AUCTIONS VS. NEGOTIATIONS: THE CASE OF FAVORITISM

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ABSTRACT. *We compare two commonly used mechanisms in procurement: auctions and negotiations. The execution of the procurement mechanism is delegated to an agent of the buyer. The agent has private information about the buyer's preferences and may collude with one of the sellers. We provide a precise definition of both mechanisms and show – contrary to conventional wisdom – that an intransparent negotiation yields a higher buyer surplus than a transparent auction for a range of parameters. In particular, for small expected punishments there exists a lower and an upper bound on the number of sellers such that the negotiation yields a higher buyer surplus with a probability arbitrary close to 1 in the parameter space. Moreover, if the expected punishment is small, the negotiation is always more efficient and generates a higher surplus for the sellers.*

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1. INTRODUCTION

Auctions are believed to be transparent procurement mechanisms and hence less prone to favoritism than private negotiations. For instance, Paul Klemperer (2000) argues that "..., allocation by bureaucrats leads to the perception - if not the reality - of favoritism and corruption. In fact some governments have probably chosen beauty contests [over auctions] precisely because they create conditions for favoring "national champions" over foreign competitors. This is unlikely to benefit consumers and taxpayers."[1]

The perception that auctions are transparent mechanisms stems from the fact that auctions are executed publicly, whereas negotiations are conducted privately. Hence, in an auction all relevant parameters and rules have to be defined *before* the bidders submit their

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[1]More recently Subramanian (2010) argues: "Auctions are more transparent processes than private negotiations, so if transparency is important, an auction is better. This is the reason that most public procurement contracts [...] are done through auctions, particularly when the government is looking to defuse criticisms of corruption or favoritism." Moreover, Martin Wolf (2000) argues that "it [the auction] is the fairest [mechanism] because it ensures that the economic value goes to the community, while eliminating the favoritism and corruption inherent in bureaucratic discretion."

offers and it is apparent whether the implemented procedures have been followed. In a negotiation – on the other hand – it is impossible to reconstruct the decision process and only the final decision becomes public.

However, public scrutiny does not imply that auctions are favoritism proof, as the parameters and procedures of an auction may be chosen in a way that benefits one of the sellers *before* the auction has even started. Moreover, even though a negotiation is conducted privately, the final outcome of the process has to be rationalized to the public *after* all offers have been collected. Thus, some public scrutiny cannot be avoided in a negotiation.[2]

This paper focuses on the definition and comparison of auctions and negotiations in the presence of favoritism. For both processes we consider a procurement setting with sellers that are horizontally differentiated with respect to the specification of the procured project.[3] Buyer surplus depends not only on the final price but also on the implemented specification. The buyer has to delegate the execution of either process to an agent who privately observes the specification preference of the buyer and colludes with one – exogenously chosen – seller.[4] The agent maximizes the surplus of his preferred agent. At the end of either process the buyer observes his true specification with a small probability and punishes the agent if the process has been manipulated.

We start our analysis by arguing that the main difference between auctions and negotiations in terms of transparency is that in an auction public scrutiny is imposed *before* the agent collects the offers of the sellers, whereas in the negotiation public scrutiny is imposed *after* collecting the offers. Hence, public scrutiny in an auction restricts the choice of the process, whereas in the negotiation public scrutiny merely places restrictions on the final decision of the agent. In our set-up, the manipulation power of the agent stems from the fact that the preferred specification of the buyer is private knowledge to the agent. Thus, public scrutiny in the auction implies that the implemented procedure has to be optimal

[2]This argument generalizes to private auctions and negotiation. Even though, private procurement is not conducted publicly the managers still have to answer to the shareholders of the procuring company.

[3]For example, consider a manufacturer of mobile phones who procures the manufacturing of a battery for a new product. Different sellers may have different manufacturing capabilities with respect to the weight of the battery and capacity of the battery given that the ratio of both factors is the same for all manufacturers.

[4]The assumption that the agent colludes with one specific seller resembles many real-life situations in public procurement. For example, Laffont and Tirole (1991) argue: "There has been much concern that the auction designer may prefer or collude with a specific buyer. And indeed most military or governmental markets acquisition regulations go to a great length to impose rules aimed at curbing favoritism. Similarly, the European Economic Comission, alarmed by the abnormally large percentage (above 95% in most countries) of government contracts awarded to domestic firms is trying to design rules that would foster fairer competition between domestic and foreign suppliers and would fit better than recent experience with the aim of fully opening borders ..."

given some feasible specification.[5] In the negotiation, public scrutiny implies that in the end the winning seller must have offered the lowest price at some feasible specification.[6] How this price was achieved is not salient to the public.

We proceed by precisely defining the resulting mechanisms and comparing them in terms of revenue and efficiency. We find that forcing the auction to be a publicly observable mechanism implies that if there is no manipulation, the auction yields a larger revenue for the buyer than the negotiation. Interestingly, if both the auction and the negotiation are manipulated, the buyer is still better off with the auction, as the optimal auction discriminates against the (manipulated) specification. However, this does not imply that the auction performs better in general. One of our main insights is that the decision whether to manipulate the auction is different from the decision whether to manipulate the negotiation. In the auction, the decision to manipulate has to be taken before the bidders submit their offers, whereas in the negotiation, the decision to manipulate can be taken after the bidders have submitted their offers. Hence, if the expected punishment is low, the agent always manipulates the auction, whereas in the negotiation, the decision to manipulate depends on the realized costs and specifications of the sellers.

To get some intuition for this result, recall that in the negotiation the agent can observe the offers of the sellers before public scrutiny forces him to reveal the specification on which his allocation decision is based. Thus, the preferred specification of the buyer is only distorted if the favorite seller can benefit from the distortion ex-post. It follows that if the favorite seller turns out to be relatively weak, the specification is set optimally and the project is allocated efficiently among the honest sellers. In the auction, the details of the process have to be set prior to collecting the offers. Therefore, the auction is manipulated whenever the favorite seller can profit from manipulation ex-ante. Thus, if the expected punishment is low, the preferred specification is distorted even if the favorite seller is relatively weak.

Three different cases are relevant for the comparison of the revenue. First, if the number of sellers and the expected punishment is low, either of the processes may generate the higher revenue depending on the initial specifications of the sellers. Second, if the expected punishment decreases and the number of sellers increases, the negotiation outperforms the auction with probability close to one in the specification space. Third, if for any fixed

[5]In this case the agent can claim that this specification is the true specification of the buyer and that the procedure is optimal.
[6]In this case the agent can claim that this is the true specification of the buyer.

expected punishment the number of sellers grows very large, the auction is not manipulated and therefore yields the optimal revenue.

Beyond the ranking of revenues, we find that if the expected punishment is low the negotiation is always more efficient than the auction. Interestingly, the favorite seller always prefers the negotiation over the auction mechanism. Thus, only the regular sellers may profit if an auction is used.

A setting in which the specification matters are spectrum auctions. Before the introduction of auctions, beauty contests were widely used for the allocation of spectrum licenses.[7] One of the reasons to move from beauty contests to auctions for the allocation of spectrum was the suspicion that beauty contests had been manipulated to favor domestic firms.[8] Given that favoritism is probable, we argue that auctions are not favoritism proof and can be influenced by manipulation of the specification of the project. Consider for example the German spectrum auction in 2010. Even though the spectrum was allocated by a simultaneous ascending auction, the required specifications in terms of coverage and implementation speed were set by the agency in charge (BNetzA) prior to the auction.[9] Among other specifications, the rules required the winner of a license to provide 80% coverage within four years.[10] These requirements significantly influenced the cost structures of the involved bidders.

Relation to the literature. One of the main contributions of this paper is that it brings together two strands of literature: the literature on favoritism in auctions, and the literature on the comparison of auctions and negotiations.

In most cases favoritism enters auctions through two different channels. First, the auctioneer can favor a seller by allowing him to adjust his bid in a first-price auction after observing all of the competing bids ("right of first refusal" or bid rigging). In this case the final allocation will be inefficient and the revenue of the buyer diminishes (Burguet and

[7]Classifying beauty contest as negotiations in the broader sense of this work seems reasonable, because the exact criteria of the decision in a beauty contest are not stated in advance but rather found in the process: "In beauty contests (also known as comparative tender), a committee typically sets a number of criteria, possibly with different weightings. Candidates' offers are then evaluated by a jury that selects the plan that has the best "mix" of those criteria, usually the highest weighting. [...] one of the criteria in a beauty contest can be a monetary one." See Prat and Valletti (2003).

