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Auctions and Negotiations in Transportation Service Procurement

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Abstract

Auction and negotiation are two typical mechanisms used for the procurement of goods and services. Many experimental studies have been conducted to compare the performances of these two mechanisms and gain insights to support their selection. However, research does not seem to have given adequate attention to the influence of the application context and the importance of conducting the experiments under conditions resembling real-life situations. This paper discusses an on-going research project aimed at comparing auction and negotiation mechanisms for transportation service procurement. Discord Laboratory and online experiments are designed to investigate the impacts of the mechanisms and the roles of task complexity and information technologies on the procurement process and outcomes. The potential contribution is to provide guidelines for appropriate design and selection of the transaction mechanisms.

Keywords: logistics procurement, auction and negotiation, task complexity, information technologies, experimental study.

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1. Introduction

The three typical exchange mechanisms in goods and services procurement are catalogue, auction, and negotiation. Internet popularized auctions which moved from narrow markets, such as art and diamonds, to all types of products and services. This popularity together with formal studies in auctions led to claims that auctions are superior to negotiations (Beam et al. 1997).

Bulow and Klemperer (1996) have shown, in one of the first formal comparative studies, that an English auction with $n + 1$ participating bidders (buyers) always yields higher revenue than a scheme they call “negotiation with n participants”. Because there may be no reason to have fewer bidders than negotiators, this implies that bilateral and multi-bilateral negotiation (i.e., negotiation between one seller and n buyers or vice versa) cannot yield better results than auctions. Kirkegaard (2004) revised Bulow and Klemperer’s theory (1996) and included non-cooperative bargaining but had a very impoverished communication protocol. Manelli and Vincent (1995) show that the effects of auction and negotiation would vary according to the situations; it is difficult to judge the effect of these two mechanisms on a given transaction without the 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 their research is that auction mechanisms are frequently inefficient in a procurement environment, which contradicts the two previous studies. In addition, these and other formal analyses are based on a set of assumptions that may not occur in real-life situations (e.g., uniform distribution of bidders’ values).

Thomas and Wilson (2002), in their experimental study of first-price auction and multi-bilateral negotiation found that transaction prices are statistically indistinguishable in these two mechanisms. They also reported that when there are few sellers, then the mechanisms are equally efficient, but when the number of sellers increases, multi-bilateral negotiation becomes more efficient. Thomas and Wilson (2005), in a more recent paper, report results from their experiments of second-price auction and verifiable multi-bilateral negotiations, non-verifiable multi-bilateral negotiations, and first-price auctions.

These and other results of formal, experimental and field studies (Kugler et al. 2006; Leffler et al. 2006; Fluck et al. 2007; Bajari et al. 2009) do not provide a clear-cut answer. One reason is the different understanding of the negotiation. In some studies the negotiations are bilateral and only when one bilateral negotiation fails, the parties may move to another negotiation with different parties (e.g., Kugler et al. 2006). In other studies the negotiations are multi-bilateral but the negotiator on the single-party side may not interact with the negotiators on the n -party side simultaneously (typical for face-to-face but not for online environments).

In studies that involved experiments the mechanism was a single attribute (price). This may be a necessary simplification but it places negotiation at a comparative disadvantage. Experiments in which the bidders (sellers) were given the utility (value) function of the buyer show that multi-attribute auctions do not provide substantial benefits over comparable single-attribute auctions (Bichler 2000). In other words, even with fully-revealed utilities the additional complexity outweighs the theoretical gains. The strength of negotiations, as the comparative field studies indicate (Leffler et al. 2006; Bajari et al. 2009), is the ability to handle complex and

multi-attribute problems effectively.

Both formal and experimental studies did not consider context and the possibility of information-rich communication. The exchanges involved solely information about the issue, thus preferences, side-deals, commitments or threats were not possible. The experimental studies used feature-poor and very simple systems that did not resemble mechanisms implemented in e-marketplaces. This allows for the comparison of mechanisms but not for the comparison of their use in concrete real-life situations; generalization of the results is very limited.

