Bribery and Public Procurement –An Experimental Study–

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Abstract

A procurement contract is granted by a bureaucrat (the auctioneer) who is interested in a low price and a bribe from the provider. The optimal bids and bribes are derived based on an iid private cost assumption. In the experiment, bribes are negatively framed (between-subjects treatment) to capture that society is better off if bribes are rare or low. Although bids are lower than predicted, behavior is qualitatively in line with the linear equilibrium prediction. When bribes generate a negative externality, there is a significant increase in the variability of the data.
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1 Introduction

Bureaucrats with discretionary power to select suppliers in procurement are arguably prone to accept (or even require) bribes. In our theoretical model as well as in the experiment we refrain from specifying how one negotiates whether and which bribes are paid. Rather, we assume an institutional setup in which both, lower offers and larger bribes, are possible ways of increasing the own chances of becoming the provider. One of our experimental treatment does (not) impose a negative externality of bribing on all members of society. Thus we address the question whether ethical considerations have any effect on bribing behavior.

One way to model corruption in procurement auctions is to focus on the ex post collusion opportunities between a corrupt bureaucrat and one specific bidder, who is given the opportunity to *re-submit* his or her bid after the bureaucrat has received all (initial) bids. This re-negotiation approach is followed, for instance, by Comte et al. (2000) and more recently by Lengwiler and Wolfstetter (2004).

In contrast, our setup reflects a situation where the bidders compete not only in prices but also in bribes, where the auctioneer's commonly known behavioral rules reflect institutionalized corruption. Here, bribes are simultaneously offered by all bidders along with their price offers. Our approach is similar to that Beck and Maher (1986) and Lien (1986), who established the fundamental isomorphism between bribes and price-competition. However, whereas these early studies assume that bidders can compete *either* in price *or* in bribe offers only, we allow bids in both dimensions, as is the case in Burguet and Che (2004).

More specifically, we study the behavior of the potential providers when facing a corrupt bureacracy, and not how bureacrats solve the conflict between their moral duties and their desire for bribes since our theoretical and experimental analysis assumes exogenous preferences of the bureacrat.[1]

In the following we introduce the game model and derive its linear equilibrium (Section 2). We then describe the experimental procedure (Section 3) and analyze the experimental data (Section 4). Section 5 concludes.

2 The model

Two a priori symmetric bidders compete for a public procurement contract to provide an indivisible good. If the contract is granted to any of the two bidders, there would be an increase of $1 + w_0$ (with $w_0 > 0$) in social welfare with respect to some status-quo level. Thus, if the final price paid to the supplier of the good is p, the social value of granting the procurement contract is $V(p) = 1 + w_0 - p$ (without taking into account the winning bidder's profit).

The bureaucrat, being society's agent, is in charge of evaluating competing bids and choosing the provider. Although the bureaucrat's duty is to maximize $V(p)$, he also takes into account any bribes accompanying the

[1] While these preferences could be experimentally induced by an appropriate payoff function of subjects playing the role of the bureaucrat, we simply implement them as an impersonal–and more or less corrupt–bureaucratic institution.

price bids. In particular,[2] denoting by b the bribe offered along the price bid p, the bureaucrat will select an offer (p, b) over the alternative (p', b') if

$$U(p, b) > U(p', b'), \tag{1}$$

where $U(p, b) = (\theta + b)V(p)$ with $\theta > 0$. Obviously the bureaucrat faces a tradeoff, since he is interested in both a low price and a high bribe.

The cost of both bidders, C and C', are two iid random variables following a Uniform [0,1] distribution. While the rules of the procurement auction necessarily remain silent about the feasible levels of the bribe component of a bid, b, they impose an upper bound $\overline{p} \leq 1 + w_0$ on the price component. Therefore bidders can only submit price bids $p, p' \in [0, \overline{p}]$. For the sake of tractability, it is also assumed that $\theta \geq (1+w_0) - \overline{p}$, so that the bureaucrat's preferences do not diverge too much from his moral duties.

We only consider the lowest-bid=price rule, in which the winning bidder receives the price specified in his own offer. Thus, if a provider with actual cost C submits an offer (p, b) while his competitor's offer is equal to (p', b'), then the former earns

$$\pi = p - C - b, \tag{2}$$

provided that (1) holds. The losing competitor, who offered (p', b'), is left empty handed and earns 0 (i.e., offered bribe is paid only by the provider).

