Reputation and Mechanism Choice in Procurement Auctions: An Experiment

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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.

Keywords: buyer-determined and price-based procurement, supplier reputation, 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 complete contingent contracts are not feasible, i.e., contracts that specify the obligations and payments of the parties involved under each conceivable circumstance (see, e.g., Shavell, 1980). Situations where contracts cannot be based on the outcome of the transaction are common, for example in online procurement where legal enforcement would be too costly or in the procurement of services, where quality or effort cannot be easily verified by a court. Specifically the outcomes of complex consulting projects, for example in IT or engineering, are often highly uncertain and diverse. Even though the buyer is able to evaluate the contractor's performance, it can be impossible to draft a complete contingent contract that would hold up in a court of law. Yet, the input provided by the consulting contractor in terms of human capital and effort may vary widely.

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. In the field, reputation has been found to influence the choice of contract type in the procurement of software customization services (Banerjee & Duflo, 2000) or supplier selection in the procurement of transportation services (Heinrich, 2012). By comparing price-based and buyer-determined auctions in a laboratory experiment, we can analyze the effect of reputation in procurement auctions under more controlled conditions. 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.[1]

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' reputations. 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.

[1] 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 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.

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 the contract cannot be conditioned on the delivered quality. We only allow for fixed-price contracts and focus on the role of reputation as an incentive to provide above minimum quality.[2]

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. The first part can also be compared to the results of previous experimental studies.[3] During the second part subjects take part in price-based or buyer-determined procurement auctions with human opponents.

3.1 The auction games

The *first-price sealed-bid procurement auction* 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, and Holt, 1980). The two bidders $i = 1, 2$ compete for a project by bidding a price for

[2] Conceptually our paper is also related to the literature pertaining 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] Employing a first training stage, after which the participants are assigned more specific roles or act in a more complicated environment, is quite common in experimental auction research (see, e.g., Brosig & Reiß, 2007, or Brunner, Goeree, Holt, Ledyard, 2010). Brosig & Reiß (2007) find that behavior in sequential procurement games is not influenced by whether subjects have participated in single first-price procurement auctions before. The single auctions in their experiment were equivalent to the ones used in the present study.

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 bidding function depending on the cost realization c_i is given by

$$\beta^{first\text{-}price}(c_i) = 200+c_i/2.$$

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

Based on the first-price auction design described above, the second part involves a series of procurement auctions that model the situation of moral hazard: 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 first-price auction, 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 $\pi_S = b_i-q_ic_i$ while the losing bidder earns zero profits. The buyer earns a profit of $\pi_B = q_iv-b_i$.

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 risk-neutral Nash-equilibrium 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 who was known to be programmed to bid according to the risk-neutral Nash-equilibrium strategy. They did not receive any feedback on the opponent's behavior, neither in the course of nor after completion of the first part, in order to increase the comparability of bidding behavior between both parts of the experiment. Subjects were informed accordingly (all instructions are included in the online Appendix). The second part consisted of 18 procurement auctions with moral hazard. Before the start of the second part new instructions were handed out. A computerized test of understanding followed that asked subjects to determine buyer and seller profits in an example, in which they had to choose the cost, the quality and the price themselves. 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. In total, there were 72 subjects participating in each of our treatments. These 72 subjects were assigned to eight matching groups (each consisting of nine subjects – three buyers and six sellers) generating eight independent observations per treatment. Within each matching group, buyers and sellers were randomly re-matched after each auction with the publicly announced restriction that subjects would not meet the same pair of participants in two consecutive auctions. 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 6 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 behavioral observations comparable across treatments the same series of costs were used in all sessions and treatments.

Table 1 – Treatments

Treatment	Part 1	Part 2	Number of Matching Groups (Independent Observations)	Number of Subjects per Matching Group	Total Number of Subjects
PB	First-price auctions	Price-based auctions	8	9 (3 buyers, 6 sellers)	72
BD	First-price auctions	Buyer-determined auctions	8	9 (3 buyers, 6 sellers)	72
Choice	First-price auctions	Price-based auctions and buyer-determined auctions	8	9 (3 buyers, 6 sellers)	72

The three 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. To isolate the influence of the auction mechanisms on behavior, we kept all other experimental variables constant across treatments. Therefore we also assigned subjects to the role of buyers in the *PB* treatment. These subjects did not make any decisions during part two. Yet, as in the buyer-determined auctions, they could observe the behavior of bidders.

