank considers anti-corruption as the heart of the Sustainable Development Goals and achieving the targets set for Financing for Development.[1] The lack of a generalized theoretical foundation and ambiguous effects of many initiatives to combat corruption, keep this issue as a very big challenge for both scholars and practitioners. Big scandals that have been exposed, relating to corruption in governments suggest that corruption in the government sector is a pressing current issue, which entails dangers to social cohesion because officers' unwarranted behavior for personal gains undermines the trust of the public opinion to governance of institutions.

A common definition of corruption is the misuse of a position of trust or authority for personal gain rather than for the benefit of the party that bestowed that position (see, e.g., [25] and [18]). This misuse of authority usually involves breaking rules ([1]) or protocols. As empirical evidence suggests, a most prevalent type of corruption is when an authorized individual accepts a monetary payoff (a bribe) in exchange for taking a specified action that benefits the donor of the bribe. Recent years have seen a rise in empirical research which documents such evidence on corruption in various sectors and associates it to variables in the economic environment. Studies have investigated the amount of bribes paid to police ([19]), judges ([16]), politicians ([24]) and port and border post officials ([23]), or the value of political connection on firms' stock price (e.g., [8], [9]) and on loans ([12]).

A crucial aspect of bribery situations is the information that the parties involved have about one another. For instance, the bribe that one party is willing to accept and the other is willing to pay. Uncertainty about these parameters could be a major impediment for the conclusion of such illicit deals because of the unknown benefits of engaging into such practices. Indeed, in the literature it has been documented that uncertainty reduces corruption through its effect on the perception of the size of the bribe that would be acceptable by a corrupt individual ([13], [14]). Other authors have highlighted the effects of uncertainty about other aspects of a corrupt environment. For example, [22] argue that under incomplete information with respect to the intrinsic moral cost of one's potential corruption partner, bribe donors have an incentive to bid lower and bribe receivers bid higher,

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thus reducing the probability that a corrupt transaction occurs in a random matching. Finally, it has been argued that uncertainty reduces corruption through its effect on the perception of the probability of being detected ([5], [4]).

We suggest that information has a more profound impact on corruption through adverse selection effects, i.e., situations where exchanges do not materialize, though they are *a priori* possible. Adverse selection occurs when the interest in an exchange unravels because the value of an exchange is uncertain, leading to a reduction of the willingness to pay which in turn further reduces the expected value of an exchange and so on. We propose to follow this lead inspired by the lessons we have learned from such 'market failures'. Our main message here is this: as economists we have identified situations where exchange fails and these can be exploited to work for us against corruption. In this way indirect anti-corruption measures can be developed around the idea of 'managing' uncertainty in order to *trigger* severe adverse selection effects which will unravel bribery temptations. Such measures can be very effective because they operate as anti-corruption tools through self interest rather than through enforcement, i.e., they are 'soft power' policy tools. [2]

Some authors have used similar ideas in other contexts. For example, [11] and [15] use such failures to inhibit exchange in illicit markets. The former established a search-theoretical model in which low switching cost induces a moral hazard problem between sellers and buyers and obtained a unique equilibrium where a mass of sellers always chose quick one-time profit and offer zero quality drugs.[3] The latter builds a model of illicit trade of credit data in an online forum and the reputation system that sustains trade. He proposes to penetrate the market with a number of sellers who cheat and a number of buyers who slander the seller so that both the market clearing price and the quantity of data provided drop. However, both the quality of drugs and the authenticity of credit data are tangible trade objects. By contrast, what a bribe is paid for is often indefinite.

In pursuing this direction we must flesh out the idea of 'managing uncertainty'. By this we mean to use variables under the control of the authorities, which in the presence of uncertainty would affect the expected cost-benefit analysis of a bribe, in a way that generates adverse selection effects. The variables which are relevant in order to achieve this,

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[2]As discussed below, these measures can also be effective in related contexts of moral hazard.

[3]However, in [17] it is demonstrated how decentralized trade may ameliorate the average quality of the goods traded.

the way they are intertwined as well as the way to choose them is much of the purpose of the present paper. We develop the idea of triggering failures of bribery in a committee decision setting. This is a promising way to fight corruption especially when a decision of a project or policy, e.g., the location of the new city center, or the financial budget plan for the next year and so on, involves values which may be far beyond the pay scales of officers who are responsible for making such decisions. We show that the interest to bribe could completely unravel if the number of (types of) individuals are chosen appropriately so that the average contribution of each group of (types of) individuals becomes smaller than the bribe necessary to corrupt them. In line with the literature our model also incorporates some relevant variables such as salaries, monitoring, punishment etc, which influence the context under which adverse selection happens. Instead of doing comparative studies on the effectiveness of salary increases or monitoring, we combine these anti-corruption tools together with adverse selection. In what follows we present a simple model of a bribery game which illustrates our point.

