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Reputation and Mechanism Choice in Procurement Auctions

An Experiment

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Jeannette Brosig and Timo Heinrich[1]

Reputation and Mechanism Choice in Procurement Auctions – An Experiment

Abstract

We experimentally study the role of reputation in procurement using two common mechanisms: price-based and buyer-determined auctions. While buyers are bound to buy from the lowest bidder in price-based auctions, they can choose between bidders in buyer-determined auctions. Only in the latter buyers can consider the reputation of bidders. We find that bidders supply higher quality in buyer-determined auctions leading to higher market efficiencies in these auctions. Accordingly, buyers prefer the buyer-determined auction over the price-based auction, while only half of the bidders do so. A more detailed analysis of buyers' and bidders' behavior and profits provides insights into their mechanism choice.

JEL Classification: D44, C91, C72

Keywords: Buyer-determined and price-based procurement; reputation information; auction choice; experimental economics

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1 Introduction

Every year companies and government agencies buy billions worth of goods and services using procurement auctions. By now, several internet marketplaces for procurement auctions exist and most major vendors integrate support of procurement auctions in their enterprise resource planning systems. Recently, several web pages have emerged that also offer procurement auctions to consumers allowing them to shop for transportation services or construction work.

As in many market interactions, trades initiated through procurement auctions are prone to moral hazard because the quality of the goods or the exerted effort is not contractible. Problems of moral hazard could be overcome by reputation. Accordingly, buyers or platforms often request references or collect information on past performances. The U.S. Federal Acquisition Regulation states that "[*w*]*hen selecting contractors to provide products or perform services, the Government will use contractors who have a track record of successful past performance or who demonstrate a current superior ability to perform*." (Federal Acquisition Regulation 2005, Paragraph 1.102-2). Similarly, the current public procurement directive of the European Union (EU Directive 2004/18/EC) allows public buyers to request "*a list of the works carried out over the past five years, accompanied by certificates of satisfactory execution for the most important works*" (Article 48, Paragraph 2).

The increasing prevalence of electronic auctions increases the scope of procurement mechanisms and eventually asks the initiators of auctions to become market-designers. They have to set starting and reserve prices and have to define award criteria. The directive of the European Union, explicitly offers the choice between two award criteria: "*the lowest price only*" or "*the most economically advantageous*", the latter allowing for a number of criteria such as "*quality, price, technical merit*" and so on (EU Directive 2004/18/EC, Article 53, Paragraph 1). In research on procurement auctions these two options are usually referred to as 'price-based procurement auctions' and 'buyer-determined procurement auctions' (Engelbrecht-Wiggans, Haruvy, & Katok, 2007). While buyers are bound to buy from the lowest bidder in price-based auctions, they can choose between bidders in buyer-determined auctions based on price and all other available criteria (often subsumed as quality).

In this study, we focus on the performance of these two auction mechanisms in a setting with moral hazard where contingent contracts are not feasible. Situations where contracts cannot be

based on the outcome of the transaction are common, e.g., in online procurement where legal enforcement would be too costly or in the procurement of services, where quality cannot be verified by a court. Our buyer-determined auctions allow buyers to choose according to two criteria: price and information about the bidder's past behavior. This gives bidders an opportunity to build up reputation. By comparing price-based and buyer-determined auctions, we can analyze the effect of reputation in procurement auctions. In addition, we study buyers' and sellers' preferences regarding price-based and buyer-determined auctions (i.e., their mechanism choice) and shed some light on the acceptance and use of reputation mechanisms.

The next section briefly overviews literature related to reputation building and the two auction mechanisms employed in our study. In section 3 we describe the auction games and the experimental procedure and in section 4 we present our observations. Section 5 summarizes the results and concludes.

2 Related Literature

Overviews of current issues in procurement auctions can be found in Beall et al. (2003), Bichler & Steinberg (2007), Elmaghraby (2007), Rothkopf & Whinston (2007), and Gupta, Koulamas, & Kyparisis (2009). In particular, Rothkopf & Whinston (2007) identify the role of reputation in procurement as an important issue for future research. According to Wilson (1985) reputation in a game-theoretic sense is the history of a player's actions as they are observed by others. In the finitely repeated versions of the chain-store game and the prisoners' dilemma players can increase their payoff by creating a reputation for 'fighting entry' or 'cooperating' as long as there is uncertainty about the type of players (Kreps, Milgrom, Roberts, & Wilson, 1982, Kreps & Wilson, 1982, Milgrom & Roberts, 1982). That is, as long as 'irrational' players of a certain type might exist, players can increase their payoffs by creating a reputation for being of that type. A similar reasoning applies to the markets of experience goods. Companies can create a reputation for supplying goods of high quality and charge higher prices to recoup investments for quality as described by Klein & Leffler (1981) and Shapiro (1983), among others. In that way reputation might help to overcome problems caused by moral hazard.[2]

[2] Contracting under moral hazard has been widely studied (see, e.g., the textbooks by Laffont & Tirole (1993), Salanié, 1997, and Bolton & Dewatripont, 2005), though only a few authors have analyzed moral hazard in procurement

When introducing reputation information about bidders in procurement auctions, as it is the case in our study, these auctions become multi-dimensional. Buyers can not only consider prices, but also bidders' reputation. The theoretical work on multi-dimensional auctions has been pioneered by Che (1993). So far three experimental studies compared the behavior in price-based and buyer-determined procurement auctions in this setting. These studies assume that bidders differ by their costs and the exogenously determined quality and that buyers can evaluate bids according to the offered price and quality. Engelbrecht-Wiggans et al. (2007) study sealed-bid auctions and show theoretically that the price-based auction only yields a higher surplus to the buyer when the correlation between costs and quality is low or when there are few bidders. They confirm their theoretical findings in an experiment. Shachat & Swarthout (2010) calculate the equilibrium predictions for the sealed-bid buyer-determined auction and for a dynamic price-based auction with bidding credits. They show theoretically that the buyer surplus is higher in the latter auction format while the former is socially efficient. Actual behavior deviates from this prediction: In their experiment buyers and sellers receive a higher surplus in the sealed-bid buyer-determined auction due to non-equilibrium bidding and non-optimal bidding credits. Katok & Wambach (2008) compare sealed-bid price-based auctions to dynamic buyer-determined auctions, assuming that bidders are uncertain about the quality of their offer. They show theoretically and empirically that under this assumption the former are less prone to collusion.

