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Profit-Share Auctions in Procurement

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Abstract

We investigate profit-share auctions in a procurement context, comparing them with traditional cash auctions to identify which mechanism yields lower expenses for buyers. We also explore whether specifying a high project value in profit-share auction contracts influences supplier bidding behavior. Using theoretical analysis and experimental methods, we observe that profit-share auctions lead to lower buyer expenses compared to traditional cash auctions. Furthermore, we find that the buyer benefits from specifying a high project value in the contract, as this commitment induces more aggressive bidding from the suppliers. While profit-share auctions result in significantly lower buyer expenses than cash auctions, the observed differences are smaller than predicted. This discrepancy is due to (i) more pronounced underbidding in cash auctions and (ii) lower efficiency in profit-share auctions caused by noisy bidding. Our findings suggest that managers can reduce procurement costs by adopting profit-share auctions and strategically committing to a high project value in contracts. However, they should be aware that real-world savings may be smaller than theoretically predicted due to supplier bidding behavior.

JEL: D44, C92

Keywords: procurement, profit-share auctions, experiment

1 Introduction

Procurement auctions are an essential tool in modern supply chain management, offering an efficient and transparent mechanism for organizations to source goods and services at competitive prices. These auctions foster competition among suppliers, helping firms achieve cost savings while promoting quality and innovation. The structured nature of procurement auctions allows buyers to clearly define specifications and requirements, enabling suppliers to tailor their bids accordingly and enhancing supply chain alignment. Additionally, they encourage market entry by leveling the playing field, particularly for small and medium-sized enterprises (SMEs) that might otherwise struggle to compete ([Hoekman and Taş 2022](#)). Research has demonstrated

that well-designed procurement auctions lower buyers' expenses and improve supply chain performance by enabling the selection of the most efficient supplier ([Jap 2002](#), [Laliviere et al. 2024](#)).

Cash auctions are the predominant auction mechanism in procurement, both in academic research and industry practice. In a cash auction, suppliers submit bids specifying the payment they demand to fulfill a contract, which may involve delivering products or completing projects. The buyer selects the supplier with the lowest (quality-adjusted) bid. The first-price procurement cash auction is widely adopted among the various auction formats. In this format, the payment made to the winning supplier equals their bid. One reason for the predominance of cash auctions may be that in settings where suppliers' costs remain their private information, the buyer can implement the optimal procurement mechanism by conducting a well-designed cash auction ([Myerson 1981](#)).

In practice, long-term relationships between buyers and winning suppliers may allow the buyer to implement auction formats that outperform cash auctions. Long-term relationships enhance the buyer's visibility into suppliers' production costs, which may allow the bidder to write more sophisticated contracts like cost-plus, profit-sharing, or revenue-sharing contracts with the winning supplier. For example, revenue-sharing contracts have been shown to increase supply chain efficiency and to allow for a more balanced risk allocation between buyer and supplier compared to wholesale price contracts ([Cachon and Lariviere 2005](#)). In this paper, we explore how revenue-sharing can be embedded in procurement auctions and the extent to which the resulting 'profit-share auction' may outperform the prevailing cash-auction format.

In a profit-share auction, suppliers submit bids specifying a share of the joint profit they demand in return for fulfilling the contract. Here, the difference between the buyer's value (as specified in the contract) and the supplier's production costs gives the joint profit. The supplier requesting the lowest share wins the contract and, in a lowest-bid profit-share auction, receives a payment such that the demanded profit share is realized. Such auctions are particularly implementable in industries characterized by enduring and collaborative partnerships in which complex products are procured. The au-

tomotive industry is an important case in point. For example, in Germany, contracts with tier-1 suppliers to car manufacturers often last for the entire production period of a model, which typically spans over six to eight years (Mueller et al. 2016). Similarly, in Japan, Toyota and Honda are famous for their deep supplier relationships (Liker and Choi 2004). Their engineers work closely with suppliers, sharing expertise and co-developing solutions that enhance product quality and efficiency.

In this paper, we argue that profit-share auctions offer notable advantages to buyers relative to the traditional cash auctions. These advantages extend beyond contexts characterized by revenue uncertainty, where they reduce the buyer’s financial risks by sharing uncertainty with the winning supplier. As we show theoretically and experimentally, profit-share auctions can also reduce buyers’ expected expenses compared to cash auctions. This cost advantage is amplified if the buyer can ex-ante commit to how profits will be calculated. Specifically, the buyer benefits from an ex-ante commitment to a high buyer value for the profit calculation because this induces more aggressive bidding by all suppliers. Importantly, such a profit-share auction requires no more information than a standard cost-plus contract.

The rest of the paper proceeds as follows. We review the related literature in Section 2. Section 3 introduces the theoretical model and analyzes equilibrium bidding behavior in profit-share and cash auctions. In Section 4, we present our experimental design and develop our hypotheses. Section 5 reports our experimental findings. In Section 6, we discuss how alternative model specifications impact the relative performance of profit-share and cash auctions. Finally, Section 7 presents the managerial implications and concludes.

2 Related Literature

Our research relates to several strands of the literature, namely: (i) procurement auctions, (ii) supply chain contracting, and (iii) auctions with securities.

2.1 Procurement Auctions

Since the 1990s, procurement auctions have been an important tool in industrial procurement. Most of the academic literature on auctions focuses on forward auctions where the auctioneer only cares about generating revenue. In contrast, the procurement auction literature focuses on situations where the auctioneer cares not only about buying items for a low price, but also about other contractual dimensions, which has important implications for the design of the procurement. [Elmaghraby \(2007\)](#) and [Rothkopf and Whinston \(2007\)](#) provide insight into procurement auction practice.

For example, if the buyer sources products or services that are yet to be produced or developed, there is often an inherent incompleteness of contracts that poses challenges such as moral hazard by the supplier. [Bajari et al. \(2014\)](#) empirically investigate the adaptation costs associated with renegotiating incomplete contracts and find them to be significant. [Lewis and Bajari \(2014\)](#) examine construction contracts and find evidence for ex-post moral hazard. [Chakraborty et al. \(2021\)](#) theoretically investigates the implications of ex-post moral hazard on procurement design. [Brosig-Koch and Heinrich \(2014\)](#), [Fugger et al. \(2019\)](#), and [Walker et al. \(2023\)](#) investigate moral hazard by the supplier experimentally and find that the auction design significantly influences supplier behavior and supply chain efficiency.

Even in settings where complete contracts are possible, the buyer faces the challenge of comparing offers by suppliers who differ with regard to their non-price attributes. This is especially frequent when procurement involves products or services that are not fully standardized. [Che \(1993\)](#) and [Asker and Cantillon \(2010\)](#) investigate how the buyer can optimally incorporate quality differences between suppliers into the procurement design and present a trade-off between price competition and efficient quality consideration that implies an underrepresentation of non-price attributes in the optimal mechanism. [Fugger et al. \(2016\)](#) theoretically and experimentally show that a lack of commitment regarding the consideration of non-price attributes in the winner-determination rule can harm competition. One important non-price attribute is supplier reliability. [Chaturvedi and Martínez-de Albéniz \(2011\)](#)

investigate the optimal procurement auction design in the presence of supply risks.

To get a precise estimate of supplier heterogeneity with regard to non-price attributes, the buyer typically has to conduct supplier screening, especially when facing entrants. Buying firms also screen suppliers to determine if a supplier is reliable enough to fulfill the contract. [Wan and Beil \(2009\)](#), [Beil \(2010\)](#), [Wan et al. \(2012\)](#), and [Zhang et al. \(2021\)](#) report that such screenings often involve visits of the buying firm’s engineers at suppliers’ production facilities. They investigate if screenings should be conducted before or after the procurement auction. Screening after the auction typically implies that the buyer conducts less screening, but it can also reduce competition in the auction. Buyers also conduct post-auction investigations of suppliers’ production sites to identify cost-reduction potentials. [Chen et al. \(2022\)](#) show that such a post-auction pre-award cost reduction investigation typically benefits the buyer and the suppliers.

In contrast to the literature presented above, we abstract from quality differences among suppliers and investigate how the profit-share auction allows the buyer to intensify competition between suppliers, making use of the ex-post availability of the winning supplier’s cost information due to screening or close collaboration over a significant time.

2.2 Supply Chain Contracting

Our investigation of profit-share and cash auctions also relates to the literature on supply chain contracting. Research on supply chain contracting analyzes how different contract designs coordinate supply chains. Simple wholesale price contracts lead to inefficiencies due to double marginalization ([Spengler 1950](#)). More complex contract designs solve this problem by aligning the supply chain members’ incentives. Another aspect of supply chain contracting research is the investigation of contract negotiations.