[8]Prominent examples of suspected favoritism in beauty contests are the spectrum allocation processes in France in 1994 and in South Korea in 1992. See McMillan (1995) or Prat and Valletti (2003) and the references therein.

[9]The Bundesnetzagentur (Federal Network Agency) is in charge of regulating the German electricity, gas, telecommunications, postal and railway markets.

[10]See the "Präsidentenkammerentscheidung - Vergabeverfahren Mobilfunk" from October 12, 2009. http://www.bundesnetzagentur.de/DE/DieBundesnetzagentur/Beschlusskammern/1BK-Geschaeftszeichen-Datenbank/BK1-GZ/2009/2009_001bis100/BK1-09-002/BK1-09-002_E_BKV.html?nn=53804.

Perry, 2007; Menezes and Monteiro, 2006; Lengwiler and Wolfstetter, 2010). In our model, the auction is undertaken under public scrutiny. Thus, such a form of bid rigging can not occur. Second, the auctioneer can manipulate the quality assessment of his favorite seller. This case is analyzed in Laffont and Tirole (1991), Burguet and Che (2004), and Celentani and Ganuza (2002). We take a different approach in assuming that the agent may misrepresent the preferences of the buyer rather than the quality assessment of the seller, which means that favoritism not only distorts the mechanism for the favorite bidder but may also distort the allocation among the honest bidders.

The second strand of literature is concerned with the comparison of auctions and negotiations. Bulow and Klemperer (1996) show in their seminal article that a simple auction with one additional bidder leads to higher revenues than the best mechanism without this bidder. The result by Bulow and Klemperer (1996) is often used to argue in favor of auctions. However, in case the number of bidders is not an issue, the best designed mechanism will be better than the simple auction. In addition, if one extends the model to allow for common values, the result no longer holds. Bulow and Klemperer (2009) compare a standard English auction to a negotiation that is defined as a sequential procedure, where in each round a new bidder might enter the negotiation, and then competes head on with any bidder left from previous rounds. In case he wins this competition, he can make a jump bid in order to deter further entry. Bulow and Klemperer (2009) show that in this context, the auction fares better in terms of revenue although the negotiation is more efficient. This is due to the fact that entrants have to incur costs to learn their true valuation. Thus, bidders may prevent further entry with pre-emptive bids thereby capturing most of the efficiency gains.

In our set-up, the negotiation also is the more efficient mechanism: the gain in efficiency is due to the fact that the negotiation is less likely to be manipulated and the optimal specification for the buyer is more likely to be implemented. Hence, contrary to Bulow and Klemperer (2009), the buyer is able to capture most of the efficiency gain and thus may benefit from the negotiation.[11]

The major challenge in comparing auctions and negotiations is to find a precise definition for each of the mechanisms. The sparse literature on this subject uses different approaches to tackle this issue. We argue that one of the main differences between both formats is the timing at which the precise rules are set and show that, contrary to previous works, negotiations can outperform auctions.

[11]Other approaches to the comparison of auctions and negotiations include McAdams and Schwarz (2006), Fluck et al. (2007) or Manelli and Vincent (1995).

The rest of the paper is organized as follows. In Section 2, we set up the model and discuss the modeling choices. In Section 3, we derive the equilibria of the mechanisms in question. In Sections 4 and 5, we provide a comparison of both mechanisms in terms of revenue, efficiency, and sellers surplus. Section 6 contains a robustness check of the results. Section 7 concludes.

2. The Model

Suppose one indivisible project has to be procured from N risk neutral sellers. Let $i \in \{1, \ldots, N\}$ index the sellers. Each of the sellers has a privately known cost c_i of delivering the project. It is common knowledge that c_i is distributed with c.d.f. F on support $[0, \bar{c}]$. The sellers are horizontally differentiated with respect to the specifications of the project. This is captured for seller i by a given location q_i along the specification space $[\underline{q}, \bar{q}]$. Seller i incurs a cost of $|q_i - q|$ to move his specification from q_i to some q. If a seller is selected to deliver the project at a price p and specification $\hat{\theta}$ the value to the buyer is $V - |\hat{\theta} - \theta| - p$ with $V \in \mathbb{R}_+$.[12] The parameter $\theta \in [\underline{q}, \bar{q}]$ represents the desired specification of the buyer and is not observed by the buyer prior to the procurement process.

The buyer has to delegate the execution of the procurement mechanism to an agent who can privately observe the parameter θ and the specifications of the sellers prior to procuring the project.[13] The auctioneer colludes with one of the sellers and may favor this seller by misrepresenting θ by announcing some $\hat{\theta}$ to the buyer. In what follows, let seller 1 be the seller in question.[14] We define and compare two different procurement mechanisms – auctions and negotiations:

Auction. An auction is conducted under full public scrutiny, i.e., all relevant dimensions of the auction have to be made publicly available prior to its start. Hence, in an auction the agent has to set all relevant parameters and procedures of a specific auction format before the sellers submit their offers.[15] Moreover, public scrutiny implies that even if the buyer

[12]Assuming that the costs of moving the specification are given by some convex function $c_i(|q - q_i|)$ for each seller i and that the value to the buyer is $V(|\theta - \hat{\theta}|)$ for some concave function V does not change our results qualitatively.

[13]For example, we can think of the buyer being the public and the agent being a bureaucrat in charge of running a public procurement. In this case, it is easy to make sense of the assumption that the agent is better informed about the preferences of the buyer than the buyer himself. See Arozamena and Weinschelbaum (2009), Burguet and Perry (2007), Celentani and Ganuza (2002), or Laffont and Tirole (1991) for an exhaustive description of such situations.

[14]We assume that the favorite bidder is exogenously given. This assumption is a good approximation for many situations in public procurement where the agent may have a well established relationship with the domestic firm.

[15]The public procurement directive of the European Union states concerning (electronic) auctions: "The electronic auction shall be based [...] on prices and/or values of the features of the tenders, when the contract is awarded to the most economically advantageous tender. The specifications shall contain [...]

is not aware of his preferred specification θ, once the auction format has been set, auction experts can point out whether the proposed auction format is optimal given some feasible specification $\hat{\theta}$. Thus, in the context of public procurement, it is reasonable to assume that the agent has to implement the optimal auction given some $\hat{\theta} \in [\underline{q}, \bar{q}]$.[16]

The timing of the auction is the following:

(i) The agent privately observes θ.
(ii) The agent publicly commits to the revenue-optimal auction given some $\hat{\theta} \in [\underline{q}, \bar{q}]$.
(iii) The sellers submit bids to the agent and the winning bidder is determined.[17]
(iv) The winning bidder is required to invest $|q_i - \hat{\theta}|$ to meet the specifications of the project.
(v) The buyer observes θ with probability ϵ and punishes the agent by imposing a fine D if $\theta \neq \hat{\theta}$.[18]

Negotiation. The negotiation is conducted privately by the agent and the process cannot be publicly observed. Thus, in a negotiation the agent is not bound by the requirement to set all the relevant parameters and procedures in advance. He is rather free to choose his decision criteria at any time during the process. Even though the negotiation is conducted privately, the agent has to publicly rationalize his final decision. Hence, some public scrutiny cannot be avoided. Public scrutiny places two restrictions on the decision of the agent.

First, the agent cannot prevent any of the bidders from submitting offers. This is due to the fact that in public procurement the contracting authority has "obligations regarding information [...]. This takes the form of publishing information notices [...]" prior to the start of the procurement process.[19] Hence, all relevant sellers are aware that the project is being procured and could appeal against the exclusion of their offers.

Second, the agent has the obligation to reveal the winner of the process and the final agreement to the buyer. Moreover, the sellers that did not win the project may request a

the quantifiable features (figures and percentages) whose values are the subject of the electronic auction and the minimum differences when bidding. [...] The invitation shall state the mathematical formula to be used to determine automatic rankings, incorporating the weighting of all the award criteria." (See the *"Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts"*).

[16]Allowing the agent to implement some other auction will reinforce our results in favor of the negotiation.

[17]Bidders are committed to their offers.

[18]We assume that the agent and the favorite seller form a perfect coalition. Thus, it does not matter who is bearing the punishment or how the additional surplus from corruption is divided. Moreover, we assume that the agent observes c_1 and that there is no information problem between the agent and seller 1. See Celentani and Ganuza (2002) for a discussion of how these assumptions are a good approximation to many situations in real-life procurement.