The quality (or the effort) is often not exogenously determined, but at the discretion of the bidder, however. Cox, Isacc, Cech, & Conn (1996) and Onderstal & Van de Meerendonk (2009) study experimentally how different auction mechanisms perform when incentive contracts are auctioned off. Different from them, we study a moral hazard setting, often encountered in practice, where quality is not contractible. We only allow for fixed-price contracts and focus on the role of reputation as an incentive to provide above minimum quality.[3]

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auctions with non-contractible quality. To our knowledge the only theoretical models in this field have been developed by Kim (1998), Doni (2006), Cesi & Albano (2008), and Calzolari & Spagnolo (2009). In these models contractors can be disciplined to exert more than minimal effort by threatening to exclude them from future auctions. If the loss of future trade is larger than the gain from shirking, contractors will refrain from opportunistic behavior.

[3] Conceptually our paper is also related to the literature to experimental studies on labor markets (see, e.g., Fehr, Kirchsteiger, & Riedl, 1993, Brown, Falk, & Fehr, 2004, and Fehr, Klein, & Schmidt, 2007), trust and reputation (see, e.g., Keser, 2003, Bolton, Katok, & Ockenfels, 2004, and Bohnet & Huck, 2004) and trust and competition (see, e.g., Bolton, Loebbecke, & Ockenfels, 2008, Dulleck, Kerschbamer, & Sutter, 2011, and Huck, Lünser, & Tyran, 2010). Even though these strands of literature extensively study the effects of reputation and competition in situations with moral hazard, they do not focus on bidding behavior or mechanism choices.

3 Experimental Design

We experimentally study the behavior in procurement auctions assuming that buyers can consider the reputation of bidders in buyer-determined auctions only. We employ sealed-bid first-price auctions with independent private values and two bidders. Our experiment consists of two parts. In the first part subjects participate as bidders in a series of first-price procurement auctions bidding against a computerized bidder. The first part is intended to familiarize subjects with the auction environment and serves as a benchmark for the behavior in the second part of the experiment. During the second part subjects take part in price-based and buyer-determined procurement auctions with human opponents.

3.1 The auction games

The *first-price sealed-bid procurement auction* (FPA) used in the first part of the experiment is analogous to the standard first-price sealed-bid auction with symmetric independent private values without reserve price (for surveys see Krishna, 2002; McAfee & McMillan, 1987; Menezes & Monteiro, 2004; Wolfstetter, 1995; on competitive bidding with private costs see Cohen & Loeb, 1990; Holt, 1980). The two bidders $i = 1, 2$ compete for a project by bidding a price for which they are willing to execute the project. Before the auction, both bidders learn about their costs for completing the project. Bidders know that their costs c_i are independently drawn from a uniform distribution with support [100, 400] and that they cannot bid above 400. We interpret this maximum bid as the buyer's valuation of the project v. The bidder offering the lowest price wins the project. In this auction the symmetric risk-neutral Nash-equilibrium (RNNE) bidding function depending on the cost realization c_i is given by

$$\beta^{FPA}(c_i) = 200+c_i/2.$$

The winning bidder (the seller) earns a profit of $\pi_S = \beta^{FPA}-c_i$ from completing the project. The losing bidder makes a profit of zero.

Based on the FPA design, the second part involves a series of procurement auctions that model the situation of moral hazard as it is prevalent in many real life procurement situations: After winning the project the seller can reduce his cost on the expense of the buyer, for example by providing lower effort or by choosing a lower quality. We account for this by introducing a quality factor q_i that is chosen by the seller from the interval [0.5, 1]. It is multiplied with the cost c_i

drawn for the seller and with the buyer's valuation v. As in the FPA, the two bidders know that their costs c_i are independently drawn from a uniform distribution with support [100, 400] and that they cannot bid above 400. The winning bidder choosing a bid b_i earns a profit of $\pi_S = b_i - q_i c_i$ while the losing bidder earns zero profits. The buyer earns a profit of $\pi_B = q_i v - b_i$.

We use two variants of procurements auctions with moral hazard: price-based and buyer-determined procurement auctions. Our *price-based procurement auctions* are strategically equivalent to first-price procurement auctions. The bidder offering the lowest price wins the project. In these auctions there is no incentive to choose a q_i larger than 0.5. It follows that the RNNE bidding function is given by

$$\beta^{PB}(c_i) = 100 + c_i/4.$$

Buyer and seller earn a profit of $\pi_B = \pi_S = 100 - c_i/4$.

The *buyer-determined procurement auctions* used in our experiment allow the buyer to determine the winning bidder. The buyer is informed about the prices offered by the two competing bidders as well as about their previous choices of q_i (specifically, the average quality $\overline{q}_i$ of all previous auctions and the quality choice made in the last auction q_i^{t-1}). In a finite game with complete information and common knowledge of rationality and selfishness, none of the bidders will choose a q_i above 0.5 in the last auction. By backward induction this quality level will be chosen in all previous auctions and bidders will bid according to β^{PB}. If we relax the assumption of rationality and selfishness, several reputation equilibria may emerge, in which subjects choose above minimum quality.