Revenue-sharing contracts determine how supply chain revenues are split between the buyer and the supplier. [Cachon and Lariviere \(2005\)](#) show that these contracts increase supply chain efficiency compared to wholesale

price contracts and, simultaneously, allow for a more balanced risk allocation between buyer and supplier. The profit-share agreements that we consider are closely related to revenue-sharing contracts. First, they are also based on contingent payments. On the one hand, this implies that they also allow for a more balanced allocation of risks between the supply chain members compared to cash auctions. On the other hand, these contingent payments may necessitate costly monitoring of revenues or profits. Second, profit-share agreements and revenue-sharing contracts have in common that they distort incentives during the contract period. For example, the buyer's incentive to increase revenues is inefficiently low because she has to share the gains with the supplier. Similar to [Cachon and Lariviere \(2005\)](#), we also consider risk-neutral firms and, hence, focus on expected profits and not on risk allocation, even though the contract design affects risk allocation.

[Katok and Wu \(2009\)](#) experimentally investigate different supply chain contracts. They find revenue-sharing contracts reach higher supply chain profits than wholesale price contracts. However, the advantage of revenue-sharing contracts is smaller than predicted, and these contracts often fail to implement efficient outcomes. [Katok and Pavlov \(2013\)](#) explore why supply chain contracts perform worse than predicted and find that fairness preferences play an important role as they lead to inefficient negotiation outcomes. The experimental literature on supply chain contracting focuses on inefficiencies due to inefficient ordering decisions or failed negotiations. [Haruvy et al. \(2020\)](#) examine how the negotiation design affects the performance of supply chain contracts and find that bargaining protocols that allow for a give and take, i.e., concessions, result in better outcomes.

While the literature on supply chain contracting focuses on bilateral negotiations, we consider a setting where the buyer faces several suppliers and conducts an auction to select one of them. Similar to the experimental research that finds that the advantages of revenue-sharing over wholesale price contracts are smaller than predicted, we find the same when comparing profit-share to cash auctions. However, in our case, the reason is that cash auctions result in lower buyer expenses than predicted.

2.3 Auctions with Securities

[Hansen \(1985\)](#) was the first to discuss the idea that bids and payments can be structured as securities, meaning they are contingent on the ex-post value of the allocated item or asset. Linking payments to the future performance or value of the auctioned asset not only determines the risk allocation between buyers and suppliers but can also affect bidding behavior and expected payments. [Riley \(1988\)](#) shows that, in general, the auctioneer can benefit from making payments depend on information that is revealed after the auction. [DeMarzo et al. \(2005\)](#) develop an extensive characterization of such security auctions and identify a broad class of security designs applicable to first-price and second-price auctions. They establish that the steepness of securities positively impacts auction performance. The steeper the security, the better the performance of the auction. Roughly speaking, one security is steeper than the other if the auctioneer’s profit is more sensitive to the relevant outcome variable (in our case, the operational costs).

Several contributions have broadened our understanding of security auctions following these seminal studies. [Abhishek et al. \(2013\)](#) and [Abhishek et al. \(2015\)](#) investigate general information settings and show that the revenue ranking established by [DeMarzo et al. \(2005\)](#) does not necessarily extend to the case of risk-averse bidders. [Che and Kim \(2010\)](#) point out that security auctions may cause an adverse selection problem, which implies that they may perform worse than cash auctions. Similarly, the possibility of post-auction moral hazard affects the relative performance of auctions ([McAfee and McMillan 1986](#), [Laffont and Tirole 1987](#), [Kogan and Morgan 2010](#)). Post-auction moral hazard represents a particularly serious risk when cost-plus contracts are auctioned. Cost-plus contracts are commonly used in procurement practice ([Rothkopf and Whinston 2007](#), [Tadelis 2012](#)), constituting an extreme example of a security auction in which the buyer absorbs all the cost variation. [Sogo et al. \(2016\)](#) consider a setting with costly entry and show that security auctions induce more entry and higher profits for the auctioneer. [Hernandez-Chanto and Fioriti \(2019\)](#) examine a setting where the allocation of the project to one bidder causes a negative externality to

the other bidders and show that including a fixed payment is optimal for the auctioneer.

To the best of our knowledge, the amount of experimental work on security auctions is quite limited. [Breig et al. \(2024\)](#) provide an experimental investigation of various security auctions. They compare two types of securities, equity and debt, with first-price and second-price payment rules. Furthermore, they also consider an informal auction format where bidders can choose between placing a debt or equity bid, and the auctioneer selects the bid she prefers. Contrary to theoretical predictions, they find equity auctions are less profitable for the auctioneer than debt auctions. [Bajoori et al. \(2024\)](#) present an experimental comparison of equity and cash auctions with first- and second-price payment rules. They find that first-price equity auctions generate the highest profit for the auctioneer. Finally, [Kogan and Morgan \(2010\)](#) experimentally investigate the moral hazard problem connected to security auctions and find, mostly in line with their theoretical predictions, that equity auctions perform better than debt auctions if the returns to effort are either high or low but not intermediate.

We are the first to theoretically and experimentally investigate the application of security auctions in a procurement setting. Our analysis shows how the profit-share auction integrates a security into a procurement auction, allowing the buyer to intensify bidder competition to her advantage. We also contribute to the security-auctions literature by identifying the project value as an essential parameter in the design of profit-share auctions.

3 Theory

In this section, we introduce our theoretical model and derive equilibrium predictions. Our model is based on [DeMarzo et al. \(2005\)](#). In contrast to them, we investigate a procurement setting. We consider cash auctions and profit-share auctions. We focus our analysis on the auctions' relative performance in terms of expected expenses for the buyer.

3.1 Model

A buyer (she) organizes a pay-as-bid auction, i.e., a first-price auction, to assign a contract to one among $n \geq 2$ risk-neutral suppliers (he), indexed $i = 1, \dots, n$.¹ If supplier i wins the contract, he incurs total costs of $k_i = u + c_i$, where $u > 0$ and c_i represent the upfront investment and operational costs, respectively. The upfront investment costs are the same for all suppliers. Suppliers' operational costs are drawn i.i.d. according to a C^2 distribution function F with support on $[\underline{c}, \bar{c}]$, $\bar{c} > \underline{c} \geq 0$. Let $Y^{(1:n)}$ and $Y^{(2:n)}$ respectively denote the lowest and second-lowest order statistic among n i.i.d. draws from F . Define $G^{(k)}$ as the distribution function of the lowest among k i.i.d. operational-cost draws according to F , i.e., $G^{(k)}(c) \equiv 1 - (1 - F(c))^k$, $c \in [\underline{c}, \bar{c}]$. The completion of the contract by the supplier generates a value v for the buyer with $v > u + \bar{c}$. Non-winning suppliers earn zero.

Cash auction: In the cash auction, each supplier i requests a cash amount $\gamma_i \geq 0$. The lowest bidder, supplier w , wins the contract and receives a payment equal to his bid. The winning supplier makes a profit of $\gamma_w - c_w - u$. If two or more suppliers place the same lowest bid, a fair lottery among these suppliers determines the winner. The buyer's expenses equal γ_w .

Profit-share auction: In the profit-share auction, the buyer first specifies a project value $\hat{v}$ that is considered for the profit calculation. $\hat{v}$ is best interpreted as a parameter in the contract, in principle unrelated to the project's actual value v . Compared to the cash auction, the profit-share auction equips the buyer with an additional lever that affects bidding behavior and outcomes. After the buyer determines $\hat{v}$, each supplier i requests a profit share $\sigma_i \in [0, 1]$. The lowest bidder, supplier w , wins the contract and receives a payment of $\sigma_w \cdot (\hat{v} - c_w) + c_w$. The winning supplier makes a profit

¹We focus on first-price auctions because the majority of industrial procurement auctions follow a first-price payment rule (Kokott et al. 2019). Palacios-Huerta et al. (2024) argues that first-price auctions are prevalent in the private sector because bidders have little reason to trust the auctioneer to respect a second-price payment rule. Indeed, Akbarpour and Li (2020) proves that first-price auctions are the only static auction mechanism where the auctioneer is incentivized to stick to the rules. Furthermore, Robinson (1985) shows theoretically that first-price auctions are less vulnerable to bidder collusion than other auction mechanisms and Hinlopen et al. (2020) provide experimental support.

of $\sigma_w \cdot (\hat{v} - c_w) - u$. If two or more suppliers place the same lowest bid, a fair lottery among these suppliers determines the winner. The buyer's expenses equal $\sigma_w \cdot (v - c_w) + c_w$.²

3.2 Equilibrium Analysis

We start our equilibrium analysis by looking at the cash auction. Applying the same techniques as [Krishna \(2009\)](#) uses for the analysis of first-price forward auctions and adjusting them to procurement auctions, we can establish equilibrium bidding strategies for the cash auction in [Proposition 1](#).

Proposition 1 *The following bidding strategy constitutes a symmetric Bayesian-Nash equilibrium of the cash auction:*

$$\gamma(c) = \frac{\int_c^{\bar{c}} (u + x) dG^{(n-1)}(x)}{1 - G^{(n-1)}(c)}. \quad (1)$$

[Proposition 1](#) implies that the equilibrium outcome is efficient as the cash auction awards the contract to the supplier with the lowest costs. The buyer's expected expenses equal $K^C = u + E\{Y^{(2:n)}\}$.³

The equilibrium bidding strategies for the profit-share auctions can be straightforwardly derived from [DeMarzo et al. \(2005\)](#)'s analysis. We establish the equilibrium bidding strategies for the profit-share auction in [Proposition 2](#).

