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Title:

Procurement Auctions and Negotiations: An Empirical Comparison

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Short title:

Procurement Auctions and Negotiations

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Abstract:

Real world procurement transactions often involve multiple attributes and multiple vendors. Successful procurement involves vendor selection through appropriate market mechanisms. The advancement of information technologies has enabled different mechanisms to be applied to similar procurement situations. Advantages and disadvantages of using such mechanisms remain unclear. The presented research compares two types of mechanisms: multi-attribute reverse auctions and multi-attribute multi-bilateral negotiations in e-procurement. Both laboratory and online experiments were carried out to examine their effects on the process, outcomes and suppliers' assessment. The results show that in procurement, reverse auctions were more efficient than negotiations in terms of the process. Auctions also led to greater gains for the buyers than negotiations but the suppliers' profit was lower in auctions. The buyer and the winning supplier jointly reached more efficient and balanced contracts in negotiations than in auctions. The results also show that the suppliers' assessment was affected by their outcomes: the winning suppliers had a more positive assessment towards the process, outcomes and the system. The findings are consistent in both the laboratory and online settings. The implications of this study for practitioners and researchers are discussed.

Keywords:

Multi-attribute auction, Multi-bilateral negotiation, Online reverse auction, E-negotiation, Electronic procurement, Experimental study.

1. Introduction

E-procurement is a key component in business-to-business (B2B) commerce, through which organizations obtain goods and services. Successful procurement depends on the selection of the right goods and services as well as the choice of the best method to buy them (Handfield and Straight 2003).

Typical methods in B2B transactions include reverse auctions and negotiations. Most auctions deal with single attribute goods or services—typically price. However, organizations are also often interested in values of attributes other than the price (Ferrin and Plank 2002). These types of decisions have been usually made through negotiations. E-procurement allows buyers to search for suppliers worldwide and online creating the need for more advanced mechanisms than either single-attribute auctions or bilateral negotiations.

Several multi-attribute reverse auction mechanisms have been recently proposed (for review see Pham, Teich et al. 2015). Some aim at combining price with the total costs of all non-price attributes, others at aggregating all attributes into utility functions. Most of these mechanisms require that buyers be willing to disclose their preferences, which they rarely do in real life (Burmeister, Ihde et al. 2002; Parkes and Kalagnanam 2005).

In business negotiations, it is typical to seek agreements on price as well as on other attributes. Buyers may negotiate with different suppliers over the same goods (sequentially or simultaneously) in order to increase their bargaining power and realize a surplus (Stenbacka and Tombak 2012). Sequential bilateral negotiations with one supplier at a time or several suppliers simultaneously over multiple attributes are both complex and inefficient, when compared to simultaneous negotiations. The buyer's simultaneous negotiations with multiple suppliers, i.e., multi-bilateral negotiations, may not be possible or may require the engagement of several procurement managers. Information technologies can support multi-bilateral negotiations; few studies, however, have modeled and examined them. One aim of this study is to show how such negotiations can be conducted online and become an alternative mechanism to online auctions.

Organizations need to select and possibly adapt market mechanisms to suit their particular

procurement situation. Models and guidelines have been proposed to aid the mechanism selection in procurement practice (e.g. Kraljic 1983; Handfield and Straight 2003; Gelderman and Van Weele 2005). Based on the supply market complexity and the importance of procurement, four types of procurement transactions have been suggested: bottleneck, strategic, noncritical and leverage. In many situations, the same type of transactions may be performed with different mechanisms. For instance, both reverse auctions and negotiations have been suggested for the “leverage” transactions (Kaufmann and Carter 2004; Subramanian and Zeckhauser 2004; Bajari, McMillan et al. 2009). These guidelines consider general sourcing strategies rather than the detailed parameters describing the marketplace and organization with its procurement process. Experimental economics and market design (Milgrom 2000; Smith 2003) empirically study mechanisms with different design characteristics, resulting in a dearth of comparisons of multi-attribute auction mechanisms (Kagel and Levin 2012).

The present research adds to the literature with empirical examination and comparison of multi-attribute auctions and multi-attribute multi-bilateral negotiations for same e-procurement tasks. The results should help researchers and practitioners to gain better understanding of the differences between procurement mechanisms, their use and the outcomes which they produce. To this end, two systems were developed in which comparable auctions and negotiations were implemented, and two experiments were carried out to validate the research and the results in laboratory and online settings.

The rest of this paper is organized as follows. Section 2 provides the background and motivation for this research, and in particular, comparative studies on multi-attribute auctions and e-negotiations. Section 3 formulates the research model and hypotheses aimed at comparing auctions and negotiations. Section 4 describes the experiments. Section 5 presents data analysis and results. Section 6 discusses the findings and their implications for practice and future research.

2. Background and motivation

Reverse auctions and online negotiations have been used in e-procurement (Bichler and Steinberg

2007; Bajari, McMillan et al. 2009; Pham, Teich et al. 2015). To provide the background and motivation for our study, this section reviews literature in which these two mechanisms and their effects have been discussed.

2.1 Multi-attribute auctions and e-negotiations

Multi-attribute auctions are designed to deal with transaction problems that involve multiple parties and multiple attributes. There are two concerns when designing and using multi-attribute auctions: (1) the representation of the buyer's preferences that allow the sellers to compare bids from the buyer's perspective; and (2) the specification of rules for information revelation during the auction.

Several multi-attribute auction mechanisms have been designed using scoring methods to represent the buyer's preferences (e.g. Bichler, Field et al. 2001; Beil and Wein 2003; Engel and Wellman 2010). One typical method is the attribute monetization method (Parkes and Kalagnanam 2005); it expresses non-price attributes in monetary terms. The method is limited to auctions with homogenous bidders and monotonic attributes and it assumes that price and the monetized attributes (e.g., costs) are independent and the buyers and sellers are risk neutral (Ausubel and Milgrom 2006; Kersten 2014).

Another concern in multi-attribute auctions pertains to information that is revealed to the bidders. It requires that the information be sufficient for the bidders so that they can make progressive bids. The revealed information may be directly or indirectly related to the buyer's preferences in one or in a combination of the following three forms: buyer's preferences, bids and constraints (Koppius and Heck 2003; Chen-Ritzo, Harrison et al. 2005; Strecker 2010; Adomavicius, Gupta et al. 2012). The efficacy and the impact of these rules were experimentally studied, and showed that information revelation affects bidders' strategies, market competition, and transactional outcomes.

Most auction mechanisms require the disclosure of the buyer's preferences so that sufficient information is provided to bidders enabling them to make progressive bids. The disclosure of preferences, however, is problematic when the buying organization views these preferences as secret; disclosing them may endanger their competitive position (Burmeister, Ihde et al. 2002; Parkes and Kalagnanam 2005). A novel auction procedure has been designed and implemented. The procedure allows for the separation of

preference representation and information revelation as well as the control of disclosure (Kersten and Wu 2015).

With the advanced development of the Internet technologies, negotiations can now be conducted online. They are conducted via e-negotiation systems (ENSs), which support, facilitate and mediate negotiations (for review see Kersten and Lai 2008). A number of ENSs have been developed, in which different models and rules are implemented to provide various forms of support.

E-negotiation studies have examined the influential factors in users' perceptions of ENSs. Vetschera et al. (2006) presented an integrated model to analyze factors that affect users' assessment of systems and their intention to use these systems. Exploratory studies of the e-negotiation participants' activities have shown difference in their objectives and orientations (Wu, Kersten et al. 2012). Some participants are predominantly concerned with the substantive objectives that focus on transactional and economic outcomes while others are interested in relational objectives.