2. Corruption Decisions

In standard models of corruption, officers are assumed to perform a certain action and may receive a bribe in order to switch to another action. In this way a bribe can be understood as a 'contract' where a monetary payoff is associated with a certain *distortion*. However, the actions performed by officers in absence of a bribe often vary. For instance not all officers perform their duties with the same diligence. At the same time, there may be several possible alternative actions that an officer can be bribed to take. Hence, when specifying an action to be taken in return for a monetary payoff, the *distortion* associated with the bribe may vary across individuals.

We build a model below which departs from the standard framework, by allowing officers to vary both with respect to the actions they perform when they are not corrupt and the actions they would be willing to take for a given bribe. In our model officers are faced with a range of alternative actions over which they can choose and may be bribed for. Individuals' heterogeneity in characteristics, such as ethics, risk preference, or education background, are captured by their most preferred action when they are 'honest', i.e., when they act under no influence or temptation. This can be understood as the diligence by which they perform their duty.

Another principle of our model is that the bribes offered are associated with an objective, a purpose, which must be accomplished by influencing the action of an individual who is at the authorized position. The key to our modeling is that the difference between individuals' most preferred action when they are honest and the action that they take when they accept a bribe is precisely what the bribe is paid for. In other words, bribes are exchanged for distortion of actions. Therefore, this difference determines the various amounts of bribe necessary for different individuals to participate into corruption and, at the same time, the different amount of bribe that the donor is willing to pay to different individuals.

By way of formalizing these ideas we view 'officers' summarized in a set I as confronted with a range of alternative choices corresponding to an interval $[x, z] \in \Re$. For example, the interval $[x, z]$ may correspond to alternative locations of a public project (e.g. a library) or a level of penalty to be imposed on an offender. Another interesting interpretation is to think of points in the interval as corresponding to randomizations between two choices x and z, representing the probability that an officer would adopt each of the choices. Each officer receives a monetary income $w > 0$ and chooses $y \in [x, z]$. The officer's preferences over the available choices are represented by a utility function $u_h(y, w)$, which is twice continuously differentiable, bounded and strictly concave in y. We assume that $D_y^2 u_h < 0$ and $D_w u_h > 0$.

For each $h \in I$, let $\overline{x}_h \in [x, z]$ denote the most preferred action, i.e., $u_h(\overline{x}_h, w) > u_h(y, w)$, $\forall y \in [x, z]$. For any given $y \neq \overline{x}_h$, one can compute the (additional) income necessary so that the officer is indifferent between $\overline{x}_h$ and y: $u_h(\overline{x}_h, w) = u_h(y, w + B_h(y))$. This income $B_h(y)$ represents the minimum bribe necessary to induce the officer to substitute $\overline{x}_h$ for y.[4] The function $B_h(y)$ is akin to the 'reservation bribe' in the literature.[5]

Corruption on behalf of the officer is understood as the acceptance of a monetary payoff $b \geq B_h(y)$ in order to substitute their preferred action $\overline{x}_h$ for y, i.e., for distorting their action by $|\overline{x}_h - y|$. Here lies the crucial point in our approach: the monetary payoff b, by inducing the action y has been effectively traded for the distortion $|\overline{x}_h - y|$, which *depends on the individual who accepts the bribe.* In other words a given monetary payoff 'buys' a

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[4]For simplicity we have not included the probability of detection and the corresponding punishment. This can be easily added by considering the expected utility weighting the utilities of receiving a bribe and of being punished, with the probability of detection. The reservation bribe $B_h(y)$ can be just as well defined in this case.

[5]Though we will not make use of it in this paper, generally this model allows for a much richer class of bribing 'contracts', so it can handle the possibility that the donor of a bribe can choose strategically both the monetary payoff and the action required.

variable distortion of the action when given to different officers, hence the 'value for money' to the donor depends on the individual who accepts the bribe. This latter observation has some very interesting implications regarding the emergence of corruption as we establish in the next section.

3. CORRUPTION AND ADVERSE SELECTION IN A STRATEGIC GAME

Let us proceed to embed the model we developed in the last section to a strategic context involving bribing. Consider two sets of players, a donor and a set of officers I. An officer $h \in I$ can be represented by the pair $(\overline{x}_h, B_h)$, as per the analysis above. We assume that the set I can be partitioned into types in a finite set $P = \{(\overline{x}_t, B_t) : t = 1, 2 \ldots, T\}$, i.e., that there is a mapping $c : I \to P$.

Let us consider the following situation. A choice of an element of $[x, z]$ will be decided collectively by a committee (say a 'jury') $H \subset I$ of officers, each of whom proposes an element in this interval and the committee decision is derived as the average of the proposed points, representing a consensus where proposals of members carry equal weight. We assume that the procedure is transparent so the proposals of each officer are publicly observable.