3.2 Experimental procedure

In the first part subjects participated in six first-price sealed-bid procurement auctions bidding against a computerized opponent programmed to bid according to the RNNE strategy. They did not receive any feedback on the opponent's behavior either in the course of or after completion of the first part. Subjects were informed accordingly (all instructions are included in the Appendix). The second part consisted of 18 procurement auctions with moral hazard. Before the start of the second part new instructions were handed out to subjects and a computerized test of understanding followed. Subjects were then randomly assigned either the role of buyer or bidder and kept this role for all 18 auctions. In each auction one buyer faced two bidders. The three subjects were

randomly re-matched after each auction with the publicly announced restriction that subjects would not meet the same participants in two consecutive auctions. In each treatment, a total of 72 subjects were re-matched within eight matching groups (each consisting of nine subjects) generating eight independent observations per treatment. After completion of the second part subjects were informed about their payoff for the first part and about the outcome of each auction in the second part.

We independently drew series of costs for the six auctions in the first part and for the 18 auctions in the second part. For the first part we drew two series of costs, one for the human bidder and one for the computerized opponent. By this, all subjects faced the same behavior and the same costs in the first part. For the second part, we drew six series of costs, one for each bidder within a matching group. To make the data comparable across treatments the same series of costs were used in all sessions and treatments.

The four treatments differed regarding the second part of the experiment only (see Table 1). The first treatment consisted of 18 price-based procurement auctions (*PB*), the second consisted of 18 buyer-determined procurement auctions (*BD*), and the third asked buyers and bidders to choose between the two auction mechanisms (*Choice*). In the *Choice* treatment all subjects had to state their preference for one of the mechanisms before each of the 18 auctions (and, in case of bidders, before learning their costs). The choice between mechanisms was incentivized. By stating their preference, each participant could increase the probability of her preferred mechanism being payoff-relevant in the respective auction by 20 percentage points. After making their choice, subjects had to state their decisions for both mechanisms not knowing which of the two has been selected in that particular auction. Decisions made in the price-based auction in *Choice* did not have a bearing on those made in the buyer-determined auction in this treatment, and vice versa.

Table 1 – Treatments

Treatment	Part 1	Part 2	*N*
PB	FPA	Price-based auctions	72
BD	FPA	Buyer-determined auctions	72
Choice	FPA	Price-based auctions and buyer-determined auctions	72

After completion of the experiment subjects received the aggregated payoff for all auctions plus a show-up fee. The average payoff was 14 Euro and the sessions lasted about 90 minutes. All sessions were run at the Magdeburg Laboratory for Experimental Economics (MaXLab), Germany, using z-Tree (Fischbacher, 2007). No subject participated in more than one session.

4 Results

4.1 First Part

The results of the first part are in line with previous experimental results on procurement auctions and reveal overly aggressive bidding behavior (Brosig & Reiß, 2007). Of the 1296 bids 75 percent were *below* the RNNE prediction. Applying two-tailed Binomial tests, we observe significant underbidding in each of the six auctions ($p = 0.000$). The underbidding in the procurement context is equivalent to overbidding in standard auctions, which is commonly observed in experiments (Kagel & Levin, 2008).

4.2 Second Part

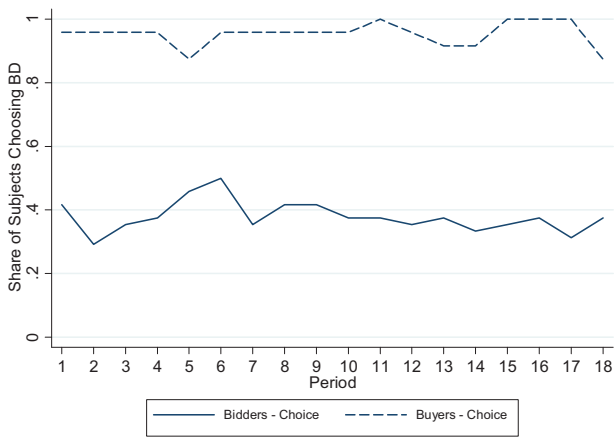
Mechanism Choice

The *Choice* treatment allows analyzing subjects' choice between the two procurement mechanisms and provides insight into their preference for reputation information. Figure 1 presents the share of buyers and bidders choosing the buyer-determined mechanism for each of the 18 auctions. Almost all buyers and somewhat less than half of the bidders prefer the buyer-determined auction. Specifically, for buyers the average frequency of those choosing this auction is significantly higher than 50 percent ($p = 0.012$, two-tailed one sample Wilcoxon test). In contrast, bidders show a tendency to prefer the price-based auction, i.e., they choose it in 62 percent of all cases which is weakly significantly larger than 50 percent ($p = 0.093$, two-tailed one sample Wilcoxon test).[4] These results imply that, in anonymous markets, there is a preference for reputation information (i.e., an institution that provides information about past behavior) – and this is true not only for buyers, but also for a considerable number of bidders. But does reputation informa-

[4] The share of buyers preferring the buyer-determined auction is significantly different (at the five percent level) from all shares up to 89 percent. The share of bidders preferring the price-based auction is significantly different (at the five percent level) from all shares below or equal to 49 percent.

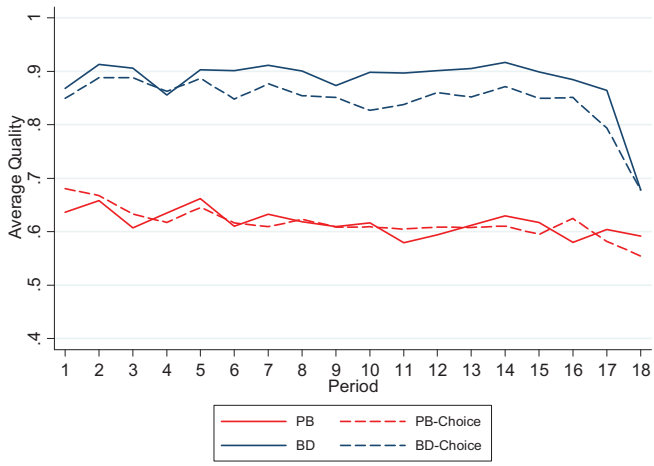
tion work, i.e., does it reduce moral hazard and increase market efficiency? Moreover, is buyers' and sellers' preference for a certain auction mechanism reflected in their profits?

