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Corruption and Renegotiation in Procurement

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Abstract

A sponsor –e.g. a government agency– uses a procurement auction to select a supplier who will be in charge of the execution of a contract. That contract is incomplete: it may be renegotiated once the auction's winner has been chosen. We examine a setting where one firm may bribe the agent in charge of monitoring contract execution so that the former is treated preferentially if renegotiation actually occurs. If a bribe is accepted, the corrupt firm will be more aggressive at the initial auction and thus win with a larger probability. We show that the equilibrium probability of corruption is larger when the initial contract is less complete, when the corrupt firm's cost is more likely to be similar to her rivals', and when it faces fewer competitors.

Keywords: Auctions, Cost overruns, Procurement, Renegotiation, Corruption.

JEL classification: C72, D44, D82.

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1 Introduction

Public procurement processes are vulnerable to corruption[1] which generates sizable costs for public administrations: higher expenses, lower quality of goods, services, and works, inefficient allocations, distortion of competition, etc.[2] This explains the efforts by governments and international organizations to reduce corruption in procurement by enforcing regulations intended to guarantee that each procurement process is open and has been announced well in advance, that the awarding procedure is not biased and that it is monitored by third parties. In this paper, however, we study a subtle way in which corruption may influence the process while not being detected or prevented by these procurement regulations, which mainly focus on the competitive phase. We study the impact that corruption may have on the whole process when it operates at one specific stage of the procurement process: renegotiation.

We provide a specific model where the contract is designed, auctioned, possibly renegotiated, and finally executed. Between contract design and the auction itself, a firm may bribe the agent to gain a larger share of the renegotiation surplus when renegotiation actually happens. We characterize the optimal bribe to be offered by the corrupt firm and the equilibrium level of corruption. Our analysis delivers several insights. First, when corruption takes place through this renegotiation channel, the pattern is as follows: prices are lower at the procurement stage but are higher at the end of the process (including the renegotiation payments); and, more importantly, corruption generates inefficiencies at the allocation stage, since the wining firm may not be the most efficient supplier. Second, the optimal bribe falls –and thus corruption is less likely– when the contract awarded through the auction is more complete. In other words, a contract that leaves less room for renego-

[1] The OECD Foreign Bribery Report (2014) provides evidence of the vulnerability of public procurement to corruption. Almost two-thirds of the foreign bribery cases analyzed occurred in sectors closely associated with contracts or licensing through public procurement, such as the extractive, construction, transportation and storage, and information and communication sectors.

[2] For example, the European Union estimated that the cost of corruption was 120 billion per year (European Commission, 2014), representing approximately 1% of the EU GDP and slightly less than the EU's annual budget of 143 billion in 2014.

tiation reduces the influence of the form of corruption we examine. Third, the equilibrium probability of corruption is larger when the corrupt firm's cost is more likely to be similar to her rivals'. Better treatment at the renegotiation stage yields a given advantage for the corrupt firm. That advantage is more valuable when it is more probable that it becomes decisive in making the corrupt firm win. Then, it becomes more valuable, generating higher bribes, when the corrupt firm is more similar, in terms of costs, to her rivals. Fourth, the equilibrium probability of corruption falls when the number of rivals that the corrupt bidder faces becomes larger. The given advantage generated by corruption is less likely to be decisive when the lowest-cost rival of the corrupt bidder is more efficient, as happens when the number of bidders grows.

These results are interesting for the corruption literature, when relating corruption with a market's competitiveness. Cost dispersion is, in general, directly related to firms' rents and, then, it can be interpreted as one signal of competition in a particular industry. Therefore, we can read our third result as stating that more competitive markets (in which firm's costs differences are small) with low firm profits are more vulnerable to corruption when it takes place through this procurement renegotiation channel. However, according to our last result, when the market is more competitive because the number of bidders is larger, it is less likely to be distorted by corruption.[3]

Our way of modeling corruption is very likely to be important in reality since renegotiation is prominent in public procurement, as shown for example in Bajari et al (2014) and Decarolis and Palumbo (2015). Moreover, this form of "competitive corruption" fits well with the Odebrecht corruption case described in Campos et al.(2021). In that case, corruption emerged in a construction sector characterized by its competitiveness and low firm profits.