[19]See the above mentioned *"Directive 2004/18/EC"* on public procurement.

statement by which means their offer is inferior to the offer of the winner.[20] In our set-up the specification and the price that a seller receives for implementing this specification are the only relevant decision dimensions. Hence, this kind of public scrutiny places a restriction on the decision of the agent in the sense that the final winning offer has to be the lowest of all submitted offers for the implemented specification.[21]

These two requirements place only little restriction on how the agent conducts the negotiation, in particular on how the agent may come to a final decision respecting the public scrutiny requirements. We explore the two fundamental ways for the agent to conduct the negotiation: he can reject offers or he can accept offers. Rejecting offers implies that the agent can credibly tell a seller that his current offer does not suffice to win the project. A seller whose offer has been rejected may then resubmit a better offer. If all offers but one have been rejected, this offer is the winning offer. This case is analyzed below. In contrast, accepting offers implies that the agent can credibly declare one offer as the winning offer and award the project to the respective seller without taking any further offers. This is subject of Section 6.

If the agent can credibly reject offers, the negotiation takes the following form:

(i) The agent privately observes θ.

(ii) Each seller submits an offer function $p_i(q)$ (with $q \in [\underline{q}, \bar{q}]$) to the agent.[22]

(iii) The agent compares the offers of the sellers and informs each seller privately whether his offer was rejected.

(iv) A bidder whose offer was rejected may submit a new offer. If he submits a new offer (iii) and (iv) are repeated.

(v) If all but one offer is rejected, the bidder of this offer is declared the winning bidder. The agent sets the final specification $\hat{\theta} \in [\underline{q}, \bar{q}]$.

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[20]For example, the public procurement directive of the European Union states: "Each contracting authority shall provide information, as soon as possible, on the decisions reached concerning the award of a contract, including grounds for not awarding it. [...] On the request of the economic operator concerned [the contacting authority should provide information on] any unsuccessful candidate of the reasons for rejecting them; any tenderer who has made an admissible tender of the relative advantages of the tender selected, as well as the name of the economic operator chosen." (See the above mentioned *"Directive 2004/18/EC"* on public procurement).

[21]Observe that if this restriction is relaxed, the comparison of auctions and negotiations becomes meaningless, as in the negotiation the agent could simply give the project to his favorite bidder at price V and discard all the other offers. A similar argument applies if the agent is not obligated to take at least one offer from each seller as in the first restriction. Hence, the obligation to take at least one offer from each seller and to award the project to the seller with the lowest offer at the implemented specification are in a sense minimal.

[22]$p_i(q)$ is the price for which bidder i will deliver specification q. The offer is only observed by the agent and bidder i. Moreover, bidders are committed to their offers.

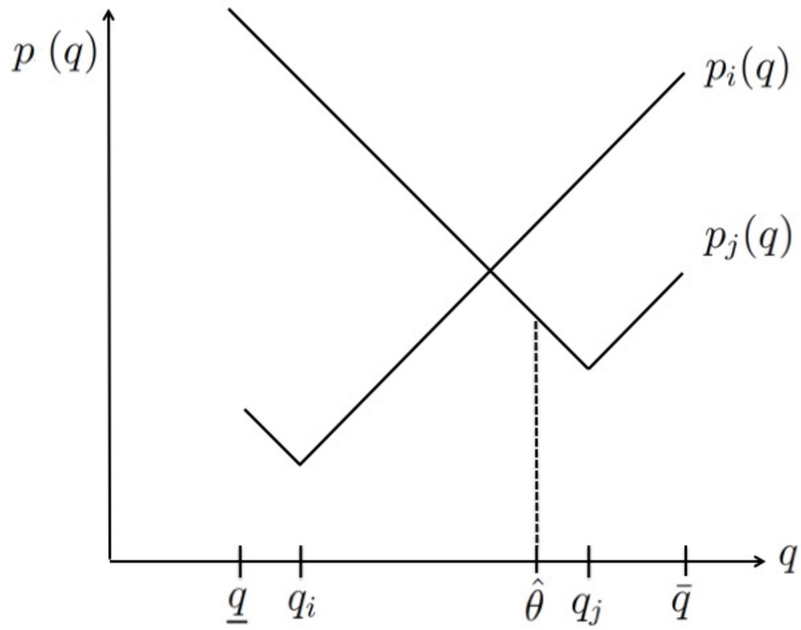

FIGURE 1. *With the appropriate choice of $\hat{\theta}$ the agent can declare bidder j as the winning bidder.*

(vi) Public scrutiny implies that if bidder i is the winning bidder, $p_i(\hat{\theta}) \leq \min_{i \neq j} p_j(\hat{\theta})$ has to hold.

(vii) The winning bidder is paid $p_i(\hat{\theta})$ and required to invest $|q_i - \hat{\theta}|$ to meet the specifications of the project.

(viii) The buyer observes θ with probability ϵ and punishes the agent by imposing a fine D if $\theta \neq \hat{\theta}$.[23]

To illustrate the public scrutiny requirement suppose that there are two offers on the table –the offer of bidder j is $p_j(q)$ while bidder i makes an offer $p_i(q)$ – as depicted in Figure 1. As argued above, at the end of the process, the final agreement and $\hat{\theta}$ have to be revealed to the buyer and the loosing sellers. If the agent announces $\hat{\theta}$ as the buyer's preferred specification, he can claim that bidder j has the lowest offer. If the offers are as depicted in Figure 2, there is no announcement of $\hat{\theta}$ such that the agent can claim that bidder j has the lowest offer without violating $p_j(\hat{\theta}) \leq \min_{i \neq j} p_i(\hat{\theta})$.

3. Final Allocations in the mechanisms

In this section, we derive the equilibria for the auction and the negotiation.

[23]To fully characterize the game, we assume that if the agent rejects all offers, or he violates public scrutiny, the agent pays a sufficiently large fine D'.

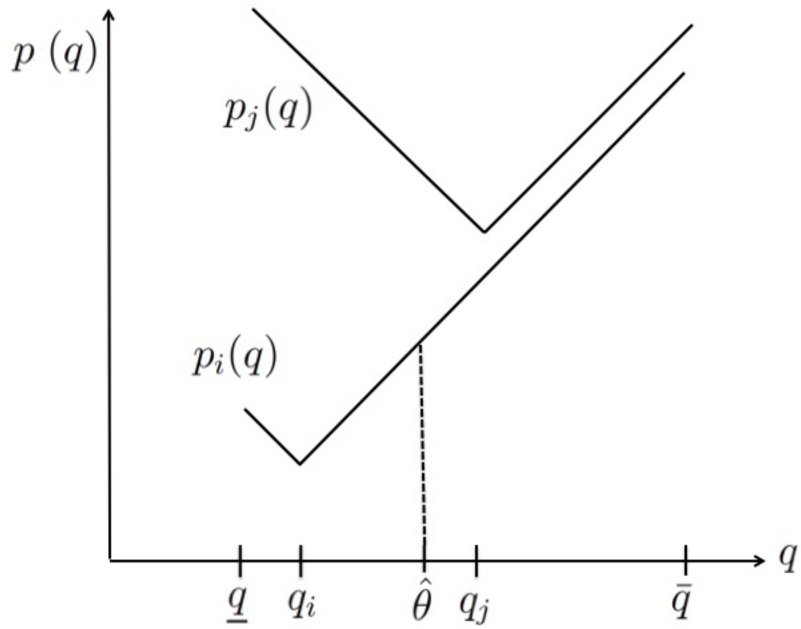

FIGURE 2. *There is no choice of $\hat{\theta}$ such that the agent can declare bidder j as the winning bidder.*

3.1. **Final allocation in the auction.** First, we derive the revenue-optimal auction that implements specification $\hat{\theta}$. To simplify the exposition, we make a standard assumption that ensures that it is always optimal to procure the object:

Assumption 1. *The following holds true for all $c \in [\underline{c}, \bar{c}]$:*

(i) $V - |q - \theta| - c - F(c)/f(c) \geq 0$ for all $q, \theta \in [\underline{q}, \bar{q}]$
(ii) $\psi(c) := c + F(c)/f(c)$ is strictly increasing in c.