Figure 1 – Share of Subjects Choosing the Buyer-determined Auction



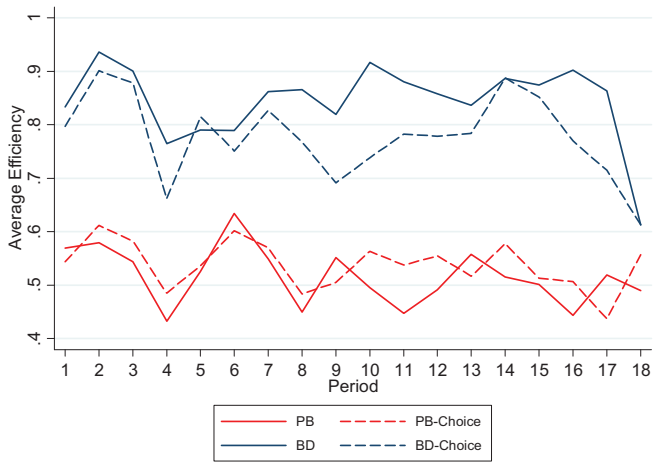
If information about past behavior reduces moral hazard, we should observe that bidders choose a higher quality in buyer-determined auctions than in price-based auctions. As illustrated in Figure 2, this is the case. Comparing matching group averages, we find significant differences for the between-treatment comparison between *PB* and *BD* ($p = 0.001$, two-tailed Mann-Whitney-*U* test) as well as for the within-treatment comparison in *Choice* ($p = 0.012$, two-tailed Wilcoxon test). There are neither significant differences between *PB* and *PB-Choice* nor between *BD* and *BD-Choice* ($p \geq 0.172$, two-tailed Mann-Whitney-*U* tests). Yet, the average quality is still significantly above 50 percent in *PB* and *PB-Choice* and significantly below 100 percent in *BD* and *BD-Choice* (two-tailed one sample Wilcoxon tests, $p = 0.012$). The significant increase in quality in buyer-determined auctions is sustained from the first to the seventeenth auction ($p \leq 0.017$, two-tailed Mann-Whitney-*U* and Wilcoxon tests). From the seventeenth to the eighteenth auction, average quality drops sharply yielding a significant endgame effect ($p \leq 0.036$, two-tailed Wilcoxon tests). Though, in the last round, average quality is still (weakly) significantly higher in buyer-determined than in price-based auctions ($p = 0.058$, two-tailed Mann-Whitney-*U* test, $p = 0.017$, two-tailed Wilcoxon test).

Figure 2 – Average Quality



Driven by the higher quality chosen by bidders, market efficiency is significantly higher in the buyer-determined auctions than in the price-based auctions (see Figure 3). This holds for the comparison between *PB* and *BD* ($p = 0.001$, two-tailed Mann-Whitney-*U* test) as well as for the comparison between *PB-Choice* and *BD-Choice* ($p = 0.012$, two-tailed Wilcoxon test). We define market efficiency as the realized sum of profits divided by the highest possible sum of profits in an auction. The latter is attained if the seller chooses a quality $q_i = 1$ and has lower costs c_i than his opponent. Accordingly, behavior in line with the standard theoretical prediction would yield a market efficiency of 50 percent. The average efficiency realized in *PB* and *PB-Choice* is not significantly different from this prediction (two-tailed one sample Wilcoxon test, $p \geq 0.124$). That is, from a welfare perspective, our price based auction mechanism is clearly dominated by our buyer-determined mechanism.

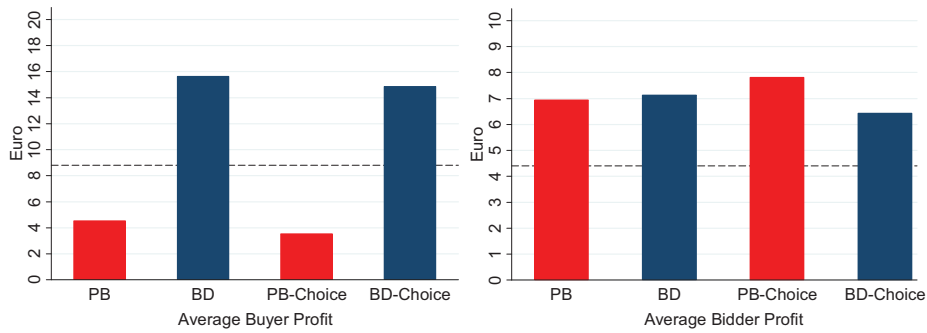
Figure 3 – Average Efficiency



Investigating the gains from trade for buyers and bidders separately, we find that buyer profits are higher in buyer-determined auctions than in price-based auctions (see Figure 4). This holds for the between-treatment comparison between *PB* and *BD* ($p = 0.001$, two-tailed Mann-Whitney-*U* test) and for the within-treatment comparison in *Choice* ($p = 0.012$, two-tailed Wilcoxon test).[5] For bidders, average profits differ much less between price-based auctions and buyer-determined auctions. Though, in *Choice* the difference is significant ($p = 0.036$, two-tailed Wilcoxon test), yielding higher bidder profits in the price-based auctions. Again, there are neither significant differences between *PB* and *PB-Choice* nor between *BD* and *BD-Choice* ($p \geq 0.172$, two-tailed Mann-Whitney-*U* tests). That is, the average profits realized by buyers and bidders are fully in line with their average mechanism choice behavior. Buyers mainly choose the buyer-determined auction where they can base their decisions on previous quality choices as well as on prices and subsequently earn larger profits. Bidders earn slightly higher profits in the price-based auctions and, accordingly, show a tendency to prefer this mechanism.