Due to the symmetry of both suppliers we focus on the symmetric equilibrium solution of the game that satisfies some obvious monotonicity properties. In particular, we restrict our analysis to linear solutions in the sense of linear functions $p(\cdot)$ and $b(\cdot)$ of the cost level C for risk-neutral bidders.

Proposition 1 *In the procurement contest with bribes there is a unique symmetric and linear equilibrium $(p^*(C), b^*(C))$ such that $p^*(C) - b^*(C)$ increases with C, namely*

$$b^*(C) = \frac{1-C}{4} + \frac{w_0 - \theta}{2}$$

[2]In the Appendix it is shown that nothing much changes if the behavior of the bureaucracy is in line with the more general criterion $(\theta + b)^\gamma V(p)^\alpha > (\theta + b')^\gamma V(p')^\alpha$, i.e., with more complex utility functions $U(p, b) = (\theta + b)^\gamma V(p)^\alpha$ of which (1) is the particular case $\alpha = 1 = \gamma$.

and

$$p^*(C) = \frac{3+C}{4} + \frac{w_0 - \theta}{2}.$$

Proof. The problem of deciding how much to bid (the choice of $0 \leq p \leq \overline{p}$) and how much to offer as a bribe (the choice of $b \geq 0$) can be solved in two steps: a supplier can first identify the set of offers that maximize his acceptance probability by the bureaucracy, and then choose p and b from this set so as to maximize his expected profit. Let us start with the first problem: For given cost C, any winning offer (p, b) with constant net revenue $p - b = k$ yields the same profit $\pi(C, k) = k - C$. Maximizing acceptance probability thus means to solve

$$\max_{p,b} U(p, b) \quad \text{s.t. } p - b = k,$$

which yields

$$b^*(k) = \begin{cases} \frac{1-k}{2} + \frac{w_0-\theta}{2} & \text{, if } \; k \in [0, 1 + w_0 - \theta], \\ 0 & \text{, if } \; k \in [1 + w_0 - \theta, \overline{p}]. \end{cases} \tag{3}$$

and

$$p^*(k) = \begin{cases} \frac{1+k}{2} + \frac{w_0-\theta}{2} & \text{, if } \; k \in [0, 1 + w_0 - \theta], \\ k & \text{, if } \; k \in [1 + w_0 - \theta, \overline{p}]. \end{cases} \tag{4}$$

Thus, what remains to be determined is the function $k = k(C)$ which allows to write p^* and b^* as functions $p^*(C)$ and $b^*(C)$. Notice that

$$U(p^*(k(C), b^*(k(C)) > U(p^*(k(C'), b^*(k(C'))$$

if and only if

$$k(C') > k(C).$$

For a monotonic (and hence invertible) function $k(\cdot)$ with $k'(\cdot) > 0$, we can therefore express a bidder's payoff, based on p^* and b^*, as

$$\begin{aligned} \pi(k) &= \int_{C' > k^{-1}(k)} (k - C) dC' \\ &= (k - C)\left(1 - k^{-1}(k)\right). \end{aligned}$$

From $\pi'(k) = 0$ one derives

$$\frac{d}{dk}k^{-1}(k) = \frac{1 - k^{-1}}{k - c} = \frac{1 - k^{-1}(k)}{k - k^{-1}(k)}$$

or for $f(k) = C(k)$,

$$f'(k) = \frac{1 - f(k)}{k - f(k)}.$$

The linear solution of this differential equation is

$$f(k) = 2k - 1.$$

Setting $C = f(k)$ yields

$$k^*(C) = \frac{1 + C}{2},$$

justifying the initial assumption of monotonicity. Thus,

$$b^*(C) = \frac{1 - C}{4} + \frac{w_0 - \theta}{2} \quad \text{and} \quad p^*(C) = \frac{3 + C}{4} + \frac{w_0 - \theta}{2}$$

is the unique symmetric, linearly monotonic equilibrium. ■

Since $p^*(C) - b^*(C) = \frac{1}{2}$, the two preference parameters θ and w_0 of the bureaucrat affect the equilibrium choices $b^*(C)$ and $p^*(C)$, but not their difference.