Suppose now that the decision of this committee affects the welfare of the donor, who prefers points in the direction of z. For simplicity we assume that $z > \overline{x}(c_h)$ for each $h \in I$, i.e., a point further away from the preferred element of each officer, so that in principle the donor would be interested in bribing each officer. Hence, the donor is interested in as many officers as possible proposing the element z, so that the decision (the average) is as close to z as possible. Accordingly the donor may offer to pay a total bribe bill $b \geq 0$ to those officers who agree to propose the action z in return.

Corruption is understood here as officers changing their proposal from their most preferred point $\overline{x}(c_h)$ to z, in exchange for a monetary payoff. For instance, in the example where the decision concerns the location of a public library, a member of the committee is corrupt if they receive a bribe in return for changing their proposal from their most preferred location to z. Similarly, in the example where the committee decision regards the penalty to an offender, a member of the committee is corrupt if they receive a bribe in return for changing their proposal from what they consider an appropriate penalty $(\overline{x}(c_h))$ to z.

The donor's strategy set can be taken to be $S_d = \Re_+$. Officers on the other hand receive a salary w and may either accept or reject the bribe offer. The decision to accept or reject a bribe is identified with the strategy set $\{0, 1\}$, where $t_h = 1$ ($t_h = 0$) corresponds to 'accept' ('reject'). Those who accept, i.e., $t_h = 1$ propose the point z and those who don't, i.e., $t_h = 0$, propose their most preferable point $\overline{x}(c_h)$. In return those officers who accept will split the bribe amongst themselves and those who reject simply receive their salary w. In other words, given a profile of strategies $t_h \in \{0, 1\}$ for each $h \in H$, each officer receives a kickback $\frac{t_h}{\sum_{h \in H} t_h} b$, where $0/0$ is defined to equal zero.

The key in this setup is that the donor offers a bribe bill to those who agree to switch their proposal to z, but is oblivious to what these officers would have proposed in absence of a bribe, i.e., how far the bribe changes their proposal. In other words since the bribe is shared equally between corrupt officers who are heterogenous, some of them receive a payoff which is higher than the minimum required in order to switch their proposal to z. At the same time the distortion of the proposals (and hence their value to the donor) varies among the corrupt officers, yet they receive the same bribe.

Let us consider a game that proceeds sequentially. In the first stage, the donor may offer a bribe bill. Then, the second stage contemplates a simultaneous move subgame among the officers in which each one may (or may not) accept to be bribed. A behavioral strategy for individuals is then a mapping $s_h : S_d \to \{0, 1\}$. Let S_h denote the collection of behavioral strategies of individual h and $S = \prod_{h \in H} S_h$. Once strategies are executed the payoffs to the donor and individuals respectively are as follows:

$$(1) \qquad \pi_d(b, t) = \frac{1}{\#H} \sum_{h \in H} [t_h z + (1 - t_h) \overline{x}(c_h)] - b$$

$$(2) \qquad \pi_h(b, t) = t_h u(c_h, w + \frac{1}{\sum_{h \in H} t_h} b, z) + (1 - t_h) u(c_h, w, \overline{x}_{c_h})$$

Notice that in expression (1) when $t_h = 1$ ($t_h = 0$) the corresponding officer has (not) signed up to the bribe and proposes the point z ($\overline{x}(c_h)$). The interpretation is that the payoff to the donor depends on the average of the proposals by all officers.[6] Correspondingly, in

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[6]For simplicity, we assumed that the donor's value of a unit distance is $V = 1$. This represents a normalization of monetary units in terms of V. In fact, one can identify the interval $[x, z]$ with $[0, 1]$ so that when $t_h = 1$ for all $h \in H$, then $\pi_d(b, \mathbf{1}_H) = V - b$.

expression (2) when $t_h = 1$ ($t_h = 0$) the corresponding individual has (not) signed up to the bribe and receives the 'corrupt' ('honest') payoff $u(c_h, w + \frac{1}{\sum_{h \in H} t_h} b, z)$ $(u(c_h, w, \overline{x}(c_h)))$.

DEFINITION 1. *An equilibrium is a collection of strategies* $(b, s) \in S_b \times S$, *which form a subgame perfect Nash equilibrium (SPNE) of the two-stage game with payoffs as defined above.*

Such an equilibrium is characterized by a set of individuals[7] $C = \{h \in H : s_h(b) = 1\}$. The corresponding payoffs to the donor and individuals are respectively:

$$\pi_d(b, s) = \frac{1}{\#H} \left[\#Cz + \sum_{h \in H \backslash C} \overline{x}(c_h) \right] - b \tag{3}$$

$$\pi_h(b, s) = u(c_h, w + \frac{1}{\#C} b, z), \ h \in C \tag{4}$$

$$\pi_h(b, s) = u(c_h, w, \overline{x}(c_h)), \ h \in H \setminus C \tag{5}$$

Equation (3) shows that the profit of the donor increases the more individuals take the action z instead of their fallback action $\overline{x}(c_h)$. Therefore, the donor's payoff is increasing when more officers accept the bribe and choose z.