Proposition 2 *Consider a profit-share auction with $\hat{v} \geq \bar{c} + u$. The following bidding strategy constitutes a symmetric Bayesian-Nash equilibrium of the profit-share auction:*

$$\sigma(c) = \frac{\int_c^{\bar{c}} \frac{u}{\hat{v} - x} dG^{(n-1)}(x)}{1 - G^{(n-1)}(c)}. \quad (2)$$

²An important assumption underlying our analysis is that the buyer is able to commit to the value for $\hat{v}$ specified in the contract. This commitment is important because, given a winning bid, the buyer's payment to the winning supplier increases in $\hat{v}$. Hence, the buyer has an incentive to ex-post downplay $\hat{v}$ to lower her expenses.

³The expected costs for the buyer follow from the usual arguments. See, for example, [Krishna \(2009\)](#), Chapter 2.

Proposition 2 implies that also the profit-share auction is efficient. The buyer's expected expenses are given by $K^S = nu \int_{\underline{c}}^{\bar{c}} \int_{\underline{c}}^{\bar{c}} \frac{\hat{v}-c}{\hat{v}-x} dG^{(n-1)}(x) dF(c) + E\{Y^{(1:n)}\}$. Since $(\hat{v}-c)/(\hat{v}-x)$ is increasing in $\hat{v}$, it follows that the buyer's expected expenses are decreasing in $\hat{v}$. On the one hand, the buyer would like to ex-post lower the project value $\hat{v}$ because, given the winning bid, a decrease of $\hat{v}$ lowers her payment toward the winning supplier. On the other hand, the buyer benefits from an ex-ante commitment to a higher value of $\hat{v}$ because it leads to more aggressive bidding. In other words, while a higher project value increases expenses for the buyer for a given winning bid, commitment to a higher project value induces more aggressive supplier bidding. The resulting increased bidding competition is so strong that it reduces the buyer's expected expenses as the specified project value rises.

Proposition 3 establishes a ranking of the procurement auction formats in terms of expected buyer expenses in equilibrium and shows that profit-share auctions result in lower buyer expenses than cash auctions.

Proposition 3 *Consider a cash auction and a profit-share auction with $\hat{v} > \bar{c} + u$. The buyer's expected expenses are strictly smaller in a profit-share auction than in the cash auction, i.e., $K^S < K^C$.*

Considering the ranking of the auctions in terms of expected buyer expenses, we find that profit-share auctions result in lower buyer expenses than cash auctions and that within the class of profit-share auctions, the buyer benefits from committing to a higher $\hat{v}$. As discussed in the literature section, the intuition behind this revenue ranking lies in the variation in the steepness of the securities across auction formats: the steeper the security, the greater the expected payoffs for the auctioneer (DeMarzo et al. 2005). While the security's steepness is zero in the cash auction, it is $1 - \sigma$ in the profit-share auction, where the profit share σ is decreasing in $\hat{v}$ in equilibrium.

4 Experimental Design and Hypotheses

In this section, we first introduce our experimental design. After that, we develop our hypotheses.⁴

4.1 Procedures and Parameters

We ran the experiment at a laboratory for research in behavioral economics at a large university in the EU. Using the online recruitment system ORSEE (Online Recruitment System for Economic Experiments, [Greiner \(2015\)](#)), we recruited 110 participants from the university’s student population who participated in 7 sessions. Participants earned €18.62 on average, including a show-up fee of €5. Each session lasted between 35 and 45 minutes. Experimental earnings were given in experimental currency units (ECU), with an exchange rate of €1 = 45 ECU. If a participant’s total earnings were negative, this participant only received the show-up fee. The online appendix includes an example of the experimental instructions.

The experiment consists of two parts. A participant can only start participating in each part after answering several comprehension questions correctly. Part 1 was the same for all participants and involved a series of auctions intending to familiarize the participants with the main experimental task, which they play in part 2. In each of the ten rounds of part 1, all participants play the role of a supplier in the cash auction, described in Section 3, competing against a computerized supplier. In every round, each participant is assigned the project’s operational costs. The upfront investment equals zero. In the auction, both suppliers offer a price for which they would complete the project. Known to the participants, for the computerized supplier, each integer between 50 and 100 is equally likely to be placed as a bid. The supplier requesting the lowest price is selected. If both suppliers request the same price, one is randomly selected. When selected, the participant supplier receives the requested price minus the costs.

⁴Our research questions and the experimental design have been preregistered at AsPredicted, number 169401. In this preregistration, we also report two additional treatments, Cash/Strangers and Share500/Strangers, that are used for another study.

At the start of part 2 of the experiment, we formed groups of two participants who interacted for 45 rounds in one of three treatments: the cash auction (Cash), the profit-share auction with $\hat{v} = 200$ (Share200), or the profit-share auction with $\hat{v} = 500$ (Share500). For statistical reasons, we do not rematch participants between rounds.⁵

The auction setting is as described above in the theory section. If supplier i wins the contract, he has total costs of $k_i = u + c_i$, where $u = 100$. Before the start of an auction, each supplier privately observes his operational costs c_i for fulfilling the contract, which is drawn from a uniform distribution on the interval $[0, 100]$. All draws of c_i are independent of one another and independent across rounds. Table 1 summarizes the design, including the number of matching groups per cell.⁶

Table 1: Summary of the Treatments

Treatment	Auction type	$\hat{v}$	# Groups	# Participants	Action set
Cash	Cash	–	18	36	$\{100, 101, \dots, 200\}$
Share200	Profit-share	200	18	36	$\{0.5, 0.505, \dots, 1\}$
Share500	Profit-share	500	18	36	$\{0.2, 0, 2005, \dots, 0.25\}$

For the sake of proper comparability across auction formats, for all treatments, participants have to choose their bid from a set of 101 possible bids, equidistant from one another, where the lowest possible bid ensures zero profits for the lowest operational cost possible, i.e., $c_i = 0$ and the highest possible bid ensures zero profits for the highest operational cost possible, i.e., $c_i = 100$. The resulting action sets are shown in Table 1. When the participants indicate a possible bid, the computer screen shows the profit the participant will earn when the bid indicated wins the auction. When bidders indicate a bid that is loss leading when winning, before confirming the bid, they get a warning, making them aware that they will risk a loss

⁵A potential concern is that the fixed matching allows suppliers to collude. However, we find no evidence of collusive behavior. The average bidding behavior is more aggressive than the equilibrium predictions in each of our three treatments.

⁶We have excluded one group in the Cash treatment because one participant in this group bid consistently below the project costs. Consequently, this participant accumulated negative earnings, distorting their incentives since lab rules require participants to receive at least their show-up fee.

when submitting that bid. After each round, every participant is informed about the bids submitted by themselves and their competitor, who won the auction, and their own payoffs.⁷

4.2 Main Hypotheses

The main hypotheses we wish to test using our experiment concern the relative performance of auction types in terms of the buyer's expected expenses and the auction's efficiency. We base these hypotheses on the risk-neutral equilibrium bidding strategies derived in the theory section. Our theoretical analysis provides equilibrium bidding strategies and a clear ranking in terms of expected buyer expenses. Our theoretical results justify the following testable hypotheses:

Hypothesis 1 *The buyer's average expenses are smaller in both versions of the profit-share auction than in the cash auction.*

Hypothesis 2 *The buyer's average expenses are smaller in the profit-share auction with $\hat{v} = 500$ than with $\hat{v} = 200$.*

Our third hypothesis involves the auctions' efficiency. Propositions 1 and 2 imply that both auction types are fully efficient in that the supplier having the lowest operational costs will always win. The implication is that the auctions are not expected to differ in terms of realized efficiency, yielding the following hypothesis:

Hypothesis 3 *The auctions do not differ in terms of efficiency.*

Figure 1 illustrates equilibrium bidding predictions for the cash and profit-share auctions in the experiment. On the x-axis, we have suppliers' operational costs c that are uniformly distributed between 0 and 100. To make bids in the different auction formats comparable, we convert bids in the profit-share auctions to bid amounts. This means that for each bid in a

⁷Screenshots of the experiment are provided in the online appendix.

profit-share auction, we calculate the payment that this supplier would receive from the buyer when winning the contract and denote this payment as the bid amount. The figure illustrates that equilibrium bidding strategies are strictly monotonic in each auction format, which implies efficient allocations. Furthermore, it shows a clear ranking regarding expected buyer expenses, which are lowest in Share500 and highest in Cash.