2.3 Comparison of auctions and negotiations

Formal comparisons of market mechanisms have been of interest to economists. The underlying assumption is that the market participants are rational and self-interested. Manelli (1995) observed that the mechanism's results depend on the market situation. The comparison becomes even more difficult when the underlying assumptions of the mechanisms significantly differ from each other, as it is the case with auctions and negotiations. Auctions assume that bidders have some knowledge of buyer's valuation of the goods and follow a strict and fixed procedure. Negotiations have significantly weaker assumptions; the often-made assumption is that the parties negotiate in good faith and that they are able to assess and compare the alternatives. There are no limitations to communication and no assumptions about the sellers' knowledge of the buyer's valuation.

Behavioral economics examines and compares different mechanisms (Roth 2002; Smith 2003). One of the purposes is to validate theoretical predications with empirical results. This requires that the rationality paradigm be extended and social-psychological variables included (Maskin 2007). Majority of studies focused on the comparison of different auction mechanisms, whereas only a few studies compared

auctions and negotiations (Thomas and Wilson 2002; Thomas and Wilson 2005; Gerke and Stiller 2006; Gattiker, Huang et al. 2007). The studies that compared these mechanisms are summarized in Table 1.

[Table 1. Empirical studies comparing auctions and negotiations]

The differences identified in these studies may be summarized in the following six points:

- (1) The number of attributes is fixed and usually small in auctions; the number of attributes in negotiations is open and often larger than in auctions;
- (2) The relationship between the buyer and the sellers is very restricted in auctions, but it is very significant in negotiations and involves interpersonal interactions;
- (3) The communication follows a fixed format, it is highly structured and unidirectional (i.e., between the sellers) in auctions, but it is open, fluid and bi-directional in negotiations;
- (4) The visibility among suppliers and the process and information transparency are higher in auctions than in negotiations; this increases the level of competition in auctions;
- (5) The length of the process is typically longer in negotiations than in auctions;
- (6) The cognitive complexity in simple, price-only and two-attribute auctions as well as multi-attribute auctions, in which the buyer's preferences are fully revealed, is much lower than in negotiations. However, the complexity drastically increases in multi-attribute auctions with hidden preferences.

2.4 Motivation and objectives

Empirical validation of the differences in auctions and negotiations and their effects can guide the practice and lead to effective procurement. It has been noted that auctions outperform negotiations in terms of economic gains from the buyer's perspective (e.g. Bulow and Klemperer 1996; Gerke and Stiller 2006). However, studies have also shown that negotiations outperform auctions (e.g. Leffler, Rucker et al. 2006; Bajari, McMillan et al. 2009).

The findings of auctions and negotiations comparisons are inconclusive. The comparative studies were either conducted in different settings or for different tasks (e.g. Kugler, Neeman et al. 2006; Fluck,

John et al. 2007). This study attempts to address the problem/weakness by focusing on two issues: (1) which mechanism outperforms the other in the same context, and (2) what conditions cause one mechanism to outperform the other.

Comparative studies on auctions and negotiations focus on a single-attribute (i.e., price-only). With the exception of studies by Thomas and Wilson (2002; 2005), only bilateral negotiations were compared with auctions, which removes the element of competition among sellers in negotiations but not in auctions. Also, their focus on theoretical verification led to the comparison of abstract models or models embedded in a rudimentary system (Thomas and Wilson 2002; Thomas and Wilson 2005). Several empirical studies compared auctions and negotiations that were implemented with richer features but in different systems (Kaufmann and Carter 2004; Gattiker, Huang et al. 2007). The results could be confounded because of the effects of user interface and system features, which could not be controlled.

The above discussion indicates a need for experimental comparison of multi-attribute auctions and multi-bilateral negotiations in a similar setting (e.g. task, implementation) so that the differences between them can be better understood. In order to study the differences two types of mechanisms have been designed and implemented (Wu, Kersten et al. 2014): a multi-attribute reverse auction and a multi-attribute multi-bilateral negotiation. Both can be used in e-procurement involving multiple parties and multiple attributes. The revelation and exchange of information in these mechanisms is based on attribute values instead of utility values, and thus there is no need to explicitly disclose the buyer's preferences. Moreover, as these mechanisms are implemented with similar user interface in the same platform, it is possible to employ the capabilities of information technologies but also to separate the effects of user interface and system features.

3. Research model and hypotheses

This study compares auctions and negotiations by examining their effects on the transaction process and outcomes. In addition, the subjective evaluation is also considered based on the participants' assessment.

The conceptual model is presented in Figure 1.

[Figure 1. Research model]

3.1 Variables and measurement

This study focuses on two different mechanisms with information revelation and exchange during the procurement process:

Auction: Multi-attribute reverse auction in which the buyer reveals the admissible bids and the current winning bid;

Negotiation: Multi-attribute multi-bilateral negotiation in which the buyer exchanges offers and messages with each supplier.

The two mechanisms are implemented in Imaras and Imbins respectively (Wu, Kersten et al. 2014). In both mechanisms, the suppliers have full access to their own bids or offers/messages throughout the process. The two mechanisms differ in terms of the types of information conveyed from the buyer to the suppliers.

In the Imaras auctions, the buyer is not involved in the transaction process; rather, the buyer defines the rules prior to the auction and the mechanism then follows the rules to evaluate the suppliers' bids, identify the winning bid, state the admissible bids, and finally announce the winner. The feedback information about the admissible bids and the bid status (winning or not) is provided to the suppliers via the Imaras system (Figure 2). Such information is public and credible, i.e. all the suppliers receive the same information at the same time, based on which they can make appropriate decisions.

[Figure 2. Screen of “Bids & Limits” after several rounds in Imaras]

In the Imbins negotiations, the buyer may disclose any constraints on all suppliers' subsequent offers (equivalent to admissible bids in the auctions) and any existing offers from the suppliers (e.g. the current outstanding offer and/or non-preferable offers) (Figure 3). While the buyer may not disclose the

offers submitted by all suppliers, she may want to provide clues to the suppliers so that they can make better offers for her, and explicitly or implicitly refer to the outstanding offer to increase the bargaining power. This makes the negotiations similar to auctions. However, such information is private and non-verifiable. The suppliers can communicate only with the buyer and have to rely on the information they obtain from the buyer. The suppliers cannot fully trust this information and the buyers do not necessarily disclose the current best offer—even if they mention that they have a better offer, the suppliers may view it as a tactic.

[Figure 3. Screen of “Offers & messages” for the supplier in Imbins]

Both economic and subjective measures are used to examine and compare the two mechanisms. Economic indicators have been used to measure individual and market performance (behavioral economics) (Roth 1995; Smith 2003). Appendix A lists the behavioral and economic measures from prior studies on auctions and negotiations (incl. Bichler 2000; Koppius and Heck 2003; Chen-Ritzo, Harrison et al. 2005; Gerke and Stiller 2006; Vetschera, Kersten et al. 2006; Jap and Haruvy 2008; Whitford, Bottom et al. 2011). This study takes into account realistic situations in e-procurement and thus does not rely on quasi-linearity and risk-neutrality assumptions. The study follows the decision and negotiation analysis approach to assess the quality of contracts based on allocative efficiency, Pareto optimality, joint gains and outcome equity.

The transaction process can be analyzed using the number of bids/offers, the amount of concessions and the convergence speed, which together indicate the process efficiency (Table A-1 in Appendix A). Because the buyer is not directly involved in auctions, the number of bids/offers and concessions are concerned with the suppliers only. The convergence speed is considered at the transactional level.

The outcomes are measured using potential profit from a contract, which is the difference between the company’s revenue from the contract and its break-even point (Table A-2 in Appendix A). This was implemented in the case used in the experiment so that a realistic situation where the participants perform a role-play in the experiments could be established; instead of directly using utilities, the notions of revenue, cost and profit help enhance the realistic context.

