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Corruption and competition in procurement auctions

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We investigate the effect of corruption on competition in procurement. Our assumption is that the bureaucrat (i.e., the agent that administers the market), if corrupt, may provide an opportunity for bid readjusments in exchange for a bribe. As firms expect to be paying a bribe, a mechanical effect of corruption is to increase the contract price by an amount corresponding to the anticipated bribe. We show, however, that a key effect of corruption is to facilitate collusion in price between firms and thereby to generate a price increase that goes far beyond the bribe received by the bureaucrat. We discuss the effect of other forms of bureaucratic discretion in the procurement process and analyze conditions under which unilateral anticorruption controls restore price competition.

1. Introduction

■ Is corruption only a transfer between the briber and the bribed, or does it inhibit competitive pressures and allocative efficiency? What are the links between corruption and competition? What are the impacts of controls and public market procedures on corruption, firms' profits, and government expenditures? This article addresses these important issues in a simple model of public market auctions. It shows that a key effect of corruption in public markets is that it undermines competition and facilitates implicit collusion in price between competing firms. This may result in high public spending and inefficient allocation.

Corruption is recognized as a serious issue in a large variety of economic contexts.[1] Experience from developing and transition countries suggests that corruption is a major obstacle to growth and development. In developed economies, increasing attention is being devoted to combating corruption, in particular in the context of public procurement.

Although there seems to be a general consensus on the undesirability of corruption in

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[1] The fight against corruption has become a top priority for international institutions like the World Bank, the IMF, and the WTO.

procurement auctions, little formal work has been done in this field.[2,3] Of particular interest are questions related to the link between competition and corruption. Our purpose in this article is to examine, in a corrupt environment, the performance of various procurement procedures with respect to the promotion of competition. We also investigate the effects of controls over firms or bureaucrats in this context.

As a benchmark, we consider the case where a public contract is allocated through a first-price auction.[4] The candidate firms are differentiated in their cost structure. Without corruption, this type of auction mechanism induces competitive pressures on firms so that the price at which the contract is allocated tends to reflect the cost structure of the "most"-efficient firms (in a sense that we make precise in Section 2).

We then introduce corruption in the following simple way. We assume that after the initial bidding in prices, the public official (the bureaucrat) may offer a firm an opportunity to readjust its initial bid and undercut its rivals. We also assume that firms compete for this favor by making bribe offers, and that competition in bribes is imperfect.[5] We will model this imperfection by assuming that the bureaucrat cannot or is not willing to accept bribes larger than, say, $\bar{B}$. One interpretation is that controls and penalties on bureaucrats in case corruption is detected limit the amount of the bribe a bureaucrat may be willing to accept.[6] How in this model does corruption affect competition in prices? Given that bidders anticipate paying a bribe, we should expect competition in prices to be reduced. If a bidder was ready to bid a price p^* without corruption, and if, with corruption, he expects to be paying a bribe b in addition to his price bid, then it will not be surprising that he inflates his original bid by b and ends up bidding $p^* + b$ in the first round. Since competition in bribes is limited to $\bar{B}$, one could expect prices not to exceed $p^* + \bar{B}$. Corruption would then have the effect of transferring revenues from the government to the bureaucrat, and imposing controls that reduce $\bar{B}$ would have the positive effect of limiting these transfers.

Our main contribution is to show that the effect of corruption on price competition may be much more dramatic than a mere transfer from the government to the bureaucrat. We find that in the corrupt environment described above, the contract may be allocated at the government's reservation price with probability one. We exhibit an equilibrium in which all firms bid the government reservation price and then offer the highest bribe the bureaucrat will accept. The bureaucrat then randomly picks one of the firms. Intuitively, these strategies are in equilibrium because when a firm deviates in the initial price auction, other firms may still participate in the bribing game, and the winner of this bribing game then has the opportunity to slightly undercut the deviators' initial price bid, thereby making the initial price deviation unprofitable. The corrupt bureaucrat's discretion thus provides firms with a mechanism to sustain implicit price collusion (in the initial price auction).

We next examine the effect of controls and see whether they can be used to reduce corruption and restore competition in prices. Our analysis should thus be contrasted with that of the literature on collusion in auctions that has emphasized the role of the reserve price as a way to fight collusion (see Graham and Marshall, 1987; McAfee and McMillan, 1992). We will instead focus on the role of controls and contrast the impact of controls on bureaucrats as opposed to controls on firms.

Our main result shows that increasing control on the bureaucrat, i.e., reducing the amount of illegal transfer he can accept, does not reduce the ability of firms to collude. The intuition is

[2] One exception is Burguet and Che (2004), which we will discuss shortly.

[3] Most theoretical studies of corruption have focused on the issue of collusion and optimal delegation in principal-supervisor-agent models of regulation (see Tirole, 1986; Laffont and Tirole, 1993). For a model of government procurement and international trade (with no corruption) using an auction theory framework, see also McAfee and McMillan (1992).

[4] Our aim is to investigate the effect of corruption on *existing* public auction procedures and the consequent impact on government procurement. In particular, we will not attempt to derive optimal "collusion-proof" or "corruption-proof" mechanisms. Also note that we investigate the effect of corruption on competition. This is in contrast with Celentani and Ganuza (2002) who investigate the effect of competitiveness of the environment on the level of corruption.

[5] The key role played by imperfections in bribe competition will be explained at length in Section 3.

[6] Note that while our modelling of imperfect competition will facilitate exposition, our results do not hinge on that particular modelling: our results also hold under more standard models of imperfect competition (see Section 3).

that corrupt bureaucrats are in a sense in competition with firms for collusive rents. Increasing controls on civil servants reduces the "price" firms have to pay to sustain collusion, which in turn makes collusion even more profitable to the firms, hence in some cases easier to sustain.

In contrast, corruption controls on efficient firms may restore competition in prices (to some extent). An efficient firm subject to controls is ready to harden price competition in the price-auction stage: it needs to compensate for its comparative disadvantage in bribe competition. By proposing a low enough price, it can make sure that other less-efficient firms cannot afford to compete in bribes. This behavior kills implicit collusion in the price-auction game and, at the same time, mitigates corruption with the bureaucrat. In such a context, unilateral controls on a firm that is a potential winner dramatically reduce public spending. So also does the entry of a sufficiently efficient outsider (that lacks connections, i.e., has in effect no bribe capacity).

Our next result, however, mitigates the positive effects of unilateral controls on firms. We consider a situation where, in addition to being able to offer an opportunity to resubmit, the bureaucrat has some limited discretion in the allocation or in the implementation of the contract, discretion that he may use to give a favorable treatment to a bidder (in addition to being able to offer an opportunity to resubmit).[7] We show that in such cases, unilateral controls on firms may further deteriorate efficiency. Their sole effect may be to exclude the controlled firm(s) from the market. The intuition is that even if they are more efficient, the controlled firms' (possible) cost advantage may not be sufficient to compensate for the favorable treatment received by the winner of the bribing game. Corruption then induces a bias in favor of uncontrolled firms.

