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How corruptible are you? Bribery under uncertainty[☆]

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ABSTRACT

We model corruption in a society as a result of bargaining for bribes between private citizens and public officials. We investigate the role that incomplete information with respect to the intrinsic moral cost of one's potential corruption partner plays out in his or her propensity to engage in bribery, and, consequently, the equilibrium level of corruption in the society. We assume that the cost of engaging in corruption is subject to strategic complementarities, which may lead to multiple corruption equilibria. We find that corruption is lowest when potential bribers and potential bribees are uncertain regarding each other's "corruptibility" and have asymmetric bargaining powers. Our *uncertainty result* provides theoretical support in favor of anti-corruption strategies, such as staff rotation in public offices, aimed at decreasing the social closeness of bribers and bribees. Our *bargaining power result* suggests that, under uncertainty, monopolistic public good provision has the same corruption-reducing effect as competitive public good provision.

1. Introduction

Corruption hinders development. Empirical studies have identified the adverse effects that corruption has on investment and growth (see Mauro, 1995; Keefer and Knack, 1995), on inequality and poverty (see Gupta et al., 1998), and on the allocation of public spending on education, health and public infrastructure (see Tanzi and Davoodi, 1997). Awareness of the dramatic effects that corruption has on a country's development has also motivated theoretical and empirical investigations into its causes and endeavors to identify which policy measures might be successful in its mitigation.

In this paper we focus on the most common form of corruption, bribery, which is defined as an illegal provision of public services or goods in exchange for private (typically monetary) compensations. We are especially interested in collusive bribery, i.e., transactions which benefit both the briber and the bribee, and are, therefore, difficult to fight, because neither party has an incentive to break the corrupt agreement.

We ask whether inducing uncertainty with respect to the "corruptibility" of one's potential corruption partner may serve as an effective anti-corruption tool. Recent empirical micro-evidence motivates our theoretical investigation. In particular, the studies by Svensson (2003), Reinikka and Svensson (2003), and Hunt (2006) suggest that bribery is often the result of bargaining between public officials and clients – either firms or citizens. This explains within-country and within-sector variations in both the frequency of corrupt transactions and the size of the bribes paid in exchange for a given public good or

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service. A few empirical studies also suggest that uncertainty has a significant impact on individuals' propensity to engage in bribery. For instance, Herrera and Rodriguez (2003) use firm-level data from the World Bank's Business Environment Surveys and show that uncertainty with respect to the size of the bribe induces firms to abstain from corruption. Lambsdorff (2007) reaches similar conclusions using cross-country data: uncertainty with respect to the size of the bribe is negatively correlated with a country's level of corruption.

Following these recent empirical studies, we model bribery as bargaining between private citizens and public officials within a society. We derive the resulting overall level of corruption in the society as the proportion of citizen–official pairs who engage in bribery, and we study how equilibrium levels of corruption depend on the degree of individuals' uncertainty with respect to others' corruptibility. We use the term "corruptibility" to refer to individuals' intrinsic moral costs associated with corruption. We assume that it is these moral costs, together with the economic costs and benefits associated with corruption, that determine citizens' and officials' highest and lowest, respectively, acceptable bribes. We are therefore interested in investigating how incomplete information with respect to the moral costs of individuals' potential corruption partners affects their willingness to engage in bribery, and, ultimately, the level of corruption in a society—or in the relevant sector of a society.

We model corruption as a frequency-dependent phenomenon subject to strategic complementarities, resulting from multiple bilateral bargaining transactions between private citizens and public officials whose total costs associated with corruption are determined endogenously by the proportion of successful corrupt transactions in the society. We compare the equilibrium levels of corruption in the society under complete information and incomplete information with respect to corruption costs, and for different configurations of bargaining power within citizen–official pairs.[1]

In line with the existing empirical literature, our theoretical findings suggest that when agents are uncertain about the intrinsic corruptibility of their potential corruption partner, they are less likely to engage in corruption. As for the resulting levels of corruption in the society, we find that, as expected, the presence of strategic complementarities in corruption decision-making may generate multiple corruption equilibria. However, individuals' uncertainty with respect to their partners' moral costs leads to a lower probability that society ends up in a systemic "corruption trap." The corruption-reducing role of incomplete information is amplified when bribers and bribees have asymmetric bargaining powers over the size of the bribe.

Our *uncertainty result* provides theoretical support to anti-corruption strategies, such as staff rotation in public offices, which reduce the chances that citizens and officials know about each other's corruptibility. Our *bargaining power result* has less obvious policy implications. The relative strength of the bargaining powers of citizens and officials in the society (or in a sector of society) is the result of how the corruption market is organized in the society or the specific sector under investigation. We can imagine that officials have full bargaining power in a society, or a sector, where they are monopolists in the delivery of the specific service or good being demanded by the citizens. On the other hand, we can imagine that citizens have full bargaining power when they are able to choose – or switch – between different officials (or offices) for the provision of a given service or good, i.e., there is competition between public providers of the same good or service. Therefore, our results suggest that, *under uncertainty*, corruption is lowest either when there is a monopolistic provision of the good or service under consideration – think of only one office being eligible to provide the good to a given citizen[2] – or when there is competition among different public providers of that good, or different offices. Note that the assumption of uncertainty with respect to the corruptibility of one's potential corruption partner is crucial for this result to hold. If citizens and officials know each other's moral costs, or corruptibility, their relative bargaining power plays no role in the likelihood that a corrupt agreement occurs; it only plays a role in determining the final size of the bribe. Finally, note that although our results under uncertainty suggest that a situation where the briber has full bargaining power is equivalent – in terms of the resulting overall level of corruption – to a situation where the bribee has full bargaining power, the size of the bribe paid when a corrupt agreement takes place is lower in the former case.

This paper is organized as follows. Section 2 presents a brief review of the related literature. Section 3 describes our bargaining model of bribery and Section 4 derives the corruption equilibria under complete information. Section 5 introduces incomplete information with respect to one's opponent's moral cost and compares the results obtained under complete and incomplete information. Section 6 concludes with a summary of the main findings and policy implications.

2. Related literature

Traditionally, theoretical studies of bribery have employed principal–agent–client models to investigate ways for a benevolent principal to monitor the moral hazard of public officials (Becker and Stigler, 1974; Rose-Ackerman, 1978; Klitgaard, 1988). In this paper, we disregard the assumption of an "honest" principal implied by these models and, instead, we model corruption as a frequency-dependent phenomenon subject to strategic complementarities. The existing literature has identified many different reasons why one's decision to engage in or abstain from corruption might depend on the level of corruption in the society. First, in a corrupt society the costs of searching for and finding a potential partner in corruption are

[1] Section 2 presents a brief overview of the existing models of corruption with strategic complementarities. See also Bardhan (1997) and Aidt (2003) for a review of recent theories of corruption.