Mechanisms used for online exchanges must be implemented in systems. The users' assessment of a mechanism is also their assessment of the system. The users' perception of the process and outcomes may affect their assessment of the mechanisms. Satisfaction has been a surrogate of the effectiveness of information systems and has been used in the acceptance and assessment of various types of systems, including e-markets and e-negotiation systems (Oörni 2003; Wang, Lim et al. 2010). A multi-dimensional scale of participants' assessment in e-markets which was developed and adapted for the study of auctions (Wu and Kersten 2013) is used to measure the suppliers' assessment.

3.2 Hypotheses

Formal and empirical studies on mechanism comparisons have shown that the performance of different mechanisms may vary in terms of process efficiency and outcomes (Koppius and Heck 2003; Kaufmann and Carter 2004; Thomas and Wilson 2005; Gerke and Stiller 2006; Mithas and Jones 2007).

Auctions provide the same feedback information to all the suppliers, whereas in negotiations the feedback is private with both structured offers and unstructured messages. The feedback information about bids in auctions can be used by the suppliers to discover the buyer's preferences, which can lead to better performance in requesting and receiving bids and thus to converge faster towards an agreement (Koppius and Heck 2003; Thomas and Wilson 2005; Strecker 2010). In negotiations, buyers often customize and exchange private information with suppliers which requires longer time and more effort (Kaufmann and Carter 2004; Subramanian 2009). Public information provided in auctions also indicates the existence and participation of other suppliers, which increases the competition and thus requires that the suppliers make larger concessions in their bids (Jap and Haruvy 2008; Granados, Gupta et al. 2010; Kersten, Vahidov et al. 2013). It should be noted that the concessions made by the bidders may also depend on their reservation levels based on the supplier's profile (e.g. resource, competency). The comparisons are based on average concessions made by the suppliers who use the same mechanisms. Thus, we expect that:

H1 Suppliers will make a greater number of bids in auctions than in negotiations.

H2 Suppliers will make larger concessions in auctions than in negotiations.

H3 In auctions the buyer and the suppliers will converge in a shorter time than in negotiations.

Auctions have been found to increase the buyer's economic gains more than negotiations (Thomas and Wilson 2002; Kaufmann and Carter 2004; Bajari, McMillan et al. 2009). This is partially due to the higher competition among suppliers in auctions. Auctions reveal information about winning bids from other suppliers, and thus the suppliers know that they are competing with others. This can be completely concealed in negotiations, in situations when the buyer does not announce any information about other suppliers and/or outstanding offers. Studies on information transparency have also found that the availability of offers from different suppliers increases market competition and thus leads to cost savings for buyers (Soh, Markus et al. 2006; Granados, Gupta et al. 2008; Granados, Gupta et al. 2010).

Experimental studies on auctions have shown mixed results regarding supplier's outcomes, particularly in multi-attribute transactions (Bichler 2000; Koppius and Heck 2003; Chen-Ritzo, Harrison et al. 2005). In negotiations, a lower level of competition may lead to smaller concessions from the suppliers and thus improve their gains (Kersten, Vahidov et al. 2013). In addition, the buyer can also make offers and counter-offers in negotiations, which often entails reciprocity and obligations and thus decreases their gains (Esser and Komorita 1975). It should also be noted that profit is measured based on the contract reached between the buyer and one of the suppliers (i.e. the winning supplier). Since the value and the cost functions vary across suppliers. Larger concessions may not always lead to lower profit and the profit may also be different for different winning suppliers. Hence, we expect that:

H4 The buyer's profit will be higher in auctions than in negotiations.

H5 The supplier's profit will be lower in auctions than in negotiations.

Taking into account both the buyer's and the suppliers' side, four indicators are used to measure their joint performance and the contract quality: allocative efficiency, Pareto optimality, joint gains and outcome equity. Revealing the buyer's preferences and other valuable information, such as winning bids, helps the suppliers make trade-offs between different attributes and seek joint improvements (Koppius and Heck 2003; Chen-Ritzo, Harrison et al. 2005; Strecker 2010). An earlier study showed that more balanced contracts were reached when more information was revealed in multi-attribute reverse auctions (Wu and Kersten 2013). In negotiations, additional information exchanged during the process may help negotiators

gain more knowledge about each other and thus achieve better joint outcomes (Vetschera, Kersten et al. 2006). Also, while auctions may focus on economic goals (i.e. the buyer will achieve the best possible contract), negotiations as social-economic process also involve relational concerns (Wu, Kersten et al. 2012). When both sides consider each other and make reciprocal offers, they may be able to reach a more balanced contract. Thus, we also expect that:

H6 Auctions will outperform negotiations in terms of allocative efficiency and Pareto optimality.

H7 Negotiations will outperform auctions in terms of joint gains and outcome equity.

Moreover, additional information revealed by the buyer may also increase the transparency of the process along with, consequently, the trust of the suppliers and a better relationship (Gattiker, Huang et al. 2007; Lösch and Lambert 2007). Reciprocity can be a vehicle for conveying sentiments and developing relationship in social exchange (Molm, Schaefer et al. 2007). Buyers in negotiations may make reciprocal offers and counter-offers, which increase the suppliers' actual gains and thus improve their feelings and the assessment of the process and outcomes. Suppliers in e-procurement are also users of such systems, and the evaluation of systems is often affected by their performance and outcomes (Venkatesh, Morris et al. 2003; Vetschera, Kersten et al. 2006). Hence, we expect that:

H8 Negotiations will lead to more positive assessment of: (1) the process, (2) the outcomes and (3) the system, than auctions.

4. Experiments and data collection

The purpose of this study is to investigate the different mechanisms in terms of their impact on the procurement process and outcomes. The two systems (Imaras and Imbins) are used to conduct procurement transactions. The proposed hypotheses are tested using an experimental approach. The experimental design, tasks and procedures for data collection are described in the following sections.

4.1 Experimental design

This study is based on laboratory and online experiments designed to test the research hypotheses.

Laboratory experiments are considered to be appropriate for establishing and testing causal relationships by manipulating the independent variables, controlling the environment and the procedure, and observing the effects on the dependent variables (Croson 2005; Kagel and Levin 2012). Online experiments have been widely conducted in e-commerce research because they replicate the natural environment and increase the external validity (Kerlinger and Lee 2000; Bapna, Jank et al. 2008). In this study, the experimental design with two mechanisms in both laboratory and online settings is used; it is shown in Table 2.

[Table 2. Experimental design and treatments]

In Experiment 1, the auctions and the negotiations were conducted in the laboratory environment in several sessions. Each session lasted two and a half hours, including preparation time and answering questionnaires. The buyers in negotiations and the suppliers were set up in different lab rooms, where the facilitators gave instructions and guided them through the experiment. The time slot for bidding and negotiating was also controlled and lasted 50 minutes. The auctions were in a multi-round setting; each round took five minutes. The bidders instantly obtained the auction updates on the rounds and the revealed information. The buyers and the suppliers in negotiations were exchanging offers and/or messages using the system; and, the system automatically posted a notice informing them about any change in their negotiation status.

In Experiment 2, the auctions and the negotiations were running online and lasted 10 days. In auctions, each round was set as one day and thus auctions could last ten rounds at most. The participants could log on and off at any time during the auction or negotiation. They were informed by emails about any updates from the ongoing auctions and negotiations, and they were required to log on to access the updates and make offers or bids.

4.2 Experimental tasks

In order to compare auction and negotiation mechanisms, a business case was developed to simulate a “leverage” type of procurement transaction. The case involved securing a one-year contract between a

milk producer and several transportation service providers. Three attributes of the transportation service were given: (1) *standard rate*; (2) *rush rate*; and (3) *penalty for delay*. There was a number of values for each attribute, and the possible ranges were known to each participant. This generated 3,375 alternatives for the contract, which provided a relatively complex task. The transaction is important for both the milk producer and the transportation service providers. Given the number of alternatives and the shortlisted service providers, it is suitable for both auction and negotiation mechanisms.

