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Are Procurement Auctions Good for Society and for Buyers?

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Abstract

Winning bids in reverse auctions are efficient solutions (providing that fairly weak assumptions about the bidders are met). The auctions are efficient, un-der the assumption that the utilities of all participants are quasi-linear. This assumption is often unrealistic. Typically then, auctions are inefficient mechanisms. This paper presents the limitations and impracticability of the quasi-linearity assumption and proposes augmenting reverse auctions with negotiations. It shows that when the efficient frontier is concave, then it is possible to improve the winning bid through negotiations that follow auctions. The efficiency of this augmented mechanism is not lower than the re-verse auctions' efficiency.

Keywords: reverse auctions, negotiations, Pareto optimality, mechanism efficiency, quasi-linear utility, concave utility, efficient frontier

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1. Introduction

Exchange mechanisms, such as auctions and negotiations, are employed when sellers want to sell and buyers want to purchase a good. In business catalogues, negotiations and reverse auctions are typical exchange mechanisms. Buyers purchase goods when price does not exceed its subjective value for the buyer, while sellers sell goods when the value of the good (typically costs) does not exceed its subjective price. This separation of value (costs) and price is violated when the price is a function of such variables as pre-payment, and prices of different components or services. The distinction is also problematic when the suppliers cannot separate price from the other attributes of the good which they design to the buyer's specifications. Such a separation may also be difficult for the buyer who has to make separate trade-offs between the price and the good configuration, its quality, delivery, etc., rather than global trade-offs between the value and price.

The purpose of this paper is to show that in many circumstances reverse auctions are inefficient mechanisms. They became a pervasive exchange mechanism in the procurement of commodities, products and services because they reduce transaction costs as well as the price the buyer has to pay for the goods [1-4]. Their use is often beneficial for the buyers who receive very good deals. However, it may not be beneficial for the society or the economy. Because the reverse auctions are widely used in procurement by governments and other public organizations, their inefficiency may lead to undesired consequences at the macro-economic scale.

Some goods are homogenous others are heterogeneous. Services, such as logistics, data processing, and distribution, are often heterogeneous when the service providers want to distinguish themselves from the competition. When goods are homogenous and the buyers need not distinguish between suppliers (based on their reliability, trust etc.), then reverse auctions are likely to be price-only. If goods are heterogeneous and the good specification is important for the buyer, then the buyer may employ negotiations or multi-attribute auctions.

The separation of price and other attributes of the good is important for the price-only auctions but this type of separation may be only superficial. This would be the case when the market participants base their buying and selling decisions on an aggregate measure of which price is only one attribute. In the case of multi-attribute exchanges it is natural that all attributes are considered in the decision-making. The assumption made here is that these decisions are based on the goods utility. Utility $u()$ is defined on the good's N attributes; the attribute values may be real, ordinal, categorical, and nominal numbers.

$$u(\boldsymbol{x}) = u(x_1, x_2, \ldots, x_N), \ \ \boldsymbol{x} = [x_{1, \ldots,} x_N] \in X \,. \qquad (1)$$

By convention the first attribute x_1 is price. The remaining N-1 attributes describe the good denoted here as $\boldsymbol{x}_{-1} = [x_{2, \ldots,} x_N]$; $\boldsymbol{x}_{-1}$ is a configuration of the good.

One of the issues discussed here is the relationship between price and other attributes. If utility is quasi-linear, then price is numeraire and its remaining component (good's value or costs) has to be expressed in the same monetary terms as price [5], [6].

It is useful to differentiate between buyers and sellers when specifying their quasi-linear utilities because this shows the different role that price and value play on the utility value. Using index b to indicate the buyer and s to indicate the seller, we have the following two quasi-linear utilities:

$$u_b(\boldsymbol{x}) = v_b(\boldsymbol{x}_{-1}) - x_1$$
$$u_s(\boldsymbol{x}) = -v_s(\boldsymbol{x}_{-1}) + x_1 \,. \tag{2}$$

Functions $v_b(\boldsymbol{x}_{-1})$ and $v_s(\boldsymbol{x}_{-1})$ are the valuation functions of the good. Valuation function $v()$ is assumed to be strictly concave (twice differentiable with $v_b' > 0$; $v_b'' < 0$, and bounded from above).

