Migration toward Market Institutions: Linking Auction and Negotiation in a Laboratory Setting*

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Abstract

In a laboratory setting with two separate trading institutions and identical supply and demand conditions, ascending auctions favor seller earnings and repeated negotiations favor buyer earnings. Linking these market institutions, in which auction precedes negotiation or vice versa, counteract these tendencies in relative earnings. Prices in the linked setting converge to levels between those paid in auction or negotiation as separate institutions. A networking externality model can explain this behavior. Linked markets alleviate costs associated with unsold inventory or selling previously produced units at a loss, and they improve quantities sold and total welfare compared to auction or negotiation alone.

Key Words: Negotiation, Auctions, Linked Markets, Experiments

JEL Codes: C91, D02, D44, D47
I. Introduction

Market institutions define the economic interaction between buyers and sellers. They establish the rules of trade that ultimately determine economic performance inherent in commerce (North 1991; North 1994). Ronald Coase (1960) argues market institutions matter because they determine, in general, the relative gains of buyers and sellers. The new institutional economics literature studies how institutions and institutional changes determine the collective benefits from coordinated or cooperative behavior (Rutherford 2001). Very often market participants have a choice regarding which institution to conduct their business. By their presence or absence, buyers and sellers can influence the success of a market institution.

Trading agents choose to participate in market institutions that best serve their interests. Sellers usually earn more through an ascending auction (Menkhaus et al. 2003; Bulow and Klemperer 2009). By way of comparison, if there are many sellers, buyers gain from a posted price market institution that is competitive. Indeed, this is the very model of a perfectly competitive market where sellers just break even and consumer surplus is maximized. Another prominent market institution is negotiation; many commodities are sold through negotiations. As a market institution it can favor the earnings of buyers when the sale of items is repeatedly negotiated (Muthoo 1999, Chapter 10) and when sellers must hold inventory before they can trade (Menkhaus et al. 2007).

Institutions are often linked through simultaneous or sequential trading activity. Agents have the option of trading in an auction or negotiating a transaction; often they can operate in both institutions at the same time or sequentially move from auction to negotiation or negotiation to auction. Vendors on eBay for example can effectively negotiate sales through “best-offer”
Buyers and sellers are allowed a limited number of counteroffers before negotiations are ended.¹ Those units not sold through negotiation can then be auctioned. Televised auto auctions attempt to sell vintage inventory through an English auction. If the reserve is met, the auctioneer makes the announcement that the reserve is off, effectively saying that the auto will be sold through the auction institution. But if bidding ceases before the reserve is met, the vendor will often negotiate with the highest unsuccessful bidder, thus linking auction with negotiation.

Agricultural and mineral commodities, as well as electricity (Maurer and Barroso 2011), are sold through combinations of auction and negotiation. Cattle producers in particular will sell in both an auction and through negotiation. As processing markets have become more concentrated, and the demands for product characteristics increase, negotiations to secure supplies have become the prevalent market institution (Ward 2008; Koontz and Lawrence 2010; Muth et al. 2008). Sellers then use regional auctions for those portions of cattle herds unsold in negotiation. For other agricultural and many mineral commodities, forward sales are most often negotiated, but spot sales are made through an auction. In these industries both auctions and negotiation are common trading institutions and can be entered in sequence. In particular, market hogs are sold through negotiation in order to guarantee sources of supply for processors over multiple years, but these processors and refiners as buyers participate in auctions to round out production or refining requirements.

Bulow and Klemperer (1996) provide an insightful theoretical comparison between auction and negotiation. They find that generally for a seller “the value of negotiating skill is small relative to the value of additional competition (p.180).” Therefore, when at least one extra

¹Buyers can usually make up to five offers per item and sellers can counter. Some categories may allow more or fewer offers. For example, eBay Motors listings allow up to 10 offers per item. See http://pages.ebay.com/bestoffer/faq/index.html#buy9.
serious bidder is expected to appear in the auction, a profit maximizing seller should seek an auction and avoid negotiation. Bulow and Klemperer (2009) later try to answer the question why do sellers (usually) prefer auctions by comparing a simple ascending auction with a sequential bidding process in which potential buyers decide in turn whether to make bids after paying an entry fee. They find that although the sequential process is always more efficient, an auction, in the absence of collusion, is more profitable for a seller, because competition is more intense among buyers. The authors cite survey results in which 80% of firms prefer to sell by auction while 90% avoid auctions as buyers. Current empirical evidence on the preferences of traders is sketchy. Leffler et al. (2007) use data from private sales of timber tracts in North Carolina and find that about half of the 360 contracts are auctioned and the rest are negotiated. Bajari et al. (2008) use a data set of private sector building contracts awarded in Northern California during the years of 1995-2000 and find that about half of the projects are negotiated. Of the other half only 18% are awarded using unrestricted open-competitive bidding.