We proceed to explore a few facts about SPNE in this game, which for expositional purposes we state as elementary lemmas.

PROPOSITION 1. *For any* $b \in S_b$ *there is* $\overline{s}(b) \in S$ *which is a Nash equilibrium in the second stage of the game.*

Proof: see the Appendix.

The proof of this proposition traces an intuitive way to identify an equilibrium in the second stage of the game, but this need not be unique. Indeed, it is possible that several different groups of individuals may corrupt for a proposed bribe b. An example may help to clarify this.

Example 1. Consider a set of individuals $\{1, 2, 3, 4\}$ *with reservation bribes corresponding to two types as follows:* $B(c_1, z) = 1$, $B(c_i, z) = 3$ *for* $i = 2, 3, 4$.

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[7]We assume that when $u(c_h, w + \frac{1}{\sum_{h \in H} t_h} b, z) = u(c_h, w, \overline{x}(c_h))$, then $s_h(b) = 1$.

-For $b \geq 12$ the whole group $C = \{1, 2, 3, 4\}$ being corrupt is the only Nash equilibrium in the second stage.

-For $9 \leq b < 12$ there are three Nash equilibria, where any three member group including individual 1 could conceivably be corrupt: $C_1 = \{1, 2, 3\}$, $C_2 = \{1, 2, 4\}$ and $C_3 = \{1, 3, 4\}$, where individuals receive a bribe $\frac{b}{3}$ each, which is at least equal to their respective reservation bribes.

-For $6 \leq b < 9$ there are three Nash equilibria, where any two member group including individual 1 could conceivably be corrupt: $C_1 = \{1, 2\}$, $C_2 = \{1, 3\}$ and $C_3 = \{1, 4\}$ with individuals receiving a bribe of $\frac{b}{2}$ each, which is at least equal to their respective reservation bribes.

-For $1 \leq b < 6$ the only Nash equilibrium is where individual 1 is corrupt: $C = \{1\}$.

-For $b < 1$ the only Nash equilibrium is where no individual is corrupt.

This example also demonstrates how unraveling happens as we go down the possible bribe values. Observe that the individual with the lowest reservation bribe is always included in every corrupt group. Agents with higher reservation bribes would drop out of any corrupt group as we lower the bribe payment.[8]

It should be noted that the benefit derived by the donor depends on which group would occur in the second stage of the game. It is this fact that affects the cost-benefit considerations of the donor. On the other hand, the exercise for anti-corruption authorities is to setup the membership of players in the game, in a way so that the group of individuals that the donor might find interesting to corrupt is minimized and ideally empty. In order to see how this may be possible, let us proceed to establish some facts about the equilibria of this game.

The following lemma establishes the fact that at an equilibrium the payoff to the donor should be at least as high as that they would receive without bribing. If one views the 'no bribe' payoff as the reservation payoff for the donor, this lemma establishes the corruption participation incentive constraint for the donor.

LEMMA 1. *(Individual rationality) At a SPNE the following must hold:*

$$(6) \qquad\qquad \pi_d(b, s(b)) \geq \frac{1}{\#H} \sum_{h \in H} \overline{x}(c_h)$$

Proof: see the Appendix.

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[8]One could extend the model and assign beliefs on the possible groups that can form a Nash equilibrium for each bribe bill. This would make expected payoffs symmetric for each player type. In the interest of simplicity, we do not pursue this argument here.

The next lemma establishes the corruption participation incentive constraint for the officers.

LEMMA 2. *(Corruption participation constraint) At a SPNE where $b > 0$ the following must hold:*

$$(7) \qquad \frac{1}{\#C}b \geq B(c_h, z), \ \forall h \in C$$

Proof: see the Appendix.

Finally the last lemma establishes that at equilibrium, since all corrupt officers receive the same monetary payoff some of them receive a higher payoff than the minimum required in order to propose the action desired by the donor.

LEMMA 3. *(Effect of type variety) Define $B_C = \max\{B(c_h, z) : h \in C\}$. At a SPNE where $b > 0$ the following must hold:*

$$(8) \qquad b = (\#C)B_C$$

Proof: see the Appendix.

The conclusions of the last three lemmas give rise to the following corollary.