Reverse auctions relay on the quasi-linearity assumption. It is a strong assumption because "it is not in general possible to model a well-behaved exchange economy as a transferable game" [6]. Luce and Raiffa [7] observe that situations in which quasi-linear utilities "can realistically happen remains obscure".

Section 2 discusses quasi-linear utilities and their implications which are relevant to reverse auctions. While these implications are useful because they assure that the reverse auctions are efficient mechanisms which result in efficient solutions, they are difficult to meet in real-life situations. One of such situations in which auctions are often employed involves goods that are not yet available and which are made only after being contracted. In such situations it is natural for both the buyer and the suppliers/producers to view prices as being dependent on other attributes and vice versa, hence they violate the assumption.

Section 3 discusses the limitations of the quasi-liner utilities. It also gives examples to support the claim that realistically this type of utilities can rarely happen.

If the market participants' utilities are concave or linear, which is considered typical for most decision problems [7], [8], [9], then the winning bid in a reverse auction may be efficient but the auction mechanism is not efficient. Section 4 shows that for such utilities it may be possible to increase the mechanism efficiency without decreasing the buyer's surplus. This increase requires that the buyer and the winning supplier engage in a post-auction negotiation

2. Quasi-linear utility and its implications

Reverse auction mechanisms are efficient providing that the buyers' and suppliers' utilities are quasi-linear. This section reviews the key characteristics of such utilities and their use in reverse auctions. In this discussion, the mechanism's efficiency or (equivalently) social welfare is measured by the sum of the buyers' and the winning supplier's utilities.

2.1 Efficient configuration

A solution obtained from the application of an exchange mechanisms is efficient if it lies on the contract curve. When the utilities are quasi-linear, then there is only one efficient configuration (see also [9]).

<u>Proposition 1</u>: If quasi-linear functions $u_b(\boldsymbol{x})$ and $u_s(\boldsymbol{x})$ represent the buyer's b and the supplier's s utilities respectively, and set $\tilde{X}_i$ is the set of efficient solutions representing trades between b and s, then there is only one efficient configuration of non-price attribute values $\tilde{\boldsymbol{x}}_{-1}$.

<u>Outline of the proof</u>: Assume that there are different efficient configurations ($\tilde{\boldsymbol{x}}_{-1}$ and $\dot{\boldsymbol{x}}_{-1}$) and define pairs of indifference curves (U_{bj}, U_{sj}, j=1,2 …). Each pair is tangential at the same point; $\tilde{\boldsymbol{x}}_{-1}$ is tangential for (U_{b1}, U_{s1}) and $\dot{\boldsymbol{x}}_{-1}$ is tangential for (U_{b2}, U_{s2}). Let $d = \tilde{x}_1 - \dot{x}_1$ and define a pair of indifference curves tangential at a point $\dot{x}_1 = \tilde{x}_1 - d$. If tangential point $(\dot{\boldsymbol{x}}_{-1}, \dot{x}_1)$ of pair (U_{b2}, U_{s2})

is different from tangential point $(\tilde{\boldsymbol{x}}_{-1}, \tilde{x}_1)$ of pair (U_{b3}, U_{s3}), the difference has to be in their respective components $v_b(\boldsymbol{x}_{-1})$ and $v_s(\boldsymbol{x}_{-1})$. This requires that $v_b(\boldsymbol{x}_{-1})$ and $-v_s(\boldsymbol{x}_{-1})$ be tangential at two different points $\dot{\boldsymbol{x}}_{-1}$ and $\tilde{\boldsymbol{x}}_{-1}$ which is not possible because by definition they are concave and convex, respectively. ♦

Proposition 1 holds if the buyer's and every supplier's utilities are quasi-linear. According to this proposition every supplier may have only one efficient configuration of the good. All but one configurations are inefficient irrespectively of their price.

2.2 Mechanism's efficiency

An exchange mechanism is efficient if its solutions maximize joint utility of the buyer and the supplier. Auction theory uses the sum of the utilities as a joint utility function and such a function is also used here. One reason for using the sum appears to be the fact that auction mechanisms, which are used by buyers and suppliers with quasi-linear utilities are efficient.