Our analysis of the determinants of competition and corruption in public auctions has interesting policy implications for the fight against corruption in international public markets. Typically, one of the main issues in that context is the effectiveness and desirability of unilateral controls, i.e., anticorruption regulations enacted by individual countries.[8] The point is that countries as a whole would benefit from fighting corruption and reducing extortion in international markets. At the same time, they fear that imposing severe legislation on their national firms, while other countries adopt a more permissive attitude, would prevent their firms from competing effectively in corrupt markets. Our framework sheds some light on this issue. When the civil servants administering the auction do not have much discretion (in the sense of being able to provide additional favors to the auction's winner, for instance), we show that this fear may not be justified. Unilateral controls, by stimulating price competition, will make domestic efficient firms more likely to win the market. When, however, these civil servants have a high degree of discretion (in evaluation or in implementation), our analysis explains why individual countries may be even more reluctant to impose unilateral controls, since the only effect of such controls would be to exclude their firms from these markets.

The work most closely connected to ours is that of Burguet and Che (2004) who analyze a game where bidders *simultaneously* compete in prices, quality, and bribes. The firm who wins the bribe competition is given a favor that takes the form of positive bias in quality assessment. Burguet and Che show that bribe competition undermines price competition and may be responsible for inefficient allocations.[9] The most notable difference with our work stems from the type of favors that the bureaucrat may offer: we assume that the bureaucrat gives an opportunity for bid readjustment, whereas they do not.

The article is organized as follows. Section 2 describes a benchmark model of first-price auction with no discretion. Section 3 introduces corruption and shows how it may allow implicit

[7] Limited discretion often arises in "best-offer" procedures, in which offers are not solely financial. The criteria for judging quality may sometimes be difficult to set *ex ante* or may not all be objectively measurable. Limited discretion also arises when the bureaucrat may readjust the contract in the course of completion, which may amount to a cost reduction to the winner.

[8] One example is the Foreign Corrupt Practices Act of 1977 enacted by the U.S. Congress.

[9] In the working paper version of this article (Compte, Lambert-Mogiliansky, and Verdier, 2000), we examine a game that bears some resemblance to that analyzed by Burguet and Che: our game is sequential, but we assume as they do that the bureaucrat only has the ability to bias price competition (and not to allow for a revised price bid). We then derive a bound on the extent to which price competition is distorted by corruption.

collusion to be sustained in the price-auction game. Section 4 considers the situation with unilateral controls on the most-efficient firm's bribe capacity. Section 5 investigates other forms of discretion. Section 6 discusses the main assumptions and concludes with some policy implications of our model. All proofs are in the Appendix.

2. A simple model with no discretion

■ There is one contract to be allocated at a price not exceeding $\overline{p}$. This reservation price has been chosen by the government. We consider n firms $i \in \{1, \ldots, n\}$ competing for the contract, and one bureaucrat in charge of allocating the contract. In the benchmark model, the firms compete for the contract through a first-price auction. The procedure thus leaves no discretion over the allocation process to the bureaucrat.

We assume that firm i has a cost c_i of completing the contract. The cost c_i is assumed to be drawn from a distribution with positive and continuous density $f_i(\cdot)$ on $[\underline{c}_i, \overline{c}_i]$. These distributions are assumed to be known to the firms only. For convenience, we will order firms so that

$$\overline{c}_1 \leq \overline{c}_2 \leq \cdots \leq \overline{c}_n.$$

We will also let $\underline{c} = \min_i \underline{c}_i$. We wish to emphasize at this stage that even if the densities f_i are important in deriving equilibrium behavior, our results will depend only on the bounds $\underline{c}$ and $\overline{c}_i$ and not on the fine details of these densities.

In a first-price auction, firms simultaneously submit a bid for the contract. Firm i submits a bid p_i, and we denote by p^* the lowest bid:

$$p^* = \min_{i \in \{1,\ldots,n\}} p_i.$$

If this price p^* is no larger than the reservation price $\overline{p}$, the firm i that submits the lowest bid obtains the contract at price p^* and makes a profit equal to

$$p^* - c_i.$$

In case several firms make the same lowest bid, the bureaucrat chooses one of them. In accordance with the fact that the bureaucrat may be ignorant about the costs of the firms (and about the distribution from which they are drawn), we shall assume that the bureaucrat chooses each lowest-bidding firm with equal probability.

The following proposition illustrates the beneficial effect of competition on efficiency and public spending:[10]

Proposition 1. Assume that $\overline{c}_1 < \overline{p}$. Then in *any* Bayesian equilibrium, the first-price auction allocates the contract at a price equal at most to $\min\{\overline{c}_2, \overline{p}\}$.

Competition between firms drives prices down to levels that are unrelated to the reservation price, as long as costs are not close to that reservation price. This is a feature of the allocation process that is particularly important to the government: as long as $\overline{p}$ reflects the government's willingness to pay for the contract, the government secures a surplus equal to at least $\overline{p} - \overline{c}_2$. In particular, this surplus increases as the cost structure moves downward. In addition, the maximal efficiency loss that may arise with this allocation process is bounded above by $\overline{c}_2 - \underline{c}$.

[10] Note that the force of Proposition 1 lies in the fact that the bound on the price contract is independent of the distributions f_i. It is actually easy to show that one cannot get a tighter bound: when each distribution f_i puts most weight near $\overline{c}_i$, the equilibrium contract price is indeed close to $\max\{\overline{c}_2, \overline{p}\}$.

3. A model with corruption

■ The previous model assumes that the bureaucrat has no discretion over the allocation process. This precludes corruption: the bureaucrat cannot take bribes in exchange for a favor, since there are no favors he can bestow. In the rest of this article, we investigate models in which the bureaucrat may affect the allocation process (and exchange favors for bribes).

Our first objective is to illustrate how corruption can alter the basic force of competition as described in the previous section. To this end, we assume that the price-bidding stage is followed by a second stage at which the bureaucrat may offer a firm an opportunity to readjust its bid and undercut its rivals, and we assume that in the second stage, firms compete for this favor by making bribe offers.

In most countries, bid readjustments are illegal. There is empirical evidence, however, that in reality such manipulations do occur, even in developed economies.[11,12] Besides, as will be discussed further in Section 6, bid manipulations do not actually always require illegal switching of envelopes.

Another key assumption we will be making is that bribe competition is *imperfect*. We will model this imperfection by assuming that the bureaucrat is limited in his ability to accept bribes: the bureaucrat is interested in the highest possible bribe, but he may not accept a bribe level above some threshold $\overline{B}$.[13] One virtue of this particular form of imperfection is that it makes computations very simple. Our main insights, however, will carry over to more general models of imperfect bribe competition.

Formally, our game has three main stages:

Stage 1: price bidding. Each firm i submits a price offer p_i to the bureaucrat. The lowest price is denoted $p^*(= \min_i p_i)$.

Stage 2: bribe bidding.

(i) The bureaucrat discloses the value p^* of the lowest price bid. Each firm i then may (or choose not to) send a bribe offer b_i to the bureaucrat (the bribe b_i may depend on p^*, p_i, and c_i).

