

Auction and Negotiation in E-procurement: The Costs and Payoffs from Buyers' Engagement

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Abstract

Experimental studies of auction and negotiation mechanisms have focused on the mechanisms often irrespectively of their embodiment in an e-marketplace system. This paper presents an on-line multi-attribute reverse auction system and a multi-bilateral e-negotiation system. Both systems share—inasmuch as possible—the same interface components. The systems were used in three exploratory experiments. The results indicate that reverse auctions, in which the winning bids are shown, produce significantly better outcomes for buyers and worse outcomes for sellers. Auctions which deadline is shorter than two hours produce better outcomes than auctions lasting several days. Overall, the sellers' satisfaction with outcome and their consideration of the outcome being favorable to the company is no significantly in auctions than in negotiations. The exception is reverse auction in which all bids are shown; this type is better for sellers and worse for bidders than both negotiation and auction in which only winning bid is shown.

Keywords: reverse auctions, multi-bilateral negotiations, multi-attribute auctions, online auctions, e-negotiations, comparative study, experimental study, decision support systems, e-procurement.

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1. Introduction

Exchange mechanisms specify the functioning of the market and the permissible behavior of its participants. There are three standard mechanisms: (1) catalogues, where requests and offers are posted; (2) auctions, where one side automates the process during which participants from the other side compete against each other; and (3) negotiations, where the participants bargain over the conditions of an exchange. One or more of these mechanisms are implemented in every e-marketplace.

There are many variants of each of these mechanisms. Catalogues may contain a fixed listing of goods and prices [1] or allow for some flexibility so that customers can obtain a price discount based on, for example, a coupon, order volume or type of credit card [2]. Electronic catalogues can also be customized for specific customer based on her profile [3]. Auctions can be either single-sided, where one seller auctions off goods to a number of bidders, or double-sided, where competition is employed on both sides of a market. They may differ in the process (e.g., ascending and descending), bidder acceptance, winner determination and other rules.

Unlike other mechanisms, negotiation is a rich and ill-defined family of processes used for exchanging goods or services among buyers and sellers, and for resolving inter-personal and inter-organizational conflicts. It is an iterative communication and decision making process between two or more participants who cannot achieve their objectives through unilateral actions. It involves an exchange of information comprised of offers, counter-offers and arguments with the purpose of reaching a consensus [4].

The economic view is dominant in mechanism design and it is almost solely concerned with auctions [5, 6]. In fact, the field of market design is focused on the mechanism design and on applied auction theory. This focus has major ramifications for the practical market: *the decision regarding which exchange mechanism to use favors auctions* [7].

Auctions are well-structured and can be described completely and unequivocally using a set of rules and formulae. This led the computer science community involved in the design of early e-market mechanism, including negotiations, to propose replacing auctions with negotiations or to claim that “negotiations are auctions”. For example, Sandholm [8], in an article that is entirely devoted to auctions, makes an opening statement saying that “Negotiation is a key component of e-commerce”. Similarly, other authors who write about electronic business negotiations discuss solely auctions [9-11].

In practice, various market mechanisms are needed. In some situations flexibility and adaptability are sought over efficiency and speed, while in others ease of use and speed may be required. The requirements may depend on the nature of exchange (e.g., complex or simple, one-shot or repetitive, involving standard or unique goods, and between anonymous or well-known participants). Furthermore, market participants may have different needs which can be satisfied by different mechanisms. Investigation of these requirements and needs motivates this research which focuses on auction and negotiation in e-procurement.

In procurement activities undertaken by business organizations differ in terms of the importance and the impact of the exchanged goods on profit as well as the inherent complexity and risk of the supply market. This led to the identification of four types of buyer-supplier relationships: acquisition, strategic, noncritical and leverage [12-14]. Different mechanisms are selectively suggested for the four types of relationships. Recent studies confirmed that business organizations follow these suggestions in implementing their

procurement strategies [15, 16]. Auctions tend to be used when purchased goods are noncritical, the goods are simple and have a low-to-medium priority, and the relationship between the buyer and sellers is of little importance. Negotiations are used when goods are complex and have a critical-to-high priority, and the relationship is important.

About 70% of corporate revenue is spent on purchasing, therefore even small per cent of savings translates into large amounts of money for companies of every size [17, 18]. Reverse auctions have been shown to achieve an average gross savings of 15-20 percent [19]. Most of these auctions are single attribute. However, a survey by Ferrin and Plank [20] found that over 90% of purchasing managers based their decisions on both price and non-price variables (e.g., durability, service, lead-time, and trust).

Consideration of attributes other than the price, describing the item and/or the bidders, introduces a level of complexity that is difficult to address for many real-life situations. Therefore, many organizations tend to modify pure single-attribute auctions [21, 22]. The modifications include [23-26]:

1. Providing bidders with an ability to aggregate attributes according to an explicit or partially explicit formula that reflects the buyer's interests;
2. Pre-selecting bidders so that only bidders who are known to meet the additional criteria are included;
3. Giving incumbents an advantage because their qualifications are known; and
4. Using disclaimers such as "the lowest bid may not be awarded the contract".

The results of such auction modifications are mixed because of collusion and selection of inferior offers [27, 28]. In some situations the process becomes an auction in name only, e.g., when the auction ends with a winner but neither the winner nor any other bidder is awarded the contract.

Most procurement decision problems are multi-attribute [20]; therefore, multi-attribute auctions that can be used in e-procurement need to be developed. The first step in this direction is the design of an auction procedure, followed by experimental studies. The most recent survey of experimental auction research does not include any multi-attribute auction experiment [29]. Therefore, conducting experimental work on multi-attribute auctions could provide valuable insights into the viability of such mechanisms under various task characteristics.

In summary, there is a need to better define the distinction between auctions and negotiations as well as to fill in a gap in the literature concerning which mechanism best fits specific e-procurement problems. The selection of the most appropriate exchange mechanism is not a trivial problem. First, the desired performances have to be identified. In this respect, at least two aspects should be considered:

1. Transactional performance (effectiveness and efficiency of the transaction) and relational performance (building or enhancing the buyer-supplier relationship); and
2. The comparison of the extent to which a given mechanism impacts performance requires distinguish such an impact from that of other variables. As such, this comparison has to be done adopting the same e-procurement problem as well as the same e-marketplace.

This paper reports on a research program which focusses on behavioral comparisons of multi-

attribute auctions and multi-bilateral negotiations. For the purpose of this program we have designed auction and negotiation protocols and implemented them in an e-marketplace system. The multi-attribute auction procedure does not require information about the bid-taker's preferences yet it allows the bidders to make progressive bids (i.e., so that in every round the bids are better for the buyer than the bids made in the previous round [30, 31]. The ability to hide preferences makes the auction process similar to negotiations in which preferences most often are hidden. The negotiation protocols provide a process model in which one party is able to negotiate with several counterparts simultaneously. In this regard, the process is similar to an auction; with the exception that the single party is directly involved in interactions rather than relies on a mechanism and, thus, leaving the rest to the multiple counterparts (bidders). The program is also concerned with the effectiveness of various decision support tools embedded in the systems and the efficacy of an IT platform for bidding and negotiating.

In an earlier paper, Kersten, Pontrandolfo, Vahidov and Gimon [32] briefly introduced two systems in which auction and negotiation mechanisms were implemented. These systems were used in two pilot experiments which led to several recommendations regarding the modification of the systems and the experimental design. This paper discusses the two systems: (1) a multi-attribute auction system (Imaras); and (2) a multi-bilateral negotiation system (Imbins) and the platform on which they were implemented. It also presents the results of the third large-scale experiment with over 800 participants. The design of this experiment follows all recommendations earlier proposed [32, p. 409-410].