The joint utility function w_{sb} also known as social welfare because it is the sum of the buyer's surplus and supplier's surplus is given by [9], [10]:

$$\begin{aligned} w_{sb} &= u_b(\boldsymbol{x}) + u_s(\boldsymbol{x}) = v_b(\boldsymbol{x}_{-1}) - x_1 + x_1 - v_s(\boldsymbol{x}_{-1}) \\ &= v_b(\boldsymbol{x}_{-1}) - v_s(\boldsymbol{x}_{-1})\,. \end{aligned} \tag{3}$$

From (3) it follows that the efficiency of the mechanism does not depend on the price x_1, which buyer b pays the winning supplier s for good $\boldsymbol{x}_{-1}$.

According to Proposition 1, for every supplier there is a unique configuration $\boldsymbol{x}^*_{-1}$ which is efficient irrespectively of price. Although every price is feasible, not every price can be accepted by the buyers and the suppliers. It is natural to assume that the buyer will not pay more than the value of the good and the suppliers would not accept a price that is lower than the costs of producing the good, i.e., their utility values are non-negative. Given these two constraints and assuming that there are $m = |S|$ suppliers ($s \in I$), we can formulate the following mechanism's efficiency maximization problem:

$$\max_{\boldsymbol{x}\in X, s\in S}\left(u_b(\boldsymbol{x}) + u_s(\boldsymbol{x})\right) = \max_{\boldsymbol{x}\in X, s\in S}\left(v_b(\boldsymbol{x}) - v_s(\boldsymbol{x})\right). \tag{4}$$

subject to:

$$v_b(\boldsymbol{x}_{-1}) - x_1 \geq 0\,. \tag{5}$$

$$v_s(\boldsymbol{x}_{-1}) + x_1 \geq 0 \; (s \in S)\,. \tag{6}$$

Assume that supplier s^* is the winner and maximum social welfare is obtained when good $\boldsymbol{x}^*_{-1}$ is selected.

If price does not affect welfare, then that maximization problem (4)-(6) maximizes social welfare for buyer b and m suppliers ($S = \{1, \ldots, m\}$). This means that as long as the utilities are quasi-linear, problem (4)-(6) maximizes social welfare. This can be generalized to every reverse auction in which utilities are quasi linear. Let:

$B = (1, 2, \ldots)$ – the set (possibly infinite) of all possible buyers;

$S^b = (1, \ldots m_b)$ – the set of all suppliers who participate in the reverse auction in which b is the buyer; and

$RA_{q\text{-}l}(b)$ – the reverse auction mechanism in which utilities of all participants, i.e., buyer b,

$b \in B$, and suppliers s, $s \in S_b$) are quasi-linear.

Proposition 2: Reverse auction mechanism $RA_{q\text{-}l}(b)$, $b \in B$, is efficient.

Outline of the proof: The proof of this proposition directly follows from Proposition 1 and the fact that the solution of the maximization problem (9)-(11) does not depend on any other assumptions regarding the buyers' and the suppliers' characteristics than the quasi-linearity of their utilities. In other words, if an auction $RA_{q\text{-}l}(b)$ set up by buyer b has a winner, then the winning bid maximizes social welfare. ♦

3. Limitations

Reverse auctions of the $RA_{q\text{-}l}$ type are efficient mechanisms and their outcomes are efficient solutions. Their underlying assumption is, however, strong and often unrealistic.

In this section, first a text-book example is discussed in order to present some of the restrictions imposed by the quasi-linearity assumptions. Following the example, several real-life auctions as well as rules for their set-up are reviewed. They show why quasi-linearity is a difficult to meet assumption.

3.1 An illustrative example

Decision and negotiation analyses deal with problems which individuals and firms encounter when they need to choose one alternative from among many. They focus on constructing and solving deterministic and probabilistic models in which decision space is continuous or discrete and in which utility functions are linear, convex, quasi-convex or piece-wise convex.

Raiffa, Richardson and Metcalfe [11] present a text-book example of a negotiation problem in which Amstore, a large retail firm, needs to build a new store and seeks a contractor. The firm engages in a negotiation with a single contractor, Nelson. They need to agree on the values of three attributes: *price*, *design*, and *delivery time*. Each decision-maker has a preference structure which can be represented by a scoring function. Armstore and Nelson use one of the decision-analytic approaches to determine scores for all attributes and for their values.