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). All subjects were students of business administration, economics, engineering or a related field. At the time of the experiment all had completed at least their second year of study. (This implies they were trained in mathematics and are familiar with the concept of Nash-equilibrium.) About half of subjects participating in each treatment were female (37 in *BD*, 29 in *PB*, and 31 in *Choice*). 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 risk-neutral Nash-equilibrium prediction. Applying two-tailed Binomial tests, we observe significant underbidding in each of the six auctions (p = 0.000). Figure 1 displays the average bids made in the six auctions as well as the linear fit. The underbidding in the procurement context is equivalent to overbidding in standard auctions, which is commonly observed in experiments (Kagel & Levin, 2008).

Figure 1 – Average bids submitted in the first part

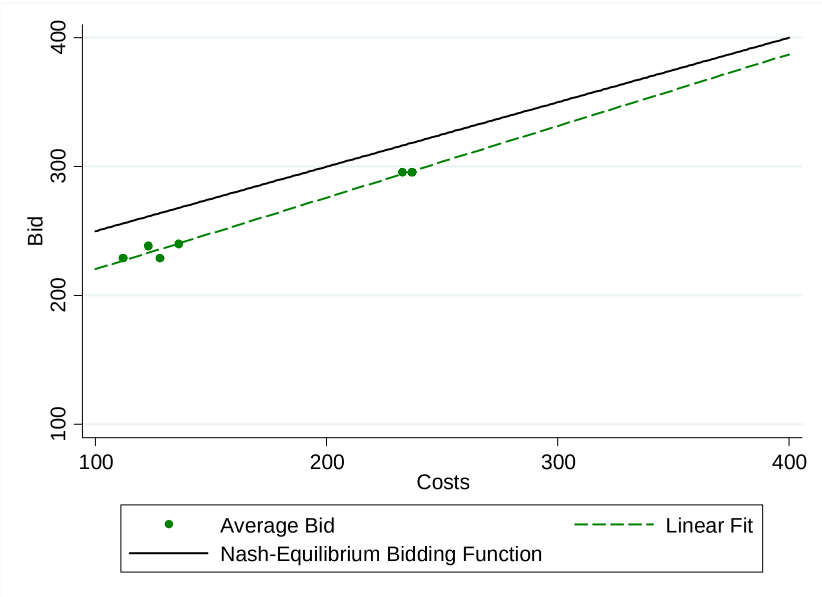
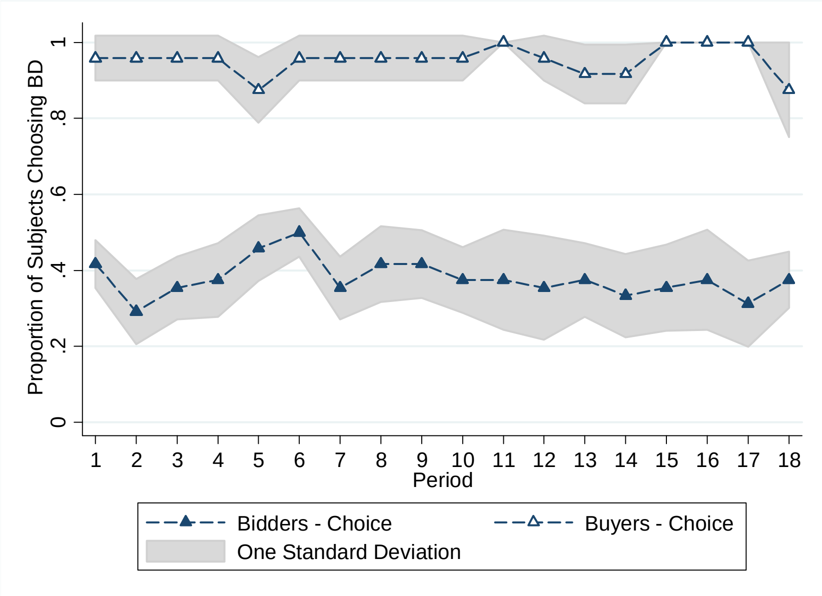