[5] Note that the analysis of the *Choice* treatment is based on hypothetical profits assuming that the respective mechanism would be payoff-relevant in all auctions.

Figure 4 – Average Profits



According to the RNNE prediction, buyer and seller within an auction earn the same amount while the losing bidder earns zero. On aggregate, this yields a predicted profit of 8.82 Euro for buyers and 4.41 Euro for bidders in our experiment as indicated by the dashed lines in Figure 4. Comparing realized with predicted profits reveals that, in buyer-determined auctions, both buyers and bidders significantly profit from increased market efficiency ($p = 0.012$, two-tailed one sample Wilcoxon tests). However, in *PB* and *PB-Choice*, where market efficiency is similar to the RNNE prediction, we observe that the total profit is split differently than predicted. While bidders earn significantly more than predicted ($p = 0.012$), buyers earn significantly less ($p \leq 0.036$).[6] Remember that the overly aggressive bidding typically observed in FPA would give the opposite result. The next section sheds more light on this phenomenon by investigating submitted bids in more detail.

Bidding Behavior

While the quality choices determine overall attainable profits, the bids determine their feasible splits. To study bidding behavior we employ three benchmarks:

i. *Standard Theory* (*ST*): The first benchmark follows the standard theoretical prediction of choosing $q_i = 0.5$ in every auction and bidding according to the RNNE prediction over the resulting range of costs [50, 200].

[6] Note that there are only small variations of the profit over time. When comparing average profits realized in the first half of the 18 auctions to those realized in the second half there are no significant differences after excluding the first and the last auction ($p \geq 0.124$, two-tailed Wilcoxon tests).

ii. *Perfect Reputation* (*PR*): The second benchmark assumes a perfect reputation mechanism that induces every bidder to choose $q_i = 1$ and to bid according to the RNNE prediction over the range of costs [100, 400].

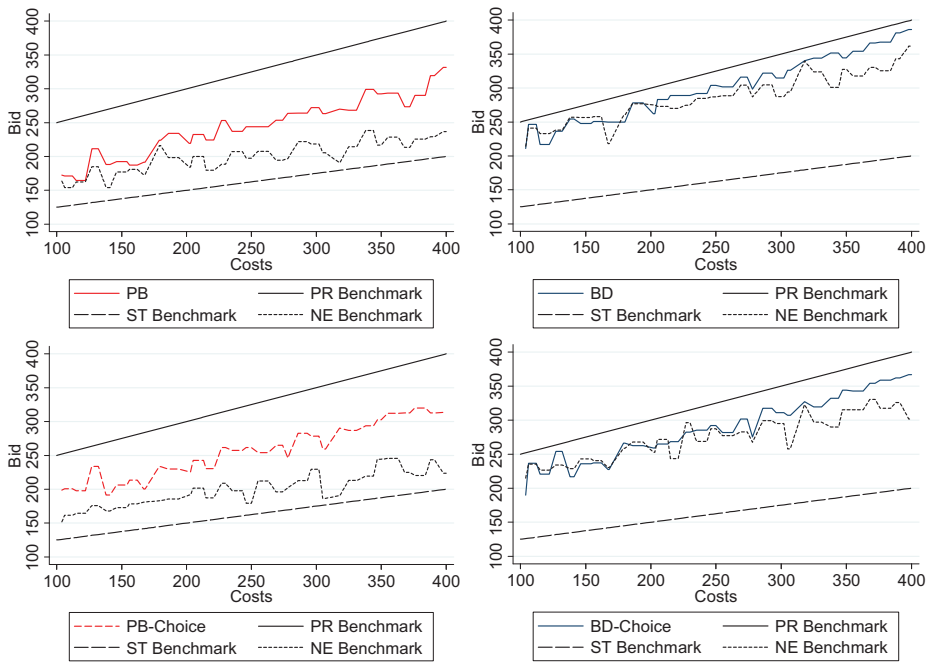
iii. *Naive Expectations* (*NE*): The third benchmark is based on the assumption that every bidder expects the others to choose the same quality q_i as himself and bids as if this quality choice was common knowledge. Accordingly, bidders bid according to the RNNE prediction over the range of costs $[100q_i, 400q_i]$.

Figure 5 displays the average bids over the costs c_i in both mechanisms relative to the three benchmarks. The higher quality supplied in the buyer-determined auctions leads to higher costs in this mechanism. Accordingly, bidders submit higher bids in the buyer-determined than in the priced-based auctions. When comparing matching-group averages this holds for the comparison between *PB* and *BD* ($p = 0.001$, two-tailed Mann-Whitney-*U* test) as well as for the comparison in the *Choice* treatment ($p = 0.012$, two-tailed Wilcoxon test). Again, there are neither significant differences between *PB* and *PB-Choice* nor between *BD* and *BD-Choice* ($p \geq 0.142$, two-tailed Mann-Whitney-*U* tests). Interestingly, not only in buyer-determined auctions, but also in price-based auctions, average bids are still significantly higher than the *ST* benchmark (and are significantly lower than the *PR* benchmark; $p = 0.012$, two-tailed one sample Wilcoxon tests). In particular, we observe that 94 percent of all 1728 bids in *PB* and *PB-Choice* are *above* the standard theoretic RNNE prediction. This is in contrast to the first part, where we observe significant underbidding of the RNNE prediction in FPA.