Armstore, rather than transacting with a single contractor, may decide to set up a multi-attribute reverse auction and use it to select the contractor who would offer the best terms. In what follows only Supplier 1 (e.g., Nelson), who is the theoretical winner (i.e., has the lowest costs), is considered.

In the case discussed by Raiffa at al. [11] the efficient solution lies on a collection of convex functions. Furthermore, each party valuates price differently, i.e., they assign different scores to price values. One may expect that in such a situation the results differ from those obtained when preferences are quasi-linear. However, even when the scoring function used is similar to quasi-linear in that it converts all attribute values to money and money has the same value (score) for both parties, the results may also differ.

The attributes, attribute values, and the scores for Buyer (Armstore) and Supplier 1 (Nelson) are shown in Table 1.

Table 1. Buyer's and supplier's attributes, their values and scores

Attribute	**Value**	**Score (in $000s)**	
		Buyer	**Supplier 1**
Price ($000s)	90	90	90
	100	100	100
	110	110	110
Design	Complete	100	40
	Enhanced	95	25
	Basic+	70	17
	Basic	60	15
Delivery date	Long	45	10
	Medium	45	30
	Short	55	30

The set of feasible alternatives for all possible configurations of the three attributes in the scoring space is shown in Figure 1. Scores are calculated in the way that is typical for multi-attribute auctions [13], that is, the buyer's score is: $u_b = v_{b,\text{ Design}} + v_{b,\text{ Delivery}} - Price$. For Supplier 1, the score is: $u_1 = Price - v_{1,\text{ Design}} - v_{1,\text{ Delivery}}$.

The buyer's and the supplier's scores for the selected alternatives are also shown in Figure 1. The efficient frontier comprises six alternatives (A to F), however, only alternatives D, E and F, maximize social welfare which is $105,000. There are other efficient alternatives (i.e., A, B and C), for which social welfare ranges from $85,000 to 95,000. This shows that some efficient alternatives maximize the social welfare and some do not.

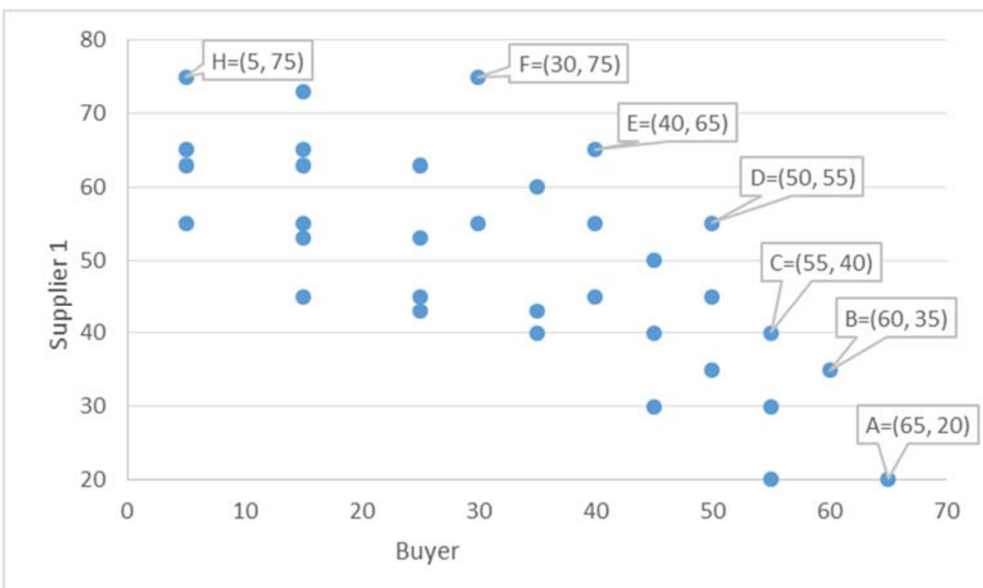

Fig. 1. Feasible alternatives for the Buyer-Supplier problem and the scoring space. Alternatives A to H are efficient.

It may not be possible to achieve social welfare equal to $100,000 when a reverse auction is used. In an auction, in addition to Supplier 1, there are other suppliers who want to win the contract. One of these suppliers may submit bid *B*, which yields the buyer's surplus equal to $60,000. This forces Supplier 1 to submit bid *A* which yields Buyer's surplus of $65,000 and Supplier1's surplus of \$20,000. Supplier 1 wins the auction after making bid *A*. If this is an English auction (second-highest-bid), then the social welfare is \$95,000; if it is the highest-bid auction, then social welfare is \$85,000. Although the winning bid is an efficient solution the mechanism is inefficient because the maximum social welfare is \$105,000.