[2] There could actually be many available offices, but each citizen is obliged to use a specific office, for instance on the basis of location of residency.

lower (Andvig and Moene, 1990). Second, given fixed governmental resources, the probability of being audited and detected is lower (Lui, 1986). Third, the probability of being fined once detected is also lower, since punishment could be avoided through bribery (Cadot, 1987). In the present paper, we do not explicitly distinguish between these and other possible reasons for strategic complementarities in corrupt transactions, and employ a reduced-form model of the extrinsic cost of acting corruptly that depends directly on the proportion of corrupt people in the society. Therefore, we assume that individuals' total cost associated with corruption consists of such endogenously determined extrinsic cost of corruption, which is the same for every individual, and their intrinsic moral costs,[3] which may or may not be known to others.

Contrary to our model, the existing theories of corruption with strategic complementarities typically maintain the assumption of complete information among the parties. On the other hand, principal–agent–client models of corruption point at incomplete information as an important cause of corruption; however, they only refer to incomplete information on the part of the principal with respect to the actions and/or morality of the agent (Klitgaard, 1988).

As a building block of our model of corrupt transactions under incomplete information, we use the k-double auction model of Chatterjee and Samuelson (1983). However, while Chatterjee and Samuelson (1983) investigated a simple bilateral bargaining transaction between a potential buyer and a potential seller, we consider a more complex setting involving multiple bilateral transactions between private citizens (i.e. potential bribers or "buyers" of the corrupt service) and public officials (i.e. potential bribees or "sellers"). Moreover, following the frequency-dependent corruption literature, we assume that citizens' and officials' extrinsic costs associated with corruption are determined endogenously by the total proportion of successful corrupt transactions. It is this proportion, i.e. the resulting level of corruption in the society, that we are interested in, both in a complete information and an incomplete information scenarios. Therefore, importantly, the general results of Myerson and Satterthwaite (1983) on the inefficiency of bilateral bargaining under incomplete information are not applicable to our setting.

3. A bargaining model of bribery

We model a society in which private citizens and public officials interact for the provision of a public service, and have the option to engage in bribery with their transaction partner. We assume that citizens and officials are randomly matched. We first look at the decision making process of a typical citizen and a typical official involved in a potentially corrupt transaction and then turn to the resulting equilibrium level of corruption in the society.

In our setting, citizens and officials have independent private valuations of the corrupt transaction, based on the costs and benefits generated by the exchange. The total cost generated by corruption comprises both the intrinsic moral cost that an individual may suffer from acting corruptly and the expected cost of receiving formal and/or informal sanctions. We assume that the probability that a corrupt individual is caught and sanctioned is subject to strategic complementarities: the more people in the society are corrupt the less likely it is that a corrupt individual is detected and receives formal and/or informal sanctions. Therefore, we define the total cost of corruption suffered by an agent i, c_i, as:

$$c_i(x) = a_i + r(1 - x).$$

Here, a_i represents an intrinsic moral cost, which we assume is uniformly distributed over the interval $[0, \bar{a}]$; x is the proportion of corrupt people in the population, i.e., the proportion of citizen–official pairs who engaged in corruption, with $0 \leq x \leq 1$. Thus, $(1 - x)$ represents the proportion of "honest" citizen–official pairs in the population, and $r(1 - x)$ is the monetary cost associated with expected formal and/or informal punishment.[4] Expected punishment enters the cost function through the endogenous variable x, due to our assumption of strategic complementarities.[5] The cost c_i is defined so that corruption is costly for any individual unless he or she is intrinsically corrupt, i.e. $a_i = 0$, and there are no honest citizens and officials in the whole society, i.e. $x = 1$, which means that any corrupt act in such society would go undetected and unpunished.

The citizen's private valuation of the corrupt transaction, v_b (where subscript b stands for "buyer" of the corrupt service), is equal to the monetary benefit she would gain from the illicit service, $y \geq r$, minus the cost generated by corruption, c_b:

$$v_b = y - a_b - r(1 - x). \tag{1}$$

[3] By not allowing intrinsic cost associated with corruption to be in itself dependent on the level of corruption, we assume that they are intrinsic costs that individuals may suffer when engaging in corruption no matter how corrupt society is. Although, as shown by Hauk and Saez Marti (2002), the level of corruption in the society may also affect the inter-generational transmission of anti-corruption values, given the static nature of our model, we can take the individuals' intrinsic cost associated with corruption as given. More generally, it is assumed in our model that an individual's cost of being corrupt has two components, one of which is common across all individuals and depends on the corruption level in the society as a whole, and the other (termed "intrinsic moral cost" here) is heterogeneous across individuals and independent of corruption.

[4] Here, $r > 0$ is a constant transformation factor that allows summing up the two components of the total cost. It will be later set to 1 without loss of generality.

[5] As stated in Section 2, in this way the total cost associated with corruption has two components: an extrinsic component, which is the same for every individual and depends negatively on the proportion of corrupt people in the society, x, and an intrinsic component, which does not depend on x and may or may not be known to others.

It is assumed that $y \geq r$ to ensure that there are citizens for whom the corrupt service has a positive net benefit at all levels of corruption $x \in [0, 1]$. Note that v_b also represents the citizen's "reservation bribe" for the corrupt service, i.e., the highest bribe that she is willing to pay in exchange for the illicit service.

The official's private valuation, which also corresponds to his "reservation bribe," v_s (where subscript s stands for "seller" of the corrupt service), is equal to the cost he would have to sustain in order to provide a corrupt service (for example the administrative cost and the cost of hiding or falsifying documents), $q \geq 0$, plus the total cost generated by corruption,[6] c_s:

$$v_s = q + a_s + r(1 - x). \tag{2}$$

Note that the cost of providing the corrupt service, q, is lower the higher the discretionary power of the official, and the more vague or complex the rules and the regulations associated with the service.[7]

A corrupt agreement involves the payment of a bribe by the private citizen and the provision of an illicit service by the public official with whom she is matched; think, for instance, of the exchange of a bribe for the cancellation of a fine or the provision of a license undercutting some of the legal requirements.[8]

The citizen and the official simultaneously decide the amount of the bribe, if any, that they would be willing respectively to pay and take in order for the corrupt transaction to occur. These bribes correspond to sealed bids in a traditional double auction with only one buyer (the citizen) and one seller (the official). A corrupt transaction occurs if and only if the bribe "submitted" by the private citizen, b_b, is higher than or equal to the bribe "submitted" by the public official, b_s. If the conditions for a transaction to take place are met, the citizen and the public official negotiate the final amount of the bribe in the range of mutually agreeable bribes. The final bribe is equal to $b = kb_b + (1 - k)b_s$, with $0 \leq k \leq 1$ (see Chatterjee and Samuelson, 1983). The parameter k represents the relative bargaining power of the private citizen. When $k = 1$ we can think of a situation where the private citizen "submits" a bribe equal to b_b, which the public official will either accept or reject without the possibility to negotiate. In other words, the case of $k = 1$ corresponds to a situation where the citizen initiates the corrupt transaction by offering an "ultimatum bribe" to the official. In this case, the official's bid only affects the probability that corruption will occur, but not the final size of the bribe. The opposite holds for $k = 0$, which corresponds to a situation where the official initiates the corrupt transaction by demanding an "ultimatum bribe" from the citizen.