3 Experimental Design

The auction mechanism described above was implemented in a laboratory experiment to compare the predicted price-bribe combinations against actual choice behavior.[3] Participants played in pairs the auction game over 30 rounds, using either a partners protocol (sessions 1 and 4) or random matching protocol (sessions 2 and 3). The partners protocol captures the idea that often the same suppliers compete in successive procurement auctions. By the strangers protocol we explore the case where, as in the theoretical analysis, no future interaction takes place. In case of the partners protocol,

[3] Rather than imposing rule (1) as a mechanism we could have invited and used actual players in the role of the bureaucrat, who could have been paid according to $U(p, b)$. This shows that our design is open also for exploring how bureaucrats cope with the ethical conflict between moral duties and own monetary incentives. Since in this study we want to focus only on how potential providers react to a corrupt bureaucracy, we have implemented (1) just as a mechanism, without employing real participants in the role of a bureaucrat.

subjects played with the same partner ten periods, so that each participant played with three different partners during the whole session. In case of the random matching protocol, pairs of participants were re-matched each period within matching groups of size 6. There were 30 participants in each session, except for session 4, which consisted of 24 participants only.

In the experiment, the random cost variable assigned to each participant in each period was *iid* Uniform $\sim [0, 100]$, and the maximum price was set equal to $\overline{p} = 150$ token. To prevent participants from making losses, they were constrained to submit bids (p, b) such that $p - C - b \geq 0$. The parameters of the allocation function $U(p, b)$ were set such that $1+w_0 = 160$ token and $\theta = 10$ token. Thus, the benchmark bid functions are

$$b^*(C) = 50 - \frac{1}{4}C \tag{5}$$

and

$$p^*(C) = 100 + \frac{1}{4}C \tag{6}$$

for all $C \in [0, 100]$.

We used the exchange rate between tokens and Euro as a treatment variable in order to implement the negative external effects created by bribery. Whereas sessions 1 and 2 relied on a fixed exchange rate of 100 token = 2.50 Euro, sessions 3 and 4 implemented a variable exchange rate, which could take on values of either 2.00 or 3.00 Euro per 100 token. In the latter case, the payments of each matching group were calculated *every 10 rounds* in the following way: The total amount of bribes offered by all members of each matching group during a block of 10 rounds was compared with the respective total amount offered by a "reference" matching group. If the players in the matching group in question offered *higher* bribes than the players in its reference group, then the former were paid 2.00 Euro for each 100 tokens they had earned during the block of 10 rounds. If they offered *lower* bribes than the reference group, then they received 3.00 Euro for each 100 tokens they earned during the block of 10 round. The reference matching group used to do this comparison was randomly chosen (for each matching group) every 10 periods among the remaining 4 groups in the session. The variable exchange rate protocol is intended to capture institutional competition in the sense that countries, regions, or industries facing less corrupt bureaucracies will, for instance, be more attractive for investors in the long run, while

	Fixed Exchange Rate		Variable Exchange Rate	
	Partners	Strangers	Partners	Strangers
Min.	3.8	3.7	1.5	5.0
1st Qu.	6.6	7.7	6.1	7.9
Median	9.0	8.9	7.2	8.5
Mean	9.1	9.1	9.0	9.7
3rd Qu.	11.3	10.8	11.4	11.4
Max.	14.0	16.1	19.9	17.0

Table 1: Distribution of Euro profits by session

those with corrupt institutions will suffer from a comparative disadvantage.

4 Results

The average payment in all treatments was between 9 and 10 Euro per person (see Table 1). Figure 1 shows that the interquartile range in the distribution of monetary payments among participants in the strangers protocol was smaller than in the partners-matching for both fixed and variable exchange rate.

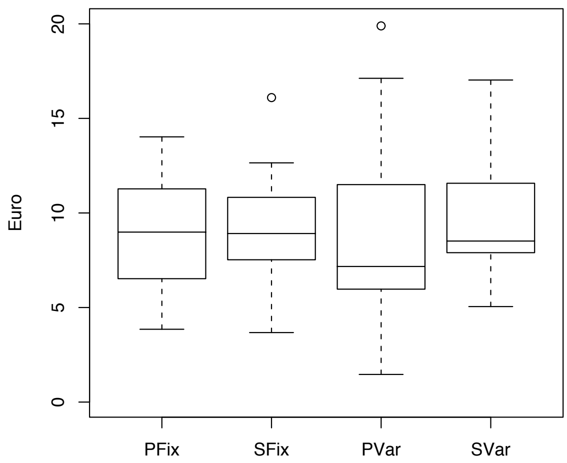

Figure 1: Distribution of Euro profits by session

Observed bid behavior as a function of cost is illustrated in Figures 2 and

3 for the partners and strangers matching protocols, respectively. Although variation in the data is quite substantial, the distribution of both the mean price and bribe bid functions seems to be linear in C. The similarity with other auction experiments is illustrated in Figure 4, which shows the distribution of the net price, $k(C) = p(C) - b(C)$, and that bid shading applies also to net prices in the form of $k^*(C) > k(C) > C$. In Figures 2 to 4, decisions made during the first 10 rounds are plotted with a circle, whereas decisions made in rounds 11 to 20 and 21 to 30 are plotted with a '+' sign and a '×' sign, respectively. It can be seen that decisions made in initial periods exhibit more variation than decisions made in the final 10 periods, suggesting learning effects.