The possible increase of social welfare is 10.5% for English auction and 23.5% for the highest-bid auction. While this may be considered as not a very large loss in mechanism efficiency, it clearly is a loss.

3.2 Multi-attribute reverse auctions

Single attribute auctions which are discussed in literature, including cases discussed by the providers of auction systems do not provide information about the buyers and sellers' preferences. Therefore, in this section multi-attribute auction are discussed.

Mars, Inc. created an electronic private exchange in which volume discount bidding and multi-attribute bidding were used most often [14]. The attributes included payment and its terms (e.g., pre-payment, payment date, and discount) as well as turnaround time, delivery schedule, product quality, type of material, and color. It is possible that the payment and the different terms of payment were linearly interdependent. In such a situation they should be incorporated into a single attribute "price". If however, pre-payment, discount and other terms were subject to bidding and non-linearly dependent, then they could not be combined with the payment attribute. In effect the scoring function would not be quasi-linear.

There are two other potential problems associated with the scoring function. They are due to the attribute *color* which is discrete, may take only several values and may be differently valuated by the buyer and the suppliers. If the preferential order of the color attribute is different, then the scoring function violates the quasi-linearity assumption.

Trade Extensions created a procurement software platform which includes reverse auctions. A review of four procurement cases (i.e., Ineos, Road resurfacing, Elderly Care Services, and Cleaning Services) shows that Trade Extension's auction mechanism requires that all attributes must be expressed in monetary terms [15]. The focus is on the minimization of the costs of procured services subject to constraints imposed on the attributes and packages. There is no indication that the costs and revenue functions need to be quasi-linear; in fact, in most cases all attributes are discrete. Another feature in all cases is that the bidding concerns services or goods that would be produced in the future; this would make price and other attributes interdependent.

The European Union has recently adopted a new public procurement directive; it requires that the procurement authority publish ex ante relative weighting of each criterion. The E.U. directives (Article 55 in 2004/17/EC or Article 53 in 2004/18/EC) require that public contracts be allocated by competitive bidding. The buyer has to either use a scoring function in which price and other attributes and their weights are given or a lexicographically ordered list of attributes. Lundberg and Marklund [16] argue that a multi-attribute scoring function should be used because it can represent society's preferences. This may be the case, but the society's preferences related to a single transaction are likely to be in conflict with the society's preferences related to the functioning of the national or regional economy.

Lundberg and Marklund (op. cit., p. 66) also note that the representation of the buyer's utility with a quasi-linear function is reasonable because "Commonly, the price of the procured product constitutes only a small fraction of the procuring authority's total budget." Neither the directive nor the authors address the issue of the utility of the suppliers and situations in which the expense is a significant item in the municipal and other public organizations' budget. Furthermore, even if a single auction involves a small portion of the budget, multiple auctions may involve a much larger portion.

In the U.S., scoring auctions, known as "A+B bidding", have been used for the procurement of highway construction work [17]. The highway authorities evaluate offers on the basis of: (1) the total costs (A); and (2) the number of days required to complete the project (B) weighted by a road user cost (i.e., the difference between the road user costs during construction and the costs after construction is completed). Asker and Cantillon [13] report that by 2003, 38 U.S. states were using auctions with scoring functions for large projects for which time was a critical factor. The state's transportation authority utility is assumed to be quasi-linear; $u_b(A, B) = A + d \times \mathrm{B}$ (where d is the road user cost parameter). This assumption appears false; although A and B are separable, they are interdependent, e.g., reduction in time required to complete the project may be achieved by adding more workers and equipment to the project, i.e., increasing its costs [18]. Furthermore, both completion time and the project's costs are typically discrete attributes and the trade-off function between them is non-linear (i.e., cost increase does not decrease completion time uniformly and vice versa).