During the period 2001-2016, Odebrecht –the largest engineering and construction com-

[3]Rose-Ackerman was one of the first scholars promoting the idea that as competition reduces rents, it also leads to lower corruption. In her book, Rose-Ackerman (1996), she states: "In general any reform that increases the competitiveness of the economy helps reduce corrupt incentives." Our results indicate that the reduction in rents associated with competition can lead to either more or less corruption, depending on whether it is driven by lower cost dispersion or by a higher number of competitors.

pany in Latin America– bribed about 600 politicians and public servants in 10 Latin American countries. According to the US Department of Justice (2016), this corruption case was the largest foreign bribery case in history, accounting for 788 millions of dollars in bribes.

Although, in exchange for the bribes, Odebrecht asked for several ways to be favored, the most prominent one was obtaining higher prices during the renegotiation process. Campos et al.(2021) shows that renegotiation revenues in Odebrecht's projects for which there is evidence of corruption were higher than in regular projects. As the theoretical discussion of the case in Campos et al.(2020) and our model predict, this renegotiation advantage translated into an advantage at the bidding stage. Odebrecht multiplied its contracts by a factor higher than 8 between 2003 and 2016 due to its corrupt practices.

Our work relates to the literature on renegotiation and cost overruns in procurement, particularly the frameworks of Bajari and Tadelis (2001) and Ganuza (2007), where the project sponsor lacks full information about the optimal design and bidders anticipate renegotiation and adjust their bids accordingly.

Our analysis is connected as well to the literature on favoritism -e.g. Laffont and Tirole (1991), McAfee and McMillan (1989) and Naegelen and Mougeot (1998)– that examines the case where the sponsor herself would prefer that, at a given price, some potential contractors win and not others, as happens when advantages are conferred to local or national firms over their foreign competitors. In particular, our model relies on Arozamena, Ganuza and Weinschelbaum (2023), which shows how renegotiation of the contract can be a way to implement favoritism even when the sponsor is constrained to use a symmetric auction mechanism. Here, whether one firm is favored or not follows from a bribing game where an agent of the sponsor may not act in her principal's best interests.

Finally, our work relates to the literature on corruption in procurement, and in particular to Campos et al. (2020). The model in that paper also points at renegotiation as a way in which a corrupt firm may be favored. There are two main differences with our approach, though. First, they take the probability of corruption as given and view the authority's bias as a result of a bribing contest where one potential supplier holds an advantage -a more efficient bribing technology. Here, we take the favored supplier's identity as given but corruption may or not take place. This depends on the outcome of a bribing game that is determined by the potential surplus generated by the corruption coalition. This allows us to analyze the factors that may impact on the probability of corruption. Second, they examine a setting where the contract to be auctioned off is fixed, while we show that unequal treatment in renegotiation influences contract design.[4]

The rest of the paper proceeds as follows. Section 2 below lays out our model in the two-bidder case, describing how the procurement contract is designed, how the auction is carried out and how renegotiation, if necessary, may proceed. Section 3 describes the equilibrium behavior that follows. Section 4 extends the analysis to the context where there may be more than two bidders. Finally, Section 5 concludes.

2 The Model

A sponsor has to hire a contractor to carry out a single, indivisible project. Initially, we assume that one of two potential suppliers will be selected through an auction, we will discuss later the case of N bidders. The auction and contract execution will be run by a procurement agent that may be corrupt. We describe in detail now the interaction among all parties involved in specifying, auctioning and carrying out the project.[5]

1. *Contract specification*

   The optimal specification of the project is uncertain. There is a set of possible contingencies (states of nature) W that may arise during project execution. The contingency that actually occurs determines the optimal design. The sponsor decides which contingencies will be anticipated in the contract and which will not. Let $e \in [0, 1]$ be the effort chosen by the sponsor in specifying the contract. Then, $W^C(e) \subset W$ will be the

[4]The study of how corruption may impact the design stage has been absent in the literature. See Burguet, Ganuza and Montalvo (2018) for a survey.

[5]We model the stages involved in the procurement process along the lines in Arozamena, Ganuza and Weinschelbaum (2023).

set of contingencies covered in the contract. Contractually specifying designs for each contingency is costly, though, so the contract chosen will be incomplete. Specifically, let $k(e)$ be the cost of selecting a specification effort e, where $k'(e), k''(e) > 0$, $k'(0) = 0$ and $\lim_{e \to 1} k(e) = \infty$. A larger value of e means that more contingencies are covered: if $e' < e''$, then $W^C(e') \subset W^C(e'')$. The sponsor values the project at v if it is carried out with the exact design that corresponds to the state of nature that occurs during contract execution –for simplicity, we assume that she values the project at zero if not. Then, as we will see below, if the contingency that occurs is not covered in the initial specification, the contract will have to be renegotiated. To simplify, we assume that if the specification effort selected is e, then the probability that the contingency actually occurring is covered in contract $W^C(e)$ is also e.