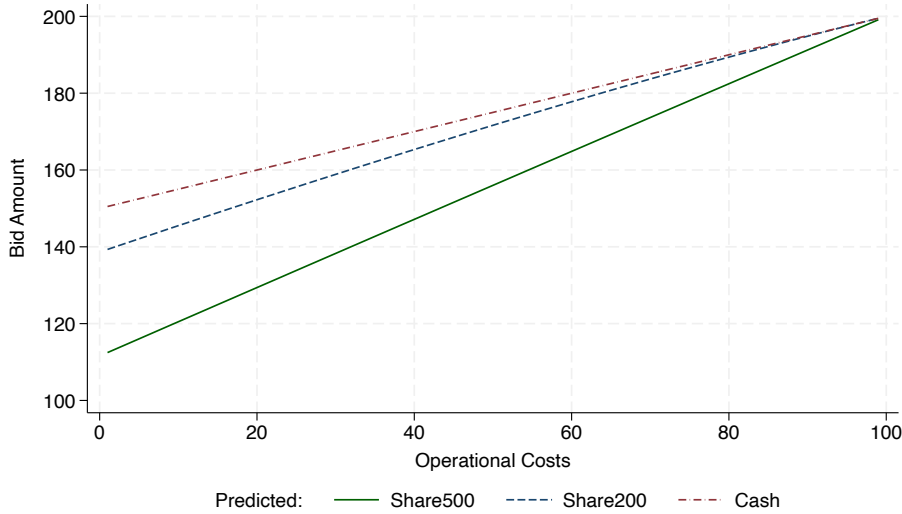


Figure 1: Cash Auction and Profit-share Auction Bidding Strategies

4.3 Alternative Hypotheses

Our hypotheses are based on the joint assumption that all bidders are risk neutral and perfectly rational, implying that they follow the same strictly monotonic bidding curves. However, since the early days of experimental research on first-price auctions, we know that participants often bid more aggressively than the risk-neutral Nash equilibrium (RNNE) predicts and that there can be substantial heterogeneity concerning individual bidding behavior.⁸ Our hypotheses may fail to hold true if the auction formats differ in terms of deviations from the RNNE. We decided not to formulate alternative hypotheses for the directional Hypotheses 1 and 2 because they may still

⁸See [Kagel \(1995\)](#) for an overview of this research.

hold true even if there is some heterogeneity in terms of the extent to which supplier behavior deviates from the RNNE. We do develop an alternative for Hypothesis 3, which states that the auction formats do not differ in terms of efficiency. Hypothesis 3 may be rejected even for relatively minor differences between the auctions in terms of RNNE deviations.

If a supplier's bid is the sum of the equilibrium bid and a noise term, the auctions may result in inefficient outcomes, and the efficiency of the different formats may differ. An important question is how to model the noise term because, in our cash auction, a bid is in monetary terms, whereas in our profit-share auctions, suppliers request a share, which implies that bids are a fraction.

One way to model this noisy bidding is to assume that the noise is in the monetary dimension. In this case, we first convert bids in the profit-share auctions into bid amounts, i.e., the payment a supplier receives when winning with his bid. Then, we add a (potentially negative) noise term to the bid amount and, to rule out dominated bids, require that the actual bid amount at least equals costs. With this kind of noisy bids, we find that profit-share auctions are more efficient than cash auctions and that within profit-share auctions, Share500 is more efficient than Share200. Intuitively, this is driven by the fact that the bidding function, in terms of the bid amount, is steepest for Share500 and flattest for the cash auction. The steeper the function, the larger the average difference between equilibrium bids and the lower the noise impact. We ran several simulations and found that, e.g., for a noise term uniformly distributed between -10 and 10, Share500 awards the contract to the lowest-cost supplier in 95%, Share200 in 90%, and the cash auction in 83% of the cases.

An alternative way to model noisy bidding is to assume that the noise depends on the bid grid. Then, we start with the equilibrium bid and add a noise term that is, e.g., plus or minus three steps on the bid grid. Again, we require the actual bid amount to be at least equal to the costs. Running simulations, we find that, in this case, Share200 is the most efficient and the cash auction is the least efficient.

Our simulations show that if bidding is noisy, the different auction for-

mats will differ in terms of their efficiency. However, the two different ways of incorporating noisy bidding imply different rankings of the auction formats. Moreover, for both ways of incorporating noise, the assumption that we made that the noise level does not differ between the different procurement auction mechanisms may not hold true, affecting the ranking in terms of efficiency. For these reasons, we abstain from stating a directed hypothesis and formulate our alternative hypothesis on efficiency as follows.

Hypothesis 4 *The auctions differ in terms of efficiency.*

5 Results

In this section, we report our experimental findings. We start the investigation by looking at group averages and non-parametric tests in Table 2, considering each group one independent observation.⁹ We report the results of the Wilcoxon-Mann-Whitney test (WMW) for pairwise comparisons of our profit-share auction treatments to the cash auction treatment, and the results of Wilcoxon signed-rank (WSR) tests to compare predicted and observed behavior. We then present a more detailed analysis of the bidding behavior using regression analysis.

5.1 Non-parametric Analysis

Table 2 summarizes participant behavior across the different treatments. It reports the average Prepauction Bid, the average Buyer Expenses, the average Bid Amount, the average Efficiency, and the average Inefficiency. Along with these averages, the table also presents the associated standard errors in parentheses. We calculate the standard errors based on group averages, i.e., they reflect the heterogeneity of group averages within each treatment.

Table 2 also presents the RNNE predictions. In the Prepauction, suppliers maximize their expected profit by bidding $\beta^{PA}(c_i) = 50 + c_i/2$. According to the RNNE, suppliers in the Cash treatment bid $\beta^C(c_i) = 150 + c_i/2$. In

⁹In the Prepauction, participants bid against a computerized competitor. Hence, each participant represents one independent observation when looking at Prepauction Bid.

Table 2: Predicted and Observed Behavior

	Observed			Predicted		
	Cash	Share200	Share500	Cash	Share200	Share500
Bid Prepauction	59.99 ⁺⁺ (1.60)	61.88 (1.01)	62.12 (1.22)	63.50		
Bid Amount	168.07 ⁺⁺⁺ (1.41)	164.18 ⁺⁺⁺ (1.63)	154.49 ^{****,+++} (0.28)	175.04	170.95	156.01
Buyer Expenses	157.24 ⁺⁺⁺ (1.79)	152.32 ⁺⁺⁺ (1.71)	141.44 ^{****} (0.44)	167.12	161.15	142.00
Efficiency	0.880 ⁺⁺⁺⁺ (0.02)	0.849 ^{*,++++} (0.02)	0.843 ^{**,++++} (0.02)	1.00		
Inefficiency	1.340 ⁺⁺⁺⁺ (0.32)	1.932 ⁺⁺⁺⁺ (0.31)	2.138 ^{*,++++} (0.36)	0.00		
Number of Groups	18	18	18			
Number of Participants	36	36	36			

Notes. Standard errors in parentheses

Comparison to Cash; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$; WMW test

Comparison to Prediction; + $p < 0.10$, ++ $p < 0.05$, +++ $p < 0.01$, ++++ $p < 0.001$; SR test

the profit-share treatments, they demand a share of $\sigma(c_i) = 100/(100 - c_i) \cdot \ln[(\hat{v} - c_i)/(\hat{v} - 100)]$, which results in a payment of $100 \cdot (\hat{v} - c_i)/(100 - c_i) \cdot \ln[(\hat{v} - c_i)/(\hat{v} - 100)] + c_i$ when winning, with $\hat{v} = 200$ in the Share200 and $\hat{v} = 500$ in the Share500 treatment. Since we use the same pre-generated cost draws for each group, the standard error of each prediction is zero.

Bid Prepauction is the average bid placed in the preparation phase of the experiments, which was the same for each participant independent of the treatment they participated in. We observe no significant treatment differences, which suggests that random assignment to treatments worked well and that the participant population does not differ in a relevant magnitude across treatments. If anything, we observe that the pre-treatment ranking regarding bidding aggressiveness is: Cash > Share200 > Share500. This goes against Hypotheses 1 and 2 so that our experiment can be considered a conservative test of these hypotheses.

We first compare the auctions in terms of bids submitted. While suppliers' bids are profit shares in our profit-share auction treatments, they are money amounts in the cash auction treatment. Hence, bids are not di-

rectly comparable across treatments. Therefore, we introduce the variable Bid Amount, which equals the payment that a supplier would receive from the buyer if he wins with his bid. We find that the bid amount is lowest in Share500 (Cash vs. Share500: $p < 0.001$ and Share200 vs. Share500: $p < 0.001$; both WMW) and does not differ significantly between Cash and Share200 ($p = 0.1038$, WMW). Comparing the bid amount to the theoretical predictions, we observe suppliers bid more aggressively than predicted in all treatments (all treatments $p < 0.001$, SR). The underbidding is more pronounced in the cash auction than in the share auctions ($p = 0.0971$, WMW).

Buyer Expenses represents the average amount that the buyer pays the selected supplier. Theory predicts that buyer expenses are highest in Cash and lowest in Share500. In line with Hypotheses 1 and 2, the buyer expenses in Share500 are lower than in the other treatments (Cash vs. Share500: $p < 0.001$ and Share200 vs. Share500: $p < 0.001$; both WMW). In line with Hypothesis 1, the average expenses for the buyer are higher in Cash than in Share200, although the difference is insignificant ($p = 0.1108$, WMW). Furthermore, we observe that buyer expenses in Cash and Share200 are significantly lower than predicted (both $p = 0.0001$; SR), while for Share500, they are statistically indistinguishable from the RNNE prediction. As a result, the observed differences between the auction formats in terms of buyer expenses are smaller than predicted (Cash vs. Share: $p = 0.0298$, WMW).