Auctions tend to focus on the owner (buyer in procurement); as long as participation in an auction can be assured, the mechanism should "take care of the process". It needs to be carefully designed so that "the auction mechanism implements a solution that maximizes the total payoff across all agents" [19, p. 106]. While this is a well-defined objective, its implementation may not be clear to auction creators and their users. Even if the buyer's utility quasi-linearity is verified, there is no guarantee that every participating supplier's utility is also quasi-linear. If it is not, then there are no assurances for meeting the stated objective.

A series of multi-attribute auctions in which over 50 health plan providers (i.e., suppliers) competed for business from three large employers began in 1999 [20]. The 1999 auctions reduced annual rates between 2 and 8% ($1.1 million) as compared to other employers' increases of between 4 and 6%, and the negotiation time was reduced from five weeks to one week. The 1999 success of the auctions led to their expansion in 2000 from 50 to 100 health providers and nine employers. In 2001, however, only four out of nine employers were participating in the auctions, subsequently the auctions were discontinued [20].

There were four price attributes and a number of non-price attributes in these auctions. The price attributes were aggregated into a composite score. However, some of the non-price attributes were interdependent with the price attributes. For example, the price composite score did not take into account attributes associated with service costs (e.g., safety, quality of service, and response time), which affected each of the four prices and to a different extent. In other words, although an effort was made to construct a quasi-linear function for the buyer, in effect the scoring function was not quasi-linear.

In this and in other cases no information was given about the suppliers' utility functions. Therefore, one cannot reject a claim that these utilities were quasi-linear. It may be possible that for every supplier the four different prices are linearly dependent and they may be aggregated into a single composite price. It may also be possible that the relationship between this composite price and all other attributes is linear. However, one cannot make such a claim without conducting a detailed study.

4. Improving winning bids in non- $RA_{q\text{-}l}$ mechanisms

4.1 Efficient frontier

One of the standard assumptions in decision analysis is that the set of feasible alternatives is non-concave. The assumption is that if there are two alternatives another alternative may be constructed by a linear combination of the two alternatives. While this may not be the case when this set is discrete it has often been assumed that such a set is bounded by a non-concave hull. For the purpose of the discussion in this section, I assume that the set of feasible alternatives is non-concave.

Utility functions map the feasible set from the decision space onto the utility space. The space considered here is two-dimensional (see Figure 1). Quasi-linear utilities map the feasible non-concave set onto a set bounded by a linear efficient frontier which a −1 slope (intersects both axes at 45°). Concave utilities (which reflect preferences of risk-averse decision makers) and a linear-cave result in a concave efficient frontier. Also linear utilities result in concave frontier providing that the buyer's and the seller's preferences over the attributes differ [8]. Concave efficient frontiers are considered here.

Figure 1 illustrates the linear efficient frontier LEF for quasi-linear utilities (shown with dotted line) and a concave efficient frontier CEF. Point A represents a winning bid which is close to the absolute maximum utility for the buyer. Point *C* represents the Nash solution which is the closest to the utopia point at which both parties reach their absolute maximum utility. In this example the maximum value of the sum of the utilities is reached at *C.*

Points on LEF are equidistant from the utopia point; they yield the same social welfare making the auction mechanism efficient (see Proposition 2). This is not the case with points on CEF: point *C* is the closest to the utopia point but point A is not.

When the efficient frontier is a concave function, then the direction for social welfare maximization (joint improvement) is North-East. This is the direction that the negotiation participants should take if they wish to achieve the, so called, win-win agreement, which also maximizes social welfare. By contrast, in auctions the direction that the bidders take is East (for the buyer's utility positioned on the horizontal axis). The result is that the winning bid may be efficient but it does not maximize social welfare efficiency.

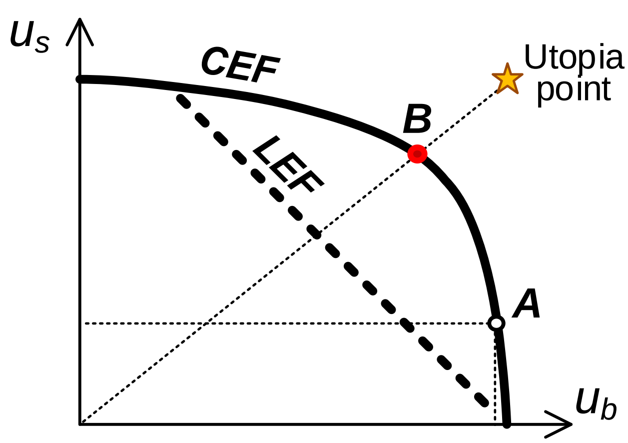

Fig. 2. Buyer *b* and seller *s* utility space. CEF –concave efficient frontier (continuous thick line) and LEF –linear efficient frontier (dotted thick line); *A* – winning bid and *B* – Nash solution.