(ii) The bureaucrat allows a firm (or one of the firms in case of ties), say firm i, that made the highest bribe offer below $\overline{B}$ to resubmit and make a more aggressive price bid $p'_i \leq p_i$.[14]

It is also interesting to note that if less agressive bidding were allowed ($p'_i > p_i$) the bidder, say bidder i, having made the lowest price offer in the first stage is very much advantaged: to win the contract, bidder i would just need to bid below the second-smallest price offer, while the others have to bid below bidder i's initial price offer. Bidders would thus have an incentive to bid agressively in the first stage, thereby reducing the amount of bribes the bureaucrat can expect.

Stage 3: selection. The official prices are $(p'_1, \ldots, p'_n)$, where $p'_k = p_k$ for all k, except possibly

[11] For example, relying on the annual report (1995) from Conseil de la Concurrence (French Competition Authority), Cartier Bresson (1998) makes a case study of corrupt practices in the allocation of contracts for the construction of the TGV North (the French high-speed train) and describes how resubmissions took place.

[12] It is interesting to note that resubmission practices are not always condemned forcefully by politicians, in particular if there is no or limited evidence of corruption associated with them. One reason is that from an *ex post* point of view, the bureaucrat may be trying to obtain a better deal.

[13] Alternatively, we could assume that the bureaucrat's gain is a function of the bribe that he accepts, and that this function has a maximum at $\overline{B}$ (for example, because there is a risk of detection and penalties in case of detection, and because this risk increases with the size of the bribe he accepts). For the firms, offering a bribe larger than $\overline{B}$ is strictly dominated by offering a bribe equal to $\overline{B}$.

[14] One motivation for allowing only more agressive bidding at this stage is that such price readjustments, if unveiled, are easier to justify in court: from an *ex post* point of view, the bureaucrat may just have been trying to obtain a better deal. (See also footnote 12.) In contrast, an upward readjustment of the price, if unveiled, would be obvious evidence that the bureaucrat is working at the expense of the public interest.

for the firm allowed to resubmit. The bureaucrat then selects a firm that has the minimal official price.

We look for (perfect Bayesian) equilibria of this game. It will sometimes be convenient to refer to *collusive equilibria* as (perfect Bayesian) equilibrium strategy profiles in which the firms choose the *same* price $p > \overline{c}_2$ in the first round (independently of the actual realization of their cost). Our main result is the following:

Proposition 2. Assume that $\overline{p} - \overline{c}_1 - \overline{B} > 0$ and $\overline{c}_2 - \underline{c} < (1/n)[\overline{p} - \underline{c} - \overline{B}]$. Then there exists a (perfect Bayesian) equilibrium in which the contract is sold at the reservation price $\overline{p}$. If in addition $\overline{c}_n < \overline{p} - \overline{B}$, the expected cost of the firm that gets the contract is at least equal to

$$\frac{1}{n}\sum_{i=1}^{n} Ec_i.$$

In other words, under the conditions of Proposition 2, competition may lose its force, public spending may rise up to the reservation price, and the expected cost of the winning firm may increase (compared to the case where there is no corruption), since $(1/n)\sum_{i=1}^{n} Ec_i$ may be larger than $\overline{c}_2$.[15] This contrasts with the no-corruption case of Proposition 1, in which in any Bayesian equilibrium, the contract is sold at a price no larger than $\overline{c}_2$.[16]

The intuition for the result is as follows. In the corruption stage (the second stage), firms compete in bribes. But competition in bribes stops at $\overline{B}$ because of the constraint on the level of bribes obtainable by the bureaucrat. As a result, if firms compete only in bribes (and not in prices), they all make positive expected profits (as long as their cost parameter does not exceed $\overline{p} - \overline{B}$). Still, since firms do not get the contract with probability one, some might wish to compete in prices in the first round so as to increase the probability that they get the contract. However, there is a high cost to doing so. For small price deviations, competition in bribes leads to ties in bribes (because many firms can afford to propose $\overline{B}$ and still make positive profits), and the deviator need not be picked with a larger probability by the bureaucrat. Thus, increasing the probability of winning would require decreasing the price bid to a level at which other firms cannot match the price and still make positive profits. This price level may be so low that each firm prefers to stick to the collusive outcome.

There are two key assumptions in our model: the bureaucrat's discretion and the fact that competition in bribes is limited. The bureaucrat's discretion about the procedure is key because it makes competition in prices ineffective: when a firm deviates to a lower price bid, the other firms are given a "second chance" to match the lower price and get the contract. Limited bribe competition is key as well: it sets a bound on what the bureaucrat can obtain in the bribing stage, so any increase in initial prices translates into higher joint profits for the firms. They thus have a joint interest in setting initial prices as high as possible.

To capture further the role of limited bribe competition, consider the case where perfect competition in bribes is restored ($\overline{B} = +\infty$). The next proposition shows that equilibrium expected profits are then identical to those obtained in an equilibrium of the game where the bureaucrat has no discretion (as in Section 2).

Proposition 3. Assume $\overline{B} = +\infty$. Consider a collusive equilibrium. Let π denote the vector of expected equilibrium profits (for firms). The vector π is also a vector of expected equilibrium profits (for firms) of the game with no discretion.

To conclude this section we wish to emphasize that our results do not hinge on our particular

[15] In our model, collusion is profitable and hence, not surprisingly, also generates *ex post* inefficiencies, as in McAfee and McMillan (1992) or Athey, Bagwell, and Sanchirico (2004).

[16] Note that we cannot conclude from Proposition 2 that the contract must be sold at the reservation price, as other equilibria exist. We note, however, that for the bidders, there is no cost associated with bidding above the others in the first stage. So there is no pressure toward low prices, and when bidders may tremble, there may even be an upward pressure, thereby making the equilibrium we exhibit quite natural.

modelling of imperfect bribe competition, nor on the particular mechanism by which offers are sent.

□ **Alternative model of bribe competition.** Limited bribe competition can be viewed as one plausible form of imperfect bribe competition. We wish to show that our insights carry over to other models of imperfect bribe competition.

To fix ideas, consider a model in which bribes consist of nonmonetary offers (trip, pool, job offer to friend or relative, etc.). Assume that each firm i may only offer bribes of some particular type and incurs a cost $\gamma(b_i)$ for delivering a bribe of size b_i. Also assume that when the bureaucrat faces the schedule $(b_1, \ldots, b_n)$, he selects firm i with probability $q_i(b_1, \ldots, b_n)$.[17] For the sake of illustration, we consider the simple case where all firms have the same cost parameter c, and where the functions $\widetilde{q}(b_i, b) = q_i(b_1, \ldots, b_n)|_{b_j=b,\ \forall\ j\neq i}$ are smooth and do not depend on the identity of i.

Proposition 4. Assume that γ is convex and that the function $\widetilde{q}_1'(b, b)$ is decreasing in b.[18] Then there exists an equilibrium in which the contract is sold at price $\overline{p}$.

The intuition is as follows. When p^* is the smallest initial price offer, bidders next compete for a prize equal to $p^* - c$. In contrast to what would happen if the prize were auctioned, the bureaucrat cannot extract the entire value of the prize (this is the sense in which bribe competition is imperfect). Firms all get positive expected profits and, under the assumption of Proposition 4, make larger expected profits when they compete for a larger prize. Hence, as in the case of limited bribe competition, they have a joint interest in choosing high initial prices.