2. Bribing stage

   The procurement agent that will run the project may be bribed. One of the potential contractors, firm 1, offers a bribe b to her in exchange for preferential treatment if renegotiation is necessary. We describe in detail how firm 1 will be favored when we introduce the renegotiation stage below. If the procurement agent takes the bribe, she incurs a cost τ. This cost includes expected penalties, but possibly idiosyncratic factors related to moral costs as well. Cost τ is distributed according to a c.d.f. $G(.)$ that is continuous, strictly increasing, and has a density $g(.)$. We assume that $x + \frac{G(x)}{g(x)}$ is increasing. Initially, then, the procurement agent learns the value of τ (her private information), and firm 1 makes an offer. The agent can only accept or reject that offer.

3. Auction

   A contractor is selected to carry out contract $W^C(e)$ through a second-price, sealed-bid auction.[6] So as to simplify, we assume that, for any $W^C(e)$, firms' costs of executing

[6]Given that, due to corruption, bidders may not be symmetric ex ante, revenue equivalence will not hold under our assumptions. Still, our results should be qualitatively valid for any auction format. We use the second price auction since it greatly simplifies our analysis.

the project are i.i.d. Specifically, firm i's cost is distributed uniformly on the interval $[c - B, c + B]$, $i = 1, 2$, where $B > 0$. Then, c is both firm's expected costs, and B provides a measure of cost dispersion in the market. Both firms learn their costs, which are private information, before the auction takes place. Note that we are assuming, for simplicity, that expected costs are independent of contract specification.

4. Contract execution and renegotiation

   As we mentioned above, the actual contingency occurring, which we will denote by w^*, is revealed after the auction but before contract execution. If $w^* \in W^C(e)$ (which happens with probability e), the initial contract can be implemented by the winning bidder without changes. However, if $w^* \notin W^C(e)$, the procurement agent and the winning contractor have to renegotiate the contract so that its execution yields value to the sponsor.[7] The cost of adapting the contract to the new contingency w^* is $c_{w^*} < v$ for any contractor.[8] We model renegotiation as a two-stage variation of that in Bajari and Tadelis (2001). First, renegotiation effort λ is chosen by the procurement agent. The cost of effort is given by $\beta\lambda^2/2$, where $\beta > 0$ captures the agent's bargaining efficiency. At the second stage, with probability $\lambda > 0$ the agent makes a take-it-or-leave-it (TIOLI) offer to the contractor, and with probability $1 - \lambda > 0$ it is the winning firm that makes the TIOLI offer. If the agent has not taken a bribe from firm 1 or firm 1 has not won the auction, she will select a renegotiation effort that maximizes the sponsor's expected utility. However, if she has taken a bribe and firm 1 won, she will treat the bribing firm preferentially. She will act as a representative of firm 1 and select $\lambda = 0$.[9] Once renegotiation (if necessary) is over, the contract is executed. We assume that $v \geq c + B + c_{w^*}$, so that the project should be carried out even if renegotiation is certain.

[7]Given a contract, the procurement agent cannot determine whether renegotiation is needed or not. She may only influence how renegotiation is carried out.

[8]We simplify greatly by assuming that c_{w^*} is independent of the initial contract and the exact contingency that occurs.

[9]The agent may face constraints that impose a minimum but positive value of λ. Since our results would not change with those constraints, we assume they do not exist.

3 Equilibrium

We solve the model backwards, starting at the final stage in renegotiation.

3.1 Renegotiation.

Recall that, under our assumptions, the surplus from renegotiation, $v - c_{w^*}$, will always be generated. Given that the procurement agent has chosen a renegotiation effort λ, if that agent makes a TIOLI offer (which happens with probability λ) she will just compensate the winning contractor for the adaptation cost c_{w^*}. If the contractor makes the offer (which happens with probability $1-\lambda$), she will be paid v and seize the entire renegotiation surplus. Then, the contractor's expected profit from renegotiation is $(1-\lambda)(v - c_{w^*})$, while the sponsor's expected profit is $\lambda(v - c_{w^*})$.