Assumption 1 is satisfied if $F(c)/f(c)$ is non-decreasing and V is sufficiently large. We use the revelation principle and restrict our attention to direct revelation mechanisms: $g_i(\boldsymbol{c})$ denotes the awarding rule - the probability of winning the project for firm i; $t_i(\boldsymbol{c})$ denotes the expected payment to firm i if the vector of announced costs is $\boldsymbol{c} = (c_1, \ldots, c_N)$.[24] The optimal auction can be described as follows:

Lemma 1. *Suppose Assumption 1 holds true. The optimal auction that implements $\hat{\theta}$ is fully characterized by the awarding rule:*

$$g_i^{\hat{\theta}}(\boldsymbol{c}) = 1 \quad \textit{if} \quad V - c_i - |q_i - \hat{\theta}| - \frac{F(c_i)}{f(c_i)} > V - c_j - |q_j - \hat{\theta}| - \frac{F(c_j)}{f(c_j)} \quad \forall j \neq i$$

$$g_i^{\hat{\theta}}(\boldsymbol{c}) = 0 \qquad \textit{otherwise.} \tag{1}$$

[24]The specification q_i is known to the buyer. Hence, it suffices to restrict our attention to direct mechanisms that ask the sellers to report their cost c_i.

The expected surplus of seller i is given by

$$U_i(\hat{\theta}, c_i) = \int_{c_i}^{\bar{c}} \int g_i^{\hat{\theta}}(s, \boldsymbol{c}_{-i}) dF^{N-1}(\boldsymbol{c}_{-i}) ds. \tag{2}$$

The expected profit of the buyer in terms of his true desired specification θ is given by

$$\Pi_a(N) := E_c \left[\sum_{i=1}^{N} g_i^{\hat{\theta}}(\boldsymbol{c}) \left(V - |\theta - \hat{\theta}| - c_i - |q_i - \hat{\theta}| - \frac{F(c_i)}{f(c_i)} \right) \right]. \tag{3}$$

Proof. Immediate from Krishna (2009, p. 70) or Naegelen (2002). □

Sellers with a specification q_i that is close to $\hat{\theta}$ have a relative cost advantage. If all sellers are treated equally, those sellers would bid less aggressively and thereby lower the revenue. Hence, the optimal awarding rule discriminates against those sellers and thereby elicits more aggressive bidding.[25]

The optimal auction can be implemented as a first- or second-score auction.[26] Hence, it is meaningful to speak about auctions in the context of this paper. We are only interested in the resulting buyer and seller surplus. Thus, we will refrain from deriving the exact scoring rules and just state the following lemma:

Lemma 2. *Let b_i^f denote the bid of firm i in a first-score auction and b_i^s the bid of firm i in a second-score auction. There exist scoring rules $W^f(q_i, b_i^f)$ for the first-score auction and $W^s(q_i, b_i^s)$ for the second-score auction such that in equilibrium the buyer and seller surplus coincides with the surplus in the optimal auction.*

Proof. Immediate from Naegelen (2002). □

The agent colludes with seller 1. Hence, the equilibrium in the auction mechanism is fully characterized by $\hat{\theta}$ that maximizes the expected utility of seller 1 from participating in the auction minus the expected punishment in case the manipulation is detected. From expressions (1) and (2) it follows that maximizing the expected utility is equivalent to maximizing the winning probability of seller 1. The winning probability of seller 1 is maximized for $q_1 = \arg\max_{\hat{\theta}} V - c - |q_1 - \hat{\theta}| - F(c)/f(c)$. We summarize this finding in the following:

Corollary 1. *In the auction the agent will set $\hat{\theta} = q_1$ if $U_1(q_1, c_1) - U_1(\theta, c_1) \geq \epsilon D$. Otherwise the agent will set $\hat{\theta} = \theta$.*

[25] To illustrate this discrimination, suppose that $F(c) = c$ and $N = 2$. In the revenue optimal auction, seller 1 wins whenever $2c_1 + |q_1 - \hat{\theta}| < 2c_2 + |q_2 - \hat{\theta}|$, where as in an efficient mechanism seller 1 wins whenever $c_1 + |q_1 - \hat{\theta}| < c_2 + |q_2 - \hat{\theta}|$. Thus, the specification advantage matters less than the cost advantage.

[26] In a first-score auction, each seller transmits a bid b_i^f. The seller with the highest score $W^f(q_i, b_i^f)$ is selected as a winner and receives a payment equal to his bid. In a second-score auction, each seller transmits a bid b_i^s. The seller with the highest score $W^s(q_i, b_i^s)$ is selected as a winner and receives a payment p^* such that $W^s(q_i, p^*) = W^s(q_j, b_j^s)$ where j is the bidder with the highest rejected score.

3.2. **Final allocation in the negotiation.** We start the analysis of the negotiation by characterizing the behavior of the honest sellers and the equilibrium outcome. To simplify notation we introduce the following definition:

Definition 1. *We call a seller active if his offer was rejected and he resubmitted a new offer or if his offer has not been rejected. Define the set of active honest sellers as $A \subseteq \{2, ...N\}$. If a seller is not active we will say that he left the negotiation.*

While we do not put any constraint on how the negotiation is conducted, the two public scruitiny requirements and the assumption that the agent can credibly commit to reject offers, allows us to derive the allocation of the negotiation. This is done in four steps:

(i) *For all honest sellers it is a weakly dominant strategy to lower their offers down to marginal costs for all specifications as long as their offers get rejected.* To see this observe that a honest seller whose offer was rejected has no chance to win the project if he does not make a new, lower offer. As long as $p_i(q) > c_i + |q - q_i|$ for some $q \in [\underline{q}, \bar{q}]$ by submitting a lower offer, the seller receives an expected surplus of at least zero.[27] If, contrary to that, $p_i(q) < c_i+|q-q_i|$ for some $q \in [\underline{q}, \bar{q}]$, the seller receives the project, and in the end the agent sets $\hat{\theta} = q$ as the final specification, the surplus of this seller will be negative. Hence, if $p_i(q)$ has been rejected and $p_i(q) > c_i + |q - q_i|$ for some $q \in [\underline{q}, \bar{q}]$, not submitting a new offer is weakly dominated by lowering $p_i(q)$ at some $q \in [\underline{q}, \bar{q}]$. Similarly, if $p_i(q) = c_i + |q - q_i|$ for all $q \in [\underline{q}, \bar{q}]$, lowering $p_i(q)$ at any $q \in [\underline{q}, \bar{q}]$ is weakly dominated by not submitting a new offer. Thus, for all honest sellers it is a weakly dominant strategy to lower their offers if it becomes rejected until for every specification their offer curve is equal to the cost of delivering the project at this specification.

(ii) *For any final $\hat{\theta}$, the project is awarded to the seller who can deliver the project at specification $\hat{\theta}$ at the lowest cost.* Public scrutiny implies that in order for seller j to win $p_j(\hat{\theta}) \leq \min_{i \neq j} p_i(\hat{\theta})$ has to hold if the agent sets $\hat{\theta}$ as the final specification. Thus, from the first observation it follows that, in order to win, seller 1 has to submit an offer that is lower than $\min_{i \neq 1} c_i + |\hat{\theta} - q_i|$ at some specification $\hat{\theta}$. This is only favorable if the costs of seller 1 ($c_1 + |\hat{\theta} - q_1|$) at this specification are below the costs of all other sellers, i.e. $\min_{i \neq 1} c_i + |\hat{\theta} - q_i|$. If it is not favorable for seller 1 to win the project, this implies that the winning seller has the lowest costs of all sellers at the final specification.

We summarize (i) and (ii) in the following proposition.

[27] The surplus is strictly positive if the negotiation stops at a price $p_i(q) > c_i + |q - q_i|$ and the agent sets $\hat{\theta} = q$.

Proposition 1. *In any equilibrium of the negotiation in undominated strategies each bidder i will resubmit a new, lower offer if his offer is rejected or leave the negotiation if $p_i(q) = c_i + |q - q_i|$ for all $q \in [\underline{q}, \bar{q}]$. Thus, for any final $\hat{\theta} \in [\underline{q}, \bar{q}]$, seller j wins the project iff $c_j + |\hat{\theta} - q_j| \leq \min_{i \neq j} c_i + |\hat{\theta} - q_i|$.*

Hence, any undominated equilibrium of the negotiation is efficient in the following sense: Given a final $\hat{\theta}$, the negotiation selects the seller who can deliver the project at specification $\hat{\theta}$ at the lowest cost. However, $\hat{\theta}$ might be chosen inefficiently by the agent. It remains to characterize the rejection strategy of the agent and the offer strategy of seller 1 that maximizes their joint surplus.