Proof. Let p^* be smallest initial bid. When other bidders choose b, the expected profit of bidder i is equal to $\widetilde{q}(b_i, b)(p^* - c - \gamma(b_i))$. Standard computations show that the symmetric-equilibrium bribe b^* satisfies

$$p^* - c = \gamma(b^*) + \frac{\gamma'(b^*)}{n\widetilde{q}_1'(b^*, b^*)}.$$

The right-hand side is increasing in b^*, so the equilibrium bribe is increasing in p^*. It follows that the equilibrium profit $(1/n)(p^* - c - \gamma(b^*))$ is also increasing in the price p^*. Hence neither player wishes to deviate from $\overline{p}$. *Q.E.D.*

In our previous analysis, for any price $p^* > c + \overline{B}$, competition in bribes would induce firms to offer $\overline{B}$. Making a price offer equal to $\overline{p} - \Delta$ rather than $\overline{p}$ does not increase the probability of winning, it just reduces the payoff obtained when winning (from $\overline{p} - c - \overline{B}$ down to $\overline{p} - c - \overline{B} - \Delta$). In the more general model outlined above, the probability of winning does not increase either, but it is no longer the case that competition in bribes is independent of the initial price offers: smaller initial price offers induce smaller bribes in equilibrium, because the firms now fight for a smaller prize. Still, under the assumptions of Proposition 4, the overall profit is reduced when initial prices are smaller.

□ **Alternative corruption mechanisms.** The corruption stage has been described as an auction mechanism that takes place after p^* is revealed. We would like to emphasize, however, that other models of the interaction between firms and the bureaucrat would yield a conclusion similar to that of Proposition 2.

As a first illustration, we replace stages 2 and 3 of our game by the following procedure. The bureaucrat reveals the lowest price bid $p^* = \min_i p_i$ to the firms. He then makes (simultaneously and secretly) a take-it-or-leave-it offer to all firms (except the lowest bidder if there is only one):

[17] The interpretation here is that the bureaucrat's preferences over possible types of bribes are not known to the firms. Hence, from the firms' point of view, the bureaucrat's choice is a random variable. A standard functional form, which satisfies the assumption of Proposition 4, is $q_i(b_1, \ldots, b_n) = b_i/(b_1 + \cdots + b_n)$.

[18] $\widetilde{q}_1'(b, b)$ denotes the partial derivative of $\widetilde{q}(b, b)$ with respect to the first argument.

he offers an opportunity to resubmit a lower bid in exchange for a bribe of $\overline{B}$. If several firms accept, he selects one of them. We have the following proposition.

Proposition 5. Assume that $\overline{c}_2 - \underline{c} + \overline{B} < (1/n)[\overline{p} - \overline{B} - \underline{c}]$. Then under the alternative corruption stage described above, there exists a (perfect Bayesian) equilibrium where the contract is sold at the reservation price $\overline{p}$.

Intuitively, this alternative mechanism changes the way rents are shared among the firms and the bureaucrat after a deviation, but it does not affect the firms' joint interest in competing for a larger prize.

As a second illustration, consider the alternative timing where price p^* is not revealed to firms prior to bribe bidding. It is easy to check that under the conditions of Proposition 2, there exists a Bayesian equilibrium where the contract is sold at the reservation price $\overline{p}$: deviations in price offers now cannot affect competition in bribes, so collusion is even easier to support.[19]

4. Unilateral controls

■ We have assumed so far that firms have unbounded bribing capacities. We now wish to investigate the case where *one* of the firms, say firm i, is constrained in its ability to make illegal transfers. It can pay only $\overline{b}$, and $\overline{b}$ is assumed to be strictly smaller than $\overline{B}$.

There are various interpretation for this threshold. One of them is unilateral controls: above the bribe level $\overline{b}$, fines or probability of detection turn out to be very high. This captures the case when firm i comes from a country where the corruption of foreign civil servants is severely prosecuted, as, for instance, in the United States. Another interpretation is that the firms' bribe capacity reflects their connections in the host country. A firm that lacks connections (i.e., an outsider) has no effective bribing capacity. It may not know who the real decision makers are, how to approach them, how to interpret corruption offers, etc.

We start with the case of an outsider. We let c^{out} denote the cost for the outsider, and b^{out} his bribe capacity. We assume that c^{out} is drawn from $[\underline{c}, \overline{c}^{\text{out}}]$.

Proposition 6. Assume that $b^{\text{out}} = 0$ and $\overline{c}^{\text{out}} < \overline{c}_1$. Then in any Bayesian equilibrium of the game, the price p^* at which the contract is sold is below $\overline{c}_1$ with probability one.

The intuition as to why competition is restored is that the outsider has no incentives to collude: He always loses when the price is high because he cannot compete in bribes. Therefore he competes in price, which drives down the equilibrium price. An interesting implication of Proposition 6 is the effect of entry on competition in a corrupt environment. The result suggests that in this context, promoting entry (and possibly subsidizing entry) of an outsider with poor connections could turn out to reduce public spending substantially.

We now consider the more general situation in which unilateral control limits firm i's bribe capacity. We establish the following result.

Proposition 7. Suppose that firm i has bribe capacity $\overline{b} < \overline{B}$, and $\underline{c}_i < \overline{c}_1$. Also assume that other firms are not constrained. Then there cannot exist a collusive equilibrium where all firms submit a price that exceeds $\overline{c}_2 + \overline{b}$.

The intuition is that when the price is too high, firm i always loses in the bribe competition because it is constrained to a low bribing level. As a consequence, it has an incentive to undercut other firms' offers in the first round. Unilateral controls thus restore competition in price.

It is interesting to note that unilateral controls have the effect of decreasing the controlled firm's expected profit. For example, in the case where $\overline{b} = 0$, Proposition 5 implies that the expected profits of the controlled firm are at most equal to $\overline{c}_2 - c_i$ (which in Proposition 2 was assumed to be strictly smaller than $(1/n)[\overline{p} - c_i - \overline{B}]$). Our model may thus explain why firms

[19] All firms bid $\overline{p}$, and firms that can afford it bid $\overline{B}$ (these are the firms for which $\overline{p} - c_i - \overline{B} > 0$). Deviating to a lower price bid does not affect bribe bidding and so may only reduce gains (in the case of being selected).

would oppose unilateral controls on their bribing behavior: unilateral controls may force firms to compete in prices in the first stage, which may reduce their expected profits.

This explanation, however, does not appear to be consistent with the standard motive for opposing unilateral controls. Firms often complain that controls exclude them from competing effectively for some contracts, while in our model, controlled firms may actually obtain contracts with higher probability (so long as they are more efficient, an assumption that complaining firms presumably make).

The following section introduces other forms of discretion, and we will see that the comparative statics with respect to controls may change.