At the first stage of renegotiation, λ is chosen by the agent. If the auction's winner is firm 1 and a bribe has been accepted, as we mentioned above, the agent will choose $\lambda = 0$, ensuring that the corrupt firm seizes all the surplus. In any other circumstance, the agent will solve

$$\max_{\lambda \in [0,1]} \quad \lambda(v - c_{w^*}) - \beta \frac{\lambda^2}{2}.$$

so that

$$\lambda^* = \frac{(v - c_{w^*})}{\beta}$$

Any firm not bribing will have expected profit from renegotiation

$$\pi^R = (1 - \lambda^*)(v - c_{w^*}) = (1 - \frac{v - c_{w^*}}{\beta})(v - c_{w^*})$$

If firm 1 has successfully bribed the agent, though, its surplus from renegotiation is

$$\pi^{Rc} = (v - c_{w^*}) > \pi^R$$

Then, the bribing firm will hold an advantage when bidding, as we will see below.

3.2 Awarding process. The second-price auction.

We move back now to the second-price auction. For any participating firm, it is weakly dominant to submit a bid such that, if it won and was compensated according to that bid, its expected profits would be zero. Focusing on this weakly dominant bidding equilibrium, all contractors will discount in their bids any expected profits from future renegotiation. That is, if the agent has not taken a bribe from firm 1, firm i ($i = 1, 2$) will bid

$$P_i^* = c_i - (1-e)\pi^R,$$

where the second term on the right-hand side is the expected renegotiation profit. If the agent has taken a bribe, though, firm 2 will bid just as above, whereas firm 1's dominant bid will be

$$P_1^* = c_1 - (1-e)\pi^{Rc}.$$

Let

$$\Delta = (1-e)(\pi^{Rc} - \pi^R) = (1-e)\frac{(v - c_{w^*})^2}{\beta}$$

be firm 1's expected extra profits from renegotiation when it has bribed the agent.[10] This renegotiation advantage impacts the auction just as a cost advantage would. The auction's result, as a function of firms' costs, is depicted in Figure 1.

Without bribing, firm 1 wins if $c_1 < c_2$, that is, in region I in the figure, while firm 2 wins in regions II and III. When the agent has taken a bribe, firm 1 wins when $c_1 - \Delta < c_2$ i.e in regions I and II. In spite of the advantage corruption provides to firm 1, firm 2 still wins in region III -although it receives a lower price, since firm 1 is bidding more aggressively. Region II captures the inefficiency costs of corruption, since the less efficient firm undertakes the project. Note that Δ is decreasing in e. Then, a more complete contract, by reducing the scope for renegotiation, makes firm 1's advantage when bribing smaller, so region II and

[10]We will concentrate in what follows in cases where $\Delta < 2B$. Otherwise, the advantage obtained by firm 1 would make it impossible for firm 2 to compete in the procurement auction.

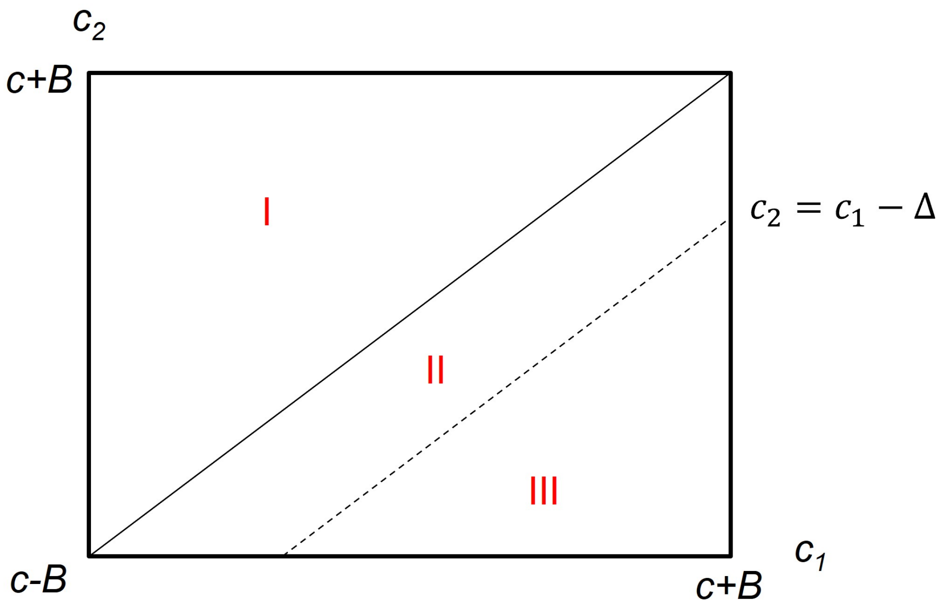

Figure 1 : Project allocation and corruption

allocation inefficiencies shrink.