Result 1 *In Share500, the buyer expenses are lower than in Cash. The buyer expenses do not differ significantly between Share200 and Cash.*

Result 2 *In Share500, the buyer expenses are lower than in Share200.*

For all three treatments, our game theoretical analysis predicts that the supplier with the lowest costs always wins the auction. For a given auction, the variable Efficiency equals 1 if the supplier with the lowest costs wins and equals 0 otherwise. In Cash, the supplier with the lowest cost wins in 88 percent of the cases. In contrast, the shares of efficient trades are significantly lower in Share200 and Share500 (Cash vs. Share200: $p = 0.0901$ and Cash vs. Share500: $p = 0.0449$, WMW). The differences between Share200 and

Share500 are not significant. Hence, we find some support for our alternative hypothesis that the auction formats differ concerning efficiency. Obviously, efficiency is lower than predicted in all treatments (all treatments $p < 0.0001$, SR).

Result 3 *The supplier having the lowest costs wins the auction more frequently in Cash than in Share200 and Share500.*

While the variable Efficiency considers the share of auctions won by the efficient supplier, the variable Inefficiency measures the additional costs, i.e., welfare loss due to inefficient supplier selection. For a given auction, inefficiency equals the difference between the winning supplier's and the efficient supplier's costs. Comparing inefficiency across treatments, we find that it is lowest in Cash. It is significantly lower in Cash than in Share500 ($p = 0.0846$, WMW). The other treatment differences are insignificant (Cash vs. Share200: $p = 0.1054$ and Share200 vs. Share500: $p = 0.7134$, WMW). Obviously, inefficiency is larger than predicted in all treatments (all treatments $p < 0.0001$, SR).

To see if our results are robust to learning, we replicate Table 2 looking at the last 15 periods only. The results are reported in Table 5, which is relegated to Appendix B. Looking only at periods 31 to 45, we observe that our key findings do not change. With the notable exception that the pairwise treatment differences between the cash auction and the profit-share auctions concerning Efficiency and Inefficiency are all significant when only looking at the last 15 periods.

5.2 Regression Analysis

In this section, we complement our non-parametric analysis based on group averages with regression analyses, which allow us to investigate time effects and account for individual behavior in the prepauctions. Furthermore, we use regressions to investigate the consistency of bidding within participants and heterogeneity in bidding between participants to shed light on the efficiency of the auction formats.

Table 3 reports the results of random-effects panel regressions with Bid Amount as the dependent variable. A linear model seems reasonable since the relationship between suppliers’ operational costs and the bid amount is (almost) linear in equilibrium (see Figure 1). For all regression models, we report clustered standard errors. Standard errors are clustered at the group level.¹⁰

Model 1 explains the bid amount based on operational costs and the auction format. Equilibrium predictions imply that operational costs should have a strong positive correlation with bid amounts, and that is what we observe. Profit-share Auction is a dummy variable that assumes a value of one if the supplier participates in Share200 or Share500 and is zero otherwise. In line with Hypothesis 1, the model shows that the bid amount a supplier demands is substantially lower in profit-share than in cash auctions.

Model 2 introduces the dummy variable High Value, which equals 1 in Share500 and is zero otherwise. Hence, we can interpret the coefficient of Profit-share Auction as the average difference between the Bid Amount in Cash and Share200. Share200 induces significantly more aggressive bidding than Cash ($p = 0.0041$, Model 2). Furthermore, the model shows that specifying a value of 500 instead of 200 in the profit-share auction decreases the average Bid Amount by another 9.7 ECU ($p < 0.001$, Model 2), which aligns with Hypothesis 2.

Model 3 includes Average Prep Bid as another independent variable. Average Prep Bid equals the average bid a subject placed in the preparation phase conducted before the experiment’s main part. Including the average prep bid allows us to control for individual differences. Even though the average prep bid strongly correlates with the bid amount, the other coefficient estimates are only mildly affected by including it as an independent variable. If anything, including the average prep bid increases the estimated effect sizes of our interventions. The high significance of the average prep bid demonstrates consistency in bidding behavior in the preparation phase

¹⁰In our case, clustering on the group level implies the most conservative estimate of standard errors. Alternative specifications result in lower estimates for standard errors and lower p -values.

and the main experiment.

Model 4 adds Period as another independent variable. We observe that bidding becomes less aggressive over time.¹¹

Table 3: Random-Effect Panel Regression of Bid Amount

	(1)	(2)	(3)	(4)
	Bid Amount	Bid Amount	Bid Amount	Bid Amount
Operational Costs	0.735**** (0.0219)	0.735**** (0.0219)	0.735**** (0.0219)	0.732**** (0.0222)
Profit-share Auction	-8.735**** (1.739)	-3.888** (1.903)	-4.528*** (1.628)	-4.528*** (1.628)
High Value		-9.694**** (1.336)	-9.776**** (1.206)	-9.776**** (1.207)
Average Prep Bid			0.339**** (0.0657)	0.339**** (0.0657)
Period				0.0776**** (0.0161)
Constant	131.3**** (2.094)	131.3**** (2.094)	110.9**** (3.933)	109.3**** (3.865)
Observations	4860	4860	4860	4860
Participants	108	108	108	108
Overall R^2	0.818	0.846	0.859	0.860

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Figure 2 illustrates the evolution of buyer expenses in our experiment. To reduce the variances due to differences in cost realizations, we merge the data from five consecutive periods, i.e., rounds 1 to 5, 6 to 10, etc. In line with our analysis, the graphical inspection shows that buyer expenses are lowest in Share500 and that in Share500, the observed buyer expenses are close to the predicted values. In Cash and Share200, buyer expenses are substantially lower than theory predicts. However, the predicted ranking, which implies that buyer expenses are lowest in Share500 and highest in Cash, still holds.

¹¹Conducting further regression analyses we find no evidence for significant treatment differences with regard to time effects.

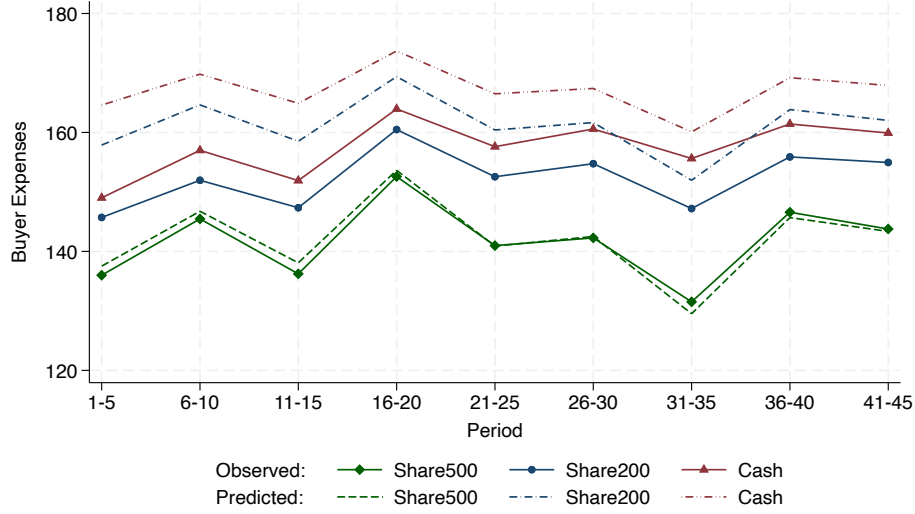


Figure 2: Evolution of Buyer Expenses

Regarding buyer expenses and bid amount, our analysis indicates that profit-share auctions induce more aggressive bidding and help the buyer reduce expenses. Within the class of profit-share auctions, we additionally find that specifying a higher project value allows the buyer to decrease her expenses further. Both observations align with our theoretical predictions.

Next, we focus on the efficiency of the different procurement auction mechanisms. Table 4 reports the results of random-effects tobit panel regressions with inefficiency as the dependent variable. We use tobit regressions with a lower limit of zero because inefficiency cannot be negative, and for 2084 out of 2430 observations, inefficiency equals zero.

Model 1 shows that inefficiency is higher in the profit-share auctions than in the cash auctions. Model 2 adds the dummy variable High Value and suggests that inefficiency is higher in the profit-share auction but that the value the buyer specifies does not affect the level of inefficiency. In Model 3, we include Cost Difference as an independent variable. The variable Cost Difference equals the difference between the costs of the less and the more efficient supplier. We find that the cost difference strongly influences inefficiency; the larger the cost difference, the lower the inefficiency. Theoretically, the cost

difference can have two opposing effects on inefficiency. On the one hand, a larger cost difference implies that the more efficient supplier is more likely to win. On the other hand, the larger the cost difference, the higher the potential inefficiency.