The buyers in negotiations represented a procurement officer for the milk producer. The suppliers played the role of a sales manager for one of the service providers. They were competing with each other to win the contract. Each contract could be awarded to only one supplier. In auctions, the one who made the best bid for the milk producer would be the winner. In negotiations, the suppliers were negotiating with the buyer in order to reach an agreement. The suppliers wanted to get the contract that would bring profits rather than losses. The participants were given the break-even points of the contract for their company.

The context and background provided in the general information document were known to every supplier, while the preferences were explained in the confidential information document that was not known to the other suppliers. The reservation and aspiration levels of each company were also indicated in their confidential information, indicating the worst and best deals respectively. A financial calculator implemented in the system and could be used by the participants to calculate the revenue and profit for each contract alternative. Based on the preferences of the buyer and each supplier, the utility distribution of alternatives could be identified and used for calculating the outcomes.

4.3 Experimental procedures

The experiments involved several steps. Before the experiment, the participants signed up online and their demographical information was gathered via a registration form. The participants were then randomly assigned different roles and one of the treatments. The participants were also required to watch a video demonstration of the system. This requirement followed a suggestion made by the participants' in an earlier study (Wu and Kersten 2013). It ensured that the participants had the same basic knowledge and experience with the system in order to test the effects due to treated conditions (Jiang and Benbasat 2007).

The participants first read the general and confidential information in order to prepare themselves for the experiment. This was followed by a quiz and pre-questionnaire. The quiz was used to improve the participants' understanding of the tasks. The participants were then asked to provide their perceptions of the task as well as their expected aspiration and reservation levels (Table B-1 in Appendix B). These measures were used to examine their understanding of the task and their expectations of the contract.

The participants could access and review the general and confidential information any time during the transaction process. In the interaction phase, the participants constructed and submitted bids or offers on behalf of the companies they represented. In negotiations, they could send messages with or without offers. Once the transaction was closed, they were asked to fill out a post-experiment questionnaire to give their perceptions and evaluation of the process, the outcomes and the system (Table B-2 in Appendix B).

The participants' activities during the transaction process were recorded in a database, which was used to analyze the transaction process and outcomes.

5. Data analysis and results

The data sample and a descriptive analysis of the experiments are discussed in this section. Then, the hypotheses are tested, followed by group comparisons to further examine the differences between the two mechanisms.

5.1 Data sample and descriptive analysis

The experiments involved over five hundred business students from North America, Europe and Eastern Asia. The majority of suppliers were undergraduate students who were studying business courses related to information technologies; graduate students in business programs played the role of buyers in the negotiations (in auctions the buyers were replaced by the mechanism). The experiments were part of their course work and worth more than six percent of the total mark, including participation and performance.

In the two experiments, 257 students registered for auctions and 262 registered for negotiations. The latter were matched with 67 buyers. After review and validation of the transactions, 82 records in the

supplier dataset were removed from the auction dataset and 64 from the negotiation dataset. The criteria for dropping those records were: (1) participant made only one bid/offer or did not make any bid/offer, and (2) there was only one participant (i.e., supplier) in the transaction. Consequently, the data records with 373 suppliers and 61 buyers were used in the subsequent analysis: Experiment 1 includes 28 auctions and 23 negotiations with the total of 181 suppliers; Experiment 2 includes 17 auctions and 38 negotiations with the total of 202 suppliers.

Most of the participants were between 20 and 25 years old. About 48 to 57 percent of the participants were female; gender does not significantly differ across the treatments. Most of the participants perceived their knowledge about auctions or negotiations to be lower than average, and majority of the participants had low or no prior experience using an auction or negotiation system for e-procurement transactions. They also perceived the task to be relatively difficult. An ANOVA test showed no significant difference in their experience and the perceived task complexity between the treatments.

5.2 Instrument testing and factor analysis

The instrument developed in an earlier study on auctions (Wu and Kersten 2013) was adapted for both auctions and negotiations in this study. Participants' responses to the post-experiment questionnaire were used to examine their assessment of the process, the outcomes and the system.

Considering the differences between auctions and negotiations, the instrument was validated with a CFA for negotiations. Due to the small sample size of the negotiation dataset in Experiment 1 ($N=60$), the dataset in Experiment 2 was first used for the CFA ($N=102$) and followed by a group analysis with the two samples.

A robust analysis was conducted—not limited by normality and sample size. The factor model provided a good fit for the data. The result of chi-square test statistic is $\chi^2=37.42$ with acceptable significance ($p=0.04$). The Bollen's IFI is 0.97 which indicates a valid model independent from the sample size (Bollen 1990). Both CFI and NNFI are above 0.95 and RMSEA is located between zero and one ($CFI=0.98$; $NNFI = 0.97$; $RMSEA=0.06$), indicating a good fit of the factor model (Hu and Bentler 1999). The results confirm that the three types of suppliers' assessment exist in the negotiations.

In terms of reliability, the values of Cronbach's α for all factors are above the recommended criteria with a cut-off of 0.70 ($AP=0.81$, $AO=0.90$, $AS=0.86$), indicating high internal consistency (Nunnally and Bernstein 1994). Moreover, the factor loadings are in an acceptable range (from 0.77 to 0.93), indicating a good convergent validity. The average variance extracted (AVE) has been recommended to indicate reliability and discriminant validity (Fornell and Larcker 1981). The AVEs for the three factors are all greater than 0.72, which satisfies the reliability criteria ($AVE>0.50$) and indicates adequate discriminant validity (the highest shared variance with 0.70 between AP and AS).

The model was further validated by a group analysis of two samples: one with online negotiations ($N=102$) and one with both laboratory and online negotiations ($N=162$). The results show no differences in two factors: assessment of the outcomes and assessment of the system. However, the AVE for assessment of the process was lower in the combined sample (0.64), which is acceptable for reliability but fails to discriminate the assessment of the system. This again may be due to the high correlation between the two factors (0.84). It indicates that when the suppliers evaluate certain aspects of the negotiations they may also consider other aspects. In particular, the suppliers who are satisfied with the process are most likely also satisfied with the system, which may be due to the fact that the mechanisms that control the processes are implemented in the systems. A weighted sum for each factor was calculated using the factor loadings, and then used to compare suppliers' assessment in subsequent data analysis.

5.3 Hypotheses testing

The hypotheses were tested with the datasets from the two experiments. Prior studies indicated that utility based variables such as concessions and outcomes may not necessarily conform to a normal distribution, thus nonparametric analysis such as Mann-Whitney U-test with independent samples has been suggested (Koppius and Heck 2003; Lösch and Lambert 2007). In this study, ANOVA tests were used to compare the mean values of the number of bids/offers, the convergence speed and the assessment, which confirmed normal distribution from the descriptive analysis. Mann-Whitney U-tests were used to compare the distribution of concessions and the outcome variables with independent samples from each treatment. Table 3 shows the results that compare the process, the outcomes and the suppliers' assessment.

[Table 3. Comparison on the process, the outcomes and the assessment]

Effects on process

In Experiment 1 (laboratory setting), the suppliers made a significantly greater number of bids in auctions than offers in negotiations (6.61 vs. 3.57, $p \leq 0.01$). They also made significantly larger concessions in auctions than in negotiations (60.89 vs. 23.08). In Experiment 2 (online setting), the differences remained but were not as significant as in Experiment 1 (4.72 vs. 3.40, $p \leq 0.05$). Thus, hypotheses H1 and H2 are supported in both laboratory and online settings.

The results show that the suppliers were more active in auctions, which might be due to the revealed public information that provided clearer directions and the same decision space for their bidding. Such information may also have increased competition between the bidders that motivated them to bid. In negotiations, each buyer was bargaining with two or more suppliers. Taking into account the average number of offers made by each supplier (3.57 in laboratory and 3.40 online), the buyer may have needed to review, evaluate and compare more than seven offers and then make decisions to reject offers or make counter-offers. Thus, the task load may have been shifted from the system to the buyers, which may have decreased the process efficiency in requesting new proposals.