Subramanian (2010) suggests four factors that practitioners should consider when deciding whether to participate in an auction or negotiate a transaction. To best illustrate his point, we borrow the figure from his book (figure 1). The arrows indicate buyer and seller profiles and characteristics of a good or service that lead traders to favor one market institution over another. Despite preferences however, there are no criteria that determine whether auction or negotiation becomes the market institution of choice and or if trading evolves toward a simultaneous or sequential use of these institutions. Frequently there is a sequential connection, which is the focus of this paper. We refer to this connection as linked auction-negotiation or linked negotiation-auction.

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To study behavior in these market environments we design laboratory experiments that simulate the core market construction from Bulow and Klemperer (1996). The purpose of our experiments is to understand buyer and seller behavior, and the resulting market outcomes, when there is a transaction choice between auction and negotiation. Laboratory markets allow us to examine different sequential linkages while avoiding market noise that exists in naturally occurring empirical studies. In our experiments sellers can choose to sell a generic good through auction, negotiation, or both. Auction and negotiation do not take place at the same time, but are sequenced. At the beginning of each trading session, a seller needs to choose the amount of goods he or she produces (i.e., advance production) with an increasing marginal cost. A seller
earns revenue by selling the goods through either auction or negotiation. A buyer earns revenue by purchasing goods either through auction or negotiation and then reselling to the experimenter. The marginal resale value is decreasing, creating a decreasing willingness to pay.

There are four experimental treatment designs. Two baseline treatments place subjects just in an auction or a negotiation institution. Two other treatment designs allow subjects to trade in either or both institutions through linked auction-negotiation or linked negotiation-auction. In all of the designs there are four sellers and four buyers. All treatments are conducted with different participants, and repeated in multiple sessions with different participants. Sellers decide how much to produce prior to trading. If auction precedes negotiation, sellers commit units to either the auction or negotiation institution. If negotiation precedes auction, whatever is not a negotiated sale goes to auction. In negotiations there are three one-minute rounds of freely flowing offers, bids, and counters with a randomly matched buyer and seller. The auction is ascending, and henceforth we shall refer to it as an English auction. Sellers are passive, but see all bids as units are brought up for sale, one unit at a time. Units are ordered according to their cost; lowest cost units are sold first. The auction continues until all units are sold.

II. Networking Externalities and Option Value in Linked Markets

If it is indeed the case that seller earnings are strictly higher in auction than in negotiation and trading agents understand this, then auction should be preferred by sellers and negotiation preferred by buyers. Linking these market institutions and giving traders a choice of institution is

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3 We find that four sellers and four buyers in an auction environment is ideal for studying market behavior (Phillips, Menkhaus, and Krogmeier 2001). Previous experimental market work has shown four sellers to be adequate. Plott (1982) finds that in offer markets “experiments with three and four sellers converge with regularity to the competitive equilibrium” (p. 1496). Smith and Williams (2000) cite “a substantial body of evidence suggests that markets organized under double-auction trading rules converge ‘rapidly’ to a CE [competitive equilibrium] price when there are as few as four sellers and four buyers” (p. 289). They find that auction convergence is robust in a duopoly: “we conclude that the CE model appears to provide a satisfactory prediction of actual market outcomes with as few as two sellers” (p. 302). Davis and Holt (1993, p. 181) conclude that posted auctions move toward the predicted equilibrium and achieve efficiency comparable to the double auction. Altogether these findings provide the impetus for us to use four buyers and four sellers in our market institutions.
then a test of which preferences prevail. We argue in this context that preferences are tempered because of networking externalities. In order to transact, buyers must be where sellers want to trade and sellers must be where buyers want to trade. Sellers benefit from more buyers in a market and buyers benefit from more sellers; in both cases there is a positive networking externality. Negative networking externalities can also exist. Seller payoffs are reduced when there are more sellers and buyer payoffs are reduced when there are more buyers.

The capability to operate sequentially in both institutions generates more access for buyers or sellers. Dynamically, sequencing the markets and giving agents the opportunity to operate in both creates networking benefits that are much like an option value for the second market in the sequence of negotiation-auction or auction-negotiation. For the reason that multiple markets provide increased access, the link may be sustainable even though the bulk of business is in one market or the other.

II.A A Networking Externality Model

The choice between auctions and negotiations as market institutions follows the basic network-externality framework, where buyer (seller) payoffs increase with the number of sellers (buyers) in the market. Market participation is strongly influenced by buyers having access to sellers and sellers having access to buyers; if buyers desire to make purchases, they must go where the units are sold; likewise sellers must take their goods to the institution where buyers want to buy. If these institutions treat agents differently there is distribution of buyers and sellers, and related access to potential trades, across the markets that must be endogenously resolved. In order to model how agents self-select market participation the following assumptions are made about buyer and seller agents.