The unclear and, in some cases, contradictory results of formal and experimental studies did not prevent researchers from formulating prescriptions regarding the use of auctions and negotiations in business transactions. Larson (2005), Handfield (2003) and others suggest the use of auctions for the procurement of simple goods and services which have low priority for the buyer. Further, auctions are preferable when there are many sellers and the buyer does not need to establish a good and lasting relationship with the supplier(s). The negotiation mechanism should be used to procure complex goods and services which are critical for the buyer, who needs to establish a long term relationship. These prescriptions appear to be rational and they can be justified by a few existing field studies. We do not know, however, whether they are applicable to different situations and reflect various buyers' needs. For example, they are based on the use of a single-attribute rather than multi-attribute auctions. Experimental studies under the conditions resembling realistic situations would allow for a better justified recommendation regarding the conditions of mechanism selection.

This paper discusses an on-going project of an experimental comparison of auction and negotiation mechanisms embedded in software and used online for transportation service procurement. Our purpose is to conduct experiments in settings which resemble real-life situations in e-business; this includes both the transaction and its context, and the software used for the purposes of participants' interactions. While both auctions and negotiations are conducted online, the negotiation participants can, if they wish, use rich communication in their interactions. The problem is situated in an e-business context to allow the participants to engage in meaningful interactions. Furthermore, the information systems used for both auction and negotiation are similar to the ones that are deployed for real transactions.

The focus of this study is threefold: 1) the comparison of the outcomes obtained from the use of different transaction mechanisms; 2) the analysis of the influence of different levels of task complexity; and 3) the examination of the impact of different information and communication technologies (ICTs) supporting mechanisms implementation to fulfill the tasks. The potential contribution is to provide general guidelines for appropriate design and selection of market mechanisms in transportation service procurement. Section 2 briefly describes this application domain. The research framework is introduced in Section 3, followed by the research design in Section 4. The preliminary results and future research are discussed in Section 5.

2. Procurement of Logistics Services

The application domain of this study is the procurement of logistics services, which represents a major quota of companies' service costs. The logistics sector has lately been going through

relevant modifications: growing economic impact due to globalization, pervasive use of ICTs, emergence of new and specialized actors as well as consequent new forms of inter-firm organizations, growing importance of logistics with respect to providing value in the hand of the final customer, so impacting on the competitive advantage. Increasingly buyers demand advanced services (Andersson et al. 2002), namely bundles of multiple services or value-adding logistics solutions (e.g., integrated transportation and warehouse management, supply chain inventory management, and reverse logistics).

Typically logistics solutions are characterized by a high level of intangibility of the involved resources, processes, and outcomes (Table 1) (Andersson et al. 2002; Giannoccaro et al. 2009). More intangible elements are: knowledge and competencies embedded in resources, design of operation processes, and future concepts of how to achieve competitive advantage. More tangible elements are equipment, such as type and number of trucks or warehouses, work instructions involved in logistics activities, and measures of logistics performances, such as lead time or inventory level.

Due to logistics services innovation and development, the relationship between buyers and suppliers has changed over time, the approach moving from competitive to collaborative. Competitive approaches are mainly adopted for spot purchases; the focus of the relationship is on the efficiency of the transaction and the price is considered as the main leverage. Conversely, the procurement of advanced services involves collaboration, information and data sharing, risks and rewards sharing, and joint investments in facilities and equipment, namely logistics partnerships (Berglund et al. 1999; Skjoett-Larsen 2000).

Table 1. Tangibility of resources, processes, and outcome in logistics service definition.