The convergence speed was not significantly different in the two mechanisms, neither in Experiment 1 nor in Experiment 2. Thus, hypothesis H3 is not supported. This may be due to the fact that the auction was multi-round with a fixed round duration (five minutes in Experiment 1 and one day in Experiment 2), which may have led to slow convergence if the suppliers submitted more bids and stayed in more rounds. In negotiations, the information exchange was two-way, meaning that both sides could make offers with certain concessions and thus could reach agreement in a shorter period. This together may have undermined the difference in the convergence speed between the two mechanisms.

Effects on outcomes

In terms of the outcomes, the buyers in Experiment 1 gained much higher profit in auctions than in

negotiations (75.82 vs. 47.13), while the suppliers reached better deals in negotiations than in auctions (23.39 vs. -7.82). The same happened in Experiment 2, though the differences were smaller (Table 3). Thus, hypotheses H4 and H5 are both fully supported in the two experiments.

This may be due to the differences in concession-making between auctions and negotiations. In auctions, the suppliers had to continuously make concessions to compete against others, which increased the buyer's gains but decreased their own profit. In fact, the suppliers were overbidding in the laboratory setting because of the highly competitive environment and time pressure. As a result, they won the contract, which, however, would not produce profit. In negotiations, the buyer made concessions with reciprocal offers from which the suppliers gained higher profit.

The allocative efficiency was significantly higher in negotiations than in auctions, whereas the Pareto optimality was higher in auctions. In both Experiment 1 and Experiment 2, the buyer and the suppliers in negotiations reached an agreement that was closer to the best achievable contract (i.e. the contract that maximizes the sum of utilities for both sides). This was not expected; it was assumed that auctions would result in higher competition between the suppliers and thus lead to more efficient contracts. Nonetheless, the suppliers were making large concessions and even overbidding in order to win the contract, which did not produce profit and made the process inefficient. In negotiations, even though the buyers made concessions that reduced their profit, the gains for both the buyer and the supplier ultimately increased the value of the contract and thus led to more efficient allocations.

Note that an efficient contract may not be Pareto optimal, i.e. there may be alternatives that can improve the deal to increase the profit for the buyer, for the supplier or for both sides without decreasing the value for any side. In the two experiments, auctions led to better solutions or contracts than negotiations in terms of Pareto optimality (i.e. the solutions from auctions were closer to the efficient frontier). This was mainly due to the fact that the suppliers had to submit admissible bids in auctions and often had to make larger concessions to win the round. The concessions merely from the supplier side would lead to contracts that favor only the buyer, leaving little room for improvement for both parties. Thus, hypothesis H6 is partially supported in terms of Pareto optimality.

In terms of joint gains and outcome equity, the results also show a higher contract quality for both the buyer and the supplier in negotiations than in auctions. In Experiment 1, the joint gains were positive and larger in negotiations than in auctions (916.57 vs. -763.50). The negative value in auctions was caused by the suppliers' overbidding and thus reaching non-profitable contracts. The joint gains in Experiment 2 were improved for the contracts achieved through auctions but still worse than the ones achieved through negotiations. The outcome equity was significantly better in negotiations than in auctions in Experiment 1 (0.68 vs. -0.06). The buyer and the supplier in negotiations were able to achieve more balanced contracts, which may be due to the concessions from both sides. In auctions, the suppliers were provided with admissible bids that may have lacked directions towards better solutions for both the buyer and the supplier. Also, the winning bids might have led the suppliers to compete with extreme values on certain attributes and thus led to more imbalanced contracts. The situation was improved in Experiment 2, where the difference between auctions and negotiations in terms of outcome equity was not significant. Thus, hypothesis H7 is fully supported in the laboratory setting (i.e. both joint gains and outcome equity), while it is partially supported in the online setting (only joint gains).

Effects on suppliers' assessment

In comparing their assessment, the suppliers who used the negotiation mechanism in Experiment 1 were more satisfied with the process and the outcomes than the suppliers who used the auction mechanism (Table 3). The suppliers did not significantly differ in the system assessment. In Experiment 2, there were no significant differences in the suppliers' assessment of the process, the outcomes and the system. Thus, hypothesis H8 is partially supported in the laboratory setting and not supported in the online setting.

It was expected that the suppliers would evaluate the systems differently since they reported different feelings about the process and the outcomes. It is possible that suppliers did not "blame" the system because of their outcomes. The results show that the systems were neither considered very good nor very bad. This suggests that there was no difference in their perception of the systems (e.g. user interface, features), which confirms that the systems used in these experiments did not generate confounding effect on the results. However, it is also possible that the suppliers provided positive or negative assessments

solely based on their own outcomes, which may have undermined the differences in system evaluation.

5.4 Comparisons

The analysis and the results of hypotheses testing also indicate potential impacts from: (1) the experimental setting (laboratory vs. online), and (2) the outcomes (winners vs. non-winners of the contract). Thus, further analyses were conducted to examine these effects.

Comparison 1: laboratory setting vs. online setting

The results of experimental setting comparison are also shown in Table 3. They show that the bidders made significantly more bids and greater concessions in the laboratory than online experiments (T1 vs. T3). In terms of the number of offers and total concession, the suppliers in negotiations did not behave differently in the two settings (T2 vs. T4). The transactions were converged significantly faster in the laboratory than in online settings for both auctions and negotiations ($p \leq 0.01$). On average, it took two times longer when the transactions were conducted online.

In terms of the outcomes, there was no significant difference in negotiations in the two settings (T2 vs. T4). In auctions, the buyer's profit was slightly more decreased in the online than in the laboratory setting (66.94 vs. 75.82, $p \leq 0.1$), while the supplier's profit was significantly improved when they worked online (3.94 vs. -7.82, $p \leq 0.05$). On average, the suppliers were able to reach profitable contracts when they were given longer time for the round duration and for the total transaction length. They also achieved more efficient contracts with higher joint gains and outcome equity ($p \leq 0.05$), though the Pareto optimality did not differ from the laboratory setting.

It was also found that the suppliers in auctions reported a higher level of assessment of the process and the outcomes when they were bidding online. There were no significant differences in their assessment of the systems in the experiments, neither in auctions nor in negotiations.

Overall, the results were consistent in the two experiments, whereas the effects of the mechanisms on the process, the outcomes and the assessment were weakened in the online setting. This was expected as stronger effects could be observed in a more controlled setting (i.e. laboratory experiment). It is also possible that the time pressure and competition level were higher in the laboratory setting, which caused

larger concessions from the suppliers in auctions and thus led to worse contracts for them.

Comparison 2: winning suppliers vs. non-winning suppliers

The winning suppliers were awarded the contract and they could have perceived themselves to be more successful than other suppliers (i.e. non-winners). Since the convergence speed and the outcome variables are measured at the transaction level (i.e. an agreement was reached between the buyer and the supplier), they are not applicable to those who did not reach a contract. Thus, the comparison was made of the suppliers' behavior in the process and their assessment of the process, the outcomes and the system.

The winning suppliers submitted greater number of bids/offers than the non-winning suppliers in three treatments: laboratory auction (8.50 vs. 5.41, $p < 0.01$), online auction (5.35 vs. 4.04, $p < 0.05$) and online negotiation (3.58 vs. 2.75, $p < 0.01$). They also made larger concessions than the non-winners did in those three treatments. This indicates that the winners were more actively participating in the transaction and in the competition against other suppliers.