The paper is organized as follows. In Section 2 we summarize earlier studies on multi-attribute auctions and negotiations. Review of the existing experimental studies is given in Section 3. The system which we have designed and implemented is briefly discussed in Section 4. How we used this system to conduct experiments is discussed in Section 5. Conclusions and future work are provided in Section 6.

2. Auctions and negotiations

Exchange mechanisms can be defined by rules and functions. In this paper we are concerned with multi-attribute auctions and multi-bilateral multi-attribute negotiations; therefore we focus here on the rules that differentiate these two mechanisms. We also discuss experimental studies in which each of these mechanisms was employed.

2.1 Protocols

Auctions are defined by an explicit set of rules which determine resource allocation and prices on the basis of the bids made by the market participants [33]. A set of rules which defines a mechanism and its use is a protocol. Auctions differ from negotiations because of the following:

1. Auction rules prescribe the allowable behavior of the bid-makers; the bid-taker(s) does not participate in the process. In negotiations, both parties participate in the process by making and taking offers and their behavior is prescribed by the rules.

2. Auction rules are *explicit*, known to bidders prior to the auction, and fixed for the auction duration. In contrast, negotiation rules may be unknown a priori; they are implicit, imprecise, and modifiable during the process.
3. The rules describe auction mechanisms completely thus allowing for the determination of one or more winners based solely on the bids. Bid takers or other parties have no discretion in the winner choice. Negotiation rules may not describe the process completely; the parties may find themselves in a situation that requires new rule formulation and approval.
4. Auction rules typically include:
 - a. *Bidding rule* stating how bids can be formulated and when they can be submitted;
 - b. *Allocation rule* describing who gets what on the basis of submitted bids; and
 - c. *Attribute rule* stating the corresponding attribute values which the winner has to agree on.
5. Negotiation rules typically include:
 - a. *Reply rule* stating that a request for information, clarification or an offer should be addressed albeit not necessarily precisely;
 - b. *Reciprocity rules* requiring that a concession made by one party should be matched by the counterpart; and
 - c. *Agreement rule* stating the form of accepting an offer and the possibility of its modification (i.e., re-negotiation).

2.2 Multi-attribute auctions

Che [34] and Branco [35] initiated studies on buyer's payoffs in two-attribute (i.e., price and quality) reverse auctions. They proposed to represent buyers' preferences and trade-offs in terms of utility and give information on buyers' utility to bidders. This allows applying the single-attribute auction design apparatus to be applied to multi-attribute cases. More recently, Beil and Wein [36] and David et al. [37] analyzed the problem of designing the multi-attribute auction. They were in particular concerned with finding a scoring rule that maximizes buyer's utility.

The highly stylized information exchange in auctions makes it impossible for the bidders to learn the preferences (needs, limitations) of the bid-taker. Therefore, much effort in multi-attribute auctions experiments has been devoted to the role and scope of preference revelation schemes. Bichler [38] conducted several experiments in which the bidders (sellers) were given information about the buyer's utility (value) function. The results show that multi-attribute auctions do not provide substantial benefits over comparable single-attribute auctions. In other words, even with fully-revealed utilities the additional complexity may outweigh gains.

Koppius and van Heck [25] conducted experimental studies of the impact of information availability on the mechanism efficiency. The information availability specifies the type of information that is given as well as when, how and to whom it becomes available during the auction. They studied two types of multi-attribute English auctions:

1. Auctions with unrestricted information availability, in which suppliers are provided with the standing of the highest bid and the corresponding bidder as well as scores or bid ranking of the most current losing bids; and
2. Auctions with restricted information availability, in which the bidders are informed only about the standing of the highest bid.

The experiments indicated that auctions with unrestricted information availability yield higher efficiency than auctions with restricted information availability.

Strecker [39] analyzed the impact of preference revelation schemes on the efficiency of multi-attribute English and Vickrey auctions. He concluded that English auctions with revealed preference structure of the buyer are more efficient than both Vickrey auctions and English auctions with hidden preferences. Chen-Ritzo, Harrison et al. [40] introduced a multi-attribute English auction, where only partial information about the buyer's utility function was revealed. They showed that this variant performs better in terms of efficiency than a single attribute (price-only) auction. This outperforming of the multi-attribute over the single attribute auctions holds even though the bids in the multi-attribute auction are far away from those predicted by theory. Notably, complexity in the auction mechanism consumes some of the efficiency gains over price-only auctions. This observation however, contradicts the findings reported by Bichler [38].

2.3 Multi-attribute negotiations

One of the main questions of the research in multi-attribute negotiation is how the representation of the attributes and the preferences affects the negotiation outcomes. We are interested in multi-bilateral negotiations. However, because we know of no negotiation study in which such a mechanism was observed and analyzed, we discuss here work on bilateral negotiations.

Davey and Olson [41] compared a value-based negotiation system that used AHP with its pairwise comparison of criteria and alternatives with a goal-based NEGO system [42] that asked users to set aspiration levels for criteria. This research confirmed the suggestion that conventional decision-making is goal-oriented and negotiators preferred to use goal-oriented method.

Lim [43] conducted an experiment involving executives and managers in Singapore and found that the acceptance of negotiation support systems mainly depends on the subjective norm and perceived behavioral control.

Several experiments were conducted using the e-negotiation system Inspire. The experimental research [44] conducted using Inspire confirmed the theoretical assumption that knowledge about counterpart's preferences contributes to the achievement of better outcomes. Negotiation Assistant [45] was used for the research on the effect of negotiation support on the results of negotiations. Experiments showed that using negotiation support systems in structured negotiation settings yields better outcomes for the negotiators as compared to face-to-face or email negotiations.

Experiments with the negotiation support system called Negoisst [46] led the authors to formulate five main challenges for computer-aided negotiations. These included the general

limitations of preference elicitation due to problem complexity, the dynamics of preferences, the dynamics of the problem structure itself and its understanding, and the necessity for integrated decision support systems to deal with issue-by-issue negotiations.

3. Experimental studies and mechanism comparison

Theoretical comparisons of auctions and negotiations are difficult because of significant differences in the assumptions underlying each mechanism, as well as differences in participants' knowledge and behavior. Auctions assume that bidders know the buyer's valuation (price) of the good and follow strict and fixed protocols. Negotiation mechanisms have significantly weaker assumptions; often the key assumption is that the parties negotiate in good faith and that they are willing to reach an agreement. There is no limitation on communication and no assumption about the sellers' knowledge of the buyer's valuation.

3.1 Comparisons of single-attribute auctions and negotiations

Bulow and Klemperer [47] have shown in one of the first formal comparative studies that simple English auction with $N+1$ participating bidders (buyers) always yields higher revenue than a scheme they call "negotiation with N participants".

Bulow and Klemperer (op. cit.) did not compare English auctions with anything that resembles negotiation as presented in social science literature. The basis for their comparison was an exchange mechanism designed so as to maximize revenue of the bid-taker. This mechanism is a type of an auction inasmuch as it does not allow for free interaction among the parties and requires that the bidders to compete among themselves.