Note that in an extreme situation the winning bid may lie on the left-hand side of B. This happens when there is one very low cost supplier and the costs of other suppliers are much higher. These suppliers' costs need to be sufficiently high for their bids resulting in their utility value to become negative when these bids yield the buyer's utility higher than $u_b(B)$. Auction theory generally assumes that sellers' costs are uniformly distributed. Such strict assumption is not required here, but the following assumption is made:

Assumption 1. There are at least two suppliers s_1 and s_2 ($s_1, s_2 \in S$), such that $u_{s1}(B) > 0$ and $u_{s2}(B) > 0$.

Proposition 3: If the efficient frontier is continuous and concave and Assumption 1 is met, then the efficient winning bid can either maximize the buyer's surplus or be allocative efficient but not both.

Outline of the proof: For continuous and concave efficient frontier, the solution of the buyer's surplus maximization problem is different from the solution of the winning supplier's surplus maximization problem. Therefore, the solution of the social welfare maximization problem, which maximizes the sum of the buyer's and the supplier's utilities yields different and lower utility for the buyer then the utility obtained from the buyer's surplus maximization problem.

4.2 Improving winning bids through negotiations

Suppliers, who participate in an auction, make bids which increase the buyer's utility. They may try to keep their own utility value at a certain level but, at some point during the auction, they have to decide whether to withdraw from it or to continue and bid at lower utility levels. The auction ends when no supplier is willing to make a bid that increases the buyer's utility. The winning bid lies on the right hand side of the Nash solution (point C in Figure 2). The farther this bid is from the Nash solution, the greater is the buyer's utility but the smaller is the social welfare. The opposite is also true, if we move along the efficient frontier towards the Nash solution, then social welfare increases but the buyer's utility decreases. When the efficient frontier is concave then the degree of the loss of social welfare depends on the degree of the frontier's concavity and the winning bid. The social welfare loss relative to the buyer's gain may be significant.

Given the set of feasible alternatives, it is not possible to improve both social welfare and the buyer's utility when the winning bid is efficient. This is the case inasmuch as the buyer and the seller remain constricted by the constraints of the problem and are not willing to consider augmenting it through, for example, side payments. If a side exchange is acceptable, then they may seek solutions which increase both social welfare and the buyer's utility. This is due to the synergy that occurs when the efficient frontier is concave: it allows for offsetting a decrease of the buyer's utility by an increase in the supplier's utility.

The process of replacing the efficient winning bid with another alternative, which may be preferable to both the buyer and the winning supplier is described below and illustrated in Figure 3.

Consider a scenario in which seller s won the auction with efficient bid A = (47; 11.5). Buyer b knows that her utility can be approximated by a concave and she is confident that $u_s(A) < u_s(C)$. Although she does not know the winning seller's utility, based on the observation of the bidding process she thinks that the bidders do not significantly differ in terms of their costs. Therefore, she consider a possibility of seeking another alternative, which would eventually allow her to achieve greater utility value than $u_b(A) = 47$.

Buyer b decides to employ an activity similar to Raiffa's post-settlement settlement activity [21].

She knows that post-settlement settlements can result in a joint improvement of the final agreement when the interim agreement is inefficient. While this is not the case here, she can utilize the auction's myopic concern with the search of the best deal for the buyer to her advantage. She selects several alternatives (*C*, *D*, *E* and *F*), which for her yield utility lower than 47. She presents these alternatives to seller s noting that some of them may not be better for him than *A* ($u_s(A)$ = 11.5), but other may be better. She adds that if there is an alternative that supplier *s* would strongly prefer, then she may consider to accept it, providing that he offers her a side payment that would offset her loss.