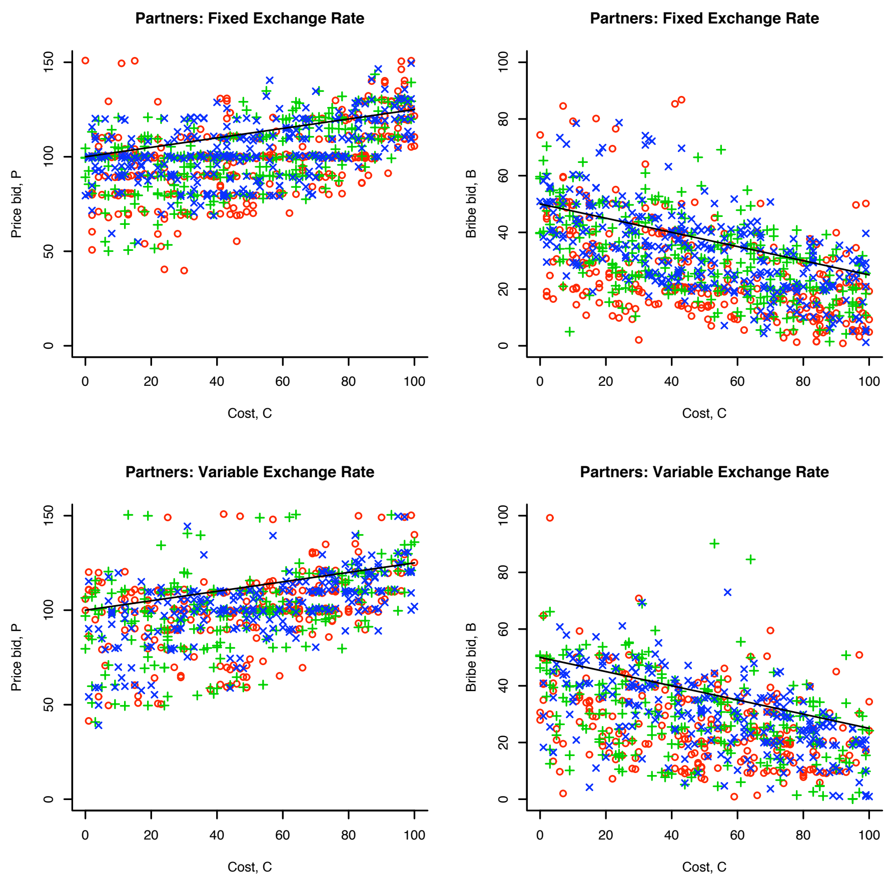

Figure 2: Observed price and bribe bids under partners-matching protocol

Since price and bribe decisions are made simultaneously, one should ex-

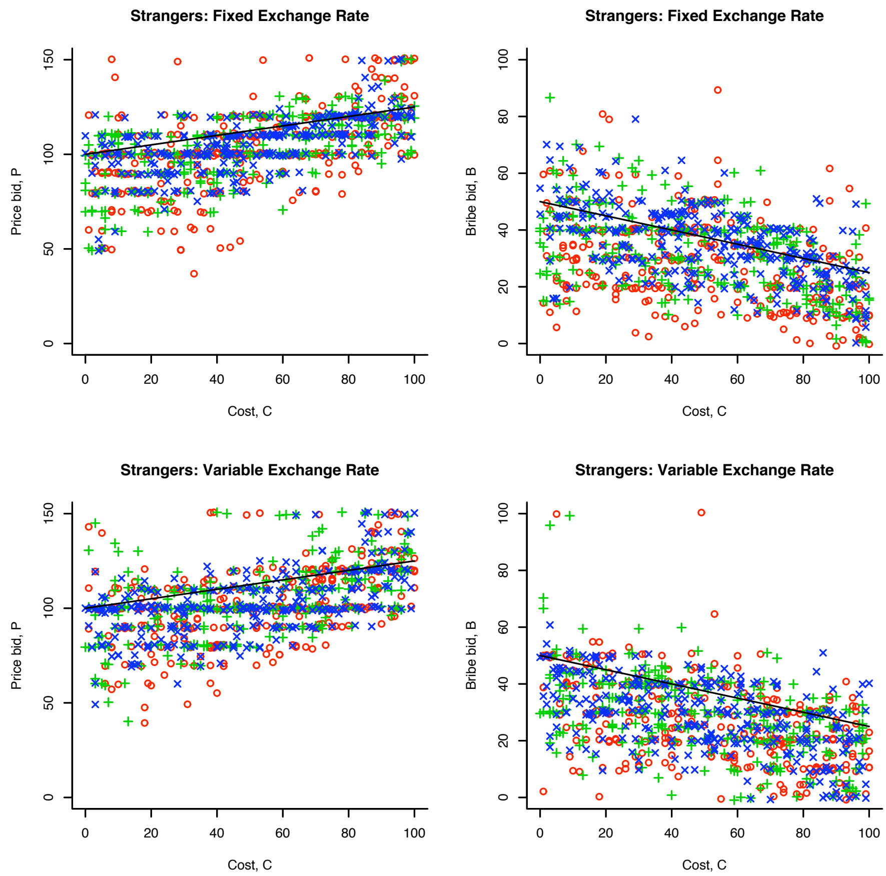

Figure 3: Observed price and bribe bids under strangers-matching protocol

pect them to be correlated. This is evidently the case, as shown in Figure 5, where the deviations between actual and equilibrium bids are plotted for each treatment. Thus, estimating price and bribe bid functions of the form

$$p = \phi_0 + \phi_1 C + \varepsilon_p$$

and

$$b = \beta_0 + \beta_1 C + \varepsilon_b$$

cannot be done independently. Therefore, we analyze the data estimating both functions simultaneously, under the assumption that the disturbance vector $\varepsilon = (\varepsilon_p, \varepsilon_b)$ follows a bivariate normal distribution with zero mean