Figure 2 – Proportion of Subjects Choosing the Buyer-Determined Auction



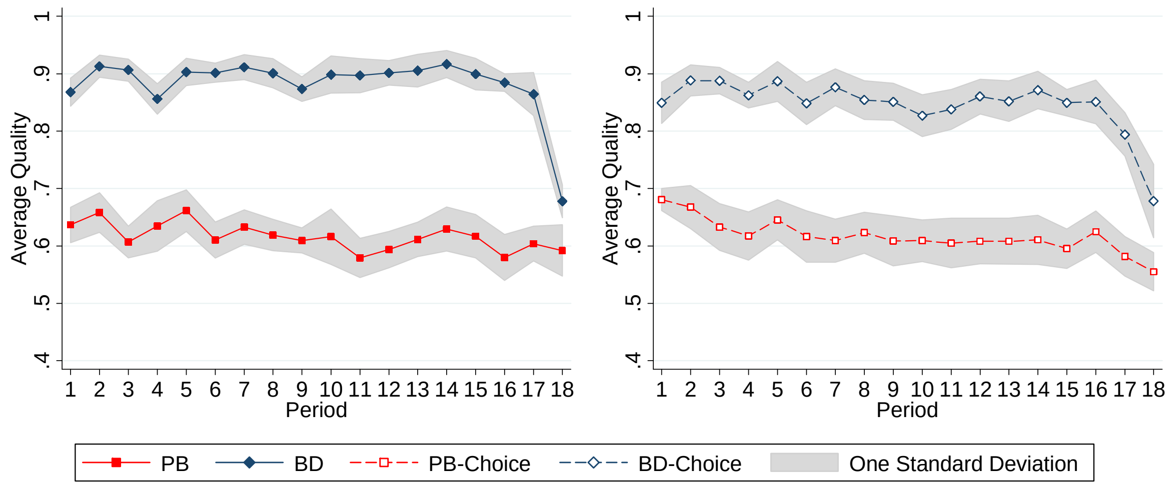
4.2 Second Part

Mechanism Choice

The *Choice* treatment allows analyzing subjects' choices between the two procurement mechanisms and provides insight into their preference for reputation information. Figure 2 presents the proportion 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] Figure 2 also plots the range of half a standard deviation below and half a standard deviation above the average. As subjects received no feedback on the auction result after each period, this range changes little over the 18 periods, suggesting only limited changes of behavior due to introspection (see also Figures 3 and 4).

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

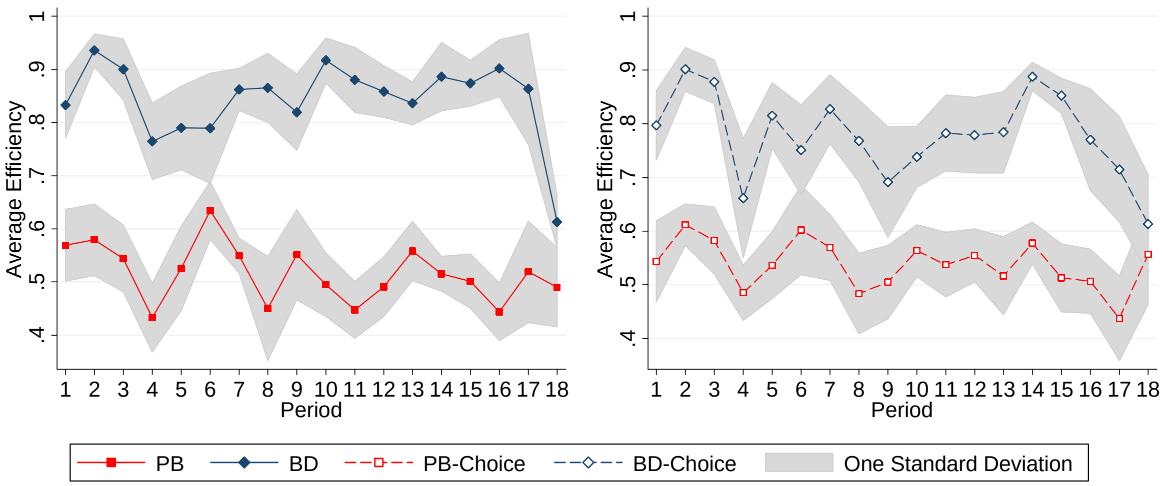
Figure 3 – Average Quality



The results on mechanism choice imply that, in anonymous markets, there is a preference for reputation information (i.e., for an institution that provides information about past behavior) driven mainly by the buyers. But does reputation information work, i.e., does it reduce moral hazard and increase market efficiency? Moreover, are buyers' and sellers' preferences for a certain auction mechanism reflected in their profits?