Overall, the winners had significantly more positive assessment of the process, the outcomes and the system than the non-winners did ($p < 0.01$). This suggests that it is the outcomes (i.e. winning or losing the contract) and not the concession-making that affects their assessment. In turn, this may indicate the low payout from making large concessions that result in losses. The only exception was their assessment of the process in the laboratory experiment, which might be due to the shorter time and faster convergence. The results indicate that the suppliers' outcomes indeed affected their perception and evaluation of the transaction process, the outcomes and the systems. When they won the competition and were awarded the contract, they had more positive attitude towards their assessment.

6. Discussion

E-procurement has advanced with the adoption of information technologies and various mechanisms, leading to cost savings, strategic advantages and enhanced business relationships. Effective procurement depends not only on the proper selection of products and services but also on the appropriate

selection and use of mechanisms. Despite a number of general guidelines that have been formulated, there is lack of empirical evidence that can assist and suggest strategic choices of various mechanisms.

Business procurement often involves multiple parties and multiple attributes, which requires advanced market mechanisms. Auctions and negotiations are traditionally two different classes of market mechanisms. With the advancement of information technologies, these two different mechanisms have recently been extended to facilitate and govern such procurement transactions as single-attribute auctions to multi-attribute auctions and bilateral negotiations to multi-bilateral negotiations. This study takes a further step to experimentally compare two mechanisms in e-procurement: multi-attribute reverse auctions and multi-attribute multi-bilateral negotiations. Their differences in the transaction process and outcomes and the suppliers' assessment were investigated in laboratory and online experiments, wherein the same procurement transaction was conducted. Group comparisons were also conducted to further examine the effects of experimental setting, suppliers' outcomes and buyer's behavior.

6.1 Findings and implications

The results from the two experiments are consistent; however, there are some differences between the two mechanisms. The results show that auctions were more efficient and more competitive than negotiations in terms of the process, including the number of bids or offers and the concessions made by the suppliers. Also, auctions outperformed negotiations in terms of the buyer's gains at the expense of the supplier's profit. The contracts reached through auctions were more efficient than those through negotiations in terms of Pareto optimality. However, the buyers and the suppliers reached more balanced contracts in negotiations than in auctions. The suppliers gained more profit in negotiations than in auctions, and they also showed higher assessment of the process and the outcomes in negotiations.

The differences between auctions and negotiations are more significant in the laboratory than in online setting. The results show significant differences mainly in auctions. In the laboratory setting, the suppliers made a greater number of bids and larger concessions, and thus achieved worse contracts and showed a lower level of assessment of the process and the outcomes.

It was expected that the suppliers' behavior and assessment would differ between the winners and

non-winners. Indeed, the results of a group comparison within each treatment show that the winning suppliers were more actively participating in the transactions and competing against others by making more bids/offers with larger concessions. The winners had significantly more positive assessment of the process, the outcomes and the system than the non-winners did.

Several implications can be drawn from these findings. First, advanced auction and negotiation mechanisms can be used for the same e-procurement transactions, wherein the number of suppliers and the number of attributes are extended from the traditional bilateral negotiations and single-attribute auctions. This may also potentially increase the capability of such mechanisms when dealing with more complex supply market and thus become applicable to both “leverage” and “strategic” types of transactions (Kraljic 1983; Handfield and Straight 2003; Gelderman and Van Weele 2005). Also, the two mechanisms demonstrated different effects even in conducting the same transactions. Organizations may use these mechanisms strategically in their procurement management. Auctions are more efficient and foster competition, which can benefit buyers in requesting and receiving proposals from different suppliers, increasing the bargaining power, and thus reaching a better deal. In a shorter period, higher competition and time pressure may lead to overbidding and non-profitable contracts for the suppliers. This may hurt their incentives to participate in such transactions. In a longer period, nonetheless, auctions can still be efficient and lead to profitable contracts for both buyers and suppliers. Negotiations can benefit both sides with profitable and more balanced contracts. This may be of particular concern when the buyer’s goal is not to maximize her profit but to improve social welfare (e.g. in public procurement) (Croom and Brandon-Jones 2005; Subramanian 2009).

Second, the buyer can make reciprocal offers with certain concessions in negotiations and thus lead to higher quality contracts. One distinction between auctions and negotiations is that while auctions focus on economic value (e.g. cost savings, profit gains), negotiations have both economic and social aspects. In auctions, the competition is among suppliers as they bid against each other. The concessions are made merely by the suppliers, thus actions favor the buyer. In negotiations, the competition between suppliers is brought about through the buyer’s involvement. It can be similar to auctions, if the buyer does not make

any concessions; however, the offers or counter-offers made by the buyer often require certain concessions and reciprocity that also benefit the suppliers (Kersten, Vahidov et al. 2013). Taking into account the counterpart's interests in the transactions, the two sides may exchange reciprocal offers and thus reach a more balanced agreement. Mechanism designers and practitioners should note such differences in concession-making between auctions and negotiations.

Moreover, the buyer's different roles can be distinguished and analyzed with respect to the types of information conveyed to the suppliers. In auctions, the information about admissible bids and winning bids is announced to all the suppliers. The information may be implicit in disclosing the buyer's preferences, but it provides sufficient guidance for the suppliers to make progressive bids. It may also lead to higher competition and thus more concessions by the suppliers as it indicates the existence of competitors. Note that the winning bids in auctions provide anchors for suppliers' decision-making in their subsequent bids, which may also direct their attention to inappropriate alternatives. Suppliers should note and avoid such risks by carefully analyzing the information obtained from the buyer through the mechanisms. Buyers may consider other choices in providing feedback information to the bidders, for instance, bid ranking and average value (Adomavicius, Gupta et al. 2012).

In negotiations, the information is private obtained through the communication between the buyer and each supplier separately. The information with message only is not verifiable; the suppliers may hesitate to make offers and concessions based merely on such information. The buyer's offers and counter-offers are not only valid information but they are also reciprocal to the suppliers, which motivates them to make counter-offers with greater concessions. In order to motivate suppliers to submit their proposals, buyers may need to provide more public and verifiable information (e.g. outstanding offers) (Thomas and Wilson 2005) and more clear guidance in directing the suppliers' offers to trade-offs between different attributes. Thus, buyers should behave strategically to convey more influential information in different contexts.

Lastly, user's assessment has been well studied and widely used in assessing information systems and online transactions (Zviran and Erlich 2003). The results from this study confirm that assessment is a multi-facet instrument and can be used to assess e-procurement transaction looking at various aspects. E-

procurement is a unique process that involves two sides and multiple parties. In such a collaborative environment, users' assessment may be influenced by their counterparts and competitors. Procurement mechanisms define the rules that prescribe participants' behavior and their interactions, which may affect their experience and thus assessment of the transactions. It is worth noticing that user's assessment is strongly affected by their performance and outcomes in such transactions. Suppliers who are awarded the contracts through their efforts are more satisfied with the process, the outcomes and the systems.

6.2 Limitations and future research

Several limitations in this study should be noted. This study addresses multi-attribute transactions in e-procurement and thus allows exchange of only complete offers and awarding a contract to one supplier. In practice, it may be feasible and required to have partial offers, multi-sourcing and nested transactions. Future research may extend the present study to compare the variants of mechanisms in those situations. For instance, researchers may consider the relative importance and interdependency of the attributes, which can be used to transform the partial offers to single-attribute or similar multi-attribute transactions.

This study compares auctions and negotiations in e-procurement, considering their differences in information exchange and buyers' participation. In future research, experiments with different controllable information may validate and extend this comparison. For example, buyers in negotiations may only send messages without making any offers, may only make verifiable offers without messages (Thomas and Wilson 2005), or may share the outstanding offers from the suppliers. This will allow for more explicit control and examination of the buyer's behavior in the process.

The transaction task in the experiment is relatively complex and the number of participants in each transaction is small. This may limit the findings to those transactions that involve business contracts with only a few potential and important suppliers. The number of suppliers involved in the process may affect the outcomes (Thomas and Wilson 2002). A comparison of the impact of the number of suppliers on the auction and negotiation outcomes was not conducted because of the small sample size. Future work may replicate the experiments and control the number of suppliers in each transaction.