Kirkegaard [48] revised Bulow and Klemperer's theory and included non-cooperative bargaining, however with very limited communication protocol. Manelli and Vincent [49] showed that the effects of auctions and negotiations would vary according to/depending on the situations; it is difficult to judge the effect of these two mechanisms on a given transaction without the/any consideration of the overall context, including the goods, participants, market, and so on. They also proposed a methodology for the mechanism selection. An important conclusion in this study was that auction mechanisms are frequently inefficient in a procurement environment, which; this finding contradicts the two previous studies. In addition to theoretical comparisons, several experimental studies were conducted to compare auctions with negotiations. Thomas and Wilson [50, 51] conducted two studies in a laboratory settings. In their first study, [51] compared second-price auctions to multi-bilateral negotiations with verifiable offers. They found that prices were lower in verifiable multi-bilateral negotiations than in second-price auctions. However, the efficiency of these two mechanisms was found to be statistically equivalent. By comparing these results to the first study, they ordered the four mechanisms (in terms of yielded transaction prices) from highest to lowest: second-price auctions, verifiable negotiations, non-verifiable negotiations, and first-price auctions.

In their second study Thomas and Wilson [50] compared first-price auctions to multi-bilateral negotiations in a procurement scenario. They found that with more sellers (four sellers) the transaction prices in multi-bilateral negotiations were not significantly different from those in first price auctions. The transaction prices in multi-bilateral negotiations were higher than in first-price auctions when the number of sellers was reduced from four to two. Moreover, these

two mechanisms were equal in terms of efficiency.

Bajari, McMillan and Tadelis [16] analyzed auctions and negotiations conducted in the construction industry. They observed that the use of the exchange mechanism depends on the knowledge and complexity of the context, task, and goods. Negotiations have advantages, if the specifications of the product to be traded are not well-defined a priori, which is often the case in this industry. Negotiations, unlike auctions, allow for the discussion and clarification of the specifications. Not surprisingly, their empirical analysis also revealed that auctions perform poorly in terms of efficiency when changes in the product design need to be made after the transaction takes place.

3.2 Comparisons of multi-attribute auctions and negotiations

The only study that we know in which multi-attribute auctions were compared with multi-issue multi-bilateral negotiations is by [32]. This was a preliminary study in which two pilot experiments were conducted leading to a series of recommendations. As we mentioned earlier, the present study build upon and extends the earlier study.

4. Overview of the Imaras and Imbins systems

Earlier experimental comparative studies of exchange mechanisms dealt with single issue auctions and negotiations (price in most cases) [51, 52]. If multiple issues are involved, the weighing of different issues should reflect the preferences of the party. However, the requirement that the auctioning or negotiating sides inform each other about their respective preferences seems unrealistic. The procedure that is embedded in the proposed auction system does not require disclosure of preference information.

We used two systems: (1) Imaras (InterNeg multi attribute reverse auction system) to conduct auctions; and (2) Imbins (InterNeg multi-bilateral negotiation system) to conduct negotiations. Both systems have been developed in the InterNeg virtual integrated transaction environment (Invite). This section briefly reviews the Invite platform and the two systems, discussed in detail by Strecker et al. [53].

4.1 Invite development environment

The Invite environment incorporates at its core process modeling elements that allow system designers to implement various exchange mechanisms. Using abstractly defined set of elements, including activities, outcomes, and transitions, designers can implement a variety of mechanisms, ranging from simple message-based negotiations and single-issue auctions to multi-bilateral negotiations and multi-issue auctions. Bidding and offer-making are the primary examples of activities. In the design of Invite environment activities are represented as web pages and page transitions.

An activity results in a concrete outcome that is recorded by the system (e.g., sending a message). In order to achieve such an outcome the user may need to perform several acts (e.g., read two previous messages and assess one offer). This led us to associate activities with pages and page components with acts. For example, the activity corresponding to the page shown in Figure 3 describes bid submission. This activity has several acts, including assessment of previous bids (shown in the table and the graph), specification and generation of bids, and finally, the choice of a single bid.

The Invite platform is based on a three-tier software architecture built on a Fusebox framework, which enables the model-view-controller (MVC) design. The three types of components and their main subcomponents are depicted in Figure 1.

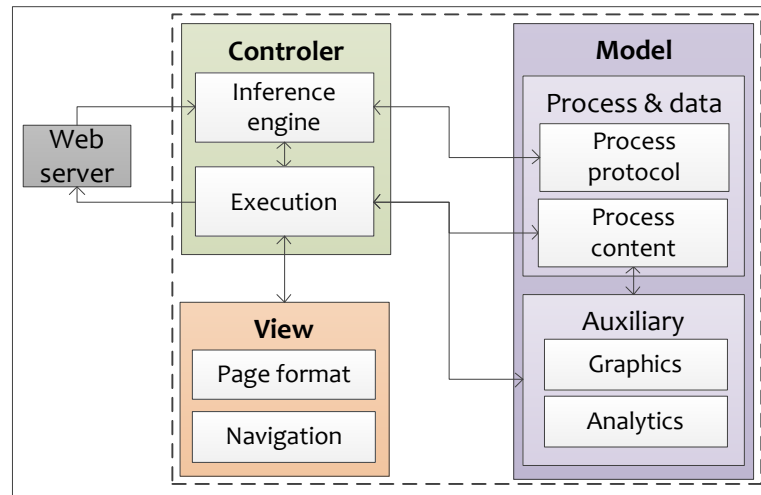


Figure 1. Logical design of Invite is based on the MVC design paradigm.

Invite generates e-negotiation or auction system instances based on the specifications of exchange mechanism design. A user can request a particular type of an existing mechanism. This request is processed by the controller that extracts the negotiation protocol (process model), which corresponds to the requested type of negotiation or auction. The protocol and other complementary models determine the type of negotiation/auction and the type and content of information exchanged between the parties via the system and between a given user and the system's modeling components. The view-type components are used to compose web pages according to a given layout and insert navigation links (Figure 1).

The architecture of Invite is depicted in Figure 2. It is a web application based on an application server in the business logic layer, and web browser technology in the presentation layer.

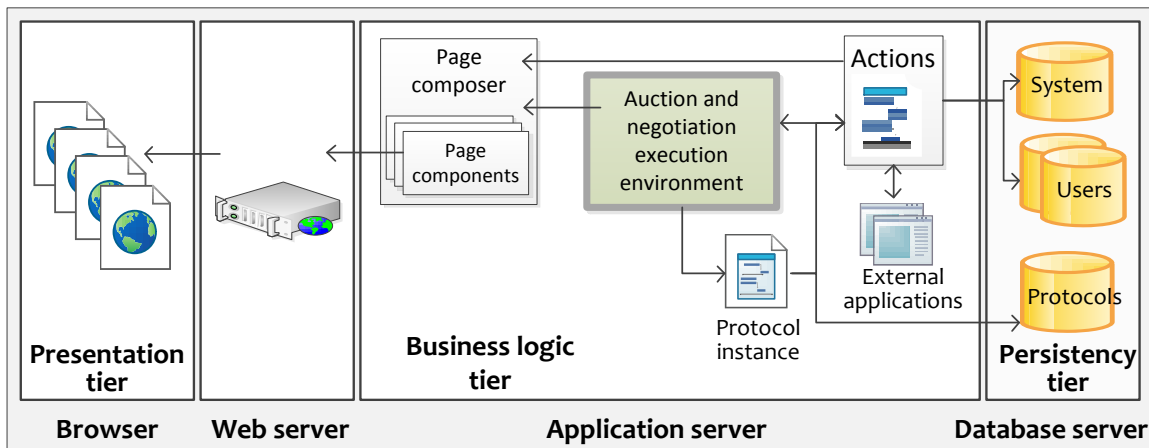


Figure 2. Invite architecture

The business logic layer separates the execution environment, protocol instances, actions and external applications. Actions are invoked by an auction and negotiation execution environment (a runtime engine) which runs instances of auctions or negotiations. The context, in which each instance runs, is the state in which the participants are at a given point in time and it is defined by the activities undertaken so far. It is stored in the persistency layer during and after a negotiation or an auction, and managed by the runtime engine.