COROLLARY 1. *At a SPNE the payoffs for the donor and individuals are respectively*

$$(9) \qquad \pi_d(b, s) = \frac{1}{\#H}\left[\#Cz + \sum_{h \in H \setminus C} \bar{x}(c_h)\right] - (\#C)B_C$$

$$(10) \qquad \pi_h(b, s) = \begin{cases} u(c_h, w + B_C, z), & h \in C \\ u(c_h, w, \bar{x}(c_h)), & h \in H \setminus C \end{cases}$$

From the view point of anti-corruption policy, the objective is to form a committee in a way that restricts corruption. The advantage of the policy maker relative to a potential donor of a bribe is that as a regular employer the policy maker may have a better knowledge of the individual's type whereas the latter is oblivious to it. In addition the authorities have the advantage of selecting the membership and population of the committee. Building on this premise we explain how the choice of a committee can be done in a way so that the desired restriction of corruption can be achieved by exploiting adverse selection effects. The idea is to select the individuals H who participate in the game, in a way that mimics the conditions of the 'market for lemons', in order to trigger the desired unraveling effects.

By renaming types if necessary we may sort the types in descending order as follows: $z - \bar{x}(1) > z - \bar{x}(2) > \ldots > z - \bar{x}(T)$. For each $A \subseteq T$ denote $\bar{x}(A) = \min\{\bar{x}(t) : t \in A\}$ and $B_A = \max\{B(t, z) : t \in A\}$[9] and associate the smallest natural number N_A so that

$$\frac{z - \bar{x}(A)}{B_A} < N_A$$

Finally, let us select a set of individuals $H \subseteq c^{-1}(T)$ such that $\#H \geq N = \max\{N_A : A \subseteq T\}$. The following proposition verifies that this procedure results in a set of individuals for whom bribery collapses.

PROPOSITION 2. *(Complete unraveling) The unique SPNE occurs for $b = 0$. Moreover, for all $h \in H$,*

$$(11) \qquad\qquad s_h(b) = \begin{cases} 0 & b = 0 \\ \bar{s}_h(b) & b > 0 \end{cases}$$

where equilibrium function $\bar{s}(b)$ is defined in the proof of lemma (1).

Proof: see the Appendix.

In some cases one might be interested in ensuring that certain (types of) members in a committee are immune to bribing. This could be the case if the planner was facing some constraints in forming a committee. The following proposition shows along the same lines that it is possible to form a committee in such a way that certain targeted types are insulated from being corrupt in any outcome of the game. Suppose that the planner is interested in making sure that individuals of certain types $T' \subset T$ in the committee are not bribed. Consider $H' \subseteq c^{-1}(T)$ where $\#H' \geq N = \max\{N_A : A \subseteq T'\}$. The following proposition can be proved along the same lines.

PROPOSITION 3. *(Partial unraveling) For any SPNE $(b, s) \in S_b \times S$ where $b > 0$, we have that $\{h \in H' : s_h(b) = 1\} \cap T' = \emptyset$, i.e., only individuals of types $T \setminus T'$ can be bribed at any equilibrium.*

4. DISCUSSION

The model considered above is an example of how adverse selection effects can be exploited to the advantage of anti-corruption authorities. Proposition (2) is akin to Akerlof's unraveling of the 'lemons market', albeit in a strategic framework. A key element in the above setting is that all the officers who choose to be corrupt share the bribe equally.

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[9]Note that the type corresponding to $\bar{x}(A)$ (the most 'valuable' type) need not be the same as the type corresponding to B_A (the type most 'expensive to corrupt').

This can be understood to reflect the classical scenario that the equal bribes amongst corrupt individuals represents the inability of the donor to distinguish across types of officers. Therefore, the donor signals a single monetary payoff to every individual, oblivious as to their actual type and hence the value of their service, i.e., how close or far their preferred proposal would be to the one desired by the donor. In other words, the officers whose most preferred proposal is close to the one required by the donor, obtain the same amount of bribe as the officers whose most preferred proposal is far away from it. At the same time some officers receive a monetary payoff which is higher than the minimum bribe required in order to induce them to choose the proposal required by the donor.

Another scenario consistent with an equal split of the bribe, is when the donor has no direct access to individual officers in a committee. In such a context all the donor can do is to signal a total bribe bill to be shared equally among all committee members willing to switch their proposals. Similarly as in the previous scenario the donor is *a priori* oblivious as to which group of committee members will sign up to the deal and consequently as to the exact benefit they will derive.

Either way donors have to form expectations about the possible benefit they will derive from a bribe. The upshot is that if the membership of the committee has been appropriately chosen in terms of types and population, the expected benefit from any bribe level does not outweigh the cost so any bribe attempt is deemed ultimately self-defeating. In short, the role of uncertainty in a committee decision setting can be exploited by the authorities to fine tune the situation so that the temptation to corruption collapses. From the policy makers' viewpoint the message of our analysis is that when a committee is formed to deal with an issue involving values which may be far beyond the pay scales of its members, then the numbers and types of members of the committee become important in avoiding corruption. Rotation of committee members is a measure that serves the purpose of creating uncertainty about the types of officers but the distribution of types and numbers in the membership of the committee is also very important in order to trigger adverse selection effects.