The overall level of corruption in the society corresponds to the proportion of citizen–official pairs that agree on a corrupt transaction, i.e., those for whom $b_b \geq b_s$.

In the next section, we investigate the equilibrium levels of corruption in the society when citizens and officials have complete information with respect to each other's corruptibility, i.e., their intrinsic moral cost. Subsequently, in Section 5, we introduce incomplete information in the corruptibility of one's potential corruption partner.

4. Equilibrium levels of corruption in the society under complete information

Consider a society where randomly matched citizens and officials can perfectly observe their opponent's private valuation of a corrupt transaction. The bribery game of complete information proceeds as follows. Nature moves first, by randomly assigning individual moral costs, a_i, to all citizens and public officials, and randomly matching them in citizen–official pairs. Then, within each pair the individual moral costs a_b and a_s are revealed to both parties, and bargaining takes place. The gain that corruption generates to a citizen, y, and the cost to provide the corrupt service, q, are common knowledge and the same for all citizen–official pairs. The level of corruption in the society, x, is common knowledge and determined endogenously in the equilibrium defined below.[9]

It is notationally convenient to introduce $d = (y - q)/2$, the per capita net gain from a corrupt transaction.[10] Also, from this point on, without loss of generality, we set $r = 1$, i.e., we render all monetary quantities dimensionless and measured in the units of r. Under complete information, for a given citizen and official characterized by intrinsic cost parameters (a_b, a_s), a corrupt transaction occurs provided that $v_b \geq v_s$, or, from Eqs. (1) to (2), provided that $(a_b + a_s)/2 \leq d - (1 - x)$.

Let $F(\cdot)$ denote the cumulative density function (cdf) of random variable $(a_b + a_s)/2$. Given that a_b and a_s are independent and uniformly distributed on $[0, \bar{a}]$, $F(\cdot)$ represents a symmetric triangular distribution with support $[0, \bar{a}]$.

[6] The bribe is simply a transfer of money from the citizen to the official.

[7] Modeling individuals' private valuations as the difference (or the sum) between the monetary benefit and the total cost, which includes the uniformly distributed intrinsic cost, allows us to benefit from the computational advantages of the uniform distribution, and provide a straightforward (and also visual) comparison of corruption equilibria under complete and incomplete information. Some of the results can be carried through in a more general model with arbitrarily distributed individuals' valuations conditional on the corruption level x. We summarize the results from this more general setting in footnotes 13, 14 and 19. The derivation of the more general model is available from the authors.

[8] We exclude the possibility that the official could take the bribe and not provide the corrupt service.

[9] As stated in the introduction, contrary to Chatterjee and Samuelson (1983) and, more generally, Myerson and Satterthwaite (1983), the bribery game of complete information so defined is not a game played by one citizen and one official, but a multi-person game played by all citizen–official pairs in the society. The equilibrium of this game is the equilibrium level of corruption in the society resulting from all citizen–official interactions.

[10] This is the net gain that citizen and official would enjoy if they decided to equally split the net returns of the corrupt transaction. However, this does not necessarily happen in the citizen–official game, since the net corruption earnings of citizen and official depend on their relative bargaining power and the submitted bribes.

Definition 1. A corruption level, x^*, constitutes an equilibrium in the bribery game of complete information if the following conditions hold:

(i) For a given pair of a citizen and a public official, (a_b, a_s), a corrupt transaction occurs if and only if

$$\frac{a_b + a_s}{2} \leq d - 1 + x^*. \tag{3}$$

(ii) The corruption level x^* is equal to the probability that a randomly drawn pair of a citizen and a public official engages in a corrupt transaction,

$$x^* = F(d - 1 + x^*). \tag{4}$$

Condition (i) can be interpreted as follows: those citizen–official pairs that have total per capita moral costs lower than the per capita gains from corruption agree on a corrupt transaction. This is more likely to happen the larger the monetary benefit that the private citizen receives from the transaction, the lower the administrative cost the public official needs to sustain to provide the corrupt service (higher discretionary power) and the higher the proportion of corrupt people in the population, as the probability of being detected and formally or informally punished is relatively low.

Condition (ii) determines the equilibrium corruption level in the society, x^*.

In this formulation, within each citizen–official game, the corruption level x can be formally treated as a belief held by both parties with respect to the existing level of corruption in the society. Given the belief and the citizen's and the official's reservation bribes, v_b and v_s, the citizen and the official simultaneously submit their bids, $b_b \leq v_b$ and $b_s \geq v_s$. Any bribe between v_s and v_b can be sustained as an equilibrium in the two-player game of complete information.[11] Condition (ii) states that the equilibrium level of corruption in the society is such that the belief about corruption held by any citizen–official pair is consistent with the actual probability that a randomly drawn citizen–official pair engages in a corrupt transaction, i.e., it is equal to the true level of corruption in the society.[12]

As seen from Eq. (4), the equilibrium level of corruption depends on the distribution of the intrinsic moral costs a_i in the population of citizens and officials. For our choice of the distribution for a_i (uniform on $[0, \bar{a}]$), the equilibrium level of corruption depends on two parameters: the highest intrinsic moral cost in the society, $\bar{a}$, and the net per capita benefit of corruption, d. The following types of equilibria may arise.

Systemic corruption, i.e., the situation where everybody is corrupt, $x = 1$, can be sustained as an equilibrium if $d \geq \bar{a}$. That is, if even the moral costs of the "most intrinsically honest" citizen–official pair in the society are not large enough to oppose the incentives associated with corruption when the whole population is behaving corruptly. Thus, we are more likely to observe $x = 1$ in equilibrium when the net benefit generated by corruption, d, is relatively large, i.e. when the administrative cost to provide the service is relatively small (the discretionary power of the public official is relatively high) and/or the benefit to the private citizen is relatively large. Society is also more likely to be trapped in a systemic corruption equilibrium when the highest possible moral cost generated by corruption in the society is relatively small.[13]

Honesty, i.e., the situation where everybody is honest, $x = 0$, can be sustained as an equilibrium if $d \leq 1$, that is when the administrative cost to provide the service is relatively large (the discretionary power on the public official is relatively small) and/or the benefit to the private citizen is relatively small.[14]

Interior equilibria, with $x \in (0, 1)$, can also be observed.