Model 4 contains Period as a further independent variable, suggesting that inefficiency increases over time.¹²

Table 4: Random-Effects Tobit Panel Regressions of Inefficiency

	(1) Inefficiency	(2) Inefficiency	(3) Inefficiency	(4) Inefficiency
Profit-share Auction	4.941** (2.468)	5.162* (2.822)	6.003* (3.118)	6.023* (3.092)
High Value		-0.446 (2.758)	-0.478 (3.037)	-0.496 (3.012)
Cost Difference			-0.579**** (0.0588)	-0.580**** (0.0584)
Period				0.142** (0.0635)
Constant	-32.86**** (2.605)	-32.86**** (2.606)	-20.90**** (2.652)	-24.01**** (3.038)
Observations	2430	2430	2430	2430
Left-censored observations	2084	2084	2084	2084
Participants	108	108	108	108
Log likelihood	-2213.8	-2213.7	-2124.7	-2122.2

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

In the simulations we conducted to motivate the alternative hypothesis for differences in efficiency, we assumed that the noise level is independent of the auction mechanism. Next, we will investigate this assumption by examining how well suppliers' costs explain their bids. To do so, we conduct simple linear panel regressions with bid as the dependent variable and operational costs as the independent variable separately for each treatment. Then, we

¹²Table 6 in Appendix B provides similar regression analyses using the dummy variable Efficiency instead of the continuous variable Inefficiency. The results also suggest that cash auctions are more efficient than profit-share auctions and that efficiency decreases over time.

compare the overall R^2 of these regressions as a measure of noisy bidding. In line with our previous observations, we find that the noise level is highest in Share500 ($R^2 = 0.662$) and the lowest in our cash auction treatment ($R^2 = 0.728$). For Share200, we get $R^2 = 0.680$. (Table 7 in Appendix B reports the regression models.)

To test if the differences in the noise levels are significant, we additionally conduct a simple panel regression with bid as the dependent variable and operational costs as the independent variable for each group and employ a WMW to check for treatment differences. Comparing the R^2 between Cash and Share500, we find a significant difference ($p = 0.0142$, WMW). The other pairwise comparisons show no significant differences (Cash vs. Share200: $p = 0.1516$ and Share200 vs. Share500: $p = 0.3389$, both WMW). Comparing the cash auction to both profit-share formats, we again find a significant difference ($p = 0.0236$, WMW). The relatively high noise levels in the profit-share auctions explain intuitively both why the profit-share auctions are less efficient than the cash auction and why the observed differences between the auction formats in terms of buyer expenses are smaller than predicted.

In summary, we find strong support for the prediction that profit-share auctions benefit the buyer as they result in lower buyer expenses than cash auctions, in particular if the buyer specifies a high project value. However, the observed differences are smaller than predicted, which is explained by (i) less underbidding in the profit-share auction than in the cash auction and (ii) relatively noisy bidding in profit-share auctions compromising efficiency.

6 Discussion

In both our theoretical analysis and experimental investigation, we focus on a stylized model to ensure the analysis remains tractable and that participants in the experiment can easily comprehend the setting. We have shown that in this setting, the buyer benefits from using profit-share auctions instead of cash auctions and that she can improve the performance of profit-share auctions by specifying a high project value $\hat{v}$. In this section, we discuss how different possible extensions of our baseline model would affect the relative

performance of profit-share auctions compared to cash auctions. We also highlight potential problems related to increasing the specified project value.

6.1 Post-award Cost-reduction Investments

In long-term contracts, suppliers can reduce costs through learning or efficiency investments. Cash auctions incentivize cost-reduction investments, as suppliers retain the full benefits of lowered costs.¹³ In profit-share auctions, payments decrease with reduced costs, making investments less attractive. For example, if a supplier reduces costs by one unit, their payment decreases by $1 - \sigma$, discouraging investments unless σ times the cost reduction exceeds the investment. Consequently, profit-share auctions may lead to less efficient cost reductions, higher expected operational costs, and higher buyer expenses. This inefficiency worsens as project values rise, increasing competition but weakening cost-reduction incentives.

6.2 Upfront Investment Cost Heterogeneity

We assumed all suppliers have identical upfront investment costs, which does not affect cash auctions since bids depend on total costs. However, in profit-share auctions, cost composition influences bids, potentially reducing efficiency and increasing buyer expenses. For example, consider one supplier with no upfront costs but high operational costs of $\hat{v} - \epsilon$, and two others with upfront costs of $\hat{v}/4$ and operational costs of $\hat{v}/4$. In a cash auction, the first supplier loses, and buyer expenses are $\hat{v}/2$. In a profit-share auction, the first supplier wins, leading to buyer expenses exceeding $\hat{v}/2$, demonstrating inefficiency and potential benefits of excluding certain suppliers.

¹³From discussions with procurement managers in the automotive industry, we know that original equipment manufacturers (OEMs) running cash auctions often include contract clauses that entitle them to a share of suppliers' cost reductions. Obviously, such clauses also distort the investment incentives for suppliers, potentially discouraging optimal cost-reduction efforts.

6.3 Cost and Project Value Uncertainty

Our analysis assumes suppliers know their operational costs and the buyer specifies a deterministic project value $\hat{v}$ for profit calculations. However, in reality, suppliers may face cost uncertainty due to input price fluctuations or technological changes. In cash auctions, suppliers bear all risk, while profit-share auctions share this risk with the buyer, potentially lowering expected buyer expenses if risk is costly for suppliers. Similarly, buyers facing project value uncertainty can share this risk with suppliers in profit-share auctions by linking $\hat{v}$ to verifiable outcomes. These dynamics highlight opportunities for further research into procurement mechanisms and risk-sharing.

7 Conclusion

Enhancing the performance of procurement auctions is a key focus in the supply chain management literature. This paper shows, both theoretically and experimentally, that buyers can reduce their expected expenses by adopting profit-share auctions instead of traditional cash auctions. Additionally, we demonstrate that within the class of profit-share auctions, buyers can achieve additional cost savings by specifying a high project value in the contract.

Although profit-share auctions lead to considerably lower costs for buyers compared to cash auctions, the observed differences are less pronounced than anticipated. Our data analysis indicates that this divergence arises from (i) more significant underbidding in the cash auction than in the profit-share auctions and (ii) relatively low efficiency in profit-share auctions caused by more noisy bidding behavior.

The following should be taken into account when implementing profit-share auctions in practice. First, while these auctions help buyers reduce expenses compared to traditional cash auctions, they require greater information transparency, particularly regarding the winning supplier's costs after the contract is awarded. As a result, profit-share auctions are particularly promising for procurement contexts characterized by close, long-term collaboration between buyers and suppliers. This is particularly relevant in

industries like automotive manufacturing, where contracts with tier-1 suppliers often span multiple years. In such settings, close quality monitoring by OEMs provides detailed insights into suppliers' production processes, which are often accompanied by high cost visibility.

Second, in line with most procurement auction literature, our analysis assumes that suppliers' production costs are exogenous. However, if suppliers can make cost-reducing investments after the contract is awarded, profit-share auctions may lead to inefficiently low investment levels compared to cash auctions. This inefficiency arises because suppliers must share the savings with the buyer in profit-share auctions, whereas in cash auctions, they retain the full benefit of any cost savings. Moreover, the inefficiency increases with the project value specified by the buyer because a higher project value reduces the profit retained by the winning supplier. Although our analysis does not explicitly account for cost-reduction investments, their potential introduces a trade-off: specifying a higher project value intensifies price competition but simultaneously further distorts the investment decisions by suppliers.

Third, as is common in the procurement auction literature and much of the operations management literature, our analysis assumes risk-neutral players, allowing us to focus on deterministic contract terms. Consequently, we have evaluated the relative performance of procurement mechanisms based on expected buyer expenses without examining their effects on risk allocation. In cash auctions, the buyer assumes the full risk related to the project's value, while the winning supplier bears all cost-related risks. In contrast, profit-share auctions enable the buyer to influence the allocation of risk between herself and the winning supplier.

Future research should explore the trade-offs between transparency requirements, incentives for cost-saving investments, and risk-sharing under various auction mechanisms, offering further insights into optimal procurement design.

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A Proofs of Propositions

Proof of Proposition 1. Assume that in equilibrium, all suppliers bid according to a strictly increasing bidding curve $\gamma : [\underline{c}, \bar{c}] \rightarrow \mathbb{R}_+$. Consider a supplier with a cost c submitting a bid $\gamma(\tilde{c})$ for some $\tilde{c} \in [\underline{c}, \bar{c}]$. If the other suppliers stick to the equilibrium bidding strategies, this supplier's expected payoffs equal $U(c, \tilde{c}) = (1 - G^{(n-1)}(\tilde{c}))(\gamma(\tilde{c}) - c - u)$. The first-order condition for the symmetric equilibrium, at $\tilde{c} = c$, is given by the differential equation $-(G^{(n-1)})'(c)(\gamma(c) - c - u) + (1 - G^{(n-1)}(c))\gamma'(c) = 0$, of which Eq. (1) is a solution. The second-order condition is satisfied as $\text{sign}(\frac{\partial U(c, \tilde{c})}{\partial \tilde{c}}) = \text{sign}(c - \tilde{c})$.