Level of intangibility	Resources	Processes	Outcome
Low	Equipment	Work instructions	Logistics performances
High	Knowledge, competencies	Processes design	Future concept

The effectiveness of a logistics partnership heavily depends on social commitment and mutual trust (Seliviaridis et al. 2007). Logistics partnerships are also characterized by a high level of complexity of organizational phenomena (Vickery et al. 2004) due to the uncertainty and difficulty of organizational tasks and the interdependence between partners (Daft et al. 1984). Therefore, the issues of forming and/or maintaining relationships need to be considered irrespective of the exchange mechanism used.

As a result, much and increasing emphasis has and needs to be given to improve logistics processes. Despite this, to our knowledge not much research has applied laboratory experiments to analyze the performance of transaction mechanisms in procurement processes and in the general field of operations and supply chain management. To a greater extent, few studies are available that emphasize the procurement of logistics services, which indeed is a major component of logistics process.

In the operations and supply chain management literature Gattiker et al. (2007) highlight that a supplier's trust in a buyer is an important outcome of both traditional face-to-face and computer-mediated mechanisms. They analyze trust variation under different procurement conditions, which depend on the type of sourcing mechanism and the complexity of the procurement situation. Their study reveals that in reverse auctions the levels of trust are lower than in both face-to-face and e-mail negotiations, and higher levels of trust in reverse auctions are observed when the procurement complexity is low. Carter and Stevens (2007) analyze suppliers' perception of the buyers' opportunistic behavior under different auction's configurations, which depend on the level of price visibility, the number of suppliers, and the suppliers' need for the contract: suppliers' perception of the buyers' opportunism is higher when the auction shows suppliers' relative ranks (rank-based visibility auction) rather than the current lowest bid (bid-based visibility auction); higher perception of opportunism is associated with higher competitive scenarios, i.e. higher number of suppliers participating in the auction. Other field studies (Jap 2003; Jap 2007) provide empirical evidence that reverse auctions result in suppliers' higher perception of the buyers' opportunism than traditional sealed bid formats do.

Acknowledging this literature gap (lack of research based on laboratory experiments devoted to assess the adoption of diverse transaction mechanisms in logistics procurement), we empirically study the auction and negotiation mechanisms in the procurement of transportation as a significant example of logistics service.

3. Research Framework

In e-business and supply chain management, the choice of auction or negotiation may not be determined solely by the mechanism's economic performance. If the difference between transaction costs is small, the parties may decide based on other mechanism's attributes, which may, for example, concern its efficacy and ease of use or issues related to the relationship building. This may be particularly the case when the procurement is frequent as well as when each side may be interested in the establishment of a long-term relationship, so that frequent changes and uncertainty associated with them are avoided.

3.1 Times Framework

The Times framework (Kersten et al. 2008) proposes that the configurations and interactions of tasks, individuals, mechanisms, environment, and systems through which these entities and components produce value for and establish relationships between the participants (individuals). The model, illustrated in Figure 1, can accommodate continuity in the key design principles of the mechanisms, as opposed to considering them as distinct classes.

The dependent constructs describe outcomes at three levels: individual, transaction, and market. The outcomes at the individual and market levels influence the transaction outcomes.

- There are two types of individual outcomes: objective and subjective. Objective outcomes are substantive and they include value of the attributes, utility value, and time spent on the transaction. Subjective outcomes include relational outcomes (e.g.,

trust, friendliness and affect) and perceptual outcomes (e.g. system assessment and different types of satisfaction).

- Transaction outcomes describe the impact on the transaction level, including transaction efficiency (e.g. time spent to achieve agreement, total number of bids) and transaction results achieved by all participants of a single transaction (e.g., joint outcome).
- The third type of results emerging from the use of exchange mechanisms describes the mechanism and its economic performance (e.g., allocative efficiency, social welfare). It also concerns here the impact of different mechanisms on the service providers and the buyer side respectively (e.g. winners among the providers and their performance).