The execution environment selects and activates the appropriate actions according to the respective user's protocol instance. Protocols specify and control activities undertaken by the participants and by the system. They are stored in the database and their instantiation corresponds to the run-time construction of a particular system, for example, Imbins or Imaras.

4.2 Imbins and Imaras' protocols

One of the distinct features of the systems built in Invite is their reliance on protocols. The system components are configured according to the selected protocol (see Figure 1). Protocols are rules which determine the process flow through its phases and the activities which must or can be undertaken in each phase. An example of such a rule is as follows:

IF 'private information' ::= true

THEN *go_to* 'offer exchange phase' and *activate_activity* 'make offer'.

This rule means that after the user reads the private information about the case, she may begin negotiations which take place in the offer exchange phase. As one can see, rules are used to control the process through connecting process phases and activities. Protocols differ because different activities and/or the connections may be different. All phases and activities used in this study are given in Table 1.

Table 1. Imaras and Imbins protocols.

Imbins	Imaras
<i>Negotiation preparation</i>	<i>Auction preparation</i>
Read public information*	Read public information*
Read private information*	Read private information*
<i>Offer exchange</i>	<i>Bid submission</i>
Make offer	Make bid
Read offer	View history
Send message	
Accept offer	
View history	
<i>Negotiation conclusion</i>	<i>Auction conclusion</i>
View agreement	View results
Review history	Review history

* Available (optional) activity in every subsequent phase.

Process phases (shown in *italic* in Table 1) are mandatory, i.e., the user has to move through every phase. Some activities are mandatory while others are optional. There are also hidden activities, which change an optional activity into a mandatory one. For example, if a counterpart makes the first offer, which is a hidden activity, then ‘read offer’ becomes the mandatory activity, otherwise “make offer” will be a mandatory activity.

The user can move from one phase to another when she finishes all obligatory activities in the current phase. Phases and activities for buyers and sellers in Imbins are the same except that the buyer can negotiate with any number of sellers, whereas one seller can negotiate only with one buyer.

In addition to the hidden, obligatory, and optional activities, there are also some parameters included in the rules, which specify the appearance of an activity and are used to set the conditions for performing them. For example, in Imaras the bidder may be given information about (1) all bids, (2) winning bids; or (3) none at all. Similarly, depending on the value of the `bid_allowed` parameter the bidder may be allowed to make only one bid or multiple bids in one round.

The protocol-based configuration of Imibins and Imaras allows for adding and removing activities and phases as well as changing information displayed and input required. Several protocols have been designed for Imaras and for Imbins; new protocols may be added as needed.

4.3 User interface

Imaras supports several types of auction settings, including:

- Disclosure of bids to bidders: only the bidder’s own bid is displayed, or both own and winning bids are displayed, or all bids are displayed;
- Bidding process: continuous (asynchronous bidding) or round-based (synchronous bidding); with rounds being defined by time (e.g., number of minutes or hours) or defined by a rule (e.g., number of submitted bids).

Imbins supports multi-bilateral negotiations in which the parties negotiate on the same or similar subsets of issues by exchanging offers consisting of one or more issues (attributes) and free text messages.

Both systems adopt the model-view-controller (MVC) design principle (Figure 1), which allows separating the different auction and negotiation protocols from the user interface. This helps us to conduct experiments with systems employing different mechanisms but having very similar user interfaces (Figures 3 and 4).

Imaras

Main Status

Auction ends in: 8 minute(s) 27 second(s)

Bids & limits

In each round, you can submit only one bid, which has to meet the limits posted in this round. There are two ways to make a bid: (1) **Formulate a bid**, or (2) **Choose a bid** from a list generated by the system. When making a bid, you need to observe the bid limits below.

Recent bids

The recent auction history is presented as a table and a graph. Your bids are indicated in **dark blue**, while the winning bids in past rounds are in **dark red**. To view all bids in the past rounds, select *Auction history* from the AUCTION menu.

The most recent bids you submitted and the winning bids in the past rounds are listed below.

Round	Standard rate	Rush rate	Penalty for delay	Rating	Comments
7	24	54	46%	31	Other's bid
7	24	54	46%	31	Your bid
6	24	66	50%	32	Other's bid
5	28	58	50%	30	Your bid

To see a bid's details, place the cursor over a point or click on it.

Make bid

(1) **Formulate a bid.** Use the drop-down list in the bid table below to select an option for each issue referring to the bid limits. Imaras uses your preferences to calculate the bid's rating.

Note: Each row in the table contains limits indicating that the bid cannot be greater or smaller than the limit value. These limits are based on the best bid made in the previous round.

Select	Standard rate	Rush rate	Penalty for delay	Rating
<input type="radio"/>	Select one ▼ ≤ 20	Select one ▼ ≤ 66	Select one ▼ ≥ 46%	26
<input type="radio"/>	Select one ▼ ≤ 28	Select one ▼ ≤ 50	Select one ▼ ≥ 50%	20
<input type="radio"/>	Select one ▼ ≤ 24	Select one ▼ ≤ 62	Select one ▼ ≥ 50%	28

Bid to be submitted: this bid is either formulated or chosen.

	Standard rate	Rush rate	Penalty for delay	Rating

To submit this bid, click **Submit bid**.

(2) **Choose a bid.** If you enter a rating of a bid you want to make, Imaras generates a list of bids that are equal to or close to that rating. The maximum rating is calculated using your preferences and the current limits.

Enter your rating (maximum 28): 28

and click **Generate bids**

If you choose one bid from the list below, then it will also be shown in the bid table on the left-hand side so that you can submit it.

Select	Standard rate	Rush rate	Penalty for delay	Rating
<input type="radio"/>	24	50	42%	26
<input type="radio"/>	20	66	46%	26
<input type="radio"/>	28	54	50%	27
<input type="radio"/>	20	66	42%	28
<input type="radio"/>	24	62	50%	28
<input type="radio"/>	20	54	34%	29
<input type="radio"/>	20	62	38%	29

AUCTION

- Public information
- Private information
- Bids & limits
- Auction history

CONTROL

- Refresh
- Log out

Round 8 ends in: 2 minute(s) 26 second(s)

Note: The bid limits are revised.

Note: Once you submit your bid in this round, the screen will automatically refresh every 30 seconds.

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Figure 3. Bid construction and submission screen

Imaras's main screen is shown in Figure 3. It is the bidding screen of a round-based auction in which the bidder can see his or her own bids as well as the winning bids. Imbins's main screen is shown in Figure 4. It is the message and offer submission screen in which the negotiator can see her own offers and messages as well as those of the counterpart. Both interfaces have four main components.

The clock (A) shows time from the beginning of the auction and the time left to the deadline. The systems' navigation bars are located on the right-hand side (B) where links to active pages are listed. For auctions the round number and clock are also given. The clock is reset at the beginning of every round.

Section C of both bidding and offer screens contains the most recent winning bids and offers made by the seller (who sees this screen) and by the buyer. In auction, only winning bids and bids made by the bidder who sees this screen are shown. In negotiation, only offers made by the buyer to all sellers or to the seller who sees the screen are shown.

Imbins Invite

Main Status A Negotiation ends in: 2 hour(s) 30 minute(s) 9 second(s)

Offers & messages

Negotiate with your counterpart by sending an offer, message or both. There are two ways to make an offer: (1) **Formulate an offer**, or (2) **Choose an offer** from a list generated by the system.

Recent offers & messages

The recent negotiation history is presented as a table and a graph. Your offers and messages are indicated in **dark red**, while your counterpart's are in **dark blue**. To view all offers/messages, select *Negotiation history* from the NEGOTIATION menu. Note: Once you receive an offer, you will see a *Negotiation update* button appear in the menu. In order to view, respond to or accept a counter-offer, you will need to click on this button.