Proof of Proposition 2. Assume that in equilibrium, all suppliers offer a profit share of the buyer's post-investment revenue according to a strictly increasing curve $\sigma : [\underline{c}, \bar{c}] \rightarrow \mathbb{R}_+$. Consider a supplier with a cost c submitting a bid $\sigma(\tilde{c})$ for some $\tilde{c} \in [\underline{c}, \bar{c}]$. If the other suppliers stick to the equilibrium strategies, this supplier's expected payoffs equal $U(c, \tilde{c}) = (1 - G^{(n-1)}(\tilde{c}))(\sigma(\tilde{c})(\hat{v} - c) - u)$. The equilibrium first-order condition, at $\tilde{c} = c$, is given by $-(G^{(n-1)})'(c)[\sigma(c)(\hat{v} - c) - u] + (1 - G^{(n-1)}(c))\sigma'(c)(\hat{v} - c) = 0$, to which Eq. (2) is a solution. The second-order condition is satisfied as $\text{sign}(\frac{\partial U(c, \tilde{c})}{\partial \tilde{c}}) = \text{sign}(c - \tilde{c})$. The expected costs for the buyer follow from:

$$\begin{aligned} K^S &= \int_{\underline{c}}^{\bar{c}} \sigma(c)(\hat{v} - c) dG^{(n)}(c) \\ &= \int_{\underline{c}}^{\bar{c}} \frac{\int_{\underline{c}}^{\bar{c}} \frac{u}{\hat{v} - x} dG^{(n-1)}(x)}{1 - G^{(n-1)}(c)} (\hat{v} - c) dG^{(n)}(c) \\ &= \int_{\underline{c}}^{\bar{c}} \int_c^{\bar{c}} \frac{\hat{v} - c}{\hat{v} - x} dG^{(n-1)}(x) dF(c). \end{aligned}$$

The last equality in the above chain follows from $(G^{(n)})'(c)/(1 - G^{(n-1)}(c)) = nF'(c)$.

Proof of Proposition 3. Under both auction formats, the supplier with the lowest costs always wins. Let the winner's costs be equal to $c \in [\underline{c}, \bar{c}]$. Conditional on c , the buyer's costs in the cash auction and the profit-share

auction are given by $\gamma(c)$ and $\sigma(c)(\hat{v} - c) + c$, respectively. The claim in the proposition holds true because for all $c \in [\underline{c}, \bar{c}]$,

$$\begin{aligned}
\gamma(c) - \sigma(c)(\hat{v} - c) - c &= \frac{\int_c^{\bar{c}} [u(1 - \frac{\hat{v}-c}{\hat{v}-x}) + x] dG^{(n-1)}(x)}{1 - G^{(n-1)}(c)} - c \\
&> \frac{\int_c^{\bar{c}} x dG^{(n-1)}(x)}{1 - G^{(n-1)}(c)} - c \\
&> \frac{\int_c^{\bar{c}} c dG^{(n-1)}(x)}{1 - G^{(n-1)}(c)} - c \\
&= 0.
\end{aligned}$$

B Further Statistical Analysis

Table 5: Predicted and Observed Behavior in Periods 31 to 45

	Observed			Predicted		
	Cash	Share200	Share500	Cash	Share200	Share500
Bid Amount	167.42 ⁺⁺⁺ (1.34)	164.08 ⁺⁺⁺ (1.31)	154.91 ^{****,++++} (0.27)	175.38	171.40	156.61
Buyer Expenses	156.01 ⁺⁺⁺⁺ (1.64)	152.13 ⁺⁺⁺⁺ (1.61)	141.92 ^{****,+++} (0.37)	167.82	161.15	143.23
Efficiency	0.893 ⁺⁺⁺⁺ (0.02)	0.844 ^{**,++++} (0.02)	0.861 ^{**,++++} (0.02)	1.00		
Inefficiency	1.481 ⁺⁺⁺⁺ (0.39)	2.024 ^{**,++++} (0.37)	1.680 ^{**,++++} (0.36)	0.00		
Number of Groups	18	18	18			
Number of Participants	36	36	36			

Notes. Standard errors in parentheses

Comparison to Cash; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$; WMW test

Comparison to Prediction; + $p < 0.10$, ++ $p < 0.05$, +++ $p < 0.01$, ++++ $p < 0.001$; SR test

Table 6: Random-Effects Probit Panel Regressions of Efficiency

	(1) Efficient	(2) Efficient	(3) Efficient	(4) Efficient
Profit-share Auction	-0.182* (0.108)	-0.190 (0.124)	-0.255* (0.152)	-0.258* (0.153)
High Value		0.0154 (0.121)	0.0231 (0.150)	0.0241 (0.150)
Cost Difference			0.0382**** (0.00252)	0.0383**** (0.00252)
Period				-0.00696*** (0.00265)
Constant	1.277**** (0.0904)	1.277**** (0.0905)	0.499**** (0.117)	0.653**** (0.131)
Observations	2430	2430	2430	2430
Participants	108	108	108	108
Log likelihood	-965.4	-965.4	-784.2	-780.8

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 7: Random-Effects Panel Regressions of Bid Amount by Treatment

	(1) Bid Cash	(2) Bid Share200	(3) Bid Share500
Operational Costs	0.612**** (0.0257)	0.329**** (0.0120)	0.0296**** (0.00123)
Constant	137.4**** (2.238)	61.40**** (1.105)	21.77**** (0.110)
Observations	1620	1620	1620
Participants	36	36	36
Overall R^2	0.728	0.680	0.662

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Overview

On the following slides, we provide the screenshots of our experiment. Screenshots appear in a red frame. The screens in the different treatments are identical up to the differences mentioned in the black frames. If there are no comments, the screen is the same for all participants. We provide the screenshots from the Cash auction treatment. For screens that differed between Cash and Share auction treatments, screenshots of a Share auction can be found in the appendix.

The experiment consists of two parts. Part 1 is the same for all participants. Part 2 differs among treatments. The experiment is preregistered (<https://aspredicted.org/gpxh-d3j5.pdf>). Note that we made the preregistration for two studies: In this study, we compare the performance of cash and profit-share auctions. In the other study, we investigate if the matching protocol (partners or strangers) affects outcomes within a mechanism.

	Cash	Share200	Share500
Number of Groups	18(+1)	18	18

Part 1

Welcome

Welcome!

Thank you for participating in our experiment! We kindly ask you to avoid communicating with other participants during the experiment and to read the following instructions carefully. If you have any questions, please raise your hand, and one of our experimenters will assist you promptly. Please be reminded that your participation in this experiment is entirely voluntary. No personal data will be processed nor saved.

This experiment consists of two independent parts. This means your actions in the first parts have no effect on the second part.

In this experiment you can earn money in the form of experimental currency units (ECU). At the end of the experiment, your earnings will be converted to Euro at an exchange rate of 1 Euro per 100 ECU. Additionally, you will receive €5.00 Euro for your participation.

Next

Part 1: Instructions

Part 1

The first part of the experiment consists of 10 rounds. In each round, you are in the role of a seller and you are matched to a computerized seller.

In each round, the buyer seeks to select one of the two sellers to complete a project. A seller who completes a project incurs production costs. These production costs can range from 0 to 60 ECU and each integer between 0 and 60 has equal probability of being drawn.

To select a seller, the buyer conducts an auction. In the auction, each seller offers a price for which they would complete the project. The seller requesting the lowest price is selected. If both sellers request the same price, then both have a 50 percent chance of being selected. The selected seller receives the requested price.

For the computerized seller, each integer between 50 and 100 is equally likely to be placed as a bid.

Profit overview

1. Profit of Selected Seller = Bid - Production Costs
2. Profit of Non-Selected Seller = 0 ECU

Please be aware that you risk losses if your offer does not cover your costs.

Part 1: Comprehension Questions

Part 1

Select the true statement:

☐ The seller with the lowest bid wins the auction.

☐ The seller with the highest bid wins the auction.

Select the true statement:

☐ Each round, the production costs stay the same.

☐ Each round, the production costs are drawn randomly.

Next

Show instructions

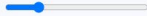
Part 1: Bidding

Auction 1 of 10

Your production costs: 8 ECU

For the computerized seller, each integer between 50 and 100 is equally likely to be placed as a bid.

Please use the slider to select a bid.



If you request a price of 21 ECU, you would earn 13 ECU when winning the auction.

Submit bid

Please be aware that you risk losses if your offer does not cover your costs.

Show instructions

Comments

- Without any user input, the text "If you request a price of .. ECU, you would earn .. ECU when winning the auction" is hidden.
- Participants can submit bids that could lead to a loss. If they try to do so, a window reading "Warning! With this bid, you would lose money if you win the auction. Do you want to proceed?" pops up. Participants have to click 'OK' in order to progress.
- Upon clicking 'Show instructions', the participant can read the instructions for part 1 again.