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 3, this is the case. Comparing matching group averages (see also Table 2), 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 period, 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 4 – Average Efficiency



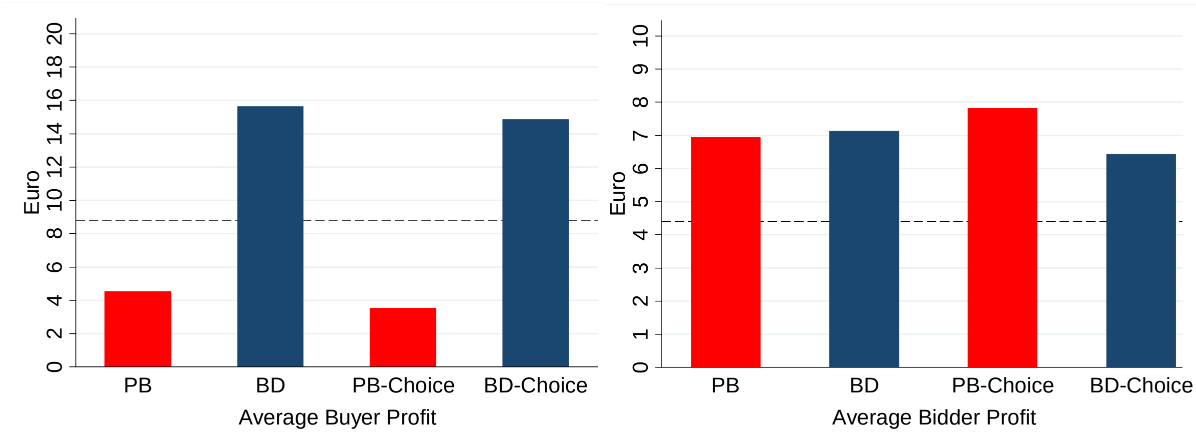
Driven by the higher quality chosen by bidders, market efficiency is significantly higher in the buyer-determined auctions than in the price-based auctions (see Figure 4 and Table 2). This holds for the comparison between *PB* and *BD* (p = 0.001, two-tailed Mann-Whitney-*U* test) as well as for the 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.

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 5 and Table 2). 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

[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.

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.

Figure 5 – Average Profits



According to the risk-neutral Nash-equilibrium prediction, buyer and seller within an auction earn the same amount while the losing bidder earns nothing. 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 5. 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, see also Table 2). However, in *PB* and *PB-Choice*, where market efficiency is similar to that expected under the risk-neutral Nash-equilibrium 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 first-price auctions

[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).

would give the opposite result. The next section sheds more light on this phenomenon by investigating submitted bids in more detail.

Table 2 – Aggregate Results

	PB	*BD*	*Choice PB*	*Choice BD*
	Mean (Std. Dev.)	Mean (Std. Dev.)	Mean (Std. Dev.)	Mean (Std. Dev.)
Market efficiency	51.65	84.40	53.80	77.85
	(6.21)	(3.34)	(6.00)	(4.79)
Quality q	0.62	0.88	0.62	0.85
	(0.18)	(0.16)	(0.18)	(0.18)
Bids (in Euro)	2.44	3.02	2.57	2.89
	(0.72)	(0.62)	(0.75)	(0.70)
Buyer profit (in Euro)	4.52	15.64	3.53	14.86
	(2.90)	(1.95)	(4.82)	(2.54)
Bidder profit (in Euro)	6.95	7.13	7.82	6.44
	(0.93)	(0.88)	(2.40)	(1.13)

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*: The first benchmark follows the standard theoretical prediction of choosing q_i = 0.5 in every auction and bidding according to the risk-neutral Nash-equilibrium prediction over the resulting range of costs [50, 200], i.e. with costs $0.5c_i$.

ii. *Perfect reputation*: The second benchmark assumes a perfect reputation mechanism that induces every bidder to choose q_i = 1 and to bid according to the risk-neutral Nash-equilibrium prediction over the range of costs [100, 400], i.e. with costs c_i.