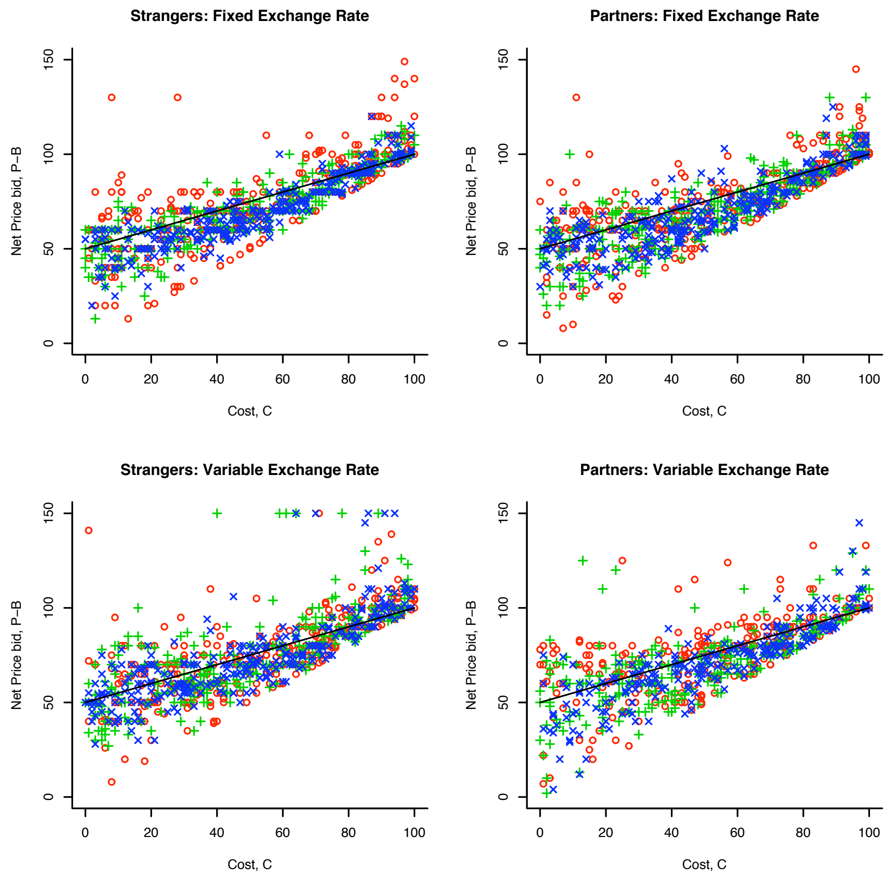

Figure 4: Observed net price bids

and variance

$$\Sigma = \sigma^2 \begin{bmatrix} 1 & -\rho \\ -\rho & s^2 \end{bmatrix}.$$

The estimated coefficients, obtained via maximum likelihood, are presented in Table 2. Using the likelihood ratio test, it is straghtforward to test several hypothesis of interest within treatments. The first two hypotheses concern the variance structure of the data, namely, $H_0(1) : s^2 = 1$ and $H_0(2) : \rho = 0$. Thus, while the former postulates equal variability of the prices and bribes bid, the latter implies that price bids are independent of the offered bribes. Also, the adequacy of the theoretical model can be