Part 1: Auction Results

Result 1 of 10

Your bid: 3 ECU
Competitor's bid: 56 ECU
You won the auction!
Your profit: -5 ECU

[Next](#)

[Show instructions](#)

Round	Your production costs	Your Bid	Competitor's Bid	Won?	Payoffs in ECU
1	8	3	56	Yes	-5

Part 1: Result

Result of Part 1

In the first part, you have earned 225 ECU.

[Next](#)

Part 2

Part 2: Instructions

Part 2

The second part of the experiment consists of 45 rounds. In each round, you are in the role of a seller. You will be matched with the same seller for all rounds.

In each round, the buyer seeks to select one of the two sellers to complete a project. If the project is completed, it generates a revenue of 200 ECU for the buyer. A seller who completes the project incurs set-up costs of 100 ECU and production costs. The production costs that a seller incurs when completing the project are randomly and independently determined at the beginning of each round for each seller. These production costs can range from 0 ECU to 100 ECU and each integer between 0 and 100 has an equal probability of being drawn. A seller only learns their own production costs, not the production costs of the other seller.

To select a seller, the buyer conducts an auction. In the auction, each seller places a bid. The bid is a request of a payment for which they would complete the project. The seller placing the lowest bid is selected. If both sellers place the same bid, then both have a 50 percent chance of being selected. The selected seller receives the requested payment. The other seller makes zero profits. Sellers can choose bids between 100 ECU and 200 ECU. Every multiple of one ECU in that range can be selected. Bids below 100 ECU cannot be chosen as they would certainly result in a loss for a seller when winning the auction.

Profit overview

- 1. Profit of Selected Seller = Bid - Production Costs - 100 ECU
- 2. Profit of Non-Selected Seller = 0 ECU

The buyer pays the selected seller's bid.

Please be aware that you risk losses if your offer does not cover your costs.

Differences

- Paragraph 3a:
 - a. [Cash] "The bid is a request of a payment for which they would complete the project."
 - b. [ShareX] "The bid is a percentage share of the net project profits, which is the difference between the buyer's revenue (200 ECU) and the seller's production costs. Notice that the seller's set-up costs (100 ECU) are not included in the project's total profits."
- Paragraph 3b:
 - a. [Cash] "... payment. (...) Sellers can choose bids between 100 ECU and 200 ECU. Every multiple of one ECU in that range can be selected. Bids below 100 ECU..."
 - b. [Share200] "...share. (...) Sellers can choose bids between 50% and 100%. Every multiple of 0.5% in that range can be selected. Bids below 50%..."
 - c. [Share500] "...share. (...) Sellers can choose bids between 20% and 25%. Every multiple of 0.05% in that range can be selected. Bids below 20%..."
- Profit overview:
 - a. [Cash] "Bid - Production Costs - 100 ECU
 - b. [ShareX] "(X ECU - Production Costs) x bid % - 100 ECU
- Last sentence:
 - a. [Cash] "The buyer pays the selected seller's bid."
 - b. [ShareX] "The buyer pays the selected seller both the production costs and the percentage share of the net project profits according to the selected seller's bid. Recall that the net project profits are the buyer's revenue of X ECU minus the selected seller's production costs."

Part 2: Comprehension Questions

Control Questions

- Which of the following statements is/are correct? Select the correct one(s).
 - ☐ The seller placing the lowest bid always wins.
 - ☐ The seller placing the highest bid always wins.
 - ☐ If both sellers place the same bid, one of them is randomly selected as the winner.
- Suppose you are a seller with set-up costs of $l=100$ ECU and production costs of $c=43$ ECU. Which of the following statements is/are correct? Select the correct one(s).
 - ☐ If I win the auction, I will incur costs that amount to a total of 143 ECU.
 - ☐ If I lose the auction, I will incur costs that amount to a total of 143 ECU.
 - ☐ If I lose the auction, I will only incur set-up costs of 100 ECU but no production costs.
 - ☐ If I lose the auction, I will incur no costs.
- Which of the following statements is/are correct? Select the correct one(s).
 - ☐ When placing a bid, a seller knows their own production costs but not the production costs of the other seller.
 - ☐ When winning the auction, each selected seller incurs set-up costs of $l=100$ ECU.
 - ☐ Production costs of a seller can never change between rounds.
- Which of the following statements is/are correct? Select the correct one(s).
 - ☐ In each of the 45 rounds, you compete with the same seller.
 - ☐ At the start of each round, you will be randomly matched with another seller.

Submit

Show instructions

Comments

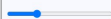
- Correct answers: Questions 1 to 4: 1a and 1b, 2a and 2d, 3a and 3b, 4a
- If a participant tries to submit the answers and they are not correct, a pop-up window will inform the participant which question(s) was (were) not correct.

Part 2: Bidding

Auction 1 of 45

Buyer's revenue: 200 ECU
Your set-up costs: 100 ECU
In this round, you have unit costs of 7 ECU.

Please use the slider to select a bid.



If you request a price of 127 ECU, you would earn 20 ECU when winning the auction.

Submit bid

Please be aware that you risk losses if your offer does not cover your costs.

Show instructions

Comments

- Sentence below slider only appears after placing the slider:
 - [Cash] "If you request a price of..."
 - [ShareX] "If you request yy.yy%"
- Participants can submit bids that could lead to a loss. If they try to do so, a window reading "Warning! With this bid, you would lose money if you win the auction. Do you want to proceed?" pops up. Participants have to click 'OK' in order to progress.

Part 2: Auction Results

Result of Auction 2 of 45

Your bid: 140 ECU

Your competitor's bid: 143 ECU

You won the auction!

Your profit: 10 ECU

Next

Show instructions

Round	Your production costs	Your Bid	Competitor's Bid	Won?	Payoffs in ECU
2	30	140	143	Yes	10
1	7	0	0	No	0

Comments

- Bid
 - [Cash] X ECU
 - [ShareX] Y.Y %
- The table at the bottom expands by one row for each finished round
- If a player clicks 'Show instructions', the instructions get displayed directly below the button. The table gets moved below.

Part 2: Results

Summary

Thank you for your participation in this experiment. Please remain seated until you are called for the payment.

You receive €5.00 for coming to this experiment. In addition, you earned 879 ECU during the experiment. Hence, rounded to the nearest Euro, you earned a total payoff of €14.00.

Please enter the details on your receipt and wait in front of the admin room for your payment.

Comments

- In Cologne, the payment was done in cash.
- The exchange rate was one Euro per 100 ECU
- We round payoffs up to the next Euro.

Appendix: Screenshots of the Profit-Share Auction

Profit-Share Auction: Instructions

Part 2

The second part of the experiment consists of 45 rounds. In each round, you are in the role of a seller. You will be matched with the same seller for all rounds.

In each round, the buyer seeks to select one of the two sellers to complete a project. If the project is completed, it generates a revenue of 200 ECU for the buyer. A seller who completes the project incurs set-up costs of 100 ECU and production costs. The production costs that a seller incurs when completing the project are randomly and independently determined at the beginning of each round for each seller. These production costs can range from 0 ECU to 100 ECU and each integer between 0 and 100 has an equal probability of being drawn. A seller only learns their own production costs, not the production costs of the other seller.

To select a seller, the buyer conducts an auction. In the auction, each seller places a bid. The bid is a percentage share of the net project profits, which is the difference between the buyer's revenue (200 ECU) and the seller's production costs. Notice that the seller's set-up costs (100 ECU) are not included in the project's total profits. The seller placing the lowest bid is selected. If both sellers place the same bid, then both have a 50 percent chance of being selected. The selected seller receives the requested share. The other seller makes zero profits. Sellers can choose bids between 50% and 100%. Every multiple of 0.5% in that range can be selected. Bids below 50% cannot be chosen as they would certainly result in a loss for a seller when winning the auction.

Profit overview

1. Profit of Selected Seller = $(200 \text{ ECU} - \text{Production Costs}) \times \text{bid \%} - 100 \text{ ECU}$
2. Profit of Non-Selected Seller = 0 ECU

The buyer pays the selected seller both the production costs and the percentage share of the net project profits according to the selected seller's bid. Recall that the net project profits are the buyer's revenue of 200 ECU minus the selected seller's production costs. Please be aware that you risk losses if your offer does not cover your costs.

Profit-Share Auction: Bidding

Auction 1 of 45

Buyer's revenue: 200 ECU
Your set-up costs: 100 ECU
In this round, you have unit costs of 17 ECU.

Please use the slider to select a bid.

If you request 65.50%, you would earn 19.87 when winning the auction.

Submit bid

Please be aware that you risk losses if your offer does not cover your costs.

Show instructions

Profit-Share Auction: Auction Results

Result of Auction 1 of 45

Your bid: 65.5 %
Your competitor's bid: 50.0 %
You lost the auction!
Your profit: 0.0 ECU

Next

Show instructions

Round	Your production costs	Your Bid	Competitor's Bid	Won?	Payoffs in ECU
1	17	65.5 %	50.0 %	No	0.0



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