5. Other forms of discretion

■ A very common form of discretion is one in which the bureaucrat is allowed to choose a firm even if it did not make the lowest price offer. A common justification for such a practice is that there may be quality concerns over the way the contract will be handled, and that the bureaucrat may better assess the relative quality of each firm's offer.[20]

Our objective is to assess how the previous analysis is altered when the bureaucrat also has the option of not choosing the lowest-bidding firm (in addition to providing the opportunity to resubmit).[21]

We model the new discretion as follows. We keep stage 1 and stage 2 unchanged. Selection stage 3 becomes

Stage 3a: selection. When price offers are equal to $(p'_1, \ldots, p'_n)$, the bureaucrat is free to choose any firm i for which $p'_i \leq \min_j p'_j + \Delta$ (and $p'_i \leq \overline{p}$).

We say that the bureaucrat administers a "best-offer" procedure.[22]

We first describe collusion possibilities under this extended form of discretion, and we show that unilateral controls on a firm may deteriorate efficiency because the only effect of such controls may be to exclude that firm from being a winner.

Proposition 8. Assume that $\Delta - \overline{B} > \overline{c}_3 - \underline{c}_1$ and $\overline{p} - \overline{B} - \overline{c}_3 > 0$. Then there exists a (perfect Bayesian) equilibrium where the contract is sold at price $\overline{p}$. If $\overline{b}_i < \overline{B}$, firm i never gets the contract in equilibrium.

The intuition for the result is that when the bureaucrat has sufficient discretion in selecting a firm that is not the lowest bidder, the price that would prevent competition in bribes is so low that no firm would make any profit. In such a situation, unilateral control on a particular firm may have no effect but to exclude that firm from the market.

Discretion in the selection process is actually not the only type of discretion for which the conclusion above would hold. Indeed, it is easy to see that Proposition 8 also applies to situations where, in exchange for bribe $\overline{B}$, the bureaucrat gives or promises a favor to the winner that amounts to a reduction in costs equal to Δ. These situations include cases where the bureaucrat can affect implementation costs by awarding modifications in the contract during the course of completion, or by loosening quality controls.[23]

Since opportunities to secretly grant cost-reducing modifications are more likely for complex

[20] Quality concerns will not be modelled here, however, as we are mainly interested in how this additional discretion affects the previous analysis.

[21] This procedure should be distinguished from the procedure that selects the firm that scores best with respect to an *ex ante* set of well-defined objective criteria including quality measures. In the latter case, and as long as the components of the criteria are objectively measurable, we are in a "first-price-auction"–like situation, i.e., *ex post* the bureaucrat has no (additional) discretion.

[22] This rule bears some resemblence to that considered by Burguet and Che (2004). Our rule corresponds to the case where all firms bid the same quality q (or may bid only quality q), and where the bureaucrat may argue that one firms' quality is higher than the other.

[23] A typical example is construction contracts in which the official who awards the contract is also the one who has discretion on its *ex post* quality controls. Indeed, according to French law (Maitrise d'Ouvrage Publics et Maitrise

contracts, one interesting implication of the observations above is that unilateral controls are likely to be ineffective and even hurt efficiency in contexts where the contract sold is complex. On the other hand, unilateral controls are more likely to boost competition in the context of simple transactions such as the public purchase of standard goods.

6. Discussion and conclusion

■ In this section we summarize our theoretical results, discuss the main assumptions of our model, and conclude with some policy implications concerning controls and entry.

□ **The main insights.** Let us summarize our three main insights: (1) Corruption may affect competition because resubmission opportunities given by a corrupt bureaucrat provide firms with a mechanism to enforce collusion in price. The effect on contract price goes far beyond the mechanical price increase that might result from firms expecting to pay some given bribe to the bureaucrat. (2) Controlling (even a few) firms may be very effective in this context, because it forces the controlled firms to compete in prices, thereby restoring price competition. (3) When the bureaucrat can offer additional favors, either during the allocation process (by evaluating the firm's proposal favorably) or during implementation (by readjusting the contract in a way favorable to the winning firm), then placing controls on only a few firms may become ineffective, as the sole effect of these controls may be to exclude the controlled firms from competing.

□ **Discussion of the main assumptions.** Our analysis is based on the ability of bureaucrats to provide favors: the possibility that a firm may be offered an opportunity to readjust its bid, or the existence of discretion that can be abused to bias competition toward a particular subset of firms. We wish to discuss the relevance of these two types of favors, as well as the extent to which existing laws prevent abuses. Our analysis also implicitly assumes that the reservation price $\overline{p}$ is public and high compared to cost levels. We briefly address the empirical relevance of this assumption.

Bid readjustments. Manipulation of envelopes is an obvious way by which bids may be readjusted. In some contexts, there are easy ways to reduce this risk. There are, however, many contexts in which it is difficult to prevent readjustments of offers. One such context is complex contracts. Firms could (possibly voluntarily) leave some ambiguity in the formulation of their proposals. Before the bureaucrat decides which firm will receive the contract, these ambiguities have to be resolved. A request to clarify an offer may then provide opportunities to the firm to match other bidders' offers. Of course, legislation often prevents prices from being modified. However, in contractual environments where both the price bid and the quality of the offer are taken into account (such as construction contracts), readjustments are more difficult to prevent. A low-price (deviating) offer can be matched by a proposal that has been properly readjusted in its quality components.

The possibility that the bureaucrat communicates with one or several firms so that they may clarify the content of their offer is simply acknowledged by the French Code on Procurement, article 95 bis. Other codes include explicit procedures to be followed when dealing with ambiguities. In the World Bank's (1997) guidelines for international competitive bidding (ICB), all requests for clarification as well as the bidder's response must be made in writing (article 2.45). The same concerns about abuses with respect to clarifications can be found in the Russian code (article 42, Prikaz n. 117), which provides precise rules for how to deal with arithmetical errors; for example, in cases where the total price does not correspond to the sum of the prices, the latter prevails (Ministerstvo Ekonomiki, 1997).

d'Oeuvre Privée, Loi no. 85-704), the public buyer can delegate to a private agent (Maitre d'Oeuvre) the administration of the market. This includes (i) the elaboration of the bidding documents, (ii) assistance in the allocation process of the contract, and (iii) controls during implementation of the contract.

Sources of discretion. Many types of favors may be provided in the course of implementation of the contract.[24] Contract modifications are an obvious candidate. More generally, we have in mind any decision taken by the bureaucrat after the allocation of the contract that leads to a significant cost reduction to the winner. Such cost-reducing decisions are in principle forbidden by law, at least when they occur shortly after the allocation of the contract (see, for example, article 95 ter, Code des marchés publics). However, some cost-reducing decisions can be difficult to detect: they include, for example, the tightness of the controls concerning the realization of the contract, or the decision to reduce penalties for late completion when "good" reasons can be found for doing so.

One remedy might be to separate allocation and implementation, so that the bureaucrat in charge of allocation cannot make any promise concerning implementation. We note, however, that separation may be undesirable, as it prevents having a single bureaucrat accountable for the realization of the public project.

The reservation price. The reservation price $\overline{p}$ plays an important role in the analysis. The fact that firms bid $\overline{p}$ will be disruptive only if $\overline{p}$ is significantly higher than the lowest cost. Also, our analysis (seemingly) requires that $\overline{p}$ be public information to the firms. We discuss each assumption in turn.