(iii) *The agent will set $\hat{\theta} = \theta$ whenever seller 1 fails to win.* The agent has two objectives when maximizing the joint surplus. First, seller 1 should receive the project whenever he can underbid the lowest offer of the other sellers at some specification $\hat{\theta}$, given that the surplus of seller 1 is higher than the expected punishment if $\hat{\theta} \neq \theta$. Second, whenever seller 1 fails to win the project no fine should be imposed on the agent. Hence, the agent prefers to set the true specification as the final specification whenever seller 1 fails to win the project. As we have shown above (Proposition 1), the honest bidders will lower their offers to marginal costs if their offers are rejected. Hence, whether seller 1 can underbid the lowest offer of the honest sellers and receive the project is independent of the rejection strategy of the agent. Thus, it comes without cost to reject offers of honest bidders based on the true specification θ. In addition, not rejecting the lowest offer on the true specification has the advantage that whenever the agent realizes that seller 1 cannot profitably win the project, he awards the project to the seller who can deliver the true specification θ without violating the public scruitiny requirement.

(iv) *The agent will set $\hat{\theta} \in \{\theta, q_1\}$ if seller 1 wins the project.* Whether $\hat{\theta} = q_1$ or $\hat{\theta} = \theta$ is chosen as the final specification if seller 1 wins the project depends on the expected punishment and the costs of the honest sellers. This follows directly from what have been said before: Seller 1 will win the project if he can underbid all other sellers either at $\hat{\theta} = q_1$ or $\hat{\theta} = \theta$. If the expected punishment from manipulation is higher (smaller) than the surplus of seller 1, $\hat{\theta} = \theta$ ($\hat{\theta} = q_1$) will be implemented if seller 1 receives the project. The following proposition summarizes the equilibrium behavior of the agent.

Proposition 2. *The following strategy maximizes the ex-post joint surplus of seller* 1 *and the agent;*

(i) If $|A| > 2$, seller 1 offers $p_1(q) \equiv V$ *and the agent rejects all offers but the offer of bidder* $j = \arg\min_{i\in A} p_i(\theta)$.

(ii) If $|A| = 1$,

(a) seller 1 *offers* $p_1(q_1) = \min_{i\neq 1} p_i(q_1)$ *and the agent rejects the offer by seller* $j = \arg\min_{i\in A} p_i(\theta)$ *if*

$$\min_{i\neq 1} p_i(q_1) - \epsilon D > \min_{i\neq 1}\{p_i(\theta) - |\theta - q_1|\} \text{ and } c_1 < \min_{i\neq 1} p_i(q_1) - \epsilon D.$$

(b) seller 1 *offers* $p_1(\theta) = \min_{i\neq 1} p_i(\theta)$ *and the agent rejects the offer by seller* $j = \arg\min_{i\in A} p_i(\theta)$ *if*

$$\min_{i\neq 1} p_i(q_1) - \epsilon D < \min_{i\neq 1}\{p_i(\theta) - |\theta - q_1|\} \text{ and } c_1 + |\theta - q_1| \leq \min_{i\neq 1} p_i(\theta).$$

(c) seller 1 *offers* $p_1(\theta) = c_1 + |q_1 - \theta|$ *and the agent rejects all offers but the offer of bidder* j *with* $j = \arg\min_{i\neq 1} p_i(\theta)$ *otherwise.*

If at the end of the process $\min_{i\neq 1} p_i(q_1) - \epsilon D > \min_{i\neq 1}\{p_i(\theta) - |\theta - q_1|\}$ and $c_1 < \min_{i\neq 1} p_i(q_1) - \epsilon D$ *the agent sets* $\hat{\theta} = q_1$ *as the final specification. Otherwise the agent sets* $\hat{\theta} = \theta$.

Proof. Suppose that at some point during the negotiation the honest bidders have submitted offer functions $p_i(q)$, $i \in \{2, ..., N\}$.

ad (i): From Proposition 1 it follows that a honest seller $i \in A$ will stay active as long as $p_i(q) > c_i + |q - q_i|$ for some q. Thus, the final pay-off of seller 1 in any equilibrium in undominated strategies is independent of A at any point during the process. Thus, as long as $|A| > 2$ it is optimal for seller 1 to submit an offer function $p_1(q) \equiv V$ and for the agent to reject all offers but the lowest offer at the true specification of the buyer, i.e. the offer of bidder $j = \arg\min_{i\in A} p_i(\theta)$. This ensures, that whenever the agent realizes that seller 1 cannot win, he can pick bidder j as the winner and θ as the final specification to avoid punishment.

ad (ii): As soon as $|A| = 1$, three cases are relevant. First, as long as manipulation is favorable at the end of the process and seller 1 has a chance to win, i.e., as long as $\min_{i\neq 1} p_i(q_1) - \epsilon D > \min_{i\neq 1}\{p_i(\theta) - |\theta - q_1|\}$ and $c_1 < \min_{i\neq 1} p_i(q_1) - \epsilon D$, it is optimal for seller 1 to submit an offer function with $p_1(q_1) = \min_{i\neq 1} p_i(q_1)$ and for the agent to reject the offer of the last active seller.[28] Second, if the agent realizes that manipulation is not worthwhile but seller 1 can still win the project, i.e., if $\min_{i\neq 1} p_i(q_1) - \epsilon D < \min_{i\neq 1}\{p_i(\theta) - |\theta - q_1|\}$ but $c_1 + |\theta - q_1| \leq \min_{i\neq 1} p_i(\theta)$, it is optimal for seller 1 to submit some offer function with $p_1(\theta) = \min_{i\neq 1} p_i(\theta)$ and for the agent to reject the offer of the last seller. Third, in any other case, seller 1 has no chance of winning. To avoid punishment it is optimal for the agent to declare the last seller in A as the winner of the project and set θ as the final specification. The offer of the last bidder $j \in A$ satisfies $j = \arg\min_{i\neq 1} p_i(\theta)$ because of (i). This strategy of the agent ensures that bidder 1 wins whenever he can offer the lowest price at some specification and that punishment can be avoided whenever seller 1 fails to win. □

Combining Proposition 2 with Proposition 1 yields that the agent only manipulates final specification if the costs of seller 1 plus the expected punishment are below of the minimal costs of all other sellers at specification q_1. In all other cases the final specification is not manipulated and the true specification of the buyer is implemented. Hence, the surplus loss from misspecification to the buyer is $|q_1 - \theta|$ and the cost of seller 1 is c_1 whenever seller 1 wins the project and the specification is manipulated. Hence, the virtual surplus to the buyer is $V - |\theta - q_1| - c_1 - F(c_1)/f(c_i)$ whenever seller 1 wins the project and the specification is manipulated. Whenever the specification is not manipulated, there is no surplus loss to the buyer but the cost to the winning seller amounts to $c_i + |q_i - \theta|$. In this case the virtual surplus to the buyer is $(V - c_i - |q_i - \theta| - F(c_i)/f(c_i))$ if the specification is not manipulated and seller i wins the project.

We can rewrite the equilibrium outcome of the negotiation - characterized by Lemma 1 and Proposition 2 - in terms of an awarding rule of a direct revelation mechanism:

Lemma 3. *The equilibrium outcome of the negotiation is equivalent to the outcome of a direct revelation mechanism characterized by the following awarding rule $g^n(c)$:*

$$
\begin{aligned}
&g_1^n(c) = 1 \quad \textit{if} \quad c_1 \leq \min_{j\neq 1}\{c_j + \max\{|q_j - q_1| - \epsilon D,\ |q_j - \theta| - |q_1 - \theta|\}\}\\
&g_1^n(c) = 0 \qquad\quad \textit{otherwise;}\\
&g_i^n(c) = 1 \quad \textit{if} \quad c_i + |q_i - \theta| \leq \min_{j\neq i}\{c_j + |q_j - \theta|\} \ \textit{and}\ \{c_j + |q_1 - q_j|\} - \epsilon D \leq c_1,\ i \neq 1\\
&g_i^n(c) = 0 \qquad\quad \textit{otherwise.}
\end{aligned}
$$

[28]If the offers of the other sellers are such that $\min_{i\neq 1} p_i(q) - |q_1 - q| > \min_{i\neq 1} p_i(q_1)$ for some $q \in [\underline{q}, \bar{q}]$, it would be optimal to manipulate with $\hat{\theta} = q$ at the end of the process. However, we will show below that this cannot be an equilibrium outcome and hence – for the sake of clarity of exposition – we do not include this case in the discussion.