The most recent offers/messages are listed below. To view a long message, click link *More...*

Standard rate	Rush rate	Penalty for delay	Rating	Message
24 (\$/kl)	62 (\$/kl)	46%	46	Thanks
36 (\$/kl)	70 (\$/kl)	42%	83	It is my p... <i>More...</i>
24 (\$/kl)	66 (\$/kl)	50%	45	(no message)
40 (\$/kl)	62 (\$/kl)	34%	87	Dear Malik... <i>More...</i>
20 (\$/kl)	54 (\$/kl)	46%	21	Thank you

C

To see an offer's details, place the cursor over a point or click on it.

B

Send offer and/or message

(1) **Formulate an offer**. Use the drop-down list in the offer table below to select an option for each issue. Imbins uses your preferences to calculate the offer's rating.

Standard rate	Rush rate	Penalty for delay	Rating
Select one	Select one	Select one	0

To write a message, type it in the box below.

(Write your message here)

D

(2) **Choose an offer**. If you enter a rating of an offer you want to make, Imbins generates a list of offers that are equal to or close to that rating.

Enter your rating (between 0 and 100): and click **Generate offers**.

If you choose one offer from the list below, then it will also be shown in the offer table on the left-hand side so that you can send it.

Select	Standard rate	Rush rate	Penalty for delay	Rating
<input type="radio"/>	40	62	50%	75
<input type="radio"/>	40	58	38%	75
<input type="radio"/>	40	54	30%	75
<input type="radio"/>	36	66	46%	76
<input type="radio"/>	32	70	34%	77
<input type="radio"/>	36	62	34%	77
<input type="radio"/>	40	58	34%	77

To send a message only, click **Send message only**. To send an offer with a message (which may be empty), click **Send offer and message**.

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Figure 4. Offer with/w-out message construction and submission screen

The most recent bids and offers are shown in both tabular and graphical forms. (The complete list of bids and offers can be seen on separate pages: “Auction history” and “Negotiation history” pages are accessible from the menu in Section B.) In this section there is a difference between the auction and negotiation pages. In the auction page, the auction round and the winning bid are listed. In the negotiation page, messages sent by a counterpart can be accessed (they are expandable). Bids and offers are constructed and submitted in Section D.

The two main differences between auction and negotiation are in the limit sets for the former and messaging facility for the latter. In Section D of the offer screen in Imbins there is a message box that allows the user to write and send a message to the counterpart.

The limit sets are determined by the multi-attribute auction procedure [31, 54]. They are bounds imposed on the attribute values and they assure that the bid in one round is not worse for the bid-taker than the winning bid in the previous round. Because there may be several limit sets (three are shown in Figure 3), the bidder can select one set (table row) and then select admissible attribute values for the given set. Then in the next table the selected values appear. This table shows the auction bid or the negotiation offer.

There are two ways to input the values into the bid and offer tables. In addition to the one described above, the user may generate bids (offers). In order to do so, he or she has to enter the preferred value of rating (utility) and click on “Generate bids” (“Generate offers”) button. Subsequently, a table (not shown) will appear below the button with up to ten bids (offers) with a rating in the proximity to the selected rating value.

5. Auction and negotiation comparison

The purpose of the three experiments discussed in this section is to examine how the differences between multi-attribute auctions and multi-bilateral negotiation (including the role of buyer, argumentation, and the buyer's ability to accept offers) affect the *substantive* outcomes.

5.1 E-procurement case

We used the same procurement case in both auctions and negotiations.

A producer of perishable goods (the buyer) is seeking a logistics service provider who would transport goods from a single depot to a large number of customers. The buyer wants to sign a one year contract with a single provider with a possibility of renewal. The buyer assures the minimum quantity of goods to be transported. There are three attributes: (1) standard rate of transportation; (2) rush rate for unexpected delivery; and (3) penalty for the non-delivery or delivery of spoiled goods. The possible ranges for each attribute are known to every participant. Both the number of attributes and their ranges differed in different experiments.

There are six providers with a proven record who are invited to the auction or negotiation.

The participants are told that the company they represent estimated a revenue function based on the problem attributes. For each configuration of attribute values, revenue value can easily be calculated using a simple calculator which is embedded in the case description. In order to simplify comparison of different offers or bids, the revenue is represented as ratings between 0 and 100 interval. Ratings are secret and the higher the rating the better the contract for the participant.

Participants are given breakeven ratings and are told that they should not accept contracts below this value. Such contracts bring forth losses for the firms they represent; values above breakeven ratings represent profit. Participants are also given reservation values for the attributes.

The above parameters are indicative. There may be three or more logistic providers seeking the contract which can have between two and five attributes (clauses). Also the revenue formulae and reservation and breakeven values may be different.

5.2 Experiment 1

The first experiment conducted in spring 2011 involved students from a Canadian university. In this experiment the case had three attributes and 216 alternatives.

Auctions and negotiations were conducted in the lab and, together with the preparation time they lasted two hours. They were also conducted online and the participants had one week to complete the process. The participants were first year undergraduate students; they were playing the role of the sellers.

One of the key differences between auctions and negotiations is the buyer's involvement. The buyer may follow different strategies and tactics, making comparison of the two processes difficult. Therefore, we selected buyers from graduate and senior undergraduate students and gave them detailed instructions regarding their behavior. Some of the buyers were asked to follow an integrative strategy, while others—a cooperative strategy.

Selected information about the results is given in Table 2.

In the lab setting, negotiations took on average longer than auctions (35 and 36 min vs. 24 min.). This is understandable because the negotiators-sellers were interacting with the buyers and they needed time to read and write messages. This can be contrasted with much longer time used in online auctions than in negotiations. In this case, however, the likely reason is the auction protocol a bidder had to follow: the time allocated to each round was fixed and equal to one day.

The number of bids (offers) made significantly differs between the lab and online condition; for online settings it is significantly lower. The difference is much smaller when auctions are compared with negotiations. This may suggest that making offers is not much more difficult than constructing bids. If confirmed, these findings are interesting because negotiators' workload is heavier (they need to consider buyers' offers and messages and also write messages).

Table 2. Experiment 1 results

	Auction		Negotiation*			
	Lab	Online	Lab-In	Lab-Cp	Online-In	Online-Cp
No. of instances	21	15	31	32	7	8
No. of sellers	77	53	110	115	29	27
Agreement (%)	—	—	93.5	93.7	100	100
No. of offers (w & w-out msg.)/bids	5.6	3.2	6.3	6.5	2.8	2.9
Seller's profit (S)	-9.5	16.3	13.9	7.7	9.1	4.7
Buyer's profit (B)	80.5	53.3	63.6	69.8	60.4	65.3
Balance (B-S)	89.3	48.8	51.2	61.3	55.4	57.1
% of dominating alternatives	0.04	1.3	0.8	0.5	2.0	2.0
Time (hrs.)	0.2	61.4	0.4	0.4	37.4	45.0
Outcome satisfaction (winners)	4.1	5.2	4.6	3.8	5.2	4.3
Outcome satisfaction (others)	3.1	3.0	2.8	2.8	2.9	3.9
Favorable outcome (winners)	4.5	5.5	3.3	4.2	3.8	4.7
Favorable outcome (other)	4.6	4.7	4.8	4.8	4.7	5.4

* In – integrative; Cp – competitive

In our experimental settings the outcome of every auction is an agreement. This is because the initial auction reservation levels are very favorable for the sellers. However, this is not the case in the negotiation in which the buyer has to accept an offer. Therefore, the percent of agreements is generally lower in negotiations than in auctions. Interestingly, the sellers reached worse agreements in lab auctions (-9.5) than in negotiations (13.9 and 7.7). In negotiations, the sellers who negotiated with integrative buyers reached better deals than those who negotiated with competitive ones. For the buyers the results were somewhat opposite: lab auctions yielded the best deals, followed by the negotiated deals when buyers were competitive, while the worst deals were achieved by cooperative buyers.