Assumption 1: Sellers ($S$) earn more in an auction than in negotiation, and benefit from increased access to buyers with available demand in both market institutions.
Assumption 2: Buyers \((B)\) earn more in negotiation than in an auction, and benefit from increased access to sellers with tradable units in both market institutions.

Let payoff functions to participants \(B\) and \(S\) in auction \((A)\) and negotiation \((N)\) be represented as \(R_{ij}\) where \(i = B\ or\ S\) and \(j = A\ or\ N\). Payoffs of buyers in an auction are therefore \(R_{BA} = R_{BA}(S_A, B_A)\), where \(S_A\) is the access to sellers (possibly represented by the number of sellers in the market) with tradable units in an auction and \(B_A\) is the access to buyers (possibly represented by the number of buyers) in an auction with unmet demand. By assumptions 1 and 2, \(\frac{\partial R_{BA}}{\partial S_A} > 0\), \(\frac{\partial R_{BA}}{\partial B_A} < 0\). Payoffs of buyers in negotiation are \(R_{BN} = R_{BN}(S_N, B_N)\), and \(\frac{\partial R_{BN}}{\partial S_N} > 0\); \(\frac{\partial R_{BN}}{\partial B_N} < 0\). Likewise for sellers, payoffs in auction are \(R_{SA} = R_{SA}(S_A, B_A)\), where \(\frac{\partial R_{SA}}{\partial S_A} < 0\) and \(\frac{\partial R_{SA}}{\partial B_A} > 0\). Finally, negotiation seller payoffs are \(R_{SN} = R_{SN}(S_N, B_N)\), and by assumption \(\frac{\partial R_{SN}}{\partial S_N} < 0\) and \(\frac{\partial R_{SN}}{\partial B_N} > 0\). Also, the total number of buyers \((B_T)\) in either market institution satisfies the restriction \(B_T = B_A + B_N\) and the total number of sellers \((S_T)\) is such that \(S_T = S_A + S_N\).

The following set of relative payoff functions satisfy these conditions:

\[
R_{BA} = (\alpha S_A - B_A)B_A,
\]

\[
R_{SA} = (\alpha B_A - S_A)S_A,
\]

\[
R_{BN} = (\eta S_N - B_N)B_N.
\]

\[
R_{SN} = (\eta B_N - S_N)S_N.
\]

The shift parameters \(\alpha > 0\) and \(\eta > 0\) are shift parameters indicating the relative value of buyers and sellers in the market institution. The first term in parentheses is a representation of price. More traders on the other side of the market increase price, while more traders on the same side of the market decrease price. The second term in each expression is a representation of sales for
buyers or sellers. Increases in B or S in either market institution will increase market participation, effectively increasing market demand or supply.

The objective is to determine the relative participation of buyers in auction and negotiation, and the same for sellers. Beginning with buyers, they seek to

$$Max R_{BA} + R_{BN} = (\alpha S_A - B_A)B_A + (\eta S_N - B_N)B_N.$$  

Letting $$R_B = R_{BA} + R_{BN}$$ and substituting the constraint $$B_T = B_A + B_N$$, the objective is

$$Max R_B = \frac{(\alpha S_A - (B_T - B_N))(B_T - B_N) + (\eta S_N - B_N)B_N}{B_N}.$$  

The single first order condition is

$$\frac{\partial R_B}{\partial B_N} = 2(B_T - B_N) - \alpha S_A - 2B_N + \eta S_N \geq 0; B_N \geq 0; \frac{\partial R_B}{\partial B_N}B_N = 0.$$  

The number of buyers in negotiation, assuming an interior solution, may be written as

$$B_N = \frac{2B_T + \eta S_N - \alpha S_A}{4} = \frac{B_T}{2} + \frac{1}{4}(\eta S_N - \alpha S_A).$$  

A similar objective exists for sellers in negotiation. Their objective is to

$$Max R_S = R_{SA} + R_{SN} = S_A(\alpha B_A - S_A) + (\eta B_N - S_N)S_N,$$

and after substituting the constraint $$S_T = S_A + S_N$$ the problem is to

$$Max R_S = \frac{(S_T - S_N)[\alpha B_A - (S_T - S_N)] + S_N(\eta B_N - S_N)}{S_N}.$$  

Solving yields

$$S_N = \frac{2S_T + \eta B_N - \alpha B_A}{4} = \frac{S_T}{2} + \frac{1}{4}(\eta B_N - \alpha B_A).$$  

The solutions for $$B_N$$ and $$S_N$$ suggest that agents will divide themselves evenly between auction and negotiation and then adjust between institutions depending on the relative values and number of their counterparts in the two institutions. If sellers are relatively more numerous and valuable in negotiation, buyers shift to negotiation; if sellers are more numerous and valuable in
auction, buyers shift to auction. Similarly if sellers find access to buyers relatively better in negotiation they migrate to negotiation; if access is better in auctions, sellers migrate to the auction institution.