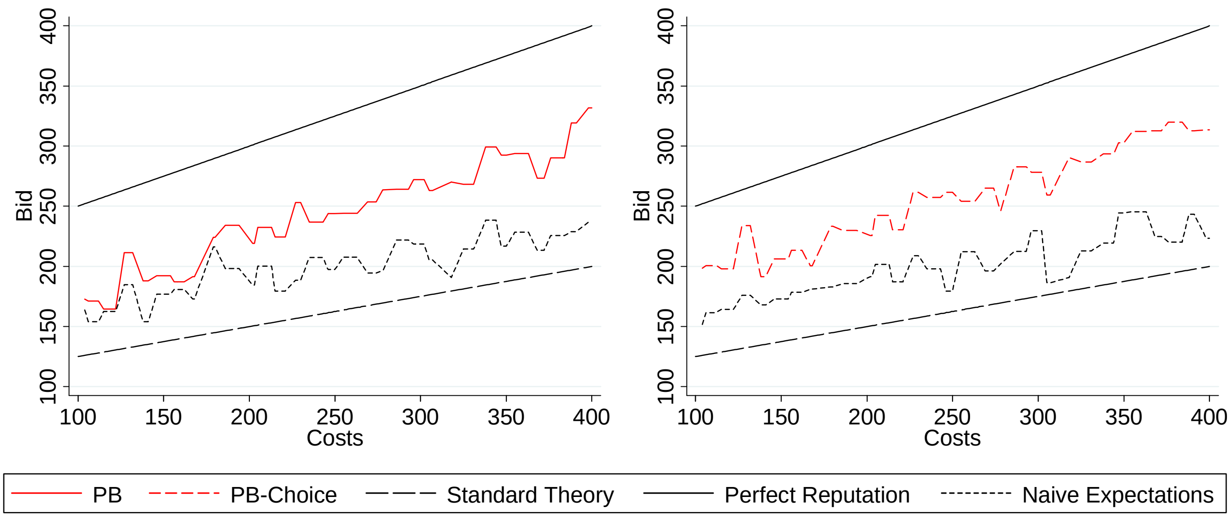
iii. *Naive expectations*: The third benchmark is based on the assumption that every bidder expects the others to choose the same quality q_i as himself and bids as if this quality choice was common knowledge. Accordingly, bidders bid according to the risk-neutral Nash-equilibrium prediction over the range of costs [$100q_i$, $400q_i$], i.e. with costs q_ic_i.

The three benchmarks are restricted to the symmetric cost setting, as we consider this to be the behaviorally most plausible. Any quality choice q_i that is common knowledge and applied by all bidders yields a linear bid functions lying between the *standard theory* benchmark and the *perfect reputation* benchmark. Of course, a bidder might expect his opponents to choose a quality different from himself and bid, for example, as if quality choices were common knowledge. Yet, the resulting auctions with asymmetric costs are analytically demanding. The optimal bid function for this setting has been derived quite recently (Kaplan & Zamir, 2010).

Figure 6 displays the average bids in both mechanisms relative to the three benchmarks in the *PB* and *PB-Choice* auctions over the costs c_i from the range [100, 400]. Figure 7 displays the average bids in the *BD* and *BD-Choice* auctions. 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, see also Table 2) 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 *standard theory* benchmark (and are significantly lower than the *perfect reputation* 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 risk-neutral Nash-equilibrium prediction. This is in contrast to the first part, where we observe significant underbidding of the risk-neutral Nash-equilibrium prediction in first-price auctions.

One of the differences between price-based auctions and first-price auctions 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 *naïve expectations* 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 *naïve expectations* benchmark is significantly larger in the price-based auctions (p = 0.012, two-tailed Wilcoxon test).[7]