Two experiments were carried out to enhance the internal and external validity of this study. The

participants were university students who study information systems in business programs. Advantages and disadvantages of this type of studies have been discussed widely in e-business literature(Jiang and Benbasat 2007). Future research may validate the hypotheses and findings with a field study where business professionals use similar systems in real-life transactions.

Tables

Table 1. Empirical studies comparing auctions and negotiations

Study	Mechanisms	Findings
<i>Experimental studies</i>		
Thomas & Wilson 2002	First-price auction, Multi-bilateral negotiation	No difference in transaction price with 4 sellers; Auction outperforms negotiation with 2 sellers; No difference in efficiency.
Thomas & Wilson 2005	Second-price auction, Multi-bilateral negotiation	Lower transaction prices in negotiations; No difference in efficiency.
Gerke & Stiller 2006	Auction, Bilateral negotiation	Auction outperforms negotiation in welfare maximization, fairness of welfare distribution, and effort.
Gattiker et al. 2007	Auction, F2F negotiation, Email negotiation	Seller's trust decreased from F2F negotiation, to email negotiation and then to auction; In a task with greater complexity, seller's trust decreased in auction, but increased in e-mail negotiation.
<i>Field studies</i>		
Bajari et al. 2009	Auction; Negotiation	Auctions may perform poorly with complex projects, incomplete contractual design and few available bidders; Negotiations have advantages when contracts are ill-defined a priori, and they facilitate discussion and clarification of the problem.
Kaufmann & Carter 2004	Auction; Negotiation	Auctions can and should be used when: items with high specificity and attractiveness, a large number of suppliers having a high degree of rivalry, and a higher level of trust in the process/system and a lower level of unethical activities.

Table 2. Experimental design and treatments

Mechanisms	Experiment 1 (Laboratory setting)	Experiment 2 (Online setting)
Auction	Treatment 1 (T1)	Treatment 3 (T3)
Negotiation	Treatment 2 (T2)	Treatment 4 (T4)

Table 3. Comparison of the process, the outcomes and the assessment

	Experiment 1		Experiment 2	
	T1	T2	T3	T4
Process				
No. of bids/offers	6.61 ^{##}	3.57	4.72 [^]	3.40
Total concession	60.89 ^{##}	23.08	46.05 [*]	25.91
Convergence speed	21.97 ⁻	19.15 ⁺	47.76	53.67
Outcomes				
Buyer's profit	75.82 ^{*-}	47.13	66.94 [*]	52.61
Supplier's profit	-7.82 ^{*+}	23.39	3.94 [*]	19.92
Allocative efficiency	62.26 ^{*+}	30.94	50.71 [*]	33.25
Pareto optimality	0.50 [*]	13.57	0.76 [*]	11.58
Joint gain	-763.50 ^{*+}	916.57	-218.06 [*]	935.74
Outcome equity	-0.06 ^{*+}	0.68	0.35	0.45
Assessment				
Process	3.52 ^{*-}	4.19	3.83	3.95
Outcomes	2.93 ^{##}	3.73	3.68	3.39
System	3.63	3.88	3.84	4.06

*Note: (1) numbers are mean values; (2) significance when comparing auction to negotiation (T1 vs. T2, T3 vs. T4): * $p < 0.01$, ^ $p < 0.05$; and, (3) significance when comparing laboratory setting to online setting (T1 vs. T3, T2 vs. T4): # $p < 0.01$, + $p < 0.05$, - $p < 0.1$.*

Figures

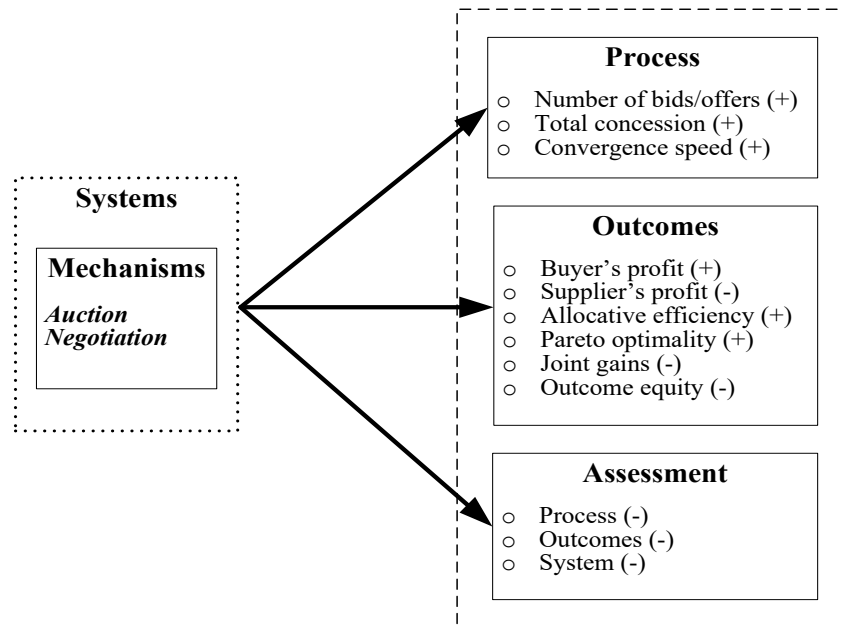


Figure 1. Research model

Note: “+” indicates a positive effect and “-” indicates a negative effect, when comparing auction to negotiation.