Due to the complementarity (or network) property of corruption there is a possibility for multiple equilibria in the bribery game of complete information. The number and location of equilibria depends on parameters $\bar{a}$ and d. Fig. 1 illustrates graphically the solutions of Eq. (4) for $\bar{a} = 1$ and different values of d. The solutions are the points of intersection of the curve $F(d - 1 + x)$ and the 45-degree line.

As seen from Fig. 1, for a relatively small d the only equilibrium is honesty, $x^* = 0$. As d increases, the curve $F(d - 1 + x)$ shifts to the left and reaches the point where two additional equilibria with $x > 0$ arise. For $d = 1$, there are three equilibria: honesty, systemic corruption, and the interior equilibrium with $x^* = 0.5$. As d increases further, the two equilibria with $x < 1$ disappear and the only remaining equilibrium is the one with systemic corruption, $x^* = 1$.[15] In the presence of multiple equilibria, the distance between the interior corruption equilibrium and the high (or systemic) corruption equilibrium determines how

[11] The final bribe will depend on the citizen's and official's bids and their relative bargaining powers. Here we worry about the existence of corruption only (and not about the size of the bribe), therefore we can restrict attention to the condition for corruption to take place, $v_b \geq v_s$, which gives condition (i) of Definition 1.

[12] Our definition of equilibrium in the bribery game is similar to the definition of competitive equilibrium in a market. There, too, buyers and sellers treat the equilibrium price as given within each transaction, while the price is determined globally by market clearing. The "supply" of, and "demand" for corruption in our "market" both increase in the "price level," x, i.e., corruption has the properties of a network good. One of the consequences is the possibility for multiple equilibria.

[13] In a more general setting, where the citizen's and the official's valuations, $v_b(x)$ and $v_s(x)$, are distributed, conditional on x, on the intervals $[\underline{v}_b(x), \bar{v}_b(x)]$ and $[\underline{v}_s(x), \bar{v}_s(x)]$ – with $\bar{v}_b(x) > \underline{v}_s(x)$ at least for some x – systemic corruption can be sustained as an equilibrium ($x^* = 1$) if and only if $\bar{v}_s(1) \leq \underline{v}_b(1)$.

[14] In the more general setting, honesty can be sustained as an equilibrium ($x^* = 0$) if and only if $\underline{v}_s(0) \geq \bar{v}_b(0)$.

[15] We note that, qualitatively, the same structure of equilibria will be observed for any bell-shaped distribution $F(\cdot)$. The results for the case of complete information are, therefore, generalizable to a wide class of distributions of moral costs a_i. We maintain the assumption of a_i being uniform, however, to be able to obtain closed-form results in the incomplete information case, Section 5.

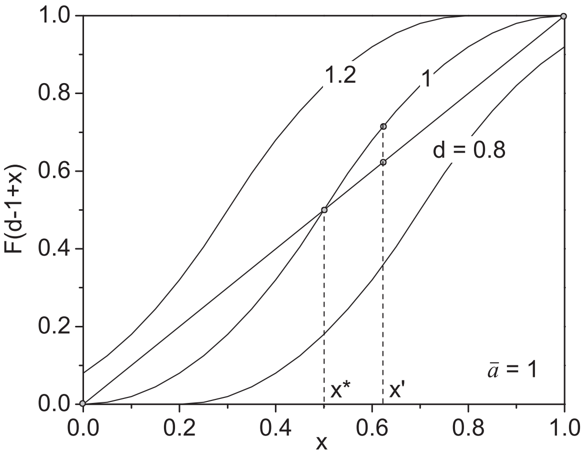

Fig. 1. An illustration of equilibria for $\bar{a} = 1$ and different values of d in the complete information case.

difficult it would be to "jump" from a high corruption to a low corruption (or a honesty) equilibrium. The closer the interior equilibrium is to the high corruption equilibrium, the easier or less costly it would be for society to escape from the high corruption trap.

Fig. 1 also allows us to discuss the stability of all possible equilibria. It is straightforward to see that in the presence of multiple equilibria – say, $x^* = 0$, 1, and 0.5, as depicted in Fig. 1 for $d = 1$ – both the honesty and the systemic corruption equilibria are stable while the interior equilibrium is *unstable*, in the following sense: if citizen–official pairs believe that the level of corruption is greater than x^* (say, x') then the probability that citizen and official agree on corruption – shown on the $F(d-1+x)$ curve – is larger than the actual proportion of corrupt people in the population, measured on the 45-degree line. As a result, corruption will increase, and this process will converge to the systemic corruption equilibrium. Similarly, if citizen–official pairs believe that the level of corruption is below x^*, such wrong belief will push the probability that citizen and official agree on corruption below the actual level of corruption and, consequently, the level of corruption in the society will decrease, with the process converging to the honesty equilibrium.

The equilibrium level of corruption x^* defined by Eq. (4) is, generally, a correspondence from the space of parameters $(\bar{a}, d)$ to interval [0, 1]. Fig. 2 shows the configurations of equilibria for selected values of $\bar{a}$ and d (the upper panels) and the complete equilibrium correspondence x^* as a function of d for different values of $\bar{a}$ (the lower panels). Consider the case of a relatively small $\bar{a}$, for example, $\bar{a} = 1$, shown in the left panels of Fig. 2. When d is small, there is a unique equilibrium with full honesty, $x^* = 0$. As d increases and crosses into the region between the two vertical dashed lines, in the bottom panel, multiple equilibria arise. First, the full honesty equilibrium co-exists with two interior equilibria with relatively high levels of corruption. Gradually, as d increases further, one of those equilibria approaches systemic corruption while the other moves down. Remember that this means that it becomes more and more difficult for the society to escape from the systemic corruption equilibrium, once/if this equilibrium is reached. Next, the full honesty equilibrium disappears and is replaced by two low-corruption interior equilibria. Finally, when d leaves the region between the vertical dashed lines, systemic corruption becomes the only equilibrium. In the multiple equilibria region, the equilibrium corresponding to the downward-sloping segment of the correspondence is unstable, whereas the other two equilibria are stable. The vertical dashed lines correspond to the *bifurcation* values of parameter d at which the structure and the number of equilibria changes.

For a larger $\bar{a}$, for example, $\bar{a} = 1.5$, in the middle panels in Fig. 2, the equilibrium correspondence as a whole shifts to the right and the multiple equilibria region becomes more narrow. Qualitatively, the transition between different equilibrium configurations is the same as for $\bar{a} = 1$, with two bifurcation points. However, for $\bar{a} = 1.5$ we observe the possibility of three co-existing interior equilibria, the middle one being unstable.