In a real market environment, either in a laboratory or natural setting, agents must learn about their relative earning potential in auctions and negotiations. Hence the shift parameters have an endogenous nature as agents learn and adjust, and this has not been captured by the model. Learning can be different based on relative experiences. If history first places agents in negotiation with a subsequent capability to migrate to auctions, the relative division of sales will be different than if agents as first placed in auction and then have the opportunity to migrate to negotiation. Strong preferences for an institution, as shown above in the solutions for $B_N$ and $S_N$ will tend to dilute the networking effect.

II.B Option Value

The above shows that access to traders on the other side of the market is important to market agents. Because of this when markets are sequenced the second market in the sequence has option value. Given advance production, it is the case that inventories are a sunk cost; hence those units not sold in the first market still have value for sellers in the second market. This option, of course, feeds back on seller behavior in the first market. Similarly for buyers the second market has as option value; as a group they bid lower in auction, for example, because units can be later found through negotiation. When negotiation precedes auction, buyers are able to hold firm on relatively low bids, knowing that if agreement is not reached, they can still purchase through an auction. Schmalensee (1972) and others have modeled this option value.

Sellers in an auction face a danger of a no sale if a reserve price (as there is in our experimental markets) that is not met. With an increasing marginal cost of production, any
unsold units are nontrivial losses to sellers. When auction is followed by negotiation, sellers worry less about no-sales because any unsold units will automatically go to negotiation rounds which serve as a backup market outlet. Also, across trading periods, if auction prices move closer to the reserve where sale prices are low and the probability of a no sale increases, negotiation becomes a better option. At the margin sellers will be indifferent between a unit sold in auction and a unit that could be sold through negotiation.

If auction follows negotiation, auction becomes the option institution, and possibly a very strong option for sellers. Sellers can learn that auction prices are generally more robust than those negotiated. This impacts their bargaining behavior in the linked negotiation institution. If prices are not to their satisfaction in negotiation, the unsold item goes to auction. The strategy of ignoring the negotiation rounds and putting all the goods in auction increases the danger of a no sale. Hence, sellers seek a balance between the relatively high prices paid in auctions and the value of an option institution to negotiation. Experienced sellers will seek “auction-level” prices in negotiation; units not sold in negotiation move to auction, but fewer units sold in auction reduces the probability of a no sale. At the margin sellers are indifferent between a unit sold in negotiation and a unit that could be sold in auction.

Once again, the pattern of trading can be very different depending on the sequence of institutions. Buyers are expected to prefer negotiation because of lower trade prices, while the higher prices generally realized in auctions will entice sellers to commit units to auction. These preferences will create tension over the number of units traded across the institutions. Buyers ready to negotiate may not find willing sellers, and sellers wanting to sell in an auction may not find willing buyers. If auction precedes negotiation, sellers will commit all or most units to auction, and buyers, while preferring to negotiate, have no later opportunities to make purchases.
if they forego the auction. On balance auction becomes the dominant institution. If negotiation precedes auction, on the other hand, buyer preferences to negotiate carry more force. Buyers can participate more heavily in the negotiation institution knowing that auction is their option for marginal purchases. Sellers follow buyers into the negotiation institution because the auction institution lacks robust buyer participation.

III. Experimental Design

The purpose of our experiments is to observe and test for differences in buyer and seller behavior, and the resulting market outcomes, when there is a choice between trading in an English auction and negotiating an exchange. Baseline data are obtained from agents operating in just one of these market institutions. The treatment designs place agents in a sequence of these institutions where they can buy and sell in an English auction followed by negotiation or buy and sell through negotiation followed by an English auction.

In all of the experiments basic market conditions are characterized by a downward sloping demand and upward sloping supply schedule shown in figure 2 with an accompanying table for buyer unit redemption values and seller unit costs. In these markets each of four buyer can resell a “unit” to the experimenter at a redemption value that begins at 130 tokens (one token is a penny) for the first purchased unit. The second unit can be redeemed at 120 tokens, and so on. Buyers earn money by making purchases at less than redemption values. Each of four sellers has unit costs as shown in figure 2. The first unit has a cost of 30, the second a cost of 40 and so on. Sellers earn money by selling units at prices above costs. The predicted competitive equilibrium price is 80 tokens and sales are between 20 and 24 units at this price as shown in figure 2.
This experimental design is based on that of Phillips and Menkhaus (2010). Eight subjects for an experimental session were recruited from university business and economics classes via email. All sessions were held in the same computer laboratory. Each participant received an initial token balance of 700 ($7.00) or 1000 ($10.00) for participating. A session began with the experimenter reading the instructions aloud. A copy of the linked treatment instructions are provided at the end of this paper. This was followed by a practice period of three minutes to familiarize participants with the software and trading rules of the market. Afterwards, questions regarding the experimental procedures were answered and more practice time was given if needed.