The heterogeneity which is responsible for the unraveling of bribing in the game presented in the previous section, originates from two sources. First, from the varying 'reservation bribes' of individuals, which reflect the different moral codes or other ethical inhibitions

of officers. This is in line with the existing literature. Second, from the varying preferred actions of officers in absence of bribing. This is a novelty proposed in this paper, which is based on the intuition that officers have some discretion over the actions that they take while performing their tasks in absence of any influence. For instance, more often than not, the definition of an official task (or the rules of conduct) is very general and so it allows for a range of actions, over which the officer has discretion and is expected to make a judgement. Even in cases where a task is precisely defined so there is no room for maneuvering over the actions to be taken, it could be argued that not all officers execute their task with the same diligence.

In the literature, officers are distinguished between corrupt or not and act the same inside these two groups. By contrast our model introduces differences among officers in both groups. On one hand, officers who are not corrupt do not necessarily have the same most preferred action. As already mentioned these differences determine the different contribution of officers to the donor when they choose to be corrupt. On the other hand, any point in the officer's range of actions could be targeted by the donor, i.e., the donor could strategically choose the action they require from corrupt officials. This is a possibility in our model, although we did not make use of it in this paper.

It would be useful to draw a distinction here from the problem of 'moral hazard', which is also associated with lack of information. This problem arises when the action of an officer is not observable so the donor cannot verify whether or not an officer carried out the action that they were bribed for. In other words whereas adverse selection refers to lack of information about the type of an officer (while the action is observable), moral hazard refers to lack of information about the actions of an officer (but the type is observable). In the game we developed in the last section we assumed that the proposals of committee members are observable, so we are clearly in a situation where uncertainty refers to the type of the officers which is reflected in the reservation bribe B_h and the most preferred point $\overline{x}_h$ of each officer. This allowed us to focus on the adverse selection effects of uncertainty, which is the point in this paper. Nevertheless, our setup can accommodate moral hazard as well under fairly mild assumptions on utility functions. Moral hazard may accentuate adverse selection effects but keeping the proposals of officers unobservable (for instance keeping the deliberations of a committee confidential) is often very hard and constrained

by accountability and transparency requirements.

It is noteworthy that the 'tuning' required in order to trigger adverse selection effects is related to variables which have been identified in the literature as relevant to anti-corruption policies, notably the wage rates[10] or the probability of detection and punishment.[11] In our model salaries and monitoring affect the reservation bribe of each type so they are related to our analysis. This observation suggests that adverse selection effects have to be considered in conjunction with these strategic tools. Indeed, officers salaries, monitoring, and punishments will depend on the importance of the project and the ability of the government to detect those briberies.

Finally, by way of comparison the particular example of the 'lemons market' obtains when: (a) $c^{-1}(t)$ is singleton for each $t \in T$. (b) The sorting of types with respect to $B(c, z)$ in descending order is the same as the sorting with respect to $z - \overline{x}(c)$. In this way for each $A \subseteq T$, $\frac{z - \overline{x}(A)}{B_A} = \frac{z - \overline{x}(\overline{t}_A)}{B_{\overline{t}_A}}$ for the 'top' type $\overline{t}_A \in A$. Therefore, one needs to consider only nested subsets $A(r) = T \cap \{r, r+1, \ldots, T\}$, where $r = 1, 2, \ldots, T$, i.e., each time excluding the 'top' type. Once N is chosen[12] so that $\frac{z - \overline{x}(\overline{t}_{A(r)})}{B_{\overline{t}_{A(r)}}} < N$ we have that in the relevant step of the proof of proposition (2)

$$\frac{1}{N} \sum_{t \in A(r)} (z - \overline{x}(t)) < z - \overline{x}(\overline{t}_{A(r)}) < (\#C) B_{\overline{t}_{A(r)}} = (\#C) B_{A(r)}$$

for each $r = 1, 2, \ldots, t$ and our proof applies.

5. CONCLUSIONS

Economics research has mainly focused on the development of methods to control corruption phenomena, which are based on suitable variables (such as wages, monitoring and penalties) that directly influence the incentives of individuals. However, anti-corruption measures can be devised by influencing the environment in which individuals operate and thus curb temptations to engage in corrupt practices in an indirect way. In particular, since such illicit transactions often require to evaluate uncertainties about the characteristics of the individuals involved, authorities could show some creativity by devising anti-corruption strategies which take advantage of the detrimental effects of adverse selection.

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[10]See [3], [2] and [6] who advocate salary increases, but also [26], [21] or [10] who cast doubts as to their effectiveness.

[11]See [20] who points out the drawbacks of such policies.

[12]In this case N refers to number of types.