The situation was very different in online settings. Online buyers achieved better deals through negotiations than through auctions. (Again, this may be due to the way auctions were set up or the time allocated.) However, the deal-making ability of integrative and competitive negotiators did not change: competitors achieved more.

The balance of buyer and seller agreement outcomes is the absolute difference of their profits; it is shown in Table 2. Because of the case set-up (i.e., the differences between the breakeven values and not strictly opposing preferences) it is not possible to state what is a good balance. We can, however, compare balance obtained from different settings. Thus we observe that outcomes in lab negotiations (51.2 and 61.3) were more balanced than in auctions (89.3). The situation was different for the online experiment, where negotiation outcomes (55.4 and 57.1) were less balanced than the auction outcomes (48.8).

The number of dominating alternatives was lower in auctions than in negotiations for both settings (see Table 2). This could be due to the design of the auction mechanism that directs bidders to make bids that yield higher value (profit) for the buyer. In negotiations there is no such feature therefore the negotiators need to direct each other to find an agreement which is (near to) non-dominated.

In Table 2 we show outcome satisfaction for winners and other sellers separately because they may have had different evaluation of outcomes. Outcome satisfaction and favorable outcome were measured on a scale from 1 to 7. In the lab experiment outcome satisfaction of the winners in auctions (4.1) was higher than in competitive negotiations (3.8) and lower than in integrative negotiations (4.6). In the online experiment outcome satisfaction of the winners in auctions (5.2) did not differ from integrative negotiations and was higher than the one in competitive negotiations (4.8). Satisfaction with outcome of other sellers did not differ between auctions and negotiations, except for the online experiment outcome satisfaction in the competitive negotiation (3.9), which was higher than in the auction (3.0).

In the lab experiment winners found the outcome more favorable in auctions (4.5) than in negotiations (3.3 and 4.2). In online experiment this tendency was the same. Winners found the outcome more favorable in auctions (5.5) than in negotiations (3.8 and 4.7).

5.3 Experiment 2

The second experiment, conducted in summer 2011, involved students from an Italian University. Both auctions and negotiations were conducted in the lab and, together with the preparation time they lasted two hours. The participants were third year undergraduate students; they were playing the role of sellers. In negotiations, the buyers were junior researchers who were trained to follow either integrative or cooperative strategies.

The main difference between Experiment 2 and the lab portion of Experiment 1 is that in this experiment two versions of the case were used. The three-attribute case used here was the same as the case used in Experiment 1. In addition, we also used two-attribute case (one attribute was dropped from the initial case).

Selected information about the results is given in Table 3.

Table 3. Experiment 2 results

	Two attributes			Three attributes		
	Auction	Integrate	Compete	Auction	Integrate	Compete
No. of instances	11	7	7	11	7	7
No. of sellers	44	28	28	44	28	27
Agreement (%)	—	100	100	—	100	100
No. of offers /bids	2.6	3.5	3.5	4.9	3.1	3.1
Seller's profit (S)	-4.9	21.8	3.3	-9.2	9	2.3
Buyer's profit (B)	76.7	55.0	65.4	77.3	60.3	67.8
Balance ($ B-S $)	79.9	33.3	56.4	81.5	47.9	64.4
% of dominating alternatives	0	0	0	0.4	3.0	2.0
Time (hrs.)	0.9	0.2	0.1	0.2	0.2	0.1
Outcome satisfaction (winners)	3.5	5.1	4.6	4.9	5.6	5.0
Outcome satisfaction (others)	2.7	2.0	2.4	2.4	3.2	2.9
Favorable outcome (winners)	4.8	3.3	4.0	5.4	3.3	4.0
Favorable outcome (others)	4.5	5.1	4.8	5.3	4.8	5.1

As shown in Table 3, in this experiment the agreement rate was 100%. In a two-attribute case the average number of offers was higher for negotiation instances than the number of bids in an auction. In a three-attribute case, however, the situation was reversed; perhaps, due to the increase of the negotiation task complexity and the required cognitive effort. Sellers' profits were lower in auctions as compared to negotiations. Sellers made more profit in integrative, vs. competitive settings. Again, for the buyers the opposite was true: they made the highest profit in auctions, followed by competitive negotiations, and then integrative negotiations. In a two attribute case non-dominated alternatives were selected while in a three-attribute case dominated alternatives were agreed upon. This especially applied to negotiation cases, with integrative settings being the worst in this respect.

The agreements were significantly more balanced (which corresponds to the smaller absolute difference in ratings) in auctions compared to integrative negotiations with both two and tree attributes. The difference was not significant when auctions were compared to competitive negotiations. This may be due to the instructions given to the integrative buyers; they were asked to seek a "reasonable compromise" and try not to push their counterparts to their limits. The opposite was true for the competitive buyers; they were asked to focus solely on the achievement of their own outcomes.

The small number of negotiation instances in each setting does not allow us to make any comparison of the effect of the buyers' behavior within a setting for this experiment.

In the two-attribute case outcome satisfaction of winners in auctions (3.5) was lower than in negotiations (5.1 and 4.6). In the three-attribute case outcome satisfaction did not differ between auctions (4.9) and the competitive negotiations; and it was higher in the integrative negotiations (5.6). The outcome satisfaction of other sellers in the two-attribute case in auctions (2.7) was higher than in negotiations (2.0 and 2.4). In the three-attribute case attributes in auctions (2.4) were lower than in negotiations (3.2 and 2.9).

Winners found the results more favorable in auctions with two attributes (4.8) than in negotiations (3.3 and 4.0). This tendency also occurred in the case with three attributes. Other sellers in the two-attribute case found the outcome less favorable in auctions (4.5) than in the integrative negotiations (5.1). The difference between auctions and the competitive negotiations (4.8) was smaller. In three-attribute case assessment of favorable outcome did not differ between auctions (5.3) and the competitive negotiations and was lower in the integrative negotiations (4.8).

5.4 Tentative results

Observation of negotiation and the bidding processes and comments from the experiment participants led us to treat the experiments as extensive testing rather than a research experiment. The earlier system and usability tests did not show that some participants lacked good understanding of the problem and the process. However, during the first experiments, we observed that a small number of participants were lost and/or uninterested [32].

From both experiments we received both positive comments (“positive overall experience”, “fun to use”, “enjoy the challenge”, and “good learning experience”) as well as negative ones (“not clear process”, “difficult construction of bids”, “no guidance”). The latter comments and the results of the experiments, in particular the losses that the winners “brought in” to the firms they represented, led us to realize that multi-attribute auctions are difficult and that we need to provide more and better tools for learning about the system, its use and the specifics of the bidding process. To this end, we have prepared several training materials. Experiment 3 discussed in the next section was designed after these changes were implemented.

The participants in our experiments are students who differ in their motivation and interest to learn the system and the case. In order to provide a more even field so that every participant knows the basics of the system and the bidding process, we developed a demo followed by a short quiz which tests students’ understanding of the system and its use. Students watch the demo and then take the quiz about one week before the experiments. The next step aiming at increasing students’ understanding of the process is breaking up the process into two separate phases. One phase is preparation which takes three days during which students log in to the system and learn about the case. Before moving to the next phase, which involves bidding or negotiating, students have to pass another test.