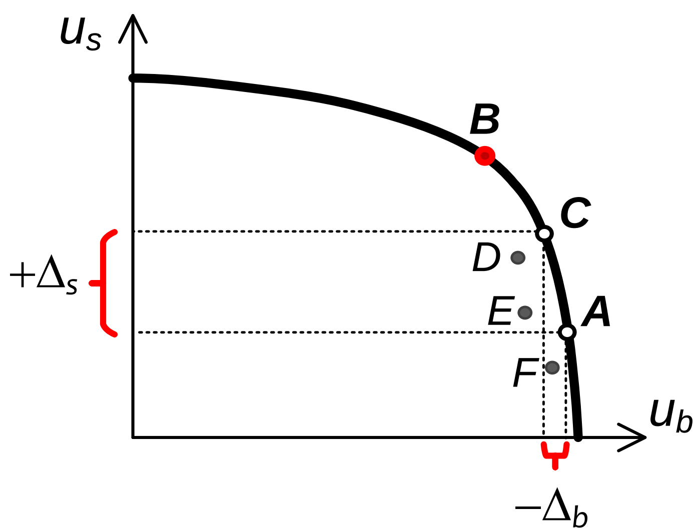

Fig. 3. Improvement of the winning bid *A* when *B* is accepted by both sides and the supplier offsets the buyer's loss.

Supplier *s* selects alternative *C* = (45; 21.5). This alternative reduces the buyer's utility by Δ_b = 2 and it increases the seller's utility by 10. The buyer converts this loss of her utility into money (or any other mean of exchange); the two units of utility are worth $2,000. She suspects that the seller's windfall from the move from alternative *A* to *C* may be greater than $2,000; therefore, she tells him that she would accept *C* if he pays her $4,500.

If the winning supplier accepts offer *C*, then his utility increases by Δ_s = 10 (from 11.5 to 21.5). After converting this utility increase to money (or any other mean of exchange) he observes that this increase is equivalent to $10,000. Thus, after paying the buyer $4,500 his net gain would be $5,500. The supplier accepts the offer and alternative *C* becomes the jointly agreed "win-win solution".

Because the buyer's loss was more than offset by the seller's side payment and the seller's utility increased more than the side payment, social welfare also increased from 58.5 (47+11.5) to 66.5 (45+21.5). While it is lower than the Nash solution *B* = (38, 31), which yields 69, the difference became much smaller.

This example shows that the choice of *C* rather than *A* with the side payment of $4,000 has the following results: (1) it increases the buyer's utility by 5% (from 47 to 49.5, after the conversion of 4,500 to 4.5 units of utility); (2) it increases the winning seller's utility by 48% (from 11.5 to 17, after the conversion of 5,500 to 5.5 units of utility); and (3) it increases social welfare by 14%.

Market participants who want to maximize social welfare need to move in the North-East direction. However, suppliers who are pushed by competition and have to maximize the buyer's surplus in order to win a contract need to move in the North-West direction. Quasi-linear preferences together with the use of the sum of utilities as the measure of social welfare, remove the conflict in directions because the East moves do not change the distance from the Utopia point (max u_b; max u_s). However, market participants should be aware of the conflict as it arises when other types of preferences and/or other welfare measures are deemed more suitable.

The above example illustrates the possibility of reaching solutions which are better than the winning bid. By employing a post-auction negotiation it may be possible to improve the results for both sides as well as increase social welfare. The negotiation may take different forms; if an intermediary (e.g., a modified auction system) has information about the buyer's and the winning supplier's preferences, then this intermediary may suggest alternatives which are efficient and lie in-between the winning bid and the Nash solution. The parties then may need to negotiate side payment values for the selected alternatives. As long as the transferred amount (∇_{sb}) is positive, i.e., $\nabla_{sb} = \nabla_s - \nabla_b > 0$, and the supplier's increases his utility, i.e., $\nabla_s - \nabla_{sb} > 0$, both sides are better off.

5. Conclusions

The discussion on quasi-linear utility and its implications shows that while such utility is assumed in auctions it may not describe preferences of the market participant satisfactorily. Decision and negotiation analyses often rely on concave and linear utilities. Economics also views concave utilities as important because these utilities characterize decision makers who are risk averse. Recent experiments show that the majority of decision-makers are risk averse even when the stakes are small and risk averse attitude strongly increases with the increase of the stakes' importance [22]. This paper proposes a revised mechanism "auctions followed by negotiations" which allows risk neutral and averse buyers and suppliers to seek improvements over winning bids in reverse auctions.

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