Finally, for a sufficiently large $\bar{a}$, for example, $\bar{a} = 2$, in the right panels in Fig. 2, the multiple equilibria region disappears, and the unique equilibrium level of corruption increases monotonically with d.

4.1. Discussion

We have shown that the values of $d = (y - q)/2$, and $\bar{a}$, as well as the initial level of corruption, determine the corruption equilibrium to which society will converge. We can now investigate which policies could be effective in reducing corruption under complete information.

Our setting suggests that an increase in q would reduce the likelihood for a corrupt agreement to take place within any citizen–official pair, by reducing the net per capita gains of corruption. Therefore, an effective anti-corruption measure would be to increase the administrative cost of providing the corrupt service, for example by lowering the discretionary power of the public officer and increasing transparency in the rules and the regulations associated with public service delivery.

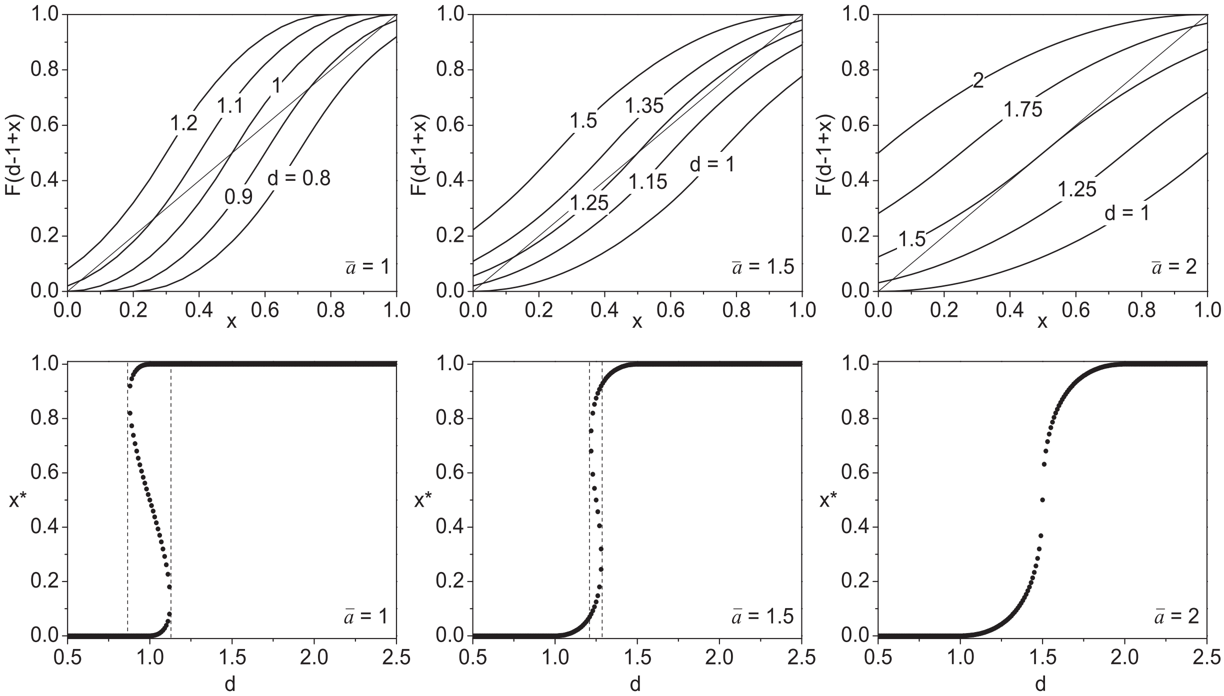

Fig. 2. The configurations of equilibria for $\bar{a} = 1$, 1.5, and 2 in the complete information case. The upper row of panels shows graphically the solutions to Eq. (4) for different values of *d*. The lower row of panels shows the complete set of solutions (the equilibrium correspondence) for *d* between 0.5 and 2.5. The vertical dashed lines show the ranges of multiple equilibria.

A comparison between the left, middle and right panels of Fig. 2 suggests that an alternative or complementary way of escaping a high corruption trap would be to modify the distribution of the moral cost associated with corruption in the society, such that for any given level of d and x, the monetary incentives of fewer briber–bribee pairs will be high enough to compensate for the higher intrinsic costs generated by corruption. For instance, public awareness campaigns and educational programs able to increase the moral cost a_i of any individual i in the population by a positive fraction z, would shift the $F(d-1+x)$ curve to the right, resulting in either a higher unstable interior corruption equilibrium, i.e. a smaller "jump" required to move from the high corruption to the low corruption equilibrium, or, for a large enough z, in the elimination of the high corruption equilibrium.

Note that in this framework, due to the presence of strategic complementarities in both the extrinsic incentives and the intrinsic motivations associated with corruption, acting on the severity of the penalty or the probability that a corrupt pair will be discovered would not be effective in reducing corruption. Recall that the expected cost of formal and informal punishment enters the cost function through the proportion of corrupt people, x. This implies that the effectiveness of anti-corruption policies aimed at increasing the probability that a corrupt citizen (briber) or a corrupt official (bribee) will be discovered and severely punished depends on how corrupt society already is. If the level of corruption is high, increasing the penalty associated with corruption is likely to be ineffective. This is due to the fact that potential bribers and bribees would still believe that the likelihood for them to be discovered is very low (for example, because even in the unlikely case of detection they could still escape the severe sanction through bribery). Similarly, increasing the probability that corrupt people will be detected, for example by increasing the number of officials in charge of vertical and horizontal controls in public offices, may also prove ineffective when the level of corruption is high, since potential bribers and bribees would expect that the inspecting officials will be willing to accept bribes themselves, in exchange for turning a blind eye.

5. Equilibrium in the bribery game of incomplete information

Consider now a society where individuals have private information about their own moral cost associated with corruption, a_i. As before, Nature moves first by randomly assigning costs a_i and matching citizens and officials in pairs. Each citizen and official then proceed to bargaining on the basis of their own private valuations of the corrupt service, v_b and v_s. As in the complete information case, the gain that corruption generates to the citizen, y, the cost to provide the corrupt service, q, and the distribution of moral costs (uniform on $[0, \bar{a}]$) are common knowledge and the same for everyone. The level of corruption in the society, x, is also common knowledge and, as before, determined endogenously in the equilibrium defined below.

Due to incomplete information, each agent now faces a trade-off between, on the one hand, acting aggressively, which for the citizen means "submitting" a low bribe and for the official "submitting" a high bribe, in order to make higher profits in case of agreement, and, on the other, lowering the risk of disagreement, i.e., "submitting" a bribe close to the reservation bribe.

As before, if the conditions for a transaction to take place are met, citizen and official negotiate the final amount of the bribe in the range of mutually agreeable bribes. The final bribe is equal to $b = kb_b + (1-k)b_s$, with $0 \le k \le 1$, where k represents the relative bargaining power of the citizen.