One of the differences between price-based auctions and FPA is that, in the former, bidders have to choose not only their bid, but also their quality. Possibly, bidders who choose quality levels larger than 0.5 are subject to some kind of false consensus and expect others to behave in the same way as themselves. Comparing average bids submitted in price-based auctions with the *NE* benchmark reveals that bidders overbid this benchmark, i.e., behave as if they expect even higher quality levels from others than they choose in these auctions themselves ($p = 0.012$, two-tailed one sample Wilcoxon test). This effect is also prevalent in buyer-determined auctions (*BD*: $p =$

0.017, *BD-Choice*: $p = 0.069$), though the difference between average bids and the NE benchmark is significantly larger in the price-based auctions ($p = 0.012$, two-tailed Wilcoxon test).[7]

Figure 5 – Average Bids



If bidders systematically overestimate the opponents' quality choice, giving feedback should reduce this expectation bias over time. In fact, running a control *Choice* treatment in which bidders receive feedback about their opponent's bid, we observe that, particularly in the second half of price-based auctions, the average difference between bids and the NE benchmark is significantly lower than in *Choice* ($p = 0.021$, two-tailed Mann-Whitney-*U* test). This is not true for buyer-determined auctions, however ($p = 0.916$). Moreover, even in the second half of the control treatment bidders significantly overbid the NE benchmark in price-based auctions ($p = 0.012$, two-tailed one sample Wilcoxon test).[8] Another possible explanation for overbidding might be

[7] Note that, in buyer-determined auctions, the average quality factor chosen by bidders is already close to 1, so there is not much room for overestimating the other's quality choice.
[8] Accordingly, all qualitative results reported in this study are also valid in the control treatment.

that the opportunity to individually select a quality factor higher than 0.5 works as an implicit coordination device. In that way higher bids might be the result of tacit collusion (as defined by Carlton & Perloff, 1999, p.188; for experimental results see Kagel & Levin, 2008), which seems to pay off for bidders: in price-based auctions, sellers receive a higher share of the total profit than predicted and than that received by buyers. The latter is not true in buyer-determined auctions, in which buyers influence the market outcome by choosing a seller. The next section focuses on this buyer behavior and provides more insight into the functioning and the value of reputation information.

Buyer Choices

In our buyer-determined auctions buyers can base their choice on information about past behavior and the prices offered. But how do subjects make use of this information? How much weight do they put on reputation?

When selecting a bidder, buyers seem to use both, the bidder's reputation information and the price, in order to calculate expected profits. In particular, we observe that each buyer selects the bidder with the highest expected profit based on information about the bidder's last quality choice in at least 12 auctions and based on information about the bidder's average of last quality choices in at least 11 auctions (note that in some auctions both rules would imply to select the same bidder). Moreover, average profits realized by buyers do not significantly differ from profits that would result from following one of these two kinds of information in all 18 auctions ($p \geq 0.124$, two-tailed Wilcoxon tests), but are significantly higher than profits that would result from following rules of thumb like "always choose the bidder with the highest price", "always choose the bidder with the highest last quality choice" and "always choose the bidder with the highest average of last quality choices" ($p = 0.012$, two-tailed Wilcoxon tests). These results imply that buyers use reputation information and that they do it in a reasonable way.

The discrete-choice setting of our experiment also allows estimating the buyers' willingness-to-pay for both measures of reputation (i.e., their willingness to accept a higher bid b_i in turn for higher values of $\overline{q}_i$ or q_i^{t-1}) using a conditional logit model (Hole, 2007). On aggregate, i.e., pooling over all choices made in auctions two to seventeen, buyers are willing to pay 2.91 Euro-cent more if a bidder has supplied an additional percent of average quality in previous auctions (95% confidence interval [1.95; 3.86], $p = 0.000$, 100 bootstrap replications). Remember that an addi-

tional percent of actually supplied quality q_i increases buyer profits by 4 Euro-cent. The influence of the last auction's quality choice on buyer choices is not significant (95% confidence interval [-0.08; 1.34], $p = 0.080$, 100 bootstrap replications). Although the two kinds of reputation information – quality in the last auction and average quality in previous auctions – are strongly correlated with each other (Spearman's rho = 0.685, $p = 0.000$), it seems that buyers value the reputation information the most which considers behavior in more than the last auction.

5 Conclusion

When initiating a procurement auction, buyers usually have to decide on how to evaluate incoming bids. If the characteristics of supplied goods or services can vary across bidders, picking the bidder who offers the lowest price will not necessarily maximize the buyer's profit from the trade (or minimize his total costs). In these cases it is common to put other bid dimensions such as quality, lead time or reputation into consideration. Previous experimental studies have focused on procurement settings where these dimensions are either exogenously determined or can be conditioned on in contracts. But in many cases private and public procurement settings are characterized by moral hazard regarding non-contractible quality, i.e., the effort exerted or quality supplied cannot be verified by a court. In such a setting reputation could provide bidders with an incentive to exert high effort or supply high quality even in the absence of legal enforcement.

In our study, we test this conjecture and compare price-based and buyer-determined auctions in a setting with moral hazard and non-contractible quality. While buyers are bound to buy from the lowest bidder in the former mechanism, they can also consider the past performance of bidders in the latter. We observe that bidders choose to build up a reputation for supplying high quality in buyer-determined auctions, but not in price-based auctions. As a result, the availability of a reputation mechanism increases market efficiency from about 50 percent to about 80 percent.

While buyers' profits are increased when implementing reputation information, bidders do not benefit from this mechanism. Accordingly, giving subjects the opportunity to choose between the price-based auction and the buyer-determined auction, buyers prefer the latter while bidders show a tendency to prefer the former mechanism. This might explain why we often, but not exclusively, observe reputation mechanisms in procurement with moral hazard. Comparing the two kinds of reputation information, we find that buyers place a higher weight on an aggregate measure of past performances than on the last performance only when choosing between bidders. This sug-

gests that buyers rely more on the whole history of a bidder's behavior than on latest behavior only.

To our knowledge no previous empirical study has analyzed mechanism choices or reputation in procurement auctions under controlled conditions. The experiment presented here had to abstract from several factors present in the field. Future work should consider auctions with moral hazard and adverse selection, less reliable reputation information, varying forms of feedback and other auction formats.

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Appendix: Instructions

Welcome to the experiment!