In order to substantiate this view, we offered a stylized model of bribery of groups of individuals in a committee or jury, which is another departure from the literature. Indeed, the existing literature views bribing as a contractual situation between a donor and one individual who is potentially corrupt. By contrast we focus on situations where a bribe is a multi-agent contract between a donor and a group of individuals. Circumstances which correspond to our setup, i.e., where donors attempt to influence decision making by committees, are quite prevalent in reality and so worthwhile of some attention by the corruption literature. As we saw in this paper these situations involve consideration of multi-agent incentives, so they require some creative thinking because they are not well covered by the standard anti-corruption recipes. The present paper is by no means exhaustive but rather a step in pursuing this line of studying anti-corruption.

We considered that officers may act heterogeneously when they are not corrupt, which blurs the cost-benefit analysis of corrupting them. This leads naturally to the idea that the uncertainty about the benefit of corrupting alternative groups of (types of) officers can be 'managed' in order to serve as anti-corruption tool. As shown above, it may be possible to condition the situation in such a way so that the adverse selection effects take a severe form that completely unravels bribe attempts. We believe that other known market failures lend themselves to such ideas, so this is a line worthwhile pursuing. As economists we are called to find ways to sustain situations which are against the private interests of individuals (i.e., minimize exchanges which are mutually beneficial for the parties involved), which is the opposite of our usual task, but we are well placed to know what it takes to achieve this outcome.

6. Appendix

Proof of Proposition 1:

Let $\{1, 2, \ldots, \hat{T}\}$ index $c^{-1}(H)$ (the types of players included in H) in accenting order, i.e., $B(t, z) < B(t + 1, z)$ for $t = 1, 2, \ldots, \hat{T} - 1$.

We can partition now the set of players H into subsets $H_t = \{h \in H : B(c_h, z) = B(t, z)\}$, for $t = 1, 2, \ldots, \hat{T}$.

We distinguish the following cases:

Case I: For each $b < B(1, z)$

In this case consider the strategy profile $\overline{s}_h(b) = 0$, $\forall h \in H$. Clearly this profile constitutes a Nash equilibrium in the second stage as no player would have an interest to switch their strategy because $b < B(t, z)$, for $t = 1, 2, \ldots, \hat{T}$.

Case II: For each $b \geq \#H \cdot B(\hat{T}, z)$

In this case consider the strategy profile $\overline{s}_h(b) = 1$, $\forall h \in H$. Clearly this profile constitutes a Nash equilibrium in the second stage as no player would have an interest to switch their strategy because $\frac{b}{\#H} \geq B(t, z)$, for $t = 1, 2, \ldots, \hat{T}$.

Case III: For each $B(1, z) \leq b < \#H \cdot B(\hat{T}, z)$

In this case let t_b be the smallest index so that

$$\#\left(\bigcup_{r \leq t_b} H_r \right) B(t_b, z) > b$$

Note that the hypothesis of Case III ensures that such a t_b exists.

• If $\left(\#\left(\bigcup_{r \leq t_b - 1} H_r \right) + 1 \right) B(t_b, z) > b$ then take $C = \bigcup_{r \leq t_b - 1} \#H_r$. Observe that by the definition of t_b it must be

$$
\begin{aligned}
\#C \cdot B(t_b - 1, z) &= \#\left(\bigcup_{r \leq t_b - 1} H_r \right) B(t_b - 1, z) \\
&\leq b
\end{aligned}
$$

Define now the strategy profile

$$
\text{(12)} \qquad \overline{s}_h(b) = \begin{cases} 1 & h \in C \\ 0 & h \notin C \end{cases}
$$

This profile constitutes a Nash equilibrium in the second stage because

-For $h \in C$: $B(c_h, z) \leq B(t_b - 1, z) \leq \frac{b}{\#C}$

-For $h \notin C$: $B(c_h, z) \geq B(t_b, z) > \frac{b}{\#C+1}$

so no player has an interest to switch their strategy.

- If $\left(\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + 1 \right) B(t_b, z) \leq b$ then identify a subset $D \subset H_{t_b}$ as follows.

Consider the function $f(x) = \left(\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + x \right) B(t_b, z) - b$, where $0 \leq x \leq \# H_{t_b}$.

We have that $f(\cdot)$ is continuous and

$$
\begin{aligned}
f(0) \quad &= \quad \# \left(\bigcup_{r \leq t_b - 1} H_r \right) B(t_b, z) - b \\[2mm]
&< \quad \left(\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + 1 \right) B(t_b, z) - b \\[2mm]
&\leq \quad 0
\end{aligned}
$$

$$
\begin{aligned}
f(\# H_{t_b}) \quad &= \quad \left(\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + \# H_{t_b} \right) B(t_b, z) - b \\[2mm]
&= \quad \# \left(\bigcup_{r \leq t_b} H_r \right) B(t_b, z) - b \\[2mm]
&> \quad 0
\end{aligned}
$$

We conclude that there exists $x^\star \in [0, \# H_{t_b}]$ such that $f(x^\star) = 0$, i.e.,

$$
\left(\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + x^\star \right) B(t_b, z) = b
$$

Choose a $D \subset H_{t_b}$ where[13] $\# D = [x^\star]$ and define $C = \left(\bigcup_{r \leq t_b - 1} H_r \right) \cup D$.