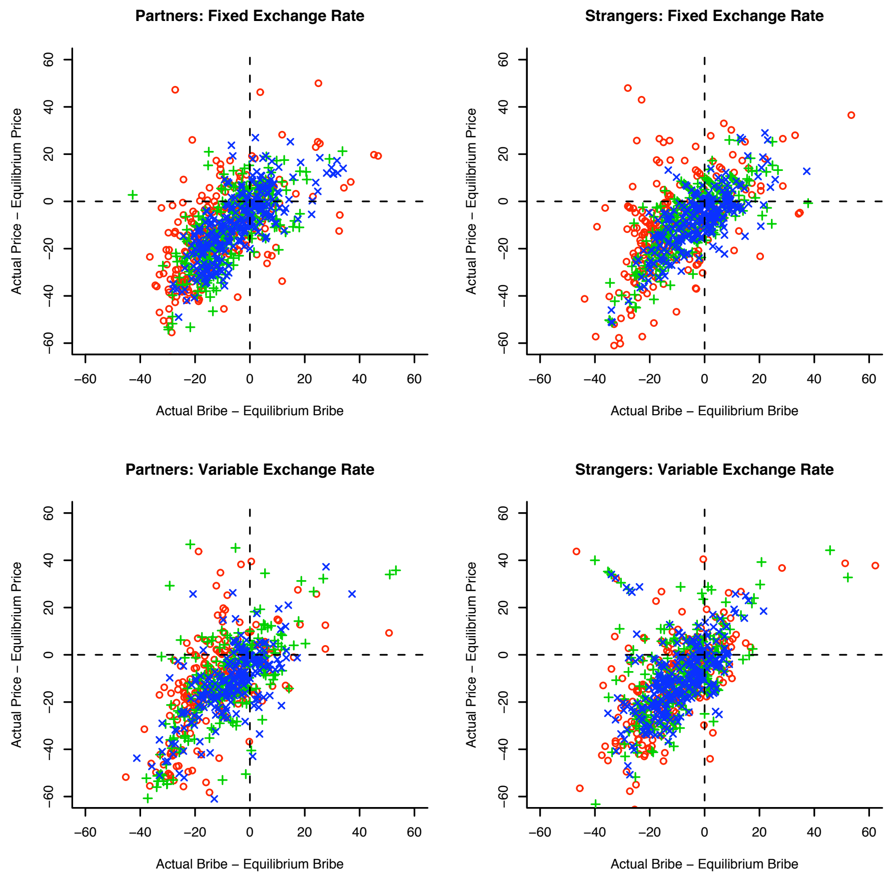

Figure 5: Deviation between actual and equilibrium bids

examined by looking at the following two hypothesis:

$$H_0(3) : [\phi_0, \phi_1, \beta_0, \beta_1] = [100, \frac{1}{4}, 50, -\frac{1}{4}], \tag{7}$$

and

$$H_0(4) : [\phi_0 - \beta_0, \phi_1 - \beta_1] = [50, \frac{1}{2}]. \tag{8}$$

Using Bonferroni critical values (for testing multiple hypothesis), we find clear evidence indicating that the price and bribe decisions are positively correlated and that the variance of the bribing behavior is smaller than that of the pricing bids (i.e., $H_0(1)$ and $H_0(2)$ are rejected).