Preface

You are taking part in an experiment about decision making in the field of experimental economics. During the experiment you and the other participants will be asked to make decisions. By doing so, you can earn money. How much you are about to earn depends on your decisions. After the experiment you will receive your earnings in cash.

The experiment will take about 90 minutes and is split up in two different parts. Each of these parts is introduced by detailed instructions.

All participants will receive exactly the same instructions.

Please keep in mind that decisions you made in one of the two parts of the experiment do not have any influence on the other part of the experiment.

None of the participants will receive any information concerning other participants during the experiment.

Part 1

Please read the following instructions. Five minutes after you have received the instructions we will come to your desk to answer remaining questions. Whenever you should have questions during the experiment please simply hold up your hand. We will come to your desk then.

During the first part of the experiment you will take part in 6 auction rounds.

Description of the auction rounds

In each of the 6 auction rounds you take part in, a project will be sold. There are exactly two bidders (= potential sellers), you and another bidder.

Procedure:

The bidders want to conduct the project. For each auction round and for both bidders we have drawn the costs for conducting the project by chance and independently of each other from 100 to 400 euro cents. All sums of this row could be realized with equal chances. Each bidder will only be informed about his own costs for conducting the project.

At the beginning of each auction round each of the two bidders can decide how much he wants to bid for the project. The bid is set to a maximum of 400 euro cents.

The bidder who puts in the lowest bid wins the auction. His earning is equal to the difference of bid and costs for conducting the project.

The bidder who puts in the highest bid loses the auction. His earning in this case equals zero.

If both bids are equal the winner will be drawn by chance (meaning each bidder wins the auction with a chance of 50 percent).

Your fellow bidder:

Your fellow bidder is a computer in each of the 6 auction rounds. The computer is programmed to maximize its expected earnings in each auction round (in fact it is bidding in every auction round according to the symmetric Nash equilibrium strategy for risk neutrality). The computer expects that you behave like it. The computer expects that your costs for conducting the project are drawn out of the range from 100 to 400 euro cents by chance and independently of each other and that all values of this range could be realized with equal chance.

Pay-out

The pay-out of all your earnings of the 6 auction rounds takes place at the end of the whole experiment.

Please keep in mind that none of the participants will get any information about his earnings per round during the first part of the experiment.

Moreover, none of the participants will get any information about the bidding behavior and the earnings of the other participants in part 1 during the whole experiment.

Screen in Part 1

Round 1 out of 6

Remaining time (for information):
Please decide now!

Round 1:
You are participant number 1 and bidder in all following auctions.

Auction:
In round 1 your costs to conduct the project add up to 200 euro cents.
Please put in your bid.
Your bid is:

Confirm bid

Please keep in mind: If you win the auction your earnings in this round = your bid - 200.

Part 2

Please read the following instructions. Ten minutes after you have received the instructions we will come to your desk to answer remaining questions. Whenever you should have questions during the experiment please simply hold up your hand. We will come to your desk then.

During the second part of the experiment you will take part in 18 auction rounds.

Description of the auction rounds

In each of the 18 auction rounds you take part in, a project will be sold. There are exactly two bidders (= potential sellers) and one buyer.

You will be told at the beginning of the first auction round if you decide in the role of a bidder or a buyer during the 18 auction rounds. You will stick to your role in each of the 18 auction rounds.

In each of the 18 rounds the other two participants will be assigned to you by chance so every time a buyer and two bidders interact. It is certain that you will not meet the same group of participants in two consecutive rounds.

Procedure:

The buyer wants to have the project conducted. His valuation for a project (with a quality of 100 percent, see below) is 400 euro cents in every auction round. The valuation says how valuable the project is for the buyer at a 100% quality rate.

The bidders want to conduct the project. For each auction round and for both bidders we have drawn the costs for conducting the project by chance and independently of each other (with a quality of 100 percent) from 100 to 400 euro cents. All values of this range could be realized with equal chance. Each bidder will only be informed about his own costs for conducting the project. The buyer does not get any information concerning the costs.

Each auction round comprises [*PB*: two; *BD*: three; *Choice*: four] stages: [*Choice*: In the "auction choice phase" the buyer as well as the bidder can decide upon the type of auction.] In the "auction phase" both bidders bid for conducting the project. [*BD, Choice*: In the "buyer choice phase" the buyer chooses a winner (= seller) based on the bids and the information he has concerning the previous bidder's choice of quality.] In the "quality choice phase" both bidders decide upon the quality of the project in case they should win the auction and receive their bid from the buyer. The four stages are described below.

[*Choice*:

Auction Choice Phase:

At the beginning of each round both bidders and the buyer can chose a specific auction type. They can choose one of the following auction types: the conduction of the auction round without a "bidder choice phase" or with a "bidder choice phase". By choosing a specific auction type you raise the probability of this auction type actually being chosen. You can imagine the auction choice as follows: each participant's decision can be represented by a ball labeled with the chosen auction type. Each of the three participants throws his chosen ball in an urn already containing two balls – one ball for each auction type. One ball will then be randomly drawn from this urn thereby deciding upon the auction type for the current round.

At the end of the experiment you will see which auction type was actually chosen. This means you have to make your decisions for each of the two auction types in case that this type will be chosen. The pay-out will be calculated based on the decisions made in the actually chosen auction type.]

Auction Phase:

At the beginning of the auction phase each of the two bidders can decide which bid he wants to make for conducting the project. The bid is made for each possible result of the auction choice phase meaning for each of the two auction types. The bid is set to a maximum of 400 euro cents.

[*PB*: The winnings per round are set as follows; *Choice*: In case the auction is chosen without a "seller choice phase" the winnings per round are set as follows]

[*PB* and *Choice*:

The bidder with the lowest bid wins the auction. His winnings per round are set due to his decision in the quality choice phase (see below).

The bidder with the highest bid loses the auction. His winnings per round are equal zero.