Figure 6 – Average Bids in Price-Based Auctions and Benchmarks

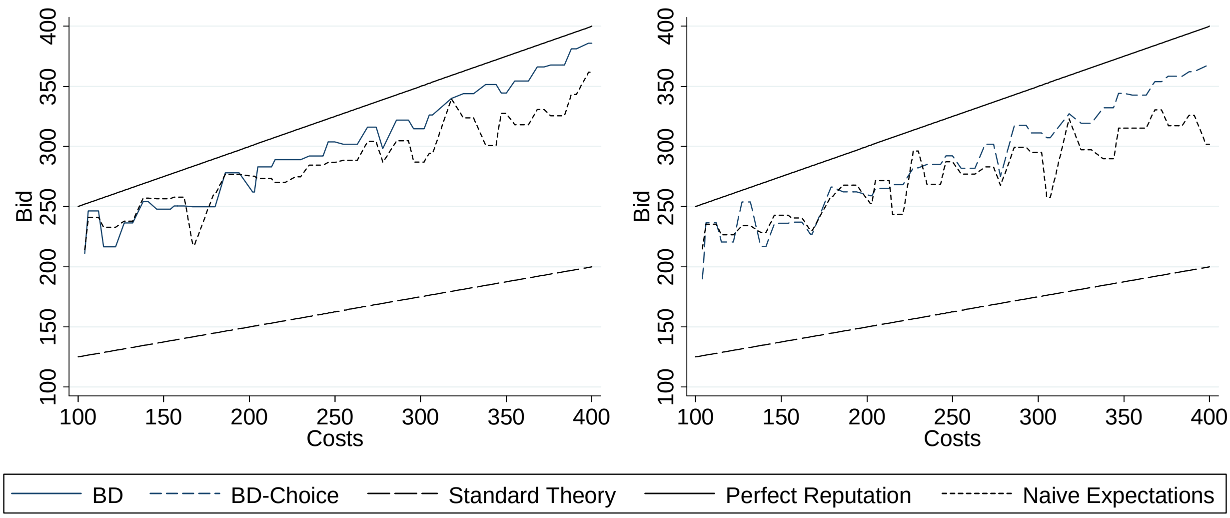


If bidders systematically overestimate the opponents' quality choice, giving feedback should reduce this expectation bias over time. We also conducted a control *Choice* treatment that only differs from the *Choice* treatment explained above in providing bidders with feedback about their opponent's bid. In fact, in this treatment we observe that, particularly in the second half of price-based auctions, the average difference between bids and the *naïve expectations* 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 *naïve expectations* benchmark in price-based auctions (p = 0.012, two-tailed one sample Wilcoxon test).[8] Another possible explanation for overbidding might be 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

[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. See also footnote 7.

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.

Figure 7 – Average Bids in Buyer-Determined Auctions and Benchmarks



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?

Comparing the observed choices between bidders to those expected under simple decision rules reveals that buyers seem to use both, the bidder's reputation information and the price. One rule could consist of calculating the expected profits using $\overline{q}_i$ as a predictor for the unknown quality choice of the current auction. Another rule would be to use $q_i^{t\text{-}1}$ as a predictor instead. Comparing actual choices to those predicted by these two rules, we observe that all of the 48 buyers (24 in *BD*, 24 in *Choice*) select the bidder offering the highest expected profit based on $q_i^{t\text{-}1}$ in at least 12 of the 18 auctions and based on $\overline{q}_i$ 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 decision rules 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 bid b_i", "always choose the bidder with the highest value of q_i^{t-1}", and "always choose the bidder with the highest value of $\overline{q}_i$" ($p = 0.012$, 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 (see, e.g., Hensher et al., 2005). Accordingly, we assume an underlying random utility model where buyers choose the bid offering the highest utility and where the utility a buyer j in period t obtains from bid i is given by

$$U_{ijt} = \beta_1 b_{ijt} + \beta_2 \overline{q}_{ijt} + \beta_3 q_{ijt}^{t-1} + \varepsilon_{ijt}.$$

The unobserved error term is denoted by ε_{ijt} and is assumed to be independently identically distributed with the type 1 extreme value distribution. Due to the linear nature of the random utility function, the willingness-to-pay for an increase in $\overline{q}_i$ or q_i^{t-1} is given by $-\beta_2/\beta_1$ or $-\beta_3/\beta_1$, respectively. We calculate confidence intervals of the willingness-to-pay using bootstrapping as we suspect unobserved heterogeneity of buyers j in our experiment. As Hole (2007) observes, bootstrapping yields the most robust estimates under these circumstances.

On aggregate, i.e., pooling over all choices made in auctions two to seventeen in *BD* and *BD-Choice*, 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). (An additional percent of actually supplied quality q_i increases buyer profits by 4 Euro-cent.) If a bidder has supplied an additional percent of quality in the last auction, buyers are willing to pay 0.63 Euro-cent more, but this effect is only weakly 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, $p = 0.000$), the results suggest that buyers place a higher value on the aggregate measure of reputation $\overline{q}_i$.

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 effort or quality, i.e., contracts cannot be based on the outcome of the transaction. 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 suggests 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!

<u>Preface</u>

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 last about 90 minutes and is split into 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 make 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 the identity of 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 have questions during the experiment, please put up your hand. We will come to your desk then.