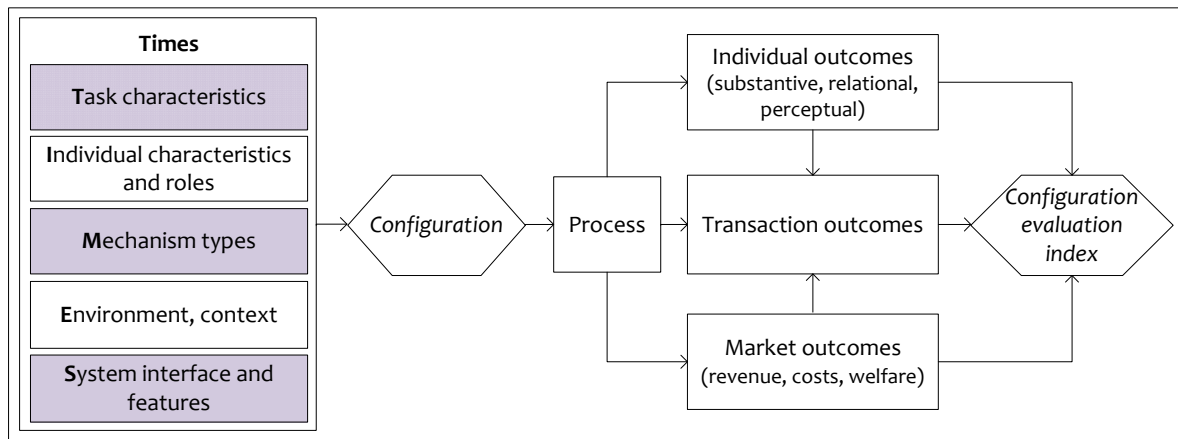


Figure 1. The Times framework and selected independent constructs

These three types of outcomes are achieved through the transaction process (i.e. negotiating and/or bidding), which composite an index in evaluating different configurations of the independent constructs (i.e. tasks, individuals, mechanisms, environment and systems). High level or value of the index indicates a “fit” among these factors, i.e. they conditionally and jointly lead to an efficient and effective exchange process and outcome; otherwise, it indicates a “misfit” which would lead to a bad performance. Note that transaction process can involve up to three phases in which participants undertake different types of activities (Benslimane et al. 2005; Kuruzovich et al. 2008): the pre-exchange phase, in which participants mainly discover their needs and search product/service information from the market; the exchange phase, where people negotiate on proposals/offers to explore values and reach deals; and, the post-exchange phase, in which the transaction is settled and fulfilled with payment and shipping.

There are five types of independent constructs in the Times framework, which affect the transaction process and outcomes.

The task characteristics, which are the specifics of the transportation service, include the service attributes (Section 2) and certain general information about the transaction problem. The task characteristics impact on the task complexity, which depends on the following aspects:

1. The number of attributes and their possible values;

2. Level of intangibility of the service attribute, which may vary from low to high;
3. Measurement of the attribute, which converts the attribute value to a component of the utility function (this function may be monotonic or achieve local maximum within the set of possible attribute values);
4. The type of utility function (e.g., additive, multiplicative, and polynomial); and
5. The relationship between the attribute value for the owner and the value for the bidders (e.g., both sides may have the same preference direction for one attribute; or the attribute value measure may achieve its maximum in different points for the bidder and for the owner).

The second type of independent constructs describes experiment participants and their roles. Role descriptions include the characteristics of the service providers discussed in Section 2. In many business transactions these characteristics affect both the process and outcomes. Negotiations explicitly allow for the consideration of, and discussion about, issues which are not associated with the transaction object. Recently, this consideration has also been proposed in, so called, *negotiauctions* (Teich et al. 2000; Teich et al. 2001), which combine auction and negotiation mechanisms. The mechanisms, which are used in the study, are discussed in Section 3.2.

The next construct concerns environmental and contextual factors, such as market competition level and recession. Also, the types of market (e.g. buyer's market or seller's market) and the number of potential suppliers in the market both affect the transaction processes and outcomes. In our study, these types of factors are controlled.