Define now the strategy profile

(13)
$$
\bar{s}_h(b) = \left\{ \begin{array}{ll} 1 & h \in C \\ 0 & h \notin C \end{array} \right.
$$

This profile constitutes a Nash equilibrium in the second stage because

---

[13] We denote by $[x]$ the integer part of x.

$$-\text{For } h \in C : \quad B(c_h, z) \leq B(t_b, z)$$
$$= \frac{b}{\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + x^\star}$$
$$\leq \frac{b}{\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + \#D}$$
$$= \frac{b}{\#C}$$

$$-\text{For } h \notin C : \quad B(c_h, z) \geq B(t_b, z)$$
$$= \frac{b}{\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + x^\star}$$
$$> \frac{b}{\# \left(\bigcup_{r \leq t_b - 1} H_r \right) + \#D + 1}$$
$$= \frac{b}{\#C + 1}$$

so no player has an interest to switch their strategy.

In conclusion, given any $b > 0$ we can construct for each case a Nash equilibrium profile of strategies, which concludes our proof $\square$

Proof of Lemma 1:

This follows from the fact that $0 \in S_b$ and the strategy $s \in S$ where $s_h(0) = 0$, $\forall h \in H$ is a Nash equilibrium in the second stage game $\square$

Proof of Lemma 2:

This is immediate from the definition of $B(c_h, z)$. By definition of the set C we have that $\forall h \in C$, $s_h(b) = 1$, so it must be

$$u(c_h, w + \frac{1}{\#C} b, z) \geq u(c_h, w, x) \equiv u(c_h, w + B(c_h, z), z)$$

It follows that $\frac{1}{\#C} b \geq B(c_h, z)$ $\square$

Proof of Lemma 3:

By lemma (2) we have $b \geq (\#C) B_C$. Suppose that $b > (\#C) B_C$.

Then by choosing $(\#C)B_C \le b' < b$, we would still have $B(c_h, z) \le B_C \le \frac{b'}{(\#C)}$ for $h \in C$.
Also, $\frac{b'}{(\#C+1)} < \frac{b}{(\#C+1)} < B(c_h, z)$ for $h \notin C$. Therefore $\{h \in H : s_h(b') = 1\} = C$.
However, in this case $\pi_d(b', s) > \pi_d(b, s)$, contradicting the SPNE $\qquad\square$

Proof of Proposition 2:

Let $(b, s) \in S_b \times S$ be a SPNE where $b > 0$ and denote $C = \{h \in H : s_h(b) = 1\}$. By
lemma (3) it must be $b = (\#C)B_C$. Since

$$\frac{\frac{1}{\#C}\sum_{h \in C}(z - \overline{x}(c_h))}{B_C} = \frac{\frac{1}{\#C}\sum_{t \in c^{-1}(C)}\#\{h \in C : c_h = t\}(z - \overline{x}(t))}{B_C}$$

$$< \frac{z - \overline{x}(C)}{B_C}$$

$$(14) \qquad\qquad < N$$

we have that

$$\frac{1}{N}\sum_{h \in C}(z - \overline{x}(c_h)) < (\#C)B_C$$

It follows that

$$\frac{1}{N}\sum_{h \in H \setminus C}\overline{x}(c_h) + \frac{1}{N}\sum_{h \in C}(z - \overline{x}(c_h)) < (\#C)B_C + \frac{1}{N}\sum_{h \in H \setminus C}\overline{x}(c_h)$$

This inequality can be rearranged as

$$\frac{1}{N}\sum_{h \in H \setminus C}\overline{x}(c_h) + \frac{1}{N}\sum_{h \in C}z - (\#C)B_C < \frac{1}{N}\sum_{h \in H \setminus C}\overline{x}(c_h) + \frac{1}{N}\sum_{h \in C}\overline{x}(c_h)$$

Hence, we conclude that

$$\frac{1}{N}\left[(\#C)z + \sum_{h \in H \setminus C}\overline{x}(c_h)\right] - (\#C)B_C < \frac{1}{N}\sum_{h \in H}\overline{x}(c_h)$$

By corollary (1) the left hand side is the equilibrium payoff for the donor, Therefore, the
above inequality implies that

$\pi_d(b, s) < \frac{1}{N}\sum_{h \in H}\overline{x}(c_h)$, which contradicts lemma (1) $\qquad\square$

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