The expected surplus of seller i is given by

$$U_i^n(c_i) = \int_{c_i}^{\bar{c}} \int g_i^n(s, \boldsymbol{c}_{-i}) dF^{N-1}(\boldsymbol{c}_{-i}) ds.$$

The expected profit of the buyer in terms of his true desired specification θ is given by

$$\begin{aligned} (4) \quad \Pi_n(N) := E_{\mathbf{c}} \Bigg[g_1^n(c) \left(V - |\theta - q_1| - c_1 - \frac{F(c_1)}{f(c_1)} \right) \\ + \sum_{i=2}^{N} g_i^n(\mathbf{c}) \left(V - c_i - |q_i - \theta| - \frac{F(c_i)}{f(c_i)} \right) \Bigg] \\ = E_{\mathbf{c}} \left[\sum_{i=1}^{N} g_i^n(\mathbf{c}) \left(V - c_i - |q_i - \theta| - \frac{F(c_i)}{f(c_i)} \right) \right]. \end{aligned}$$

4. Revenue

We will show that if the number of sellers is rather small, the negotiation may outperform the auction depending on $q = (q_1, \ldots, q_N)$, ϵD, and θ. Then, as long as the expected gains from manipulation in the auction are positive, the negotiation becomes more profitable with an increasing number of sellers and outperforms the auction for most of the parameter values. If the expected gains from manipulation in the auction turn negative, the auction always outperforms the negotiation in terms of revenue.

As noted in Section 3, the optimal auction discriminates against sellers with a specification close to $\hat{\theta}$. The negotiation, however, selects the seller who can deliver $\hat{\theta}$ at the lowest costs but leaves him with more rent. Whenever both mechanisms are manipulated, manipulation gives seller 1 an advantage by moving $\hat{\theta}$ to his specification q_1. Because of the mentioned discrimination, this advantage is less valuable in the auction. No such discrimination takes place in the negotiation, and seller 1 can fully benefit from the manipulation. Hence, the auction generates a higher buyer surplus if both mechanisms are manipulated.[29] However, even if the expected punishment is arbitrary small, the negotiation is not always manipulated. This is due to the fact that in the negotiation, the agent observes the offers of the other sellers before choosing the final $\hat{\theta}$. Whenever the realization of c_1 is such that seller 1 cannot benefit from manipulation ex-post, the agent chooses not to manipulate the preferred specification.[30] In this case, the winner delivers the efficient specification and the unmanipulated negotiation generates in most cases more buyer surplus than the manipulated auction.

[29]Similarly, if no mechanism is manipulated, the auction generates a higher buyer surplus.

[30]This is the case whenever $c_1 > \min_{j \neq 1} c_j + \max\{|q_j - q_1| - \epsilon D,\ |q_j - \theta| - |q_1 - \theta|\}$. The probability of this event approaches 1 if N becomes large.

As long as the expected punishment is sufficiently small, manipulation remains optimal in the auction, whereas the probability that the agent manipulates the negotiation approaches zero with an increasing number of sellers. Hence, the negotiation becomes more profitable. If N becomes very large, however, and the expected punishment is larger than the expected gains from manipulation, manipulation in the auction will no longer be profitable. In this case, the auction yields the optimal surplus.

Summing up, whenever both mechanisms are manipulated or the auction is not manipulated, the auction generates a higher revenue. If the auction is manipulated but not the negotiation, the negotiation in most cases yields a higher revenue. With small expected punishments, the latter case becomes more likely with an increasing number of sellers.

For a meaningful comparison of both mechanisms along the specification space, we assume that each q_i is drawn from a continuous distribution F_q on $[\underline{q}, \bar{q}]$ and asses the probability over q that the revenue from the auction mechanism ($\Pi_a(N)$) exceeds the revenue from the negotiation ($\Pi_n(N)$). We will show that if ϵ is sufficiently small, there exists a lower and an upper bound on the number of sellers such that the probability that the auction generates more revenue than the negotiation becomes arbitrarily small (smaller than any $\delta \in (0,1)$). Moreover, for any $\epsilon > 0$ there exist a lower bound on the number of sellers such that the auction generates more revenue than the negotiation with probability 1. However, this lower bound approaches infinity if the expected punishment approaches 0.[31]

Proposition 3. *For each $\delta \in (0,1)$, there exist an $\epsilon > 0$ and $N_1(\delta,\epsilon) \leq N_2(\delta,\epsilon) < N_3(\epsilon)$ in $\mathbb{N}$ such that*

(i) if $N_1(\delta,\epsilon) \leq N \leq N_2(\delta,\epsilon)$, the surplus of the buyer in the negotiation is higher than in the auction with high probability, i.e., $Prob_q[\Pi_n(N) > \Pi_a(N)] > 1-\delta$.

(ii) If $N \geq N_3(\epsilon)$, the surplus of the buyer in the auction is higher than in the negotiation with probability one, i.e., $Prob_q[(\Pi_a(N) > \Pi_n(N)] = 1$.

Moreover, $\lim_{\epsilon\to 0} N_1(\epsilon,\delta) < \infty$ *and* $\lim_{\epsilon\to 0} N_3(\epsilon) = \infty$.

Proof. For any $\epsilon > 0$, define $N_3(\epsilon)$ such that iff $N \geq N_3(\epsilon)$, $\text{Prob}_q[U_1(q_1,\bar{c}) - U_1(\theta,\bar{c}) > \epsilon D] = 0$. As $\lim_{N\to\infty} U_1(q_1,\bar{c}) - U_1(\theta,\bar{c}) = 0$ for all $q \in [\underline{q},\bar{q}]^N$, $N_3(\epsilon)$ is finite for any fixed ϵ.

[31] Note that the probability that the auction mechanism will generate more revenue than the negotiation will never be equal to zero as long as $\epsilon > 0$. This is due to the fact that if $\theta \leq q_1 \leq \min_{i\neq 1} q_i$ or $\theta \geq q_1 \geq \max_{i\neq 1} q_i$, $U_1(q_1,c_1) - U_1(\theta,c_1) = 0$ for any realization of c_1 and the favorite bidder cannot gain from the manipulation of the auction mechanism. The auction then generates the optimal revenue.

Observe next that $U_1(q_1, \bar{c}) - U_1(\theta, \bar{c}) = 0$ whenever $|q_1 - \theta| - |q_i - \theta| = |q_1 - q_i|$ for all $i \in \{2, \dots, N\}$ and $U_1(q_1, \bar{c}) - U_1(\theta, \bar{c}) > 0$ otherwise. It follows that

$$\lim_{N\to\infty} \mathrm{Prob}_q[U_1(q_1, \bar{c}) - U_1(\theta, \bar{c}) > 0] = 1$$

and hence

$$\lim_{N\to\infty} \lim_{\epsilon\to 0} \mathrm{Prob}_q[U_1(q_1, \bar{c}) - U_1(\theta, \bar{c}) > \epsilon D] = 1.$$

.