5.5 Experiment 3

In fall 2011 we conducted the third experiment in which the above mentioned instructional changes (i.e., videos, additional training materials, and two tests) were implemented. More than eight hundred students from Canada, Austria, the USA, Poland and Taiwan participated. As in Experiment 1, there were lab and online settings. The online experiments took 10 days while in the lab the participants were given 2.5 hours to complete their activities.

In each negotiation there were between three and five sellers negotiating with one buyer. Correspondingly, in each auction, there were between three and five bidders. In auctions there were two information revelation schemes; in one scheme all bids were shown to all bidders and in another scheme only the winning bids of each round were shown. In addition, the case constraints were changed so that the number of alternatives increased from 216 (in Experiment 1) to 3375 (the number of attributes remained the same).

These combinations of auction or negotiation mechanisms conducted in the lab and online

with a different information revelation schemes and the number of alternatives resulted in five treatments. The main results of the experiment are shown in Table 4.

First, we compared pairs of auction and negotiation treatments that were conducted in the same conditions (lab or online). The duration of online negotiations (70.5) was significantly shorter than the duration of win-bid auctions (85.6). This discrepancy can be explained by the rules that trigger negotiation or auction closing. A negotiation could be closed before the deadline if the parties reach an agreement before that time. The closing of an auction could be triggered either when only one bidder submits a bid in a round (theoretically that means that other bidders have reached their reservation levels) or if the bidders are not allowed to make bids because there is no space to improve a bid in the buyer's rating. Both conditions in the experiment settings can occur only when the bidders' ratings of bids are low. The difference in the duration of negotiations and auctions in the lab settings is not significant.

Table 4. Experiment 3 results

Mechanism	Negotiations		Auctions		
	Online	Lab	Online		Lab
Setting					
No. of instances	40	23	17	13	28
No. of sellers	151	76	74	58	110
No. of alternatives	3375	3375	3375	3375	3375
Bids shown	—	—	Winning	All	Winning
Agreement (%)	95	100	—	—	—
No. of offers/bids	3.0	3.1	4.4 [^]	3.0 [*]	6.2 ⁺
Seller's profit (S)	19.9	23.4	3.9 [^]	30.0 [*]	-7.8 ⁺
Buyer's profit (B)	52.6	47.1	66.9 [^]	45.3 [*]	75.8 ⁺
Balance (B-S)	34.2	30.3	70.4 [^]	40.1 [*]	82.5 ⁺
% of dominating alternatives	1.9	7.2	6.4	18.3 ^{##*}	5.4
Time (hrs.)	70.5	0.3	85.6 [^]	52.9 [*]	0.4
Outcome satisfaction (winners)	5.1	5.1	5.9	5.3	4.7
Outcome satisfaction (others)	2.8	3.2	3.1	4.3 ^{##*}	3.3
Favorable outcome (winners)	2.8	2.4	3.9 [^]	4.3 [#]	3.3 ⁺
Favorable outcome (others)	2.5	2.8	3.1 [^]	3.4 [#]	2.5

[^] Significance (p<0.05) between online negotiations and win-bids auctions

[#] Significance (p<0.05) between online negotiations and all bids-auctions

⁺ Significance (p<0.05) between lab negotiations and lab win-bids auctions

^{*} Significance (p<0.05) between win-bids auctions and all-bids auctions (online)

The average number of offers made by sellers (between 2.8 and 3.1) was significantly lower in negotiations than the number of bids in auctions (between 3.0 and 6.2) for all settings except of the case when negotiations were compared to “show all-bids” auctions. This difference between auctions and negotiations might confirm that offer making in negotiations requires higher workload than bidding in auctions. The difference is lower in online experiments where time and workload are not as critical as they are in lab experiments with shorter duration of activities.

The average sellers' profit in online negotiations (19.9) was significantly higher than in auctions with winning bids (3.9). The average buyers' profit in negotiations (52.6) was significantly lower than in auctions with winning bids (66.9). The difference in the buyers' profit between online negotiations and "show all-bids" auctions was not significant. In the lab negotiations, the average sellers' profit (23.4) was significantly higher than in lab auctions (-7.8). The buyers' profit in these negotiations (47.1) was significantly lower than in auctions (75.8).

The average balance was significantly lower in online negotiations (34.2) than in online auctions with "show winning-bids" (70.4). The average balance was significantly lower in lab negotiations (30.3) than in lab auctions with "show winning-bids" (82.5). That means that the outcomes in negotiations were more balanced than in auctions.

We use a relative number of dominating alternatives in order to compare the treatment results. The number of dominating alternatives was significantly higher in all-bids online auctions (18.3%) than in online negotiations (1.9%). That means that agreements in negotiations were better than in auctions for both sides.

The results described above show that the sellers' substantive outcomes in negotiations were better than in auctions, except for the "show all-bids" auctions in which the results were not significantly different. Buyers achieved better results in auctions than in negotiations with the same settings.

Regarding the difference in preferences disclosure schemas, we analyzed the effect of revealing buyers' preferences separately in auctions and negotiations.

We are interested in the impact of the buyers' involvement on outcomes. In negotiations, buyers' preferences and demands are revealed through buyer's offers and messages. We tested the effect of the buyer's first offer on his/her profit, which a seller may interpret as the buyer's most desirable alternative. Because there was no significant difference in the average profit between the online and the lab negotiations, we combined these two settings. The correlation between the rating of the buyer's first offer and his/her profit for both the lab and the online negotiations was $r(56) = 0.358$ ($p = 0.006$). This means that the buyers who did not present extreme offers, which might be the case with the cooperative negotiators, achieved worse results than those whose first offer was an extreme one.

The number and the length (in characters) of buyers' messages were not correlated with the buyer's outcome in any negotiation setting. Both were significantly lower in the lab than in online negotiations, which is not surprising because buyers had a much shorter time in the lab experiment. The interesting observation is that the average buyers' profit is not significantly different in these settings. This finding suggests that buyers' messages may not affect their profit.

The winners' assessments of outcomes were not significantly different in auctions and negotiations. This finding is interesting because the sellers' profit was significantly lower in auctions than in negotiations with the exception of the "show all-bid" auctions. This means that the sellers who won in auctions were as satisfied with their relatively lower outcome as the sellers in negotiations with the higher outcomes. One of the explanations could be higher importance of victory in auctions, which could be caused by a stronger feeling of the competition. In auctions the sellers were better informed about other sellers' bids, whereas in negotiations they could know what other sellers offered only if the buyer would tell them about it through messages. This may result in the higher feeling of competition in auctions

and, as a result, higher evaluation of the achieved results. For similar reasons winners might have found outcomes in auctions (between 3.3 and 4.3) significantly more favorable than in negotiation (between 2.4 and 2.8).

Also the outcome satisfaction of sellers who did not win was not significantly different in auctions and in negotiations. The “show all-bids” auctions were the exception with the outcome satisfaction (4.3) being significantly higher than in negotiations (2.8). This could also be explained by the feeling of competition. In these auction sellers knew more about other sellers’ bids than in negotiations and the win-bid auctions. Thus, sellers may have been more satisfied with the outcome when they knew that they were competing against others, despite failing to win an agreement.

6. Discussion

In this paper we described two pilot experiments and one exploratory experiment aimed at investigating the differences between multi-attribute reverse auctions and multi-attribute multi-bilateral negotiations. The results indicate that there may be important differences between the two types of mechanisms in terms of the process and outcome variables. Before we discuss the main results, in Table 5 we briefly summarize the three experiments.