Following Chatterjee and Samuelson (1983), we describe the bargaining game of incomplete information between a private citizen and a public official by bidding functions, $B_b(a_b)$ and $B_s(a_s)$, which prescribe the bribe "bids" for each party as functions of their private moral costs. Provided that the distribution of moral cost is uniform, and assuming risk-neutrality of players, we look for equilibrium bidding functions in the linear form (Chatterjee and Samuelson, 1983). The result is given by the following proposition (all proofs are in Appendix A).

Proposition 1. *In the bargaining game of a citizen and public official with respective private moral costs a_b and a_s, and relative bargaining power k, the equilibrium bidding functions in the range of agreeable bids are*

$$B_b(a_b) = \frac{2-k}{2}y + \frac{k}{2}q - (1-k)(1-x) - \frac{a_b}{1+k}, \quad B_s(a_s) = \frac{1-k}{2}y + \frac{1+k}{2}q + k(1-x) + \frac{a_s}{2-k}. \tag{5}$$

Note that the equilibrium bidding functions of citizen and official both depend on the benefit generated by corruption to the citizen, y, the cost sustained by the official, q, the proportion of honest people in the society $(1-x)$ and the citizen's and official's own intrinsic moral costs. The bidding functions only differ in the weights assigned to each variable, which depend on the citizen's and the official's relative bargaining power.[16] For a given citizen-official pair (a_b, a_s), a corrupt transaction occurs whenever $B_b(a_b) \ge B_s(a_s)$. Using Eqs. (5), this leads to the following definition.

Definition 2. A corruption level, x^*, constitutes an equilibrium in the bribery game of incomplete information if the following conditions hold:

(i) For a given pair of a citizen and a public official, (a_b, a_s), a corrupt transaction occurs if and only if

$$\frac{a_b}{1+k} + \frac{a_s}{2-k} \le d - 1 + x^*. \tag{6}$$

(ii) The corruption level x^* is equal to the probability that a randomly drawn pair of a citizen and a public official engages in a corrupt transaction,

$$x^* = \Phi_k(d - 1 + x^*). \tag{7}$$

Here, $\Phi_k(\cdot)$ is the cdf of random variable $A_k = a_b/(1+k) + a_s/(2-k)$.[17]

Conditions (i) and (ii) of Definition 2 are similar to those of Definition 1. Condition (i) states that the likelihood that a corrupt transaction occurs now also depends on the relative bargaining power of citizens. Qualitatively, however, the types of equilibria (honesty, systemic corruption, and interior) and the possible configurations of single/multiple equilibria are the same as in the complete information case.[18]

If we compare the equilibrium configurations under complete and incomplete information, it is easy to see that for any $k \in [0, 1]$ variable A_k first-order stochastically dominates variable $(a_b + a_s)/2$. We conclude that for any given value of parameter d a corrupt transaction is less likely under incomplete information. Indeed, in the incomplete information case buyers have an incentive to bid below, and sellers above their reservation value, therefore the probability that a transaction occurs drops compared to the complete information case (see, e.g., Chatterjee and Samuelson, 1983; Myerson and Satterthwaite, 1983). In the multi-person bribery game, however, the comparison of corruption levels under different information conditions is not as straightforward due to the possibility of multiple equilibria. The results are summarized in the following proposition.

Proposition 2.

(i) *In both bribery games of complete and incomplete information, the honesty equilibrium ($x^* = 0$) exists if and only if $d \le 1$.*
(ii) *In the bribery game of complete information, the systemic corruption equilibrium ($x^* = 1$) exists if and only if $d \ge \bar{a}$.*
(iii) *In the bribery game of incomplete information, the systemic corruption equilibrium ($x^* = 1$) exists if and only if $d \ge 3\bar{a}/((1+k)(2-k))$.*

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[16] Note that the intrinsic moral cost enters the citizen's total cost function with a positive sign and the official's total cost function with a negative sign.

[17] For a_b and a_s distributed uniformly on $[0, \bar{a}]$, A_k has a distribution in the form of an isosceles trapezoid with the lower base $[0, 3\bar{a}/((1+k)(2-k))]$, the upper base $[\bar{a}/(2-k), \bar{a}/(1+k)]$ and height of $(1+k)/\bar{a}$ (for $k \le 1/2$, without loss of generality). In the symmetric case of $k = 1/2$, the distribution of $A_{1/2}$ is triangular with base $[0, 4\bar{a}/3]$.

[18] For some constellations of parameters it is possible to have a continuum of interior equilibria, which may arise due to the trapezoid shape of the distribution of A_k. Specifically, in the range of A_k within the upper base of the trapezoid, function $\Phi_k(\cdot)$ is linear with slope $\min\{1+k, 2-k\}/\bar{a}$, and the continuum of interior equilibria arises if this slope is equal to 1. See, for example, curve c in the left panel of Fig. 3, for which the condition is satisfied. Such equilibria are nongeneric, and we ignore them in further discussions.

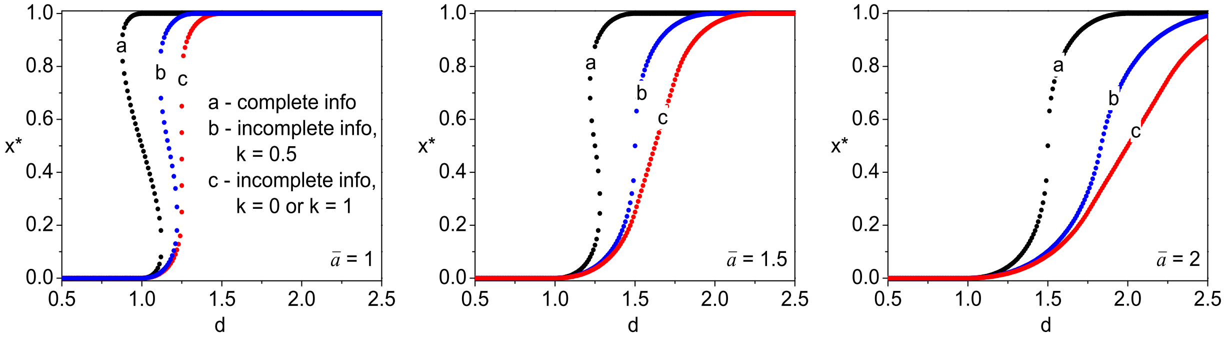

Fig. 3. The equilibrium correspondence, x^*, as a function of d for $\bar{a}=1$, 1.5, and 2 in the cases of complete information (a), incomplete information with $k=1/2$ (b), and incomplete information with $k=0$.