Thus, if the expected punishment converges to 0, the agent manipulates the auction and sets $\hat{\theta} = q_1$ with probability one even if the number of bidders is high, i.e. $\lim_{\epsilon\to 0} N_3(\epsilon) = \infty$. It follows that

$$\begin{aligned}(5)\quad \lim_{N\to\infty} \lim_{\epsilon\to 0} \mathrm{Prob}_q \Bigg[& \Pi_a(N) = V - |\theta - \hat{\theta}| - \\ & E_c\left[\sum_{i=1}^{N} g_i^{q_1}(\mathbf{c}) \left(c_i + |q_i - \hat{\theta}| + \frac{F(c_i)}{f(c_i)} \right)\right] = V - |\theta - q_1| \Bigg] = 1.\end{aligned}$$

The agent manipulates the negotiation if and only if $c_1 \le \min_{j\neq 1} c_j + |q_j - q_1| - \epsilon D$. It follows that $\lim_{N\to\infty} \mathrm{Prob}[c_1 \le \min_{j\neq 1} c_j + |q_j - q_1| - \epsilon D] = 0$ for all $q \in [\underline{q}, \bar{q}]$. Thus,

$$\begin{aligned}(6)\quad \lim_{N\to\infty} \lim_{\epsilon\to 0} \mathrm{Prob}_q \Bigg[& \Pi_n(N) = V - |a - \hat{\theta}| \\ & - E_c\left[\sum_{i=1}^{N} g_i^{n}(\mathbf{c}) \left(c_i + |q_i - \hat{\theta}| + \frac{F(c_i)}{f(c_i)} \right)\right] = V \Bigg] = 1.\end{aligned}$$

Hence,

$$\lim_{N\to\infty} \lim_{\epsilon\to 0} \mathrm{Prob}_q \left[\Pi_n(N) > \Pi_a(N)\right] = 1. \tag{7}$$

For any $\epsilon > 0$ define $N_1(\epsilon, \delta)$ as the (possibly infinite) infinum of N such that

$$\mathrm{Prob}_q \left[\Pi_n(N) > \Pi_a(N)\right] > 1 - \delta.$$

Together with the fact that F_q is continuous, equation (7) implies that $\lim_{\epsilon\to 0} N_1(\delta, \epsilon) < \infty$. Hence, $N_1(\epsilon, \delta)$ defines a convergent family of natural numbers. Thus, there exists a $\bar{\epsilon}$ such that $N_1(\epsilon, \delta) = \lim_{\epsilon\to 0} N_1(\delta, \epsilon)$ for all $\epsilon \le \bar{\epsilon}$. Summing up, there exists an $\epsilon > 0$ such that $N_1(\delta, \epsilon) < \infty$, $N_3(\epsilon) > N_1(\delta, \epsilon)$, and therefore there also must exist a $N_2(\delta, \epsilon)$ with the desired properties. □

Proposition 3 is inconclusive about the ranking of the revenue of both mechanisms if N is small. The following example illustrates that for small N, the revenue can be higher in each of the formats with positive probability.

Example 1. Let $N = 2$, $c \backsim U[0,1]$, and ϵ be close to zero. In this case, the agent manipulates the auction with probability one, seller 1 receives the object whenever $c_1 \leq |q_1 - q_2|/2 + c_2$, and the implemented specification is $\hat{\theta} = q_1$. The agent manipulates the negotiation whenever $c_1 \leq |q_1 - q_2| + c_2$. In this case, seller 1 receives the object and the implemented specification is $\hat{\theta} = q_1$. If $c_1 > |q_1 - q_2| + c_2$, the agent does not manipulate the negotiation, seller 2 receives the object, and the implemented specification is $\hat{\theta} = \theta$. The expected surplus of the buyer in the auction can be calculated using expression (3). It amounts to

$$\Pi_a(2) = V - \frac{2}{3} - |q_1 - \theta| - \frac{1}{2}|q_1 - q_2| + \frac{|q_1 - q_2|^2}{4}. \tag{8}$$

The expected surplus of the buyer in the negotiation can be calculated using expression (4). It amounts to

$$\Pi_s(2) = V - \frac{2}{3} - \frac{1}{2}(|q_1 - \theta| + |q_2 - \theta|) - |q_2 - q_1|(|q_1 - \theta| - |q_2 - \theta|) - |q_1 - q_2|^2. \tag{9}$$

Hence, the auction generates a higher surplus whenever the right hand side of expression(8) is larger than the right hand side of expression (9). Figure 3 illustrates that buyer surplus can be larger in the auction or the negotiation depending on the chosen parameters. Applying the terminology of Proposition 3 it follows that if q_i is distributed with a continuous distribution function F_q with full support on $[\underline{q}, \bar{q}]$, $0 < \text{Prob}_q[\Pi_a(2) > \Pi_s(2)] < 1$ holds. Moreover, depending on F_q, $\text{Prob}_q[\Pi_a(2) > \Pi_n(2)]$ can be arbitrary close to zero or one.

5. Efficiency

In this section, we will show that if the expected punishment is sufficiently small, the negotiation is more efficient with probability one. This result holds independent of whether the auction or the negotiation leads to larger revenue. This is due to the fact that the negotiation allocates the project to the seller who can deliver the – possibly manipulated – specification at the lowest cost.

For the comparison of efficiency of both formats four cases are relevant: (i) Both mechanisms are manipulated, (ii) the auction is manipulated but not the negotiation, (iii) the

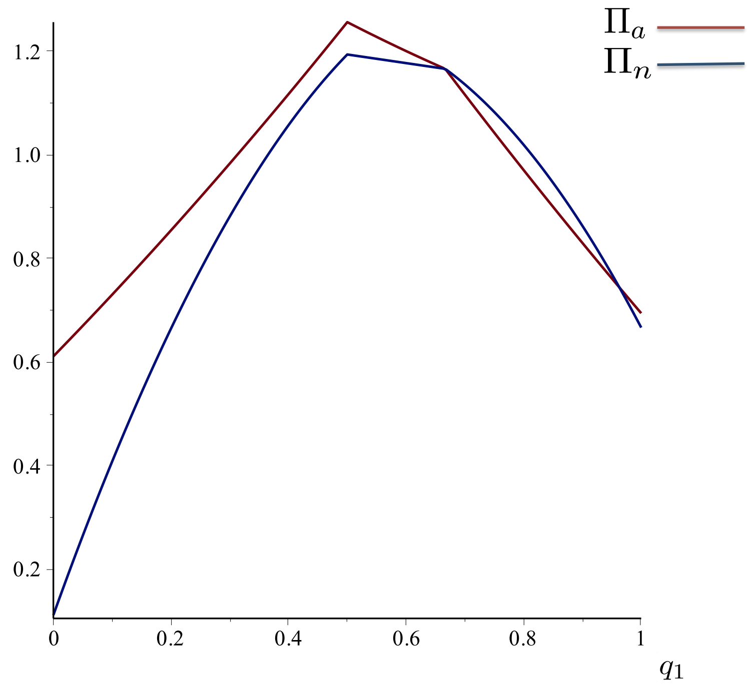

FIGURE 3. Buyer surplus for $V = 2$, $N = 2$, $\theta = 1/2$, $q_2 = 2/3$, and $q_1 \in [0, 1]$.

negotiation is manipulated but not the auction and (iv) both mechanisms are not manipulated. However, if the expected punishment is sufficiently low, the auction is always manipulated and the third and the fourth case are not relevant for our comparison.[32]

If both, the auction and the negotiation, are manipulated (case (i)), the efficiency loss from the misspecification is the same ($|q_1 - \theta|$) in both mechanisms. However, as stated above, the agent will manipulate the negotiation if and only if seller 1 can deliver specification q_1 at the lowest price of all sellers. Hence, allocating the object to seller 1 – given that specification q_1 has to be delivered – is efficient. Thus, the negotiation is more efficient than the auction if both mechanisms are manipulated. If the auction is manipulated but not the negotiation, the negotiation is the fully efficient mechanism and thus more efficient than the auction.

Summing up, if the expected punishment is small the auction is always manipulated. Moreover, the negotiation is more efficient with probability one whenever both mechanisms are manipulated or the negotiation is not manipulated. Hence, the negotiation is more efficient than the auction.

Proposition 4. *As long as* $U_1(q_1, \bar{c}) - U_1(\theta, \bar{c}) \geq \epsilon D$ *the negotiation is more efficient than the auction .*

[32]Nevertheless, if both mechanism are not manipulated the negotiation is the more efficient mechanism.

Proof. If $U_1(q_1, \bar{c}) - U_1(a, \bar{c}) \geq \epsilon D$, the agent manipulates the auction. The ex-post social surplus from the auction is given by

$$V - |q_1 - \theta| - c_i - |q_i - q_1| \tag{10}$$

and $q_i \neq q_1$ with positive probability. If the agent does not manipulate the negotiation, the negotiation yields the ex-post fully efficient outcome: $V - \min_{i \in \{1,\dots,N\}} \{c_i + |q_i - \theta|\}$. If the agent manipulates the negotiation,

$$c_1 < \min_{i \in \{2,\dots,N\}} c_i + |q_i - q_1| \tag{11}$$

has to hold. The ex-post social surplus of the negotiation is given by

$$V - |q_1 - \theta| - c_1. \tag{12}$$

Comparing expression (10) and (12) and using expression(11) yields the result. □

We have shown that for small ϵ the negotiation is always more efficient than the auction, and that for small N there exist parameter values such that the auction generates a higher revenue. From this it directly follows that there exist parameter values such that the sellers receive a higher surplus in the negotiation. However, most of this surplus is captured by seller 1. The following proposition demonstrates that if the expected punishment is small, seller 1 prefers the negotiation over the auction.