Lastly, the mechanisms are implemented in information systems with various ICTs. The systems may have different features and user interfaces (e.g. analytical support, visualization support), which comprises the fifth type of independent constructs. The systems are discussed in Section 3.3.

3.2 Auctions, Negotiations and Hybrid-mechanisms

We consider three types of exchange mechanisms: 1) a limited-information multi-attribute English auction; 2) a multi-bilateral multi-attribute negotiation; and 3) a buyer-determined multi attribute English auction. These mechanisms all support exchanging multi-attribute offers in the form of packages (i.e. a set of service attributes).

The limited-information multi-attribute English auction allows multiple-bid submission, while the buyer's preference structure is not directly revealed to the bidders (i.e. service providers). Once a successful bid is submitted, it will be evaluated according to the buyer's value function and then either listed in order (if acceptable) or discarded. In this way, the buyer's preference structure is indirectly revealed through the current best offer and the reservation level.

The multi-bilateral negotiation mechanism has a similar process in which the service providers submit multi-attribute offers to the buyer simultaneously and a similar way to reveal the buyer's preference structure; however, the buyer is also allowed to communicate with the service providers on their offers.

Finally, in the buyer-determined multi-attribute English auction, suppliers bid on the service

attributes in the same way as the limited-information auction described above. Moreover, the buyer reserves the right to determine the winning supplier based on a value function that includes other attributes—unknown by the bidders—which may be important to the buyer. These attributes typically include information describing the service providers’ characteristics (e.g. past experience and financial performance). Thus, once a bid is submitted it will be evaluated taking into account both the value of service attributes contained in the bid and the providers’ characteristics evaluated by the buyer.

3.3 Invite Platform and its Systems

The Invite software platform is capable of supporting multiple negotiation and auction mechanisms and can generate a class of systems with configurable features and user interface. These systems can be configured with various features using different ICTs, for instance, analytical support (i.e. preference elicitation, offer comparison and analysis), communication support (e.g. messaging) and visualization support (e.g. graphical display of preference and negotiation process).

Users of the systems in which the exchange mechanism are implemented may have difficulties in distinguishing the impact of the interface from the implemented tools and mechanisms. Therefore, in order to study both the impact of the embedded mechanisms in the systems and the impact of the ICTs used to implement the mechanisms, we built and configured three systems to: 1) support and compare the selected mechanisms (i.e. English auction, buyer-determined auction, multi-bilateral negotiation) with very similar user interface; and 2) support and compare the systems features and user interface across selected mechanisms (i.e. analytical support, visualization support, communication support). Table 2 summarizes the systems design.

Table 2. The system design across selected mechanisms

	Auction system (InAuction)	Buyer-determined auction system (BD-Auction)	Multi bilateral negotiation system (Imbins)
Analytical support	<ul style="list-style-type: none"> • Preference • Offer/Bid 	<ul style="list-style-type: none"> • Preference • Offer/Bid 	<ul style="list-style-type: none"> • Preference • Offer/Bid
Visualization support	<ul style="list-style-type: none"> • Preference • Offer/Bid 	<ul style="list-style-type: none"> • Preference • Offer/Bid 	<ul style="list-style-type: none"> • Preference • Offer/Bid
Communication support	<ul style="list-style-type: none"> • No 	<ul style="list-style-type: none"> • One-way • After auction 	<ul style="list-style-type: none"> • One-way • Through the process

4. Research Design

This study focuses on the three selected constructs, while the individual characteristics (e.g. demographics, conflict mode) and roles (i.e. buyer, suppliers) are controlled. The preliminary experimental design is derived from this choice (See Table 3).

Taking into account the transaction process, a 2-phase model (the pre-exchange phase and the exchange phase) will be used to distinguish and control the effects of the factors across

transaction phases on the outcomes. More specifically, we examine whether the performance of the participants/mechanisms would be affected if they discover their own needs or if they are given the preference structure. This is manipulated by two settings in the experiments (Table 3): 1) the participants elicit their own preference structure in the pre-exchange phase, and then they negotiate/bid using this structure in the exchange phase; and 2) the participants are given the preference structure and they directly engage in the exchange phase.