(iv) *For any* $k \in [0, 1]$, *systemic corruption is (weakly) more likely in the complete information case than in the incomplete information case.*

(v) *In the incomplete information case, the likelihood of systemic corruption (weakly) decreases in* $|k-1/2|$.

Part (i) of Proposition 2 states that the existence of the honesty equilibrium is independent of the information condition. It is determined solely by the magnitude of parameter d—the net per capita benefit from a corrupt transaction.

Parts (ii) and (iii) of Proposition 2 determine the conditions under which the systemic corruption arises. In both information conditions, an increase in d and/or a decrease in $\bar{a}$ makes systemic corruption more likely.

Part (iv) of Proposition 2 implies that systemic corruption is less likely under incomplete information.

Finally, part (v) of Proposition 2 addresses the dependence of the likelihood of systemic corruption on the relative bargaining powers of citizens and officials. It appears that systemic corruption is less likely the more asymmetric the bargaining powers of briber and bribee.[19]

The results are illustrated in Fig. 3. Fig. 3 shows the equilibrium correspondence, x^*, as a function of d for $\bar{a}=1$, 1.5, and 2. For each $\bar{a}$, x^* is shown for the case of complete information (a), incomplete information with $k=1/2$ (b), and incomplete information with $k=0$ (c). The cases of $k=1/2$ and $k=0$ under incomplete information represent the two extreme cases of the distribution of the relative bargaining power of citizens and officials. For $k=1/2$, bargaining is symmetric, whereas for $k=0$ the entire bargaining power belongs to public officials.[20] For k between 0 and 1/2, due to part (v) of Proposition 2, the equilibrium correspondence lies in between the extremes. For $k \in [1/2, 1]$, the shape of the equilibrium correspondence is the same, with k replaced by $1-k$.

As seen from Fig. 3, the qualitative shape of the equilibrium correspondence is the same under complete and incomplete information. Depending on $\bar{a}$, the correspondence either does or does not include a multiple-equilibria region. For example, For $\bar{a}=1$, there is a multiple-equilibria region in the cases of complete information and incomplete information with $k=1/2$, but no such region (except for a single point $d=1.25$ with a continuum of equilibria) in the case of incomplete information with $k=0$. As $\bar{a}$ increases, the multiple-equilibria region becomes more narrow and ultimately disappears.

The relative position of the curves in Fig. 3 illustrates Proposition 2. For $d \le 1$, the full honesty equilibrium exists for all information conditions. Depending on the information condition and bargaining powers, it may, however, coexist with the systemic corruption and/or interior equilibria. The onset of the systemic corruption equilibrium, on the other hand, depends on the information condition and bargaining powers. It occurs for larger d in the case of incomplete information as compared to complete information, and, under incomplete information, it also occurs for larger d the more asymmetric the bargaining powers of briber and bribee are.

6. Concluding remarks

In this paper, we used a simple bargaining model to study the strategic interaction between potential bribers and potential bribees and the resulting corruption equilibrium in the society. We assumed that the decision to engage in bribery is subject to strategic complementarities and that individuals are heterogeneous with respect to the intrinsic moral cost associated with corruption. Our framework made it possible to look at the corruption decision-making of both the briber and the bribee rather than focusing only on one side of the market, as has been traditionally done in the literature. We investigated how uncertainty regarding the intrinsic corruptibility of one's potential corruption partner affects the decision to engage in bribery and the resulting overall level of corruption in the society.

[19] Our findings in the more general setting confirm that honesty (systemic corruption) is more (less) likely to emerge under incomplete than under complete information. However, in this setting, we cannot compare the interior equilibria in the two cases, and we cannot reach conclusions about the bargaining powers of citizens and officials. The derivation of the general model is available from the authors upon request.

[20] The other extreme case, $k=1$, when citizens have the full bargaining power, leads to the same corruption outcomes as $k=0$, cf. part (v) of Proposition 2.

We found that when individuals are uncertain with respect to their opponent's intrinsic corruptibility, they are less likely to engage in corruption. This leads to a lower likelihood that society ends up in a systemic corruption trap. Moreover, under uncertainty, any reduction in the equilibrium proportion of corrupt people can be achieved at a lower cost. In other words, under incomplete information a smaller reduction in the net economic benefits associated with corruption is needed in order to make society move from a high corruption to a low corruption equilibrium. Similarly, if educational or ethical campaigns are used to fight corruption, under incomplete information a relatively smaller increase in the highest moral cost in the society is required to escape a high corruption trap. Finally, the corruption-reducing role of incomplete information is higher the more asymmetric the bargaining powers of briber and bribee. Intuitively, while monopoly bargaining power places either the citizen or the official in the position of extracting higher gains from corruption, at the same time it increases the chances that citizen and official will not reach an agreement.

Our findings have interesting policy implications. First of all, it is reasonable to believe that uncertainty is higher in environments where the social distance among bribers and bribees is relatively large, i.e., where bribers and bribees are less likely to have either direct or indirect information about each other's corruptibility (see Tanzi, 1995). Therefore, our *uncertainty result* provides theoretical support to anti-corruption measures, such as staff rotation in public offices, aimed at increasing the social distance between public officials and private citizens (or firms). Staff rotation has proven to be an effective anti-corruption tool in a number of countries and contexts.[21] However, rotation schemes are usually advocated as effective tools to break long-term corruption networks between regular bribers and bribees in the context of grand corruption. In this paper we have suggested that job rotation may prove an effective anti-corruption tool even in the context of one-shot petty bribery exchanges, where uncertainty regarding the intrinsic corruptibility of one's potential corruption partner may act as a corruption deterrent.

Finally, our finding with respect to the relative bargaining power of citizens and officials suggests that, under uncertainty, corruption is lowest when either the briber or the bribee has full bargaining power over the size of the bribe to be paid in case of corruption agreement. This implies that, as long as citizens and officials have incomplete information about each other's corruptibility, monopolistic (or perfectly centralized) service provision and perfectly competitive service provision[22] have identical consequences on the overall level of corruption resulting from collusive bribery interactions between public officials and private citizens (or firms).

A note of caution is required at this point. While we have shown that, under uncertainty, for any parameterization of our model, monopoly and competition lead to the same levels of corruption, this does not imply that they are equally "desirable" (or "undesirable"). Whether full bargaining power is placed on the briber or the bribee side also determines the final size of the bribe exchanged by *corrupt* bribers and bribees. A system that gives higher bargaining power to the citizens (or firms) than to the officials would result in lower bribes as compared to a system that gives higher bargaining power to the officials.