(i) According to the World Bank's (1997) ICB guidelines, article 2.61 (and as is the practice in the French Ministry of Equipment), a public buyer should consider rejecting all bids when the lowest bids significantly exceed his own cost estimate (in France, by about 25%). This still leaves a reasonable margin for collusive gains and distortive effects.

(ii) With respect to our assumption that $\overline{p}$ is public information to the firms, it is true that, as noted in McAfee and McMillan (1992), reservation prices are, in practice, often kept secret. This procedure is sometimes explained as an anti-cartel device. In our context, revealing the reserve price presumably facilitates coordination in the price-bidding stage. Coordination at this stage, however, is not key to our result. In the case of a reservation price that would be secret to the bidders (but known to the bureaucrat), the bureaucrat could disclose the value of the reserve price in the bribing stage (say, in case the lowest bid lies above that reserve price). Our insights would thus carry over to the case of a secret reserve price.

□ **Policy implications.** Let us conclude with two types of policy implications on controls and entry policy. Our analysis allows us to contrast the impact of controls on bureaucrats versus controls on firms. Proposition 3 shows that controls on firms work when they prevent a rather efficient firm from competing in bribes; then this firm is left with no choice but to compete in prices, thus forcing the others to compete in prices too. Tighter controls on bureaucrats, in contrast, do not seem to be very effective in our context. Indeed, one interpretation of the threshold $\overline{B}$ is that because of controls, the bureaucrat cannot take the risk of accepting a bribe larger than $\overline{B}$ or, more generally, that the value to the bureaucrat of accepting a bribe b has a maximum at $\overline{B}$. Then reducing $\overline{B}$ does not appear to reduce firms' ability to collude, but only to enlarge the total profits realized by firms.[25]

Finally, our model also has implications for entry policy. Proposition 3 suggests that one way to break collusion and corruption is to introduce a low-cost entrant whose bribe capacity is low.

[24] These are post-allocation favors. Pre-allocation favors are also frequent. To reduce discretion in the allocation process, proposals are often evaluated according to predefined criteria. Such criteria, however, may be tailored *ex ante* to a particular firm's (or subset of firms') comparative advantages. Firms that cannot offer a bribe may then be discriminated against in competition.

[25] We would not conclude, however, that weaker controls diminish the scope for collusion. It is, after all, in the bureaucrat's interest that collusion be sustainable. If asking for the largest possible bribe were to destroy collusion (and ultimately the benefits of corruption for the bureaucrat), then the bureaucrat would have an incentive to commit to a reasonably low upper bound on bribes, or to build a reputation for not accepting bribes that would be too large.

In other words, this suggests that promoting and even subsidizing the entry of an outsider who lacks connections to the local corruption network can be quite efficient in securing competition in procurement contracts.[26]

Appendix

■ Proofs of Propositions 1 through 8 follow.

Proof of Proposition 1. Consider a (Bayesian) equilibrium σ. For any realization $(p_1, \ldots, p_n)$ of the price bids, we let $p^* = \min\{p_1, \ldots, p_n, \overline{p}\}$. Our aim is to show that for any $\varepsilon > 0$, the probability

$$Q(\varepsilon) \equiv \Pr_\sigma\{p^* > \overline{c}_2 + \varepsilon\}$$

is equal to zero. Fix $\varepsilon > 0$ and suppose by contradiction that $Q(\varepsilon) > 0$. Before proceeding, we define

$$\overline{p}_i = \sup\{p, \Pr_{\sigma_i}\{p_i > p\} > 0\}.$$

Price $\overline{p}_i$ can be interpreted as the highest price chosen by firm i in equilibrium. We also define

$$Q_i = \lim_{p_i \nearrow \overline{p}_i} \Pr_{\sigma_i}\{p_i > p\}.$$

We proceed in steps.

Step 1. Whatever its own cost c_i, each firm $i \in \{1, 2\}$ must make a profit at least equal to $\varepsilon Q(\varepsilon)$ in equilibrium. Indeed, since firms 1 and 2's costs are bounded by $\overline{c}_2$, whatever its costs $c_i \leq \overline{c}_2$, each firm $i \in \{1, 2\}$ may secure an expected profit at least equal to $\varepsilon Q(\varepsilon)$ by bidding $\overline{c}_2 + \varepsilon$, hence its equilibrium profit is at least equal to $\varepsilon Q(\varepsilon)$ too (otherwise, bidding $\overline{c}_2 + \varepsilon$ would be a profitable deviation).

Step 2. We must have $\overline{p}_1 = \overline{p}_2$ and $Q_i > 0$ for $i = 1, 2$. Indeed, if $\overline{p}_1 < \overline{p}_2$, then firm 2 makes zero profits when choosing $p > \overline{p}_1$. Since firm 2 is supposed to obtain at least $\varepsilon Q(\varepsilon)$ in equilibrium, the probability that firm 2 chooses a price strictly above $\overline{p}_1$ in equilibrium must be equal to zero, contradicting $\overline{p}_2 > \overline{p}_1$. By the same argument, we cannot have $\overline{p}_2 < \overline{p}_1$.

Now assume that $\overline{p}_1 = \overline{p}_2$ and $Q_1 = 0$. If firm 2 chooses a price $p \in (\overline{p}_1 - \eta, \overline{p}_2]$, then its expected profit is at most equal to

$$[\overline{p}_2 - \underline{c}] \Pr_{\sigma_1}\{p_1 > \overline{p}_1 - \eta\}.$$

Since $Q_1 = 0$, this profit gets arbitrarily small when η tends to zero (hence smaller $\varepsilon Q(\varepsilon)$). It follows that there must exist $\eta > 0$ such that firm 2 never bids above $\overline{p}_1 - \eta$, implying that $\overline{p}_2 \leq \overline{p}_1 - \eta$, hence contradicting $\overline{p}_2 = \overline{p}_1$.

Step 3. We cannot have $\overline{p}_1 = \overline{p}_2$ and $Q_i > 0$ for $i = 1, 2$ in equilibrium. Indeed, either firm 1 or firm 2, say firm 2, would strictly prefer to bid slightly below $\overline{p}_1$, contradicting $Q_2 > 0$. *Q.E.D.*

Proof of Proposition 2. A strategy for firm i specifies a price p_i (which may depend on c_i) and a bribe b_i (which may depend on p_i, p^*, and c_i). A strategy for the bureaucrat specifies a firm i^* that is allowed to resubmit (as a function of the bribe and initial price profiles), and a firm that gets the contract (as a function of the bribe, initial, and official price profiles). We test whether submitting $\overline{p}$ in the first stage is part of an equilibrium strategy.