In all experiment periods, sellers made a production decision, incurred the unit production costs, and held inventory before trading. They each could produce between 0 and 8 units. Unsold units became a sunk cost. Trading did not begin, either through negotiation or auction, until all sellers had made their production decisions. Traders were not informed of how many total units were produced, or of the number of total units unsold at the end of a trading period.

III.A Negotiation Design – Baseline Treatment

In negotiation four buyers and four sellers were randomly matched in a computerized trading platform. Random matching of buyers and sellers was done to control for reputation effects (Phillips et al. 2014). Once paired, buyers and sellers could simultaneously place bids and offers on a unit. Initial bids and offers were made by manually typing in the bid or offer and pressing ‘Enter.’ Bids (offers) then could be raised (lowered) by one token with a single click of the mouse or changed by more than one token by typing in new values. Buyers and sellers had one minute to negotiate trade prices for as many units as time would allow, one unit at a time.

The participation fee was raised from $7.00 in those treatments that had less than a minimum of 20 trading periods.
An improvement rule was in place so that valid bids became progressively higher and valid offers became progressively lower. Once a bid or offer was accepted, negotiations instantly began on the next unit until the minute elapsed. After the minute expired, participants were again randomly matched for another one-minute trading round. Three one-minute rounds comprised a period.\(^5\)

Each experiment went at least 20 periods. Participants were not informed of the exact number of periods to prevent any unusual behavior in the final round. After period 20, a random number was generated between one and 100. If the number fell between one and 20, the experiment was completed. If the number fell between 21 and 100 the experiment continued. At the completion of the experiment, tokens were exchanged for cash at the rate of one cent per token. Six sessions of this design were conducted.

**III.B English Auction Design --Baseline Treatment**

All units produced were sold one at a time to the highest bidder. The lowest cost unit was sold first and if multiple units with the same unit cost were available for sale from the sellers, the computer randomly selected one of the units for sale. After production sellers observed the bidding on each unit and a list showing the price of each sold unit was kept for sellers. Otherwise, sellers were passive. The information on sales in each production period was a guide for producing next period. There was a low reserve price of 40 tokens on each unit. If an item did not meet the reserve, the item became a sunk cost to the seller.\(^6\)

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\(^5\) Late in a period it was possible that a matched pair had no profitable trading opportunities. The marginal resale value was below cost. In this case the computer screen allowed no bids and offers; subjects waited for the next match.

\(^6\) A bidding ring could let prices fall to nearly zero before a winning bid is entered. A reserve was put in place to block aggressive collusive tendencies. Winning bids just above the reserve would indicate the existence of a tacit bidding ring. We have found in past work that rings are effectively controlled if buyers do not know the number of units available for sale (Phillips et al. 2003) and through the production decision (Phillips and Menkhaus 2009). An unknown number of units make it difficult to coordinate the distribution sales among buyers. With respect to the production decision, low winning bids cause sellers to produce and sell less inventory in future periods, thus
The computer served as the auctioneer in this experiment. When the bidding began for an item the screen displayed “Do I have a bid?” The screen would show the initial sale price at 45 tokens. If a buyer wanted to bid higher, he/she used the mouse to click on the bid box shown on the screen. The bid amount went up by one token as players clicked on the bid box. If the participant had the high bid, the screen displayed “You have the bid,” otherwise, it showed the current bid. Individuals continued bidding until the screen flashed “going once, going twice.” The computer waited two seconds for new bids before flashing this message. The flashing message gave subjects another five seconds to make a bid. If there were none, the unit was awarded to the highest bidder. When a sale was made the message “Sold!!” and the price at which the unit was sold appeared on everyone’s screen. Bidders were not informed of the identity number of the winning bidder. At least 15 English auction rounds were conducted in each of three sessions.

III.C Linked Market Design: Negotiation-English Auction

Sellers had a choice of offering units first through negotiations and then an ascending auction. During the production phase sellers were asked how many units they wished to commit to negotiations. The remainder was committed to the auction. However if units intended for sale through negotiation were not sold, they automatically went to auction. Hence the number of units committed to negotiation by a seller was nonbinding. Units not sold in the auction became a sunk cost. The experimental design for each phase of negotiation-auction is as described above. This linked design was repeated for at least 10 periods in each session. Five sessions were conducted.

III.D Linked Market Design: English Auction-Negotiation

restricting the future flow of goods. In these auction experiments initial bidding quickly went above the reserve price in all but a very few cases when it appeared bidders were caught off-guard by how rapidly the price ticked down at the opening.
The second treatment sequenced the market institutions with English auction first. All trading is preceded with a production decision, as before. Sellers elected the number of units they wish to sell in the auction and all of these units were brought to buyers for bidding. Only if a unit did not meet the reserve could it later be sold through negotiation. This linked design was repeated for at least 10 periods in each session. Five sessions were conducted.