Also, hypothesis $H_0(3)$ is rejected for all treatments, confirming that behavior is significantly different from the theoretical prediction regarding

	Fixed Exchange Rate		Variable Exchange Rate	
Coefficients	Partners	Strangers	Partners	Strangers
Price bid:				
ϕ_0	86.2319	85.4661	83.7707	85.5287
ϕ_1	0.2938	0.3668	0.3388	0.3383
Bribe bid:				
β_0	44.0869	43.6383	39.0160	40.3708
β_1	-0.2870	-0.2340	-0.2133	-0.2432
Variance matrix:				
σ^2	230.2144	218.3924	235.0101	244.1888
s^2	0.6937	0.7967	0.6438	0.6164
ρ	0.5588	0.6079	0.4688	0.4224
log-likelihood	-7037.3216	-7010.1230	-5757.4873	-7152.1265
AIC	14088.6432	14034.2460	11528.9746	14318.2530

Table 2: Maximum-likelihood estimates of bivariate bid function

the bivariate distribution of p and b. The less stringent hypothesis $H_0(4)$, however, is not rejected neither in the partners nor in the strangers protocol under variable exchange rate. This indicates that the equilibrium net price prediction, $p^*(C) - b^*(C) = 50 - \frac{1}{2}C$, can only be rejected in case of a fixed exchange rate, i.e., if bribing externalities are absent.

Nevertheless, the statistical results concerning $H_0(4)$ must be taken cautiously, since the variable exchange rate treatment may have triggered more risk-aversion, which in turn could have increased the variance in behavior. Indeed, if we look at differences between treatments, also using likelihood ratio tests for multiple comparisons between samples, the estimates of the variance matrix Σ do not significantly differ between partners and strangers design (for any given an exchange rate treatment), although there is evidence of an exchange rate effect (holding the matching protocol fixed). In other words, failure to reject $H_0(4)$ in the variable exchange rate treatments may be simply due to the larger variability of the data.

Finally, Table 3 shows the p-values from the likelihood ratio tests for five pairwise comparisons of mean bribing behavior between treatments. Only the comparisons where strangers matching and fixed exchange rate are involved show a significant difference in mean bribing behavior. As illustrated in Figure 6 (where the continuous straight line is the theoretical prediction and the dashed line the maximum-likelihood estimate from Table 2), mean bribing behavior is slightly closer to the theoretical prediction in

$H_0 : [\beta_0, \beta_1]$ is equal between treatments	
Comparison	p-value
SFix vs. PFix	$< 10^{-7}$
SVar vs. PVar	0.1304
SVar vs. SFix	$< 10^{-7}$
PVar vs. PFix	0.2887
SFix vs. PVar	$< 10^{-7}$
(Bonferroni 5% critical value is 10^{-7})	

Table 3: Likelihood ratio tests for pairwise comparisons of mean bribing behavior between treatments.

case of a fixed exchange rate under a strangers matching design, as compared to all other treatments.

5 Conclusions

Assuming a corrupt bureaucracy via condition (1) and our specification of $U(p, b)$, we have derived the equilibrium behavior of risk-neutral bidders, and collected experimental evidence on actual pricing and bribing behavior by competing bidders. As predicted, bribes are actively used, even when they are framed negatively (in the variable exchange rate treatment). As had to be expected for a highly stochastic setting with private cost information, the effect of the (partners versus strangers) matching protocol is minor.

The main implication of our findings is that, when being confronted with a corrupt bureaucracy, people do not mind engaging in active bribery, at least when there is no threat of (legal) punishment. A second implication is that being aware that corruption is detrimental for society does not help much: It mainly increases heterogeneity in behavior due to idiosyncratic reactions to such social effects. In our 2×2 factorial design, only the constellation of strangers matching and fixed exchange rate seems to elicit significant differences in bribing behavior (Table 3).

Nothing in our design (and the benchmark solution) would prevent actual participants from playing the role of the bureaucracy; it would suffice to pay them according to the evaluation function $U(p, b)$, following the standard experimental practice in the induced-value tradition. Although this would not affect the validity of our benchmark solution, it would nevertheless enrich too much the social structure of the experimental scenario and