Concerning the strategies of the firms, we propose that (i) each firm i submits $p_i = \overline{p}$ in the first round; (ii) if the realized minimum price $p^* = \min p_i$ satisfies $p^* - \overline{B} - \overline{c}_2 > 0$, then each firm i submits the maximum bribe below $\overline{B}$ it can afford (that is, $b_i = \overline{B}$ if $p^* - c_i - \overline{B} > 0$, $b_i = p^* - c_i$ if $p^* \in (c_i, c_i + \overline{B}]$, and no bribe otherwise); (iii) if $p^* > \overline{c}_2$ and $p^* \leq \overline{B} + \overline{c}_2$, players keep the same priors concerning firm 1 and 2's cost parameters, and we choose (any) continuation strategies forming a Bayesian equilibrium of the continuation game; (iv) if $p^* \leq \overline{c}_2$, we choose any continuation strategies forming a Bayesian equilibrium of the continuation game; and (v) firm i, if selected by the bureaucrat, submits p^* as its official price.

Concerning the strategy of the bureaucrat, we propose that he selects the firm allowed to resubmit as follows. Let b^* denote the highest bribe offer below $\overline{B}$. Given the bureaucrat's preferences, it is sufficient to describe which firm he selects in case of ties. In this case, he selects each of them with equal probability unless one of them, say firm i, made a price offer p_i strictly below the others. In the latter case, he selects firm i with probability $1/n$, and the other(s) with equal

[26] Obviously, a controversial aspect of such a policy is that it can be manipulated by governments for protectionist or mercantilist reasons, thereby impeding the smooth functioning of international trade transactions.

probability. Finally, in the last stage, the bureaucrat gives the contract to i^* (the firm selected in the bribe-competition stage) if its official price is no larger than p^*, and to any other firm i such that $p_i = p^*$ otherwise.[27]

When firms conform to the above strategy, any firm with cost parameter c such that $\overline{p} - c - \overline{B} \geq 0$ obtains the contract with probability at least equal to $1/n$ and hence makes an expected profit at least equal to

$$\frac{1}{n}[\overline{p} - c - \overline{B}].$$

Assume now that firm k deviates and chooses a price $p_k < \overline{p}$. Then $p^* = p_k$, and firms next submit bribe offers. We distinguish three cases.

Case 1. $p^* - \overline{c}_2 > \overline{B}$. Under the proposed continuation strategies, both firm 1 and firm 2 submit a bribe offer equal to $\overline{B}$, and firm k therefore obtains an expected profit at most equal to $\max\{\frac{1}{n}[p^* - c - \overline{B}], 0\}$, which is no larger than the profit it would have obtained by bidding $\overline{p}$ in the first round (thus the deviation is not worthwhile). The proposed continuation strategies are in equilibrium, because any firm that submits bribe offers according to these strategies makes positive expected profits (even strictly positive for firm 1 and 2), and any firm that bids differently makes at most zero profits (firm i is not selected if $b_i \neq \overline{B}$, and it makes negative expected profits if $b_i = \overline{B}$ and $p^* - c_i < \overline{B}$).

Case 2. $0 < p^* - \overline{c}_2 \leq \overline{B}$. We claim the following (to be proved shortly):

Claim A1. Assume that $0 < p^* - \overline{c}_2 \leq \overline{B}$ and let $B^* \equiv p^* - \overline{c}_2$. Then in any continuation equilibrium, with probability one, at least one firm submits a bribe offer at least equal to B^*.

The intuition of this claim is that the subgame is a standard first-price auction in bribes where the value of the object for firm i is distributed on $[\underline{b}_i, \overline{b}]$, with $\overline{b} = p^* - \underline{c}$ and $\underline{b}_i = p^* - \overline{c}_i$. For a reason similar to Proposition 1, the equilibrium bid is at least equal to $\underline{b}_2 = p^* - \overline{c}_2 (= B^*)$.

Given Claim A1, any firm getting the contract in equilibrium must therefore pay a bribe at least equal to B^*, which yields a profit at most equal to

$$p^* - c - B^* = \overline{c}_2 - c.$$

Under the conditions of Proposition 2, we have that $\overline{c}_2 - c < (1/n)[\overline{p} - c - \overline{B}]$, and hence the deviation is not profitable.

Claim 3. $p^* \leq \overline{c}_2$. Then the gain from the deviation is at most equal to $\overline{c}_2 - \underline{c}$, and hence it is not profitable. *Q.E.D.*

Proof of Claim A1. We show that in any continuation equilibrium, with probability one, at least one firm chooses a bribe offer at least equal to B^*. Choose any $\widehat{b} < B^*$. Assume by contradiction that with positive probability, all firms choose a bribe below $\widehat{b}$. Then by choosing a bribe offer b such that $\widehat{b} < b < B^*$, any firm with a cost parameter $c \leq \overline{c}_2$ makes an expected profit bounded away from zero (since $p^* - b - \overline{c}_2 > 0$). In particular this is true for firms 1 and 2. Let σ_i denote the strategy followed by firm i and define

$$\underline{b}_i = \inf\{b, \Pr_{\sigma_i}(b_i < b \mid p^*, p_i) > 0\}.$$

That is, $\underline{b}_i$ may be interpreted as the lowest bribe offer made by firm i under σ_i. We also let

$$Q_i = \lim_{b \searrow \underline{b}_i} \Pr_{\sigma_i}(b_i < b \mid p^*, p_i).$$

By an argument similar to the one in Proposition 1, we must have that $\underline{b}_1 = \underline{b}_2 = \underline{b}$ and $Q_i > 0$, for $i = 1, 2$. (This is because if $\underline{b}_1 < \underline{b}_2$, or if $\underline{b}_1 = \underline{b}_2$ and $Q_2 = 0$, firm 1 would obtain profits close to zero by choosing a bribe b close to $\underline{b}_1$, contradicting the fact that firm 1 must get expected profits bounded away from zero in the continuation equilibrium.) But when $Q_1 > 0$ and $Q_2 > 0$, either firm 1 or firm 2 strictly prefers to make a slightly higher bribe offer, yielding a contradiction. We may thus conclude that with probability one, at least one firm chooses a bribe offer at least equal to $\widehat{b}$. Since this is true for any $\widehat{b} < B^*$, we get the desired conclusion. *Q.E.D.*

Proof of Proposition 3. Consider a collusive equilibrium σ^* in which the contract is sold at price $\widetilde{p} > \overline{c}_2$.[28] We use the strategy profile σ^* to construct a strategy profile for the game without corruption. We consider the strategy for firm i that consists of bidding $p_i = \widetilde{p} - b_i$ whenever it would have bid $b_i \geq 0$ on the equilibrium path of σ^* and $p_i = \widehat{p} > \overline{p}$

[27] There are other strategies by the bureaucrat that also allow firms to sustain collusion. We choose this particular one because it facilitates computations.