IV. Estimating Convergence

In each experimental session, data were collected on the price of units traded, number of units traded, and the earnings of buyers and sellers. Similar to Noussaire, Plott, and Riezman (1997) and Phillips and Menkhaus (2010), we analyze these data using a general convergence model:

\[
Z_{it} = \sum_{j=1}^{I} \alpha_j D_{jt} \left[\frac{(t-1)}{t}\right] + \sum_{j=1}^{I} \beta_j D_{jt} \left(\frac{1}{t}\right) + u_{it}
\]

where \(Z_{it}\) is the variable of interest such as average sale price, number of units traded, or earnings across sessions for each of \(t\) trading periods in the treatment cross section \(j=1 \ldots I\). The coefficients \(\alpha_j\) are the predicted asymptote for each treatment, and \(\beta_j\) are the starting levels of the dependent variable (e.g. price, trades, or earnings outcome). \(D_{jt}\) is a treatment dummy variable, and \(u_{it}\) is an error term.

The Parks method (Parks 1967) was used to estimate the model to account for unique statistical properties of the experiments’ panel data. Analyses were conducted with Stata using the ‘xtgls’ procedure (Stata 2011), and correcting for cross-sectional correlation, heteroskedasticity, and panel-specific autocorrelation (ar1). The Wald-test was used to infer differences between convergence estimates (e.g. ‘test \(\alpha_j = \alpha_k\)’) with residual normality confirmed by Shapiro-Wilk tests. In the discussion that follows, we base our conclusions on both
the reported data and the convergence or asymptote levels for the variables of interest associated with alternative treatments given failure to reject normality.

V. Data and Analysis

We report data from four experimental designs. The two baseline designs are labeled private negotiation spot (PNS) and English auction spot (EAS). The two linked treatment designs are referred to as negotiation-English auction (PN-EA Linked), and English auction-negotiation (EA-PN Linked). Figures 3 through 7 report by period over the five replications for each design the average outcomes for price, trades, total earnings, buyer earnings, and seller earnings. All sessions for the design PNS went at least 20 trading periods. Sessions for EAS went at least 15 trading periods. The linked sessions went at least 10 trading periods. The designs have a different number of trading periods because it was difficult to recruit subjects in a lab setting for more than 2.5 hours; nearly all sessions went this long. To ensure consistent comparisons within the regression analysis, only the first 10 trading periods of the non-linked treatments (private negotiation or English Auction) were used to estimate the convergence levels. Earnings and market outcomes for each design are reported below.

V.A Private Negotiation and the English Auction Baselines

Figure 3 maps the average trading prices for all the experiment designs. Our analysis begins with observations on the baselines. The highest reported prices are in English spot auctions (EAS). Average prices begin at about 105 tokens and then converge to an asymptote price of 93.56 after 10 periods as reported in table 1. Figure 3 shows the average near 95 tokens beginning in period 11. The lowest reported prices are in private negotiation spot (PNS) market institutions. For the 20 periods shown in figure 3 average prices begin at 70 tokens and move to about 75 tokens toward the end. The estimated convergence level is 71.16 tokens after 10
periods. This price is significantly different from 80 tokens at the intersection of the induced supply and demand schedules.

Table 1 reports the average quantities produced and then traded; both estimates are virtually identical, indicating there was very little lost inventory cost for sellers. Most noticeable when comparing the baseline market institutions is that significantly fewer units are produced and traded in negotiation. This, of course, is due to the lower prices in PNS. Hence buyers earn relatively more in negotiation but it is at the cost of a smaller market size as shown by the total earnings reported for PNS and EAS in table 1. The difference in buyer earnings (BE) between PNS and EAS is (158.52-69.55 = 88.97), and the difference in seller earnings (SE) between EAS and PNS is (211.26-98.54 = 112.72). Sellers as a group in EAS could compensate buyers to participate in an English auction and still earn more than in negotiation.

The literature has argued, e.g. Bulow and Klemperer (1996 and 2009), that an English auction should dominate negotiation as the institution of choice for sellers. Our results confirm this. As reported in table 1 seller earnings are more than double in EAS than PNS. Relative to negotiation, English auctions create a substantial degree of “institutional favoritism” for sellers. If sellers have the capability to choose the institution in which they will trade, it is auction. Conversely negotiation creates institutional favoritism for buyers. They seek to buy low and a negotiation institution delivers the lowest prices. In table 1, buyer PNS earnings are more than double EAS after the first 10 periods. Hence if buyers are capable of choosing the institution in which they trade, it is PNS. Clearly the choice of market institution should matter greatly to buyers and sellers, as its determination, whether by convention or through legislation, is important to the relative distribution of total market surplus. Even if agents behave competitively
within each of these market institutions, the prevailing institution effectively creates an advantage for either sellers or buyers.