Table 3. The experimental design

	The pre-exchange phase	The exchange phase
Task complexity	Choice set size (high vs. low) Intangibility of attributes (high vs. low)	Choice set size (high vs. low) Intangibility of attributes (high vs. low)
Mechanisms	Preference structure (elicited vs. given)	English auction Multi-bilateral negotiation Buyer-Determined auction
ICTs	Analytical support Visualization support	Analytical support Visualization support Communication support

There are two stages in this study. In the first stage, we conduct laboratory experiments in which the mechanisms, task complexity, and ICTs are manipulated to investigate their impact on the individual behaviors, perceptions and market outcomes. In the second stage, we run online experiments with the same manipulations in order to generalize the findings in Stage 1 and to establish a real-life setting. In this study, two other factors are controlled: the individual characteristics and roles, and the environment and context.

4.1 Mechanisms and Systems

The experiments involve the three mechanisms described in Section 3.2: the limited-information multi-attribute English auction, the multi-attribute multi-bilateral negotiation, and the buyer-determined multi attribute English auction.

As illustrated in Section 3.3, the similar user interface configuration in the three systems allows us to reduce the potential impact of the systems in term of users' "look and feel" on the process and output, and thus focus on the impact of the mechanisms. In InAuction, the providers bid with each other and the system automatically lists and orders the acceptable bids according to the buyer's preference in a table format; thus, no human agent is needed to act as the buyer. In Imbins, however, as it allows the buyer to communicate with the service providers, a human agent will be involved. The buyer can send free-text messages to one, two or all the three providers discussing their offers; nevertheless, the buyer cannot exchange offers with the providers. Moreover, the bidding process is also available to all the bidders in a graph format, which depicts three dot-lines presenting the values from the current bidder's perspective (i.e. value is calculated based on the viewer's preference structure). This demonstrates the bidding behavior/strategy of other bidders, and it may also indirectly reveal the preference structure of other bidders.

In the pre-exchange phase, the preference structure of each party is either elicited by the

participants themselves or given with the designed 'value function' on behalf of the providers. When it is elicited two different user interfaces are provided: an attribute-based display, which shows the attributes and the optional values; and an alternative-based display, which shows different service packages composited with certain optional values for each attribute. The former provides an analytical approach to discover participants' needs and preferences, while the latter gives a holistic view of different packages. Thus, the preference structure can be elicited using ratings of the attributes and rankings of the packages, respectively (Kamis et al. 2008).

In the exchange phase, the manipulation of the system features is across the three exchange mechanisms, on different ways of offer construction and messaging support (Table 2). Literature indicates that comprehensive tasks require visualization support while analytical tasks can be better performed with tabular representation (Vessey 1991; Huang et al. 2006). Bidding on price only is an example of comprehensive or holistic approach to constructing offers, where merely one value point (price or utility value) is concerned. In contrast, negotiations usually involve discussion and argument of one attribute within an offer package. Tables provide details of the composition of the offer and can be easily used to compare/analyze the differences between offers.

4.2 Tasks: Procurement of Transportation Services

The transaction is undertaken directly between transportation service providers and client (buyer), i.e. no mediator or other third-parties involved. With their different roles, the parties have different concerns on the issues or service attributes to be negotiated and the criterion in determining the winner. The same numbers of parties are involved in the transaction for the auction and multi-bilateral negotiation settings, i.e. one buyer and three service providers. In the auctions, the providers bid with each other and the system automatically order the bids according to the buyer's preference structure or value function; thus, no human agent is needed to act as the buyer. In the negotiations, however, as it allows the buyer to communicate with the service providers, a human agent is involved.

We characterize the transportation service by several attributes. Table 4 illustrates the attributes and the possible options for each attribute.