3.3 Corruption profits

Ex ante, then, firm 1's expected profit if it has not bribed is

$$\Pi_1 = Prob(c_1 < c_2)E[c_2 - c_1 | c_1 < c_2] = \frac{B}{3}$$

There is no profit from renegotiation since expected renegotiation surplus is competed away when bidding. If it has bribed the agent, firm 1's expected profit is

$$\Pi_1^c = Prob(c_1 - \Delta < c_2)E[c_2 - c_1 + \Delta | c_1 - \Delta < c_2]$$

$$= \frac{8B^3 + 12B^2\Delta + 6B\Delta^2 - \Delta^3}{24B^2}$$

In this case, firm 1 seizes a positive expected profit from renegotiation: given that it will be treated preferentially at the renegotiation stage, not all its surplus will be completed away when bidding.

The ex-ante extra profit derived from corruption, then, is

$$\Pi_1^c - \Pi_1 = \frac{\Delta}{2} + \frac{\Delta^2}{4B} - \frac{\Delta^3}{24B^2}$$

It is straightforward to show that, since $\Delta < 2B$, the additional expected profit that firm 1 obtains when bribing is increasing in Δ and decreasing in B. A rise in Δ makes bribing more attractive, since the extra profits that renegotiation yields are larger. In addition, when B grows, cost distributions are more dispersed, which implies that firm 1's advantage when bribing changes the auction's outcome with lower probability -i.e. the probability that costs take values in region II in Figure 1 falls.

Using Figure 1, we can give a more general interpretation of expected corruption profits. Firm 1's expected profit without corruption is just the expected value of the difference between firms 2's cost and firm 1's in region I, where $c_2 > c_1$. That is, $\Pi_1 = \int\int_{R_I}(c_2 - c_1)f(c_2, c_1)dc_2dc_1$. With corruption, firm 1's expected profit is the expected value of the same cost difference plus the corruption advantage Δ in regions 1 and 2, where $c_2 > c_1 - \Delta$: $\Pi_1^c = \int\int_{R_I+R_{II}}(c_2 - c_1 + \Delta)f(c_2, c_1)dc_2dc_1$

Then, additional profits for corruption can be written as

$$\Pi_1^c - \Pi_1 = \frac{\Delta}{2} + \int\int_{R_{II}}(c_2 - c_1 + \Delta)f(c_2, c_1)dc_2dc_1$$

Now, it is intuitive to see that, even without the uniform distribution, the more disperse the cost distribution is, the less mass there will be around the diagonal (where costs are closer to each other), and the lower will be $\int\int_{R_{II}}(c_2 - c_1 + \Delta)f(c_2, c_1)dc_2dc_1$, so the gains from and the incentives to be involved in corruption will fall. We will return to the effect of cost dispersion on gains from corruption when we discuss the case with N bidders below.

3.4 The bribing game.

Moving back to the bribing stage, firm 1 has to decide which bribe b it will offer. The procurement agent will take the bribe if it outweighs its cost -i.e. if $b > \tau$. So the probability that a bribe b will be accepted (the probability of corruption) is $G(b)$. Then, firm 1 chooses the bribe b that solves the following problem.

$$\max_{b} \quad \Pi_1^c G(b) + \Pi_1 (1 - G(b)) \tag{1}$$

Let b^* be the optimal bribe, the solution of firm 1's bribing problem. It satisfies

$$b^* + \frac{G(b^*)}{g(b^*)} = \Pi_1^c - \Pi_1$$

We can now state an interesting comparative statics result

Proposition 1 *When N=2, the equilibrium bribe and the probability of corruption are decreasing in the level of specification e and in cost parameter B.*

The left-hand side of the first order condition is increasing in b^*, and the right-hand side is decreasing in e (since Δ is decreasing in e) and B, so the result follows.