### V.B Linked Market Institutions

Against these baselines we consider the two linked institutional designs. Figure 3 maps average prices for all sessions in private negotiation-English auction (PN-EA linked) and English auction-private negotiation (EA-PN linked). The main conclusion to draw from the data is that linked institutions temper the price impact of the separate institutions. Figure 3 shows EA-PN linked prices are around 90 tokens. The convergence estimate is 90.13 (table 1). PN-EA linked prices are about 85 tokens from figure 3 and converge to 86.67 tokens (table 1).

For the first few rounds of the experiment, there is substantial difference in the average trading prices between the two treatments. However the gap shrinks as subjects gain experience; still the difference remains significant at the end of 10 periods, the EA-PN linked market has consistently has higher average trading prices. The trends in figure 3 suggest that if the experiment went more periods the difference could diminish further. Linked prices are significantly different than those reported for EAS and PNS. They are about 22% to 27% higher than PNS prices and 4% to 8% lower than EAS prices.

While significant, the difference between EAS and linked prices is not large. The reason is that in the linked EA-PN markets most of the trading is conducted in auctions. Table 1 shows that on average 19.4 units are sold in auction (EA1) and total linked sales are 20.87. The degree to which negotiations can temper relatively high auction prices is limited. Sellers of course choose to have their units sold in an auction since this institution fetches higher prices. It is interesting that tempering is greater in the PN-EA linked institution. When negotiations precede auctions, sellers behave differently than in the EA-PN linked institution. In particular
for this linked treatment they choose to sell about half of their units through negotiations; _PN1 is 10.19 in table 1 and total PN-EA is 20.74.

There is no significant difference in the total average quantities traded between the two linked treatments. Amounts are just over 20 units as reported in table 1. Figure 4 confirms that these quantities traded are (1) remarkably stable for the duration of the experiment and (2) significantly higher than quantities traded in PNS and EAS. Why does changing the sequence of negotiation and auction change the trading prices but not the quantity traded? Illustrated in figure 4, nearly all units in EA-PN are sold in auction while it appears stable that just half of the units in PN-EA are sold in auction. The essence of the question is therefore why do sellers in PN-EA persist in selling half of their units in negotiations when they can earn more by keeping them for the auction.

This can be explained in two ways that are not necessarily exclusive: one, sellers are extremely risk averse and seek to sell their wares at the earliest opportunity; or two, the outcomes from negotiations in PN-EA are satisficing for them. We believe that when units represent a potential sunk cost sellers seek to effectively satisfice. In EA-PN seller earnings are 199.04 and in PN-EA they are 180.50. Sellers are earning 18.54 tokens less (about 10%) in PN-EA versus the EA-PN linked market. This is a premium sellers pay for not moving their units to auction, yet it persists because we believe sellers are afraid of unsold inventory. Even when prices are very high in EAS, this fear of unsold inventory lingers. At prices above 80 tokens sellers should be producing more and selling more than 24 units. Yet table 1 reports and figure 4 confirms that sales are around 19 units.

**V.C Relative Earnings and Market Efficiency**
Significantly more units are produced in the linked designs than EAS or PNS. Sellers produce more because the second market provides insurance against sunk costs, and because the presence of an auction raises prices. Sellers produce about 10% more than EAS and up to 40% more units than PNS after the first 10 trading periods. Figure 5 shows that the higher production levels push total earnings (total surplus) near the maximum attainable. For the 10 periods reported, the linked market institutions generate more total surplus than either of the non-linked markets. Market efficiency is about 15%-19% higher than the PNS treatment.

The least efficient market structure PNS gives buyers the highest earnings (figure 6). A negotiations institution, in general, is better for buyers. Buyer earnings improve over EAS in linked designs because there is negotiation in the institution. Relative to just a negotiation institution sellers benefit from a linked design because there is an auction component. There is no significant difference between seller earnings in EAS and EA-PN linked because the auction phase of the institution is so robust. Figure 7 shows that for the 10 periods of linked transactions, there is very little difference in seller earnings between the linked designs and EAS. Buyers gain from a linked institution from more sales and at least some that are negotiated compared to EAS.

VI. Conclusion

Ascending auctions favor the earnings of sellers. Negotiations favor the earnings of buyers in repeated trading when there is advance production. A linked market institution, whether EA-PN or PN-EA, cause a migration of market participants such that prices converge to levels between those paid in auctions or negotiation. Networking externalities cause buyers to move to where there is increased access to sellers with tradable units and sellers to migrate where there is increased access to buyers. The sequencing of the market institutions determines the
history and learning of agents, so migration patterns differ. We believe it also is the case that the sequencing of the market institutions creates option value for the second institution.