Appendix A. Proofs of propositions

A.1. Proof of Proposition 1

We consider a special case of the Chatterjee and Samuelson (1983) model of bargaining under incomplete information. There is a buyer (the citizen) and a seller (the public official) with reservation prices $v_b = y - a_b - (1-x)$ and $v_s = q + a_s + (1-x)$, respectively. Parameters y, q and x are common knowledge, whereas moral costs a_b and a_s are private information with the commonly known distribution Uniform $[0, \bar{a}]$. The buyer and the seller simultaneously submit bids b_b and b_s. If $b_b < b_s$, the bargain does not occur; if $b_b \geq b_s$, the bargain occurs at the price $b = kb_b + (1-k)b_s$, where $k \in [0, 1]$ measures the bargaining power of the buyer relative to the seller.

It is shown by Chatterjee and Samuelson (1983) that, under risk neutrality, in the range of successful bargains the buyer's and the seller's equilibrium bidding functions are linear and increasing in their reservation prices. We, therefore, seek the equilibrium bidding functions for the buyer and the seller in the form $b_b = B_b(a_b) = \alpha + \beta a_b$, and $b_s = B_s(a_b) = \gamma + \delta a_s$, where α, β, γ and δ are constants to be determined.

From the buyer's perspective, the seller's bid is uniformly distributed on the interval $[\gamma, \gamma + \delta\bar{a}]$. The expected payoff of the buyer bidding b_b is

$$\pi_b = Pr(b_b \geq b_s)[y - a_b - (1-x) - kb_b - (1-k)E(b_s|b_s \leq b_b)].$$

Here,

$$Pr(b_b \geq b_s) = \frac{b_b - \gamma}{\delta\bar{a}}, \quad E(b_s|b_s \leq b_b) = \frac{\gamma + b_b}{2}.$$

[21] Probably the most well-known example of the use of staff rotation in public offices as part of a comprehensive anti-corruption strategy can be found in Singapore (see Ali, 2000).

[22] For interesting discussions on the industrial organization of corruption, see Shleifer and Vishny (1993) and the recent work by Drugov (2010).

Maximizing the resulting quadratic in b_b, obtain the optimal bid of the buyer:

$$b_b^* = \frac{y - a_b - (1-x) + k\gamma}{1+k}. \tag{8}$$

Similarly, from the seller's perspective, the buyer's bid is uniformly distributed on the interval $[\alpha+\beta\bar{a}, \alpha]$. (Note that $\beta<0$ due to the fact that the bidding function is increasing in the reservation price.) The expected payoff of the seller bidding b_s is

$$\pi_s = Pr(b_b \geq b_s)[kE(b_b|b_s \leq b_b) + (1-k)b_s - a_s - (1-x) - q].$$

Here,

$$Pr(b_b \geq b_s) = \frac{\alpha - b_s}{-\beta\bar{a}}, \quad E(b_b|b_s \leq b_b) = \frac{\alpha + b_s}{2}.$$

Maximizing the resulting quadratic in b_s, obtain the optimal bid of the seller:

$$b_s^* = \frac{q + a_s + (1-x) + (1-k)\alpha}{2-k}. \tag{9}$$

As expected, the optimal bids (8) and (9) are linear in a_b and a_s, respectively. Setting $b_b^* = \alpha + \beta a_b$ and $b_s^* = \gamma + \delta a_s$, and equating the coefficients, we obtain:

$$\alpha = \frac{2-k}{2}y + \frac{k}{2}q - (1-k)(1-x), \quad \beta = -\frac{1}{1+k}, \quad \gamma = \frac{1-k}{2}y + \frac{1+k}{2}q + k(1-x), \quad \delta = \frac{1}{2-k}.$$

A.2. Proof of Proposition 2

Parts (i)–(iii) follow directly from Eqs. (4) to (7), and the definitions of functions F and Φ_k as the cdfs of random variables $(a_b + a_s)/2$ and A_k, respectively.

Part (iv) is a corollary of parts (ii) and (iii). Indeed, it is easy to see that for any $k \in [0, 1]$

$$\frac{3}{(1+k)(2-k)} > 1,$$

therefore, if there is a systemic corruption equilibrium in the incomplete information case, there necessarily is one also in the complete information case, but the reverse is not true.

Part (v) follows from the fact that, for $k, k' \in [0, 1/2]$, A_k first-order stochastically dominates $A_{k'}$ provided $k<k'$, and the opposite is true for $k, k' \in [1/2, 1]$. To show this, consider random variable $A_k = a_b/(1+k) + a_s/(2-k)$, where a_b and a_s are i.i.d. uniform on the interval [0, 1] (we set $\bar{a} = 1$ without loss of generality for the purposes of this proof only). Let $u(x)$ and $U(x)$ denote, respectively, the pdf and cdf of a_b and a_s.

The pdf of A_k can be expressed as follows:

$$f_A(x) = (1+k)(2-k)\int dyu((1+k)(x-y))u((2-k)y) = (1+k)\int dyu\left((1+k)\left(x - \frac{y}{2-k}\right)\right)u(y).$$

The cdf of A_k then is

$$F_A(x) = \int dyU\left((1+k)\left(x - \frac{y}{2-k}\right)\right)u(y). \tag{10}$$

Let $k \in [0, 1/2]$. To show that A_k first-order stochastically dominates $A_{k'}$ for $k<k'$, it is sufficient to show that $F_A(x)$ is a nondecreasing function of k for any x. From Eq. (10), we have

$$\frac{\partial F_A}{\partial k} = \int dyu\left((1+k)\left(x - \frac{y}{2-k}\right)\right)u(y)\left(x - \frac{3y}{(2-k)^2}\right). \tag{11}$$

Note that the expression under the integral in Eq. (11) is not equal to zero only when both arguments of functions $u(\cdot)$ are between 0 and 1, i.e., for

$$y \in [(2-k)x - (2-k)/(1+k), (2-k)x] \cap [0, 1]. \tag{12}$$

The domain defined by (12) can be represented in the (x, y) space as a union of three regions: (i) $x \in [0, 1/(2-k)]$ and $y \in [0, (2-k)x]$; (ii) $x \in [1/(2-k), 1/(1+k)]$ and $y \in [0, 1]$; (iii) $x \in [1/(1+k), 3/((1+k)(2-k))]$ and $y \in [(2-k)x - (2-k)/(1+k), 1]$. Integrating over each region separately in Eq. (11), obtain

$$\frac{\partial F_A}{\partial k} = \begin{cases} x^2(1/2-k), & x \in [0, 1/(2-k)], \\ x - 3/[2(2-k)^2], & x \in [1/(2-k), 1/(1+k)], \\ (1/2-k)\left\{9/[(1+k)^2(2-k)^2] - x^2\right\}, & x \in [1/(1+k), 3/((1+k)(2-k))]. \end{cases}$$

It is easy to see that $(\partial F_A/\partial k) \geq 0$ for all x in each segment. The result for the case of $k \in [1/2, 1]$ follows by introducing $l = 1 - k$.

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