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

Description of the auction rounds

In each of the 6 auction rounds you participate in, one 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 randomly and independently of each other from the range between 100 and 400 euro cents. All sums of this range could be realized with equal probability. Each of the two bidders 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 earnings in this round are equal to the difference between his bid and his costs for conducting the project.
>
> The bidder who puts in the highest bid loses the auction. In this case, his earnings in this round are equal to zero.
>
> If both bids are equal, the winner will be determined randomly (i.e. each bidder wins the auction with a probability of 50%).

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 under risk neutrality). The computer expects that you behave in the same way. The computer expects that your costs for conducting the project are drawn randomly and independently of each other out of the range from 100 to 400 euro cents and that all values of this range could be realized with equal probability.

Pay-out

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

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

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

<u>Screen in Part 1</u>

Round 1 out of 6

Remaining time (for orientation):
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 amount to 200 euro cents.
Please enter 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 have questions during the experiment, please put up your hand. We will come to your desk then.

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

Description of the auction rounds

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

You will be informed at the beginning of the first auction round whether you decide in the role of a bidder or in the role of a buyer during the 18 auction rounds. You will maintain this role in all of the 18 auction rounds.

In each of the 18 rounds, the other two participants will be assigned to you randomly, so every time a buyer and two bidders interact. It is guaranteed 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 conducted project (with a quality of 100%, see below) is 400 euro cents in every auction round. The valuation determines 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 (with a quality of 100%) randomly and independently of each other from the range between 100 and 400 euro cents. All values of this range could be realized with equal probability. Each bidder will only be informed about his own costs for conducting the project. The buyer does not receive 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 about 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 about the quality they conduct the project with, in case they should win the auction and are paid their bid by the buyer. The four stages are described in more detail 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 implementation of the auction round without a "seller choice phase" or with a "seller choice phase". By choosing a specific auction type, you raise the probability of this auction type actually being realized. 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 the urn thereby deciding about the auction type realized in the current round.

At the end of the experiment you will see which auction type was actually realized. This means you have to make your decisions for each of the two auction types for the case that this type will actually be realized. The pay-out will be calculated based on the decisions made in the actually realized 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. [*Choice*: The bid is made for each possible result of the auction choice phase, i.e. for each of the two auction types.] The maximum bid is 400 euro cents.

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

[*PB* and *Choice*:

> The bidder who puts in the lowest bid wins the auction. His earnings in this round is determined based on his decision in the quality choice phase (see below).
>
> The bidder who puts in the highest bid loses the auction. In this case, his earnings in this round are equal to zero.
>
> If the both bids are equal, the winner will be determined randomly (i.e. each bidder wins the auction with a probability of 50%).]

[*BD*: The earnings per round are determined based on the choices made in the "seller choice phase" and the "quality choice phase" (see below).; *Choice*: In case the auction with a "seller choice phase" is realized, the earnings per round are determined based on 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 about the winner (= seller) [*Choice*: for the case that the auction with a seller choice phase is realized]. For this he receives 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 about the quality they conduct the project with, in case they should win the auction and are paid their bid by the buyer. [*Choice*: The decision about the quality has to be made for each possible result of the auction choice phase, i.e. 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 the costs for conducting the project that were 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 buyer's valuation of the project 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. 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 earnings per round together with your earnings of the first part of the experiment will be 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.

<u>**Screens for bidders (= potential sellers) in part 2**</u>

[*Choice*:]
Auction choice phase:

Round	
2 out of 18	Remaining time (for orientation): Please decide now!

Round 2:

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

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

Please indicate which auction type you choose:

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 orientation):
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 decide on the bid [*Choice*: for the case that the auction <u>without</u> a seller choice phase is realized].

Your bid is:

QUALITY CHOICE PHASE:

Please decide on the quality [*Choice*: for the case that the auction <u>without</u> 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 orientation):
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 decide on the bid [*Choice*: for the case that the auction with a seller choice phase is realized].

Your bid is:

QUALITY CHOICE PHASE:

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

Your quality is:

The buyer 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 orientation):
Please decide now!

Round 2:

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

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

Please indicate which auction type you choose:

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 orientation):
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 round, is the lowest bidder bidding a price of 200 euro cents.

Please keep in mind: your earnings in this round = 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 orientation):
Please decide now!

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

SELLER CHOICE PHASE:

BIDDER A:

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

The bidder's quality [*Choice*: for the auction with a 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, who you are randomly matched with in this round, bids a price of 300 euro cents.

The bidder's quality [*Choice*: for the auction with a 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 earnings in this round = quality [%]*400 [euro cents] - bid

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

Bidder A
Bidder B

OK