The second part of Proposition 1 states that the probability of corruption falls with B. When B increases, cost dispersion is larger. As we mentioned above, it becomes less likely that the corruption advantage makes firm 1 win when it would lose without bribing. Thus, the incentives to bribe are lower.

The first part –i.e. that the equilibrium probability of corruption falls with the specification effort e– suggests that an effective way of coping with the form of corruption that we are analyzing should be increasing contract specification. Indeed, we can now complete our description of the equilibrium by moving back to the contract specification stage, and verify that this is the case.

3.5 Specification stage

The sponsor selects the specification effort e that maximizes her expected surplus. Without corruption, that surplus (without considering specification costs) is given by

$$\Pi_S = v - E(max(c_1, c_2)) - (1-e)c_{w^*}$$

$$= v - c - \frac{B}{3} - (1-e)c_{w^*}$$

If a bribe is accepted, that surplus is

$$\Pi_S^c = v - E(max(c_1 - \Delta, c_2)) - (1-e)c_{w^*}$$

$$-(1-e)Prob(c_1 - \Delta < c_2))\Delta$$

Anticipating the possibility of corruption when selecting a specification level, the sponsor's problem is[11]

$$max_e \quad \Pi_S^c G(b^*) + \Pi_S(1 - G(b^*)) - k(e) \tag{2}$$

If corruption were impossible, the sponsor would solve

$$max_e \quad \Pi_S - k(e) \tag{3}$$

We can now compare the solutions to these problems

Lemma 2 *The sponsor selects a more complete contract with than without corruption.*

[11]Note that, since the sponsor does not take into account the corrupt firm's and the procurement agent's utilities, she does not choose a level of e that maximizes total surplus.

Proof. In problem (3), the first-order condition is

$$\frac{\partial \Pi_S}{\partial e} = k'(e) \tag{4}$$

The first-order condition for problem (2) is

$$\frac{\partial \Pi_S}{\partial e} + (\frac{\partial \Pi_S^c}{\partial e} - \frac{\partial \Pi_S}{\partial e})G(b^*) + (\Pi_S^c - \Pi_S)g(b^*)\frac{db^*}{de} = k'(e) \tag{5}$$

Since, from Proposition 1, $\frac{db^*}{de} < 0$, and given that $\Pi_S^c < \Pi_S$, the third term on the left-hand side in (5) is positive. A few computational steps yield

$$\frac{\partial \Pi_S^c}{\partial e} - \frac{\partial \Pi_S}{\partial e} = \frac{(1-e)(3B-\Delta)(\pi^{Rc} - \pi^R)^2}{2B^2}$$

In our cases of interest (see footnote 10), we have $3B - \Delta > 0$, so the second term on the left-hand side in (5) is also positive. Given that $k'(e)$ is increasing, then, the solution to (5) is larger than the solution to (4). ■

Alternatively, it may be the procurement agent that chooses the specification level e. To examine that setting, we have to determine first what her selected level would be if she were honest (or, equivalently, for very large values of τ). In that case, the agent would never accept a bribe, and would then maximize the sponsor's expected surplus in the case where corruption is absent, Π_S. Her choice would be the solution to (3). If her idiosyncratic corruption cost were lower, so that accepting a bribe is possible, the procurement agent would reveal that she is corrupt if she selects a specification level that is different than the solution to (3). Then, we would expect her to make a selection that mimicks that of an honest agent.

4 Competition, renegotiation and corruption

We move on now to the case where $N \geq 2$. As above, firm 1 is the bidder that may offer a bribe to the procurement agent. Our previous analysis is mostly valid with more than two bidders. Behavior at the renegotiation stage and in the second-price auction remains the same. The main instance where allowing for $N \geq 2$ may impact our previous analysis is when establishing how much firm 1 expects to gain from corruption.