If the both bids are equal the winner is drawn by chance (meaning each bidder has a 50% probability to win the auction).]

[*BD*: The winnings per round are set due to the choices made in the "seller choice phase" and the "quality choice phase" (see below).; *Choice*: In case the auction is chosen without a "seller choice phase" the winnings per round are set due to the decisions made in the "seller choice phase" and in the "quality choice phase" (see below).]

[*BD* and *Choice*:

Seller Choice Phase:

In the seller choice phase the buyer decides upon the winner (= seller) in case the auction with a seller choice phase is realized. Therefore, he gets the following information about each bidder: his bid for this auction type, his quality decision for this auction type in the previous round and the average of his quality decisions in all previous rounds of this auction type.]

Quality Choice Phase:

In the quality choice phase the bidders decide upon the quality of the conducting the project in case they win the auction and receive their bid from the buyer. [*Choice*: The decision upon quality has to be made for each possible result of the auction choice phase meaning for each of the two auction types.]

The quality rate has to be set between 50% and 100%. Each percent of quality costs the winner of the auction (= seller) one percent of his costs for conducting the project drawn for him in the corresponding round. Therefore the seller's costs for conducting the project with 100% quality correspond to his costs and the costs for conducting the project with 50% quality correspond to half of his costs.

Winner's earnings per round = bid – quality [%]*costs for conducting the project

The valuation of the project for the buyer decreases with each percent less quality by one percent (i.e. by 4 euro cents). Therefore the buyer's valuation for the project at a quality of 100% is equal to 400 euro cents and at a quality of 50% it is equal to 200 euro cents.

Buyer's earnings per round = quality [%]*400 – auction's price

Pay-out

After the 18 auction rounds the sum of your winnings per round together with your winnings of the first part of the experiment are paid out in cash.

Before we start with the second part of the experiment in a few moments we ask you to fill out a test of understanding on the computer.

Screens for bidders (= potential sellers) in part 2

[*Choice*:]
Auction choice phase:

Round

2 out of 18

Remaining time (for information):
Please decide now!

Round 2:

You are participant No 1 and bidder in all following auctions.

The auction can be carried out with a seller choice phase or without a seller choice phase.

Please mark which auction type you chose:

Auction with seller choice phase
Auction without seller choice phase

OK

[*PB* and *Choice*:]
Auction and quality choice phase [*Choice*: for the auction without a seller choice phase]:

Round

2 out of 18

Remaining time (for information):
Please decide now!

You are participant No 1 and bidder in all following auctions.

AUCTION [*Choice*: WITHOUT SELLER CHOICE PHASE]:

In round 2 your costs for conducting the project are 200 euro cents at a rate of 100% quality.

AUCTION PHASE:

Please bid [*Choice*: for the case where the auction without a seller choice phase is realized].

Your bid is:

QUALITY CHOICE PHASE:

Please decide on the quality [*Choice*: for the case where the auction without a seller choice phase is realized].

Your quality is:

Please keep in mind: If you win an auction your earnings in this round = your bid- quality (%)*200 (euro cents)

Confirm price and quality

[*BD* and *Choice*:]
Auction and quality choice phase [*Choice*: for the auction with a seller choice phase]:

Round

2 out of 18

Remaining time (for information):
Please decide now!

You are participant No 1 and bidder in all following auctions.

AUCTION [*Choice*: WITH SELLER CHOICE PHASE]:

In round 2 your costs for conducting the project are 200 euro cents at a quality rate of 100%.

AUCTION PHASE:

Please bid [*Choice*: for the case where the auction with a seller choice phase is realized].

Your bid is:

QUALITY CHOICE PHASE:

Please decide on the quality [*Choice*: for the case where the auction with a seller choice phase is realized].

Your quality is:

The seller in this round receives the following information about you:

The bidder's quality [*Choice*: for the auction with a seller choice phase] was 100 in the previous round.

The average bidder's quality in the previous auctions [*Choice*: with a seller choice phase] was 100.

Please keep in mind: If you win an auction your earnings in this round = your bid- quality (%)*200 (euro cents).

Confirm price and quality

Screens for buyer in part 2

[*Choice*]
Auction choice phase:

Round
2 out of 18

Remaining time (for information):
Please decide now!

Round 2:

You are participant No 3 and buyer in all following auctions.

The auction can be carried out with a seller choice phase or without a seller choice phase.

Please mark which auction type you chose:

Auction with a seller choice phase
Auction without a seller choice phase

OK

[*PB*:]
Information for the buyer:

Round
1 out of 18

Remaining time (for information):
Please decide now!

You are participant No 3 and buyer in all following auctions.

BIDDER A:

The bidder who has been randomly matched with you as bidder A in this period is the lowest bidder bidding a price of 200 euro cents.

Please keep in mind: your round earnings = quality (%)*400 (euro cents) - bid

Bidder A will conduct the project.

OK

[*BD* and *Choice*:]
Seller choice phase:

Round

2 out of 18

Remaining time (for information):
Please decide now!

You are participant No 3 and buyer in all following auctions.

SELLER CHOICE PHASE:

BIDDER A:

Bidder A you are randomly matched with in this round bids a price of 300 euro cents.

The bidder's quality [*Choice*: for the auction with seller choice phase] in the previous round was 50.

The bidder's average quality [*Choice*: in the previous auctions with a seller choice phase] was 50.

BIDDER B:

Bidder B you are randomly matched with in this round bids a price of 300 euro cents.

The bidder's quality [*Choice*: for the auction with seller choice phase] in the previous round was 50.

The bidder's average quality[*Choice*: in the previous auctions with a seller choice phase] was 50.

Please keep in mind: your round earnings = quality (%)*400 (euro cents) - bid

Please decide between the bidders [*Choice*: for the case that the auction is realized with a seller choice phase]:

Bidder A
Bidder B

OK