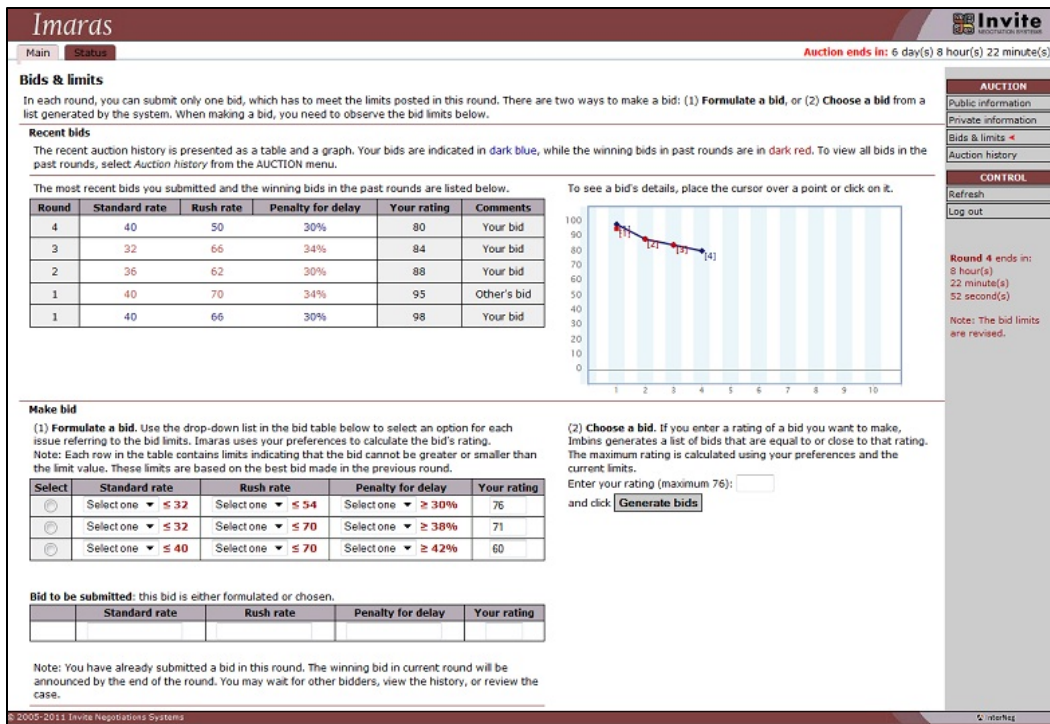


Figure 2. Screen of “Bids & Limits” after several rounds in Imaras

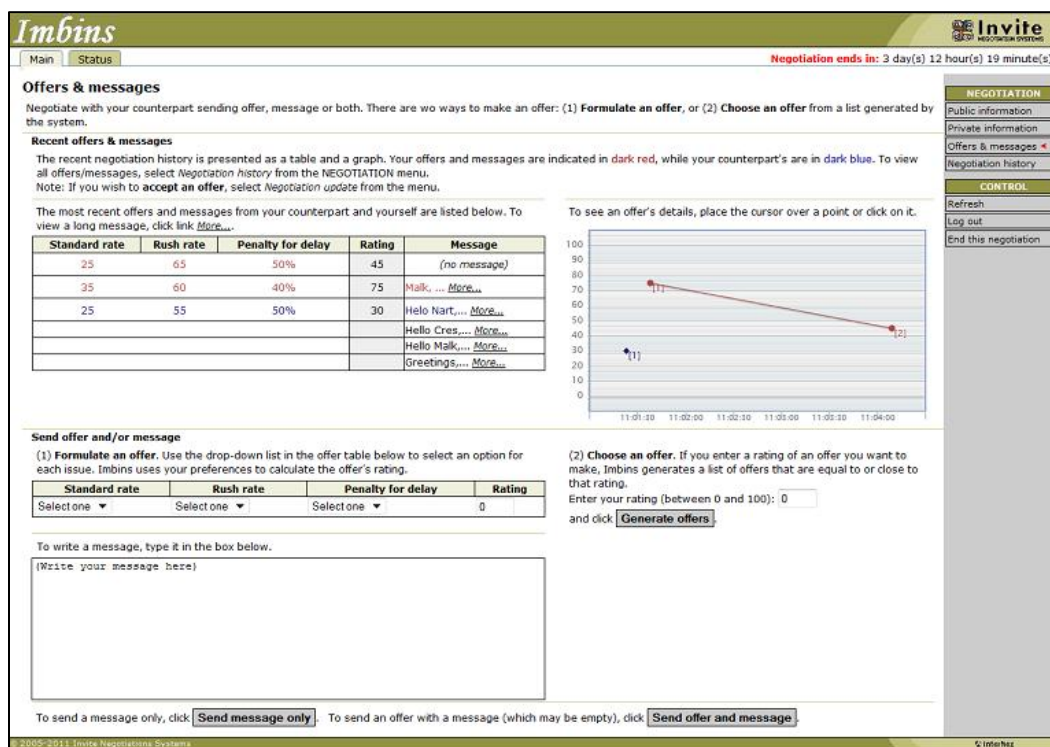


Figure 3. Screen of “Offers & messages” for the supplier in Imbins

Appendices

Appendix A: Measurement of process and outcomes

Table A-1. Variables and measurement of process

Variables	Measures and scales	Relevant studies
Number of bids	Individual level: The total number of bids submitted by each individual. Transaction level: The total number of bids submitted by all the participants in the same auction. (<i>Scale: integer number greater or equal to 0</i>)	(Bichler 2000; Koppius and Heck 2003; Jap and Haruvy 2008)
Number of offers (with /without message)	Individual level: The total number of offers made by each individual. Transaction level: The total number of offers made by all the participants in the same negotiation. (<i>Scale: integer number greater or equal to 0</i>)	(Kersten and Noronha 1999; Vetschera et al. 2006)
Concessions	The value change between bids or offers made by the same party. The value is the revenue of the proposed contract with a rating scale of 0–100. The suppliers' total concession is the value change between their first bid/offer and their final bid/offer. This indicates how much value the suppliers have compromised through the transaction. (<i>Scale: integer number between 0 and 100</i>)	(Nastase 2006; Vetschera 2007; Johnson and Cooper 2009; Wachowicz and Wu 2010; Whitford et al. 2011; Kersten et al. 2013)
Convergence speed	The amount of time to close the transaction with or without an agreement (i.e., actual interaction time) divided by the announced time length. It indicates how fast a transaction converged or reached a result. (<i>Scale: percentage between 0 and 100%</i>)	(Koppius et al. 2000; Koppius and Heck 2003)

Table A-2. Variables and measurement of outcomes

Variables	Descriptions and scales	Relevant studies
Buyer's profit	The difference between the buyer's revenue of the contract and her break-even point. (<i>Scale: integer number between -100 and 100</i>)	(Bichler 2000; Koppius and Heck 2003; Chen-Ritzo et al. 2005; Strecker 2010)
Supplier's profit	The difference between the winning supplier's revenue of the contract and her break-even point. (<i>integer number between -100 and 100</i>)	
Allocative efficiency	The deviation of the achieved contract from the Nash solution (i.e. alternative which maximizes the product value of the buyers' and winning supplier's profits). It is calculated with the Euclidean distance between the product value of an achieved contract and the Nash solution. It indicates the distance from the contract to the best possible deal in the utility space. The smaller the value, the more efficient the contract. (<i>Scale: real number between 0 and 100</i>)	(Koppius, Kumar et al. 2000; Koppius and Heck 2003)
Pareto optimality	The number of alternatives that dominate the achieved contract to the Pareto frontier (i.e., number of solutions that are even better for both the buyer and supplier, comparing to the contract they reached). It indicates the possible decision space that the buyer and supplier may explore or improve to gain more value for both. The smaller the value, the higher efficient the contract and the smaller room for contract improvement. (<i>Scale: integer number between 0 and 3375</i>)	(Koppius, Kumar et al. 2000; Koppius and Heck 2003)
Joint gains	The product of the buyer's profit and the winning supplier's profit based on the contract, which indicates the social welfare for both sides from the achieved contract. The larger the value, the greater the social welfare for both the buyer and supplier. (<i>Scale: integer number between -10000 and 10000</i>)	(Weingart et al. 1993; Foroughi et al. 1995; Gerke and Stiller 2006; Strecker 2010)
Outcome equity	The division of the winner's profit over the buyer's profit based on the contract, which indicates the contract balance between the two sides. The closer the value to one, the higher equity the contract. (<i>Scale: real number between -100 and 100</i>)	(Croson 1999; Foroughi et al. 2001; Gerke and Stiller 2006; Whitford et al. 2011)

Appendix B: Questionnaires

Table B-1. Pre-experiment questionnaire

	Items and scales	Relevant studies
Task complexity	Understanding of the case I just read was ... Based on the case description, I expect the contracting task to be ... (7-point Liker scale, "Very difficult" to "Very easy")	(Gattiker et al. 2007; Bellosta et al. 2008)
Aspirations levels	After reading the case, what agreement/contract do you think you will reach? (list of values for each attribute)	
Reservation levels	What is the worst offer that you think you may still accept? (list of values for each attribute)	

Table B-2. Post-experiment questionnaire

	Items	Questions and scales	Relevant studies
Assessment of process	AP1 AP2 AP3	It was easy to keep track of the process. The organization of process in phases and steps was useful. This process was stimulating. (7-point Liker scale from "Strongly disagree" to "Strongly agree")	(Curhan et al. 2006; Wang et al. 2010)
Assessment of outcomes	AO1 AO2 AO3	I am satisfied with the results that I achieved. I am satisfied with the results as compared to my expectations. I think I obtained the best results for the company that I represent. (7-point Liker scale from "Strongly disagree" to "Strongly agree")	
Assessment of system	AS1 AS2 AS3	The system was helpful in achieving my objectives. The system was helpful in improving my performance. The system was helpful in managing the process. (7-point Liker scale from "Strongly disagree" to "Strongly agree")	(Vetschera et al. 2006; Wang et al. 2010)

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