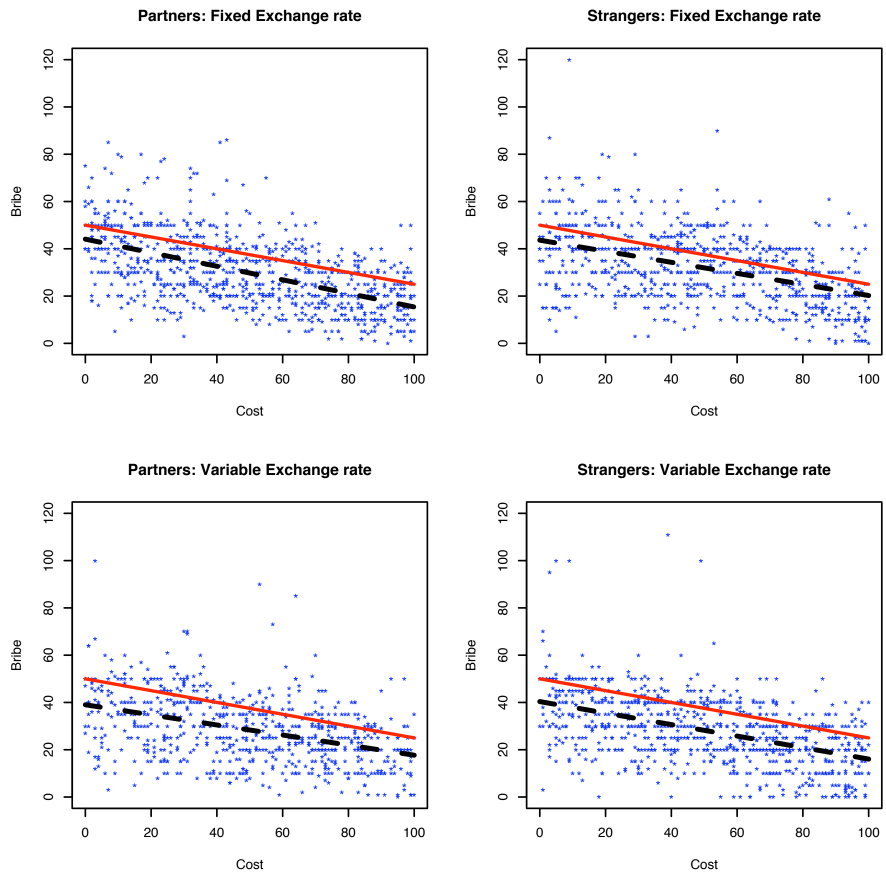

Figure 6: Estimated bribing function

introduce additional moral constraints. For instance, bidders would have to ask themselves whether it is appropriate to seduce the bureucrat, and the bureaucrat would face a tradeoff between an ethical and a financial reward. In the investigation presented here, therefore, the role of the bureacrat has been excluded altogether, focusing the analysis on bidders' behavior. The laboratory results obtained in this restricted scenario lead us to conclude that, whenever the existence of a clearly corrupt and anonymous bureaucracy is commonly known, bidders will engage in active bribing!

Appendix

Here we derive the solution for $U(p,b) = (1+w_0-p)^\alpha(\theta+b)^\gamma$ with $\alpha, \gamma > 0$ instead of (1) where $\alpha = 1 = \gamma$.

From the first order conditions of the Lagrangian

$$\mathcal{L} = U(p,b) - \lambda(p - b - k)$$

one obtains

$$p^*(k) = \frac{\gamma(1+w_0) - \alpha\theta}{\alpha+\gamma} + \frac{\alpha}{\alpha+\gamma}k$$

and

$$b^*(k) = \frac{\gamma(1+w_0) - \alpha\theta}{\alpha+\gamma} - \frac{\gamma}{\alpha+\gamma}k.$$

Assuming $k(C)$ with $k'(C) > 0$, and noting that $k < 1 + w_0 + \theta$, it is possible to show that

$$\frac{\partial U(p^*, b^*)}{\partial C} = \left[\frac{\partial U(p^*, b^*)}{\partial p} \cdot \frac{\partial p^*}{\partial k} + \frac{\partial U(p^*, b^*)}{\partial b} \cdot \frac{\partial b^*}{\partial k}\right] k'(C) < 0,$$

or, equivalently,

$$U(p^*(C), b^*(C)) > U(p^*(C'), b^*(C')) \;\Leftrightarrow\; C < C'.$$

Thus, we can write the cost type C's expected payoff as

$$\begin{aligned}\pi(k) &= \int_{C' > k^{-1}(k)} (k - C)dC' \\ &= (k - C)\left[1 - k^{-1}(k)\right],\end{aligned}$$

which is identical to what has been derived for the special case $\alpha = 1 = \gamma$. The function $k^*(C)$ obviously satisfies $k'(\cdot) > 0$ and therefore applies here, too.

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