Proposition 5. *There exists an $\hat{\epsilon}$ such that seller 1 prefers the negotiation over the auction for all $\epsilon \leq \hat{\epsilon}$.*

Proof. Either $|q_1 - \theta| - |q_i - \theta| = |q_1 - q_i|$ or there exists a $\epsilon_1 > 0$ such that $U_1(q_1, \bar{c}) - U_1(\theta, \bar{c}) > \epsilon D$ for all $\epsilon \leq \epsilon_1$. In both cases, Lemma 1 can be used to write the expected utility of seller 1 as

$$\begin{aligned} U_1^a(q_1, c_1) &:= \int_{c_1}^{\bar{c}} \int g_i^{q_1}(c_1, c_{-1}) dF^{N-1}(c_{-1}) dc_1 \\ &= \int_{c_1}^{\bar{c}} \prod_{i=2}^{N} (1 - F(\psi^{-1}(-|q_i - q_1| + \psi(c_1))) dc_1. \end{aligned} \tag{13}$$

Observe that

$$\begin{aligned} -|q_i - q_1| + c_1 &< \psi^{-1}(-|q_i - q_1| + \psi(c_1)) \\ \Leftrightarrow \psi(-|q_i - q_1| + c_1) &< -|q_i - q_1| + \psi(c_1) \\ \Leftrightarrow -|q_i - q_1| + c_1 + \frac{F(-|q_i - q_1| + c_1)}{f(-|q_i - q_1| + c_1)} &< -|q_i - q_1| + c_1 + \frac{F(c_1)}{f(c_1)}. \end{aligned}$$

The last inequality is true as we assumed that $F(c_1)/f(c_1)$ is increasing. Hence, there exists a $\epsilon_2 > 0$ such that $-|q_i - q_1| + c_1 + \epsilon D < \psi^{-1}(-|q_i - q_1| + \psi(c_1))$ for all $\epsilon \leq \epsilon_2$.

The expected surplus of seller 1 in the negotiation can be written as

$$(14) \quad U_1^n(c_1) = \int_{c_1}^{\bar{c}} \int g_i^n(c_1, c_{-1}) dF^{N-1}(c_{-1}) dc_1$$
$$\geq \int_{c_1}^{\bar{c}} \prod_{i=2}^{N} (1 - F(-|q_i - q_1| + c_1 + \epsilon D) dc_1.$$

Take $\hat{\epsilon} = \min\{\epsilon_1, \epsilon_2\}$. It follows that $U_1^n(q_1, c_1) \geq U_1^a(q_1, c_1)$ for all $\epsilon \leq \hat{\epsilon}$. □

Whether the honest sellers appropriate a higher surplus is uncertain. Most of the additional surplus that is captured by seller 1 in the negotiation is due to the fact that the negotiation does not discriminate against sellers with a favorable specification q_i. Hence, he is able to capture all of the additional surplus from the manipulation in the negotiation. Whether the honest sellers prefer the negotiation over the auction depends therefore on how close their specification q_i is to the specification q_1 of seller 1.

6. Robustness

In deriving the negotiation procedure in Section 2 we have assumed that the agent can credibly *reject* the offers of the sellers. In this section we will focus on the case where the agent can credibly *accept* offers. Thus, we modify the negotiation procedure from Section 2 by allowing the agent to award the project to one of the sellers after collecting at least one offer from each seller. As the agent – to benefit his preferred seller – always prefers higher offers to lower offers, he will never inform one of the honest sellers before the end of the process whether his first offer was sufficient to win the project and thereby give him no chance to improve his offer. Hence, essentially, if the agent can credibly accept offers each seller submits exactly one offer and the negotiation takes the following form:

(i) The agent privately observes θ.

(ii) Sellers submit an offer function $p_i(q)$, $q \in [\underline{q}, \bar{q}]$.

(iii) After collecting the offers, the agent chooses the winning bidder and sets the final specification $\hat{\theta}$.

(iv) The winning bidder is paid $p_i(\hat{\theta})$ and required to invest $|q_i - \hat{\theta}|$ to meet the specifications of the project.

(v) The buyer observes θ with probability ϵ and punishes the agent by imposing a fine D if $\theta \neq \hat{\theta}$.

As before, the winning bid has to satisfy $p_i(\hat{\theta}) \leq \min_{j \neq i} p_j(\hat{\theta})$.

The strategy that maximizes joint surplus of the agent and seller 1 is straightforward:

(i) whenever $\min_{j \neq 1} p_j(q_1) - c_1 > \epsilon D$ the agent sets $\hat{\theta} = q_1$ and seller 1 offers $p_1(q_1) = \min_{j \neq 1} p_j(q_1)$;

(ii) whenever $\min_{j \neq 1} p_j(q_1) - c_1 < \epsilon D$ the agent sets $\hat{\theta} = \theta$ and seller 1 offers $p_1(\theta) = \max\{\min_{j \neq 1} p_j(\theta), c_1 + |\theta - q_1|\}$.

For the honest bidders, the problem of choosing an optimal offer for each possible $\hat{\theta}$ is essentially the same as choosing bids in a family of asymmetric first-price auctions with a stochastic reserve price.[33] An equilibrium for this game is known to exist.[34] However, a closed-form solution for the bidding strategies is hard to derive.

Nevertheless, due to the fact that in equilibrium $p_i(q) > c_i + |q_i - q|$ and $\lim_{N \to \infty} p_i(q) = c_i + |q_i - q|$ has to hold for all $i \neq 1$, the revenue result from Section 4 also holds for the negotiation at hand: if N is sufficiently small and the expected punishment is sufficiently low, the auction and the negotiation are both manipulated with a high probability. Manipulation then gives seller 1 a specification advantage over the other sellers. However, this advantage is less valuable in the auction as it discriminates against sellers with such an advantage. The allocation is less distorted than in the negotiation in which seller 1 can fully benefit from the manipulation. Hence, the auction with favoritism may generate a higher buyer surplus for small N. However, if the number of sellers grows but the expected punishment remains small, the outcome of the negotiation converges to the outcome characterized in Section 3 as $\lim_{N \to \infty} p_i(q) = c_i + |q_i - q|$. In this case, we know from Proposition 3 that the revenue from the negotiation exceeds the revenue from the auction with high probability. Hence, the negotiation generates a higher revenue than the auction mechanism if N grows. If N becomes so large that manipulation of the auction is not optimal, the auction is the optimal mechanism and generates a higher revenue than the negotiation. We summarize this finding in the following:

[33] The bid of the corrupt seller 1 resembles a stochastic reserve price.
[34] See Athey (2001).

Corollary 2. *The negotiation generates a higher revenue than the auction if ϵ is sufficiently small and N is sufficiently large. If N is very large, the auction generates a higher revenue than the negotiation.*

7. Conclusion

We have shown that – contrary to common wisdom – the transparency of an auction does not render it favoritism proof. If the agent of the buyer is able to manipulate the specification of the procured project, an intransparent negotiation is more efficient and may generate more buyer surplus. This is due to the fact that in the auction, public scrutiny forces the agent to decide whether to manipulate the process *before* sellers submit their offers. In the negotiation on the other hand, *after* observing the offers of the sellers, the agent may still decide not to manipulate if he realizes that his preferred seller is not able to win the project.

If no manipulation takes place, the auction is the revenue-optimal mechanism. Moreover, if the specification is manipulated in both procedures, the auction is the revenue optimal mechanism that implements the manipulated specification. In those cases, the auction will outperform the negotiation. However, if the auction is manipulated but not the negotiation, the negotiation may generate more surplus. This difference in manipulation is due to the fact that the auction is manipulated whenever the expected punishment is low. The negotiation, on the other hand, may not be manipulated even if the expected punishment is low because after observing the offers of the honest sellers, the agent may realize that his preferred seller has no chance of winning the project. This becomes more likely if the number of sellers increases.

This paper sheds light on the question whether auctions or negotiations should be used when designing a public procurement mechanism. We have argued that a seemingly straightforward reasoning that auctions – because of their transparency – should be preferred in the presence of favoritism does not apply. Whether an auction should be used over a negotiation depends on the number of participating sellers and the buyers' ability to detect deviations from his preferred specification.

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