Table 5. Overview of three experiments

	Experiment 1	Experiment 2	Experiment 3
Time	Spring 2011	Summer 2011	Fall 2011
Setting & location	Lab (Canada) & online	Lab (Italy)	Lab (Canada) & online
Buyers strategy	Competitive/integrative	Competitive/integrative	No instructions
Case: attributes	Three	Two and three	Three
Case: alternatives	216	36 and 216	3375
Information revelation	All bids	Winning bids	All bids & winning bids
Buyers	Canada: Graduate	Italy: Graduate	Canada, Taiwan, Austria: Graduate
Sellers	Canada: Undergrad	Italy: Undergrad	Canada, USA, Austria, Poland: Undergrad
No. of participants	489	227	532
No. of instances	114	50	121
- auctions	36	22	63
- negotiations	78	28	58

The differences in the set-up of Experiments 1 and 2 and, in the case of Experiment 1, the system problems and inadequate instruction of the participants led us to treat both experiments as pilots treating the results as tentative so that they could be tested in the subsequent experiment. Consequently, the first two experiments led us to modify the experimental process, by adding video explaining the systems, instructional material and quizzes. These changes were implemented in Experiment 3.

Due to the differences between the first two experiments (including location, setting and treatments) not all settings could be replicated. However, when the settings were comparable the results showed that most of the findings from Experiment 3 were consistent with Experiments 1 and 2. The main findings are shown in Table 6.

Table 6. Main results from three experiments.

	Experiment 1	Experiment 2	Experiment 3
Time	Lab: auctions shorter Online: auctions longer	Auctions longer	Confirmed for online auctions
Number of offers and bids	No difference between auctions and negotiations	2-attribute case: fewer bids than offers 3-attribute case: more bids than offers	Confirmed; as in 3-attribute case. Exception: show all-bids
Sellers' profit	Lab: negotiators' profit higher than bidders'	Negotiators' profit higher than bidders'	Confirmed. Exception: show all-bids
Buyer's profit	Lab: buyers' profit higher in auctions.	Buyers' profit higher in auctions	Confirmed. Exception: show all-bids
Balance	Lab: negotiations are more balanced. Online: auctions are more balanced	Negotiations are more balanced	Confirmed: Negotiations are more balanced. Exception: show all-bids
No. of dominating alternatives	Fewer in auctions	Fewer in auctions	No significant difference. Exception: higher in show all-bids
Auction setting	—	—	Show all bids: better agreements for bidders
Outcome satisfaction (winners)	Lab: auction higher than competitive and lower than integrative negotiation. Online: auctions the same as integrative and higher than competitive nego.	2-attribute case: lower in auctions; 3-attribute case: auction similar to competitive and lower than in integrative negotiations	No significant difference
Outcome satisfaction (others)	Lab: is similar. Online: auctions similar to integrative and lower than in competitive negotiations	2-attribute case: higher in auctions; 3-attribute case: lower in auctions;	No significant difference Exception: In show all-bids higher than in negotiation
Favorable outcome (winners)	Higher in auctions	Higher in auctions	Confirmed: higher in auctions
Favorable outcome (others)	No significant difference	Similar in auctions and competitive negotiation	Online: Higher in auctions; Lab: No difference

The results from Experiment 3 allow us to compare, albeit imperfectly, auctions and negotiations using three general categories: (1) resources required, (2) substantive outcomes achieved, and (3) assessments. The comparison is imperfect because we can use only some indicators for the resource and assessment categories.

Before we compare results of auctions and negotiations from Experiment 3, we need to note that there were two types of auctions differing in information available to bidders. Auctions in which only the winning and own bids were shown differed dramatically from auctions in which all bids were displayed. The results show (Table 4) that when sellers obtain more information, then the auction takes less time, the winner obtains higher profit, the buyer's profit is smaller and the auction efficiency (measured by the per cent of dominating alternatives) is lower. However, the "show all bids" auction takes significantly less time to complete.

These results partially contradict the results obtained by Koppius and Van Heck [25]. They report that multi-attribute auctions in which sellers obtain more information (i.e., the winning bid, the corresponding bidder, and the value of the other bids) result in higher proportion of non-dominated winning bids. We, however, found that there are significantly more non-dominated alternatives in this type of auction. Our results are similar to these obtained by Dufwenberg and Gneezy [55] from repetitive price-only single bid auctions, who conclude (p. 442): "Based on this observation, we now venture upon the following piece of advice to auctioneers: you may announce winning bids, but keep the losing bids secret!".

The difference between Koppius and Van Heck's [25] and our experiments may be in the auction protocol. In the protocol used in online experiments each round took 24 hours and there was a maximum 10 rounds. If at most one bid was made in a round, then the auction closed. The "show all bids" auction lasted significantly shorter than the "show winning bid" auction and several bidders won due to the others' inactivity. This lack of competition could be the result of the higher profits achieved by winners. This observation led us to augment the auction process rule; Imaras protocol allows now for rounds shorter than 24 hours and rounds automatically extended when only one bid was made. In addition, after one bid an automatic email is sent to the remaining bidders.

In the following we compare negotiations with the "show winning bids only" auctions.

Time is one resource and the results indicate that online auctions take longer to complete than negotiations. This is surprising because formulating a bid appears to be easier than formulating an offer which often is accompanied by a message. Interaction with buyers and the need to wait for their responses also should extend the negotiation time. One reason why auctions took more time than negotiations may be that, on average, there were more bids than offers per process. We need to point out that the total time allocated to both auctions and negotiations was the same, i.e., the participants were given the same deadline.

These results should be investigated further. On the one hand, the time allocated to both processes should be varied so that one can determine whether the outcomes depend on available time. On the other hand, other resource indicators should also be included. In addition to allocated time to complete the process, time actually spent on process activities may provide relevant information.

Our results indicate that buyers' profit is higher in auctions and, correspondingly, the sellers profit is higher in negotiations. While the process was not a zero-sum type in which an increase of profit for one side always required a decrease for the other side, the general direction was that sellers' profit depended on the buyers' profit and vice versa. The profit values achieved in auctions and negotiations led to more balanced and equitable profit distribution in negotiations than in auctions.

One may expect that sellers who participated in negotiations should be more satisfied with the outcome than those who participated in auctions. The results from the pilot studies show that participants in the integrative negotiations are more satisfied than others (Table 6). The auction participants, however are more (or similarly) satisfied than participants in the competitive negotiation. In Experiment 3, in which buyers were not instructed to be competitors or cooperators, no significant difference was found.

The last assessment (Table 6) describes the participants' consideration of the outcome being favorable for the companies they represent. In the case of the winners this refers to the contract they achieved, for the others the outcome favorability refers to the fact that they did not get a bad contract for their company. The results are puzzling because bidders find outcomes more favorable than the negotiators. This may be the case for the auctions' non-winners but the winners' outcome would result in losses (lab auctions) or very low profit (online auctions). Notwithstanding, they considered these outcomes as more favorable than the negotiators who achieved significantly higher profits.

We mentioned above that there is no significant difference between assessments (outcome satisfaction and favorable outcome) of the winners and other bidders on one hand and the seller-negotiators on the other. This might not have been true if the bidders had known the results of negotiations, that is, that the sellers negotiated significantly better contracts than the winning bidders. In practice some business associations recommend that their members avoid reverse auctions and instead either employ a sealed single-bid process or negotiations [55]. The argument is that price should not be the sole criterion and the focus on price pushes the sellers to their absolute bottom line forgoing delivery, quality, warranties and other attributes which differentiate suppliers' goods. Our results indicate that the addition of other attributes does not change the outcomes; it is the process in which the sellers compete with each other that pushes them to their bottom line and beyond. They either can quit or try to get the contract. In auctions, unlike in negotiations, the sellers cannot try to persuade the buyers.

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