In addition, in the buyer-determined auction we need to include information describing service providers, such as:

1. Past experiences and/or external opinions about each supplier which may impact interactions and affect the decision, for example, the willingness to establish long-term relationships;
2. Financial performance of the suppliers which may affect their continuity of service and regular improvement of equipments and service;
3. The geographical coverage of the supplier which may create access to a new market for the buyer; and
4. The capability of the supplier to provide value-adding services and to ensure the continuity of the service provision.

Table 4. Service attributes and options for bid determination

Service attributes	Description	Options
Price	Transportation price for a total quantity	10,000; 10,100; 10,200; 10,300 (dollars)
Delivery frequency	Frequency of deliveries within the supply period (time interval)	5; 7; 10; 15 (days)
Flexibility on order quantity	Flexibility on total freight quantity	1%; 5%; 10%; 15%
Warranty	Warranty conditions on freight damage	Less than 1%; less than 3%; less than 5%
Reliability on service level	Percentage of delivery guaranteed on time	At least 90%; at least 93%; at least 95%; at least 97%; 100%

One of the objective of this study is to observe the relationship (if any) between task complexity and outcomes. The task complexity manipulated in the experiments depends on the following two aspects: 1) the choice set size, which is determined by the number of attributes and the number of options for each attribute; and 2) the level of intangibility of the attributes.

Table 5. Levels of intangibility of service attributes.

Level of intangibility	Transportation service attribute	Description
Low	<ul style="list-style-type: none"> • Transportation quantity • Mode of transportation • Transportation lead time 	<ul style="list-style-type: none"> • Total quantity to be transported • Full truck load or Less-than-Full truck load • Time needed to carry out the transportation from buyer location to distributor/final customer location
High	<ul style="list-style-type: none"> • Flexibility • Reliability • Responsiveness 	<ul style="list-style-type: none"> • Possibility to change order details • Ability to perform the service dependably as promise • Willingness to help customer and capability to respond immediately to customer requests

The two aspects are both due to the nature of the transaction task, i.e. the attributes to be negotiated. The choice set size is determined by the number of attributes and the number of options for each attribute. The higher/bigger the size the higher level of task complexity because more information requires to be handled, which increases cognitive load (e.g. Kamis et al. 2008). The level of intangibility stands for the inherent difficulty to measure a given service attribute with respect to a certain mechanism. For instance, it could be difficult to define an index to measure the time or quantity flexibility to handle a transportation order through an auction, whereas it could be less difficult to deal with it through a negotiation. Table 5 classifies different service attributes according to their level of tangibility.

5. Discussion

This paper presents an ongoing research on the role of task complexity, transaction mechanisms, and information technologies in logistics services procurement. We aim at formulating guidelines for design and selection of mechanisms in transportation service procurement. We expect that the three mechanisms will have different impacts on the transaction process and outcomes. A preliminary experiment was conducted in which two mechanisms were manipulated (limited-information auction and multi-bilateral negotiation) and the task complexity and system features were controlled (Yu 2007). The results show that mechanisms alone have no significant effect on the economic outcomes. Nevertheless, the mechanisms did affect the participants' perceptions in assessing their own outcome and performance. This may imply that relying purely on economic outcomes may mislead participants in evaluating and selecting transaction mechanisms.

The innovative approach in our research concerns the adoption of behavioral laboratory experiments in the specific domain of logistics. More laboratory research has been called for by scholars in the context of supply chain management (Bendoly et al. 2006); however, only few studies have analyzed the impact of different mechanisms on buyer-supplier relationships (e.g., Carter and Stevens 2007; Gattiker et al. 2007). Moreover, focusing on logistics service allows the effect of task complexity on both economic and relational outcomes to be examined.

Future work will concern experiments to compare the buyer-determined auction mechanism with the other two. Different levels of task complexity and system design will also be manipulated. This will allow us to analyze the impact of different configurations of markets on the transaction process as well as outcomes in a real life situation—transportation services procurement.

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