[28] Note that in a collusive equilibrium, even a firm i for which $c_i > \widetilde{p}$ participates and bids $\widetilde{p}$ in the first round. It does not make negative profits, however, because since $\widetilde{p} > \overline{c}_2$, the highest bribe offer must be strictly positive and hence firm i may avoid getting the contract by making a bribe offer equal to zero in the bribing stage. Also note that Proposition 3 would also hold if we assumed that in a collusive equilibrium in which the contract is sold at $\widetilde{p}$, only firms for which c_i is no larger than $\widetilde{p}$ participate (or bid seriously).

otherwise. These strategies generate the same profile of expected profits. Note in particular that no firms make negative profits under this strategy profile (see also footnote 28). Firm i does not have an incentive to deviate to some other $p_i' \leq \widetilde{p}$, because if this were the case, it would also have an incentive to deviate to $b_i' = \widetilde{p} - p_i'$ in the game with corruption. It does not have an incentive to deviate to $p_i' > \widetilde{p}$ either, because it would obtain zero profits by doing so (since other firms choose a price no larger than $\widetilde{p}$). *Q.E.D.*

Proof of Proposition 4. The proof follows the steps of Proposition 2. Concerning the strategy of the firms, the only difference is that each firm i may now either accept or reject the proposal of the bureaucrat (to pay $\overline{B}$ in exchange for the right to resubmit). We propose that any firm that can afford to accept does accept. Concerning the strategy of the bureaucrat, he selects one firm from the pool of firms that have accepted (if at least one has accepted); otherwise he selects any firm that has offered the minimum price offer p^*.

When firms conform to the above strategy profile, any firm with cost parameter c such that $\overline{p} - c - \overline{B} \geq 0$ obtains the contract with probability at least equal to $1/n$ (as in Proposition 2) and hence makes an expected profit at least equal to

$$\frac{1}{n}[\overline{p} - c - \overline{B}].$$

Assume now that firm k deviates and chooses a price $p_k < \overline{p}$. Then $p^* = p_k$, and the bureaucrat makes a take-it-or-leave-it offer to the firms. We distinguish two cases.

Case 1. $p^* - \overline{c}_2 > \overline{B}$. Under the proposed continuation strategies, both firm 1 and firm 2 would accept the bureaucrat's proposal. Firm k therefore obtains a profit equal to zero. The proposed continuation strategies are in equilibrium because as soon as one firm i is willing to accept, any firm that can afford to accept prefers to accept.

Case 2. $p^* - \overline{c}_2 \leq \overline{B}$. Then firm k makes a profit at most equal to $\overline{c}_2 + \overline{B} - c$, which is smaller than $(1/n)[\overline{p} - c - \overline{B}]$ by assumption. *Q.E.D.*

Proof of Proposition 5. Consider a Bayesian equilibrium. We first show that if the outsider chooses a price $p^{\text{out}} > \overline{c}_1$, then it makes zero profits. Indeed, when the outsider chooses $p^{\text{out}} > \overline{c}_1$, then (i) either $p^{\text{out}} > \min\{p_i\}$ and the outsider cannot get the contract because it cannot participate in the corruption game, or (ii) $p^{\text{out}} = \min\{p_i\}$.

Consider the continuation game and assume that the outsider gets the contract with probability $q > 0$. Let Q denote the probability that $b_i = 0$ for all $i \neq 1$. We must have $q \leq Q$, since the outsider may getonly the object when $b_i = 0$ for all i. By choosing $b_1 = 0$, firm 1 obtains at most $(Q - q)(p^{\text{out}} - c_1)$. By choosing $b_1 = \varepsilon > 0$, firm 1 obtains the contract with probability at least equal to Q and hence gets an expected profit at least equal to $Q(p^{\text{out}} - c_1 - \varepsilon)$, which is strictly larger than $(Q - q)(p^{\text{out}} - c_1)$ when ε is small enough (since $p^{\text{out}} > \overline{c}_1$). Hence choosing $b_1 = 0$ cannot be optimal for firm 1, contradicting the hypothesis $q > 0$. So if $p^{\text{out}} > \overline{c}_1$, the outsider cannot get the contract in equilibrium and hence makes zero profits. Yet if the outsider bids $p^{\text{out}} \in (\overline{c}^{\text{out}}, \overline{c}_1)$, it can secure itself a strictly positive expected profit (since with some positive probability no firm can match its bid in the bribe auction). It follows that in equilibrium at least one firm (the outsider) bids below $\overline{c}_1$. *Q.E.D.*

Proof of Proposition 6. Assume by contradiction that there exists a collusive equilibrium where all firms submit a price $\widetilde{p} > \overline{c}_2 + \overline{b}$. Consider the subgame where each firm i has chosen $\widetilde{p}$, and assume that in the continuation equilibrium, there is a positive probability that the maximal bribe offer b^* is no larger than $\overline{b}$. Then both firm 1 and firm 2 would make positive expected profits, whatever their cost parameters $c_1, c_2 \leq \overline{c}_2$ are (because each one could choose a bribe slightly larger than $\overline{b}$). By the same argument as the one developed in Proposition 2, we obtain a contradiction. So in equilibrium, with probability one, at least one firm must choose a bribe offer exceeding strictly $\overline{b}$. Hence firm i would obtain zero profit in equilibrium.

However, firm i can secure a strictly positive expected profit by choosing p_i such that $c_i < p_i < \overline{c}_1$ (since with positive probability, no firm will then be able to match price p_i). Hence it cannot be that all firms choose contract prices above $\overline{c}_2 + \overline{b}$ with probability one in equilibrium. *Q.E.D.*

Proof of Proposition 7. We follow the steps of Proposition 2 and test whether $p_i = \overline{p}$ for all firms is part of an equilibrium. The strategies we propose for the firms are such that (i) all firms submit $\overline{p}$ in the first round; (ii) if the realized minimum price $p^* = \min p_i$ is no smaller than $\underline{c} > 0$, then each firm $j \in \{1, 2, 3\}$ submits the maximum bribe below $\overline{B}$ it is allowed to offer; (iii) a firm, if selected, resubmits a price $p_i' = \min\{p_i, p^* + \Delta\}$.

Concerning the strategy of the bureaucrat when selecting a firm allowed to resubmit, we propose the same strategy as the one proposed in the proof of Proposition 2. We also propose that the bureaucrat gives the contract to the selected firm if $p_i' \leq \min\{p_i, p^* + \Delta\}$.

When firms conform to the above strategy profile, firm i (the constrained firm) obtains zero profits because it cannot match the bribes $\overline{B}$ offered by at least two other firms. Any firm with cost parameter c such that $\overline{p} - c - \overline{B} > 0$ obtains the contract with probability at least equal to $1/(n-1)$ and hence makes an expected profit at least equal to

$$\frac{1}{n-1}[\overline{p} - c - \overline{B}].$$

First observe that no firm may obtain strictly positive profits by choosing a price below or equal to $\underline{c}$. Also observe

that in any continuation game where $p^* \in (\underline{c}, \overline{p})$, at least two firms among $\{1, 2, 3\}$ submit a bribe offer equal to $\overline{B}$ (because at most one is constrained). It is indeed optimal for an unconstrained firm to do so because this is its only chance to get selected, and if it is selected, it obtains a profit at least equal to $\min\{p^* + \Delta, \overline{p}\} - \overline{B} - \overline{c}_3$, which is positive under the conditions of Proposition 7, since $p^* > \underline{c}$.

It follows from the above observations that no deviation of the constrained firm i can generate strictly positive profits (because it cannot match $\overline{B}$). Since for any $p^* \in (\underline{c}, \overline{p})$ there are always at least two firms offering $\overline{B}$, any unconstrained firm cannot improve the probability of being selected by deviating. Thus no unconstrained firm has a profitable deviation either. *Q.E.D.*

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