Without bribing, firm 1 wins if $c_1 < min_{i>1} c_i$. When the agent has taken a bribe, firm 1 wins when $c_1 - \Delta < min_{i>1} c_i$. Given that costs are distributed uniformly, we can compute directly firm 1's expected profit:

$$\Pi_1(B, N) = Prob(c_1 < min_{i>1} c_i) E[min_{i>1} c_i - c_1 | c_1 < min_{i>1} c_i] = \frac{2B}{N + N^2}$$

As above, there is no profit from renegotiation since expected renegotiation surplus is competed away when bidding. If firm 1 has bribed the agent, its expected profit is

$$\Pi_1^c(\Delta, B, N) = Prob(c_1 - \Delta < min_{i>1} c_i)[E[min_{i>1} c_i - c_1 | c_1 - \Delta < min_{i>1} c_i] + \Delta]$$

$$= \frac{2B}{N + N^2} + \frac{\Delta}{N} + \frac{\Delta^2}{4B} - \frac{\Delta^{N+1}}{2^N B^N (N + N^2)}$$

Again, not all of firm 1's surplus will be completed away when bidding. Since we are assuming that $\Delta < 2B$, it is easy to verify that the expected profit that firm 1 obtains when bribing is increasing in Δ.

The ex-ante extra profit derived from corruption, then, is

$$\Pi_1^c(\Delta, B, N) - \Pi_1(B, N) = \frac{\Delta}{N} + \frac{\Delta^2}{4B} - \frac{\Delta^{N+1}}{2^N B^N (N + N^2)}$$

How valuable that corruption advantage is depends on how likely it is that the contract will be renegotiated and on the competitive environment bidder 1 faces. The following proposition summarizes our results.

Proposition 3 *The expected profit derived from corruption is decreasing in the level of specification e, in cost parameter B and in the number of bidders, N.*

It is straightforward that rise in e, which generates a fall in Δ makes the extra profits that renegotiation yields smaller. Given our uniform distributions, we can compute

$$\frac{\partial(\Pi_1^c(\Delta,B,N)-\Pi_1(B,N))}{\partial B} = -\left(\frac{\Delta}{2B}\right)^2 + \left(\frac{\Delta}{2B}\right)^{N+1}\frac{2}{N+1} < 0$$

since $\Delta < 2B$ and $N \geq 2$. Then, just as in the two-bidder case, the renegotiation advantage is more valuable when costs are more likely to be similar, as reflected in a lower value of B.

As for how the value of the renegotiation advantage depends on N, we may resort again to Figure 1 for intuition, interpreting bidder 2 now as the lowest-cost rival that firm 1 faces in the auction. As N grows, regions I and II should become less relevant, since it becomes more likely that the minumum rival valuation that bidder 1 faces is lower. It is region II that reflects the corruption advantage, and we now show that the value of that advantage falls with N. For $N > 2$, we take

$$\Pi_1^c(\Delta,B,N)-\Pi_1(B,N)-[\Pi_1^c(\Delta,B,N-1)-\Pi_1(B,N-1)]$$

$$= \frac{-2^N B^N (N+1)\Delta + \Delta^N 2B(N+1) - \Delta^{N+1}(N-1)}{2^N B^N N(N+1)}$$

The denominator in this expression is positive, while the third term in the numerator is negative. It is straightforward to show that, since $\Delta < 2B$, the sum of the first two terms in the numerator is negative as well. We then conclude that the corruption advantage's value falls as bidder 1 faces more competitors.

Note, finally, that our conclusions under $N = 2$ extend to the $N-$bidder case as regards both the bribing and design stages. In particular, corruption is more likely when cost dispersion is lower and when N is smaller. Then, if the sponsor selects the specification level e, she will design a more complete contract when B is smaller and N is larger.

5 Final comments

We have analyzed the renegotiation channel as a means to implement corruption in procurement, and shown how it distorts the efficient allocation of contracts. Additionally, we have shown that this form of corruption is more likely to occur in markets characterized by low price dispersion, where firms rents are relatively low. This can be interpreted as corruption being more likely in more competitive markets. However, given a fixed cost structure, we have shown that an increase in competition driven by a higher number of competitors reduces the likelihood of corruption. The theoretical analysis predicts that corruption may lead to lower initial prices but higher final costs, due to renegotiations and inefficient project allocation. We hope this pattern can be used in future empirical work to help identify potential cases of corruption using real procurement data.

From a policy perspective, this paper raises important challenges since regulating renegotiation is significantly more difficult than regulating the procurement auction. Limiting renegotiation directly may be counterproductive, leading to important inefficiencies. As our analysis shows, regulatory restrictions on the renegotiation phase have to be combined with more detailed initial contracts. However, this is costly and may be difficult for some administrations that lack technical capabilities and that at the same time, could be the ones more threatened by the risk of corruption.

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