Sellers fear the sunk cost of unsold inventory when there is advance production, particularly in negotiation (Menkhaus et al. 2003). Linked markets alleviate this fear and production levels are higher in both auction-negotiation and negotiation-auction market institutions. Linked markets are more efficient than either market institution operating alone.

We find that if auction precedes negotiation, auction becomes virtually the only exchange institution; very few units are sold through negotiation. However, if negotiation precedes auction, half of the goods are sold in negotiation and half are sold in auction. The latter occurs despite the fact that if sellers had put all the goods in auction, greater profits could have been earned. If an auction follows negotiation, we find that negotiation prices are much higher than if the negotiation was the only institution. In a sense price discovery in auction carries forward to negotiation. If negotiation follows an auction, auction prices are lower than if all goods were sold in auction. Thus negotiations temper auction prices or price discovery in negotiation carries forward to auction.

Online trading platforms are making linked market institutions more common. Commodities are often sold in linked institutions where sellers have the freedom of taking their production to auction and/or negotiate sales. In these commodity industries, negotiation has steadily become the institution of choice for buyers. Sellers complain about a transition from auction to negotiation resulting in a problem of captive supplies, i.e. products that processors own or contract to purchase for future delivery. At issue is the effect captive supplies have on prices paid to sellers. Negotiation is an institution that fosters vertical contracting to the exclusion of “more competitive” auction trading. Sellers are forsaking auction markets—where
they as a group are advantaged over buyers—as they believe production of specialized attributes demanded by buyers may improve their earnings. Moreover, fear of being at a disadvantage by not trading in negotiations may be an issue. If collusion is a problem in auctions or buyers encourage increased contracting for consistency in qualities and or quantities of supplies, and sellers move production to negotiation, our work shows that this transition will favor buyers as a group. The preferred trading institution for buyers is negotiation.

Lines of distinction between auction and negotiation can be blurred. Vivid descriptions by Guhan Subramanian (2010) in *Negotiauctions* make this obvious. One such description involves selling the syndicated rights to the television series Frazier. As the details of the sale unfold, it is hard to know when an auction ends and negotiation begins. In the experimental work above, negotiations are in essence a double auction between one buyer and one seller making bids, offers, and counters. In online trading, the increased use of reserves and a clock move an ascending auction closer to negotiations. As institutions become linked or meld into new institutions that have features of other trading methods there will not be a neutral effect on buyers and sellers. Agents have a measurable stake in the market institution in which they transact business. Our work suggests that economic welfare is improved when institutions are linked. Moreover, it is expected that the opportunity for effective collusion is reduced in linked institutions.
References:


Figure 2. Induced aggregate market demand and induced market supply for four buyers and four sellers baseline treatment

Redemption values and costs

<table>
<thead>
<tr>
<th>Unit</th>
<th>Redemption Value/Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>130/30</td>
</tr>
<tr>
<td>2</td>
<td>120/40</td>
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<tr>
<td>3</td>
<td>110/50</td>
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<td>80/80</td>
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<tr>
<td>7</td>
<td>70/90</td>
</tr>
<tr>
<td>8</td>
<td>60/100</td>
</tr>
</tbody>
</table>
Table 1. Convergence Estimates for Negotiations and Auction Treatments

<table>
<thead>
<tr>
<th>Experiment Treatment</th>
<th>Prices</th>
<th>Quantity Produced</th>
<th>Quantity Traded</th>
<th>Buyer Earnings (BE)</th>
<th>Seller Earnings (SE)</th>
<th>Total Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNS</td>
<td>71.16&lt;sup&gt;a&lt;/sup&gt; (0.697)</td>
<td>14.81</td>
<td>14.68</td>
<td>158.52 (2.031)</td>
<td>98.54 (2.626)</td>
<td>1,009.96</td>
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<tr>
<td>EAS</td>
<td>93.56 (1.211)</td>
<td>19.31</td>
<td>19.01</td>
<td>69.55 (5.907)</td>
<td>211.26&lt;sup&gt;a&lt;/sup&gt; (8.153)</td>
<td>1,144.08</td>
</tr>
<tr>
<td>PN-EA Linked</td>
<td>86.67 (0.307)</td>
<td>21.09&lt;sup&gt;a&lt;/sup&gt; (0.602)</td>
<td>20.74&lt;sup&gt;a&lt;/sup&gt; (0.400)</td>
<td>119.04 (2.710)</td>
<td>180.50 (1.953)</td>
<td>1,197.57&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>_PN1</td>
<td>85.38&lt;sup&gt;b&lt;/sup&gt; (0.883)</td>
<td>10.19&lt;sup&gt;b&lt;/sup&gt; (0.197)</td>
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<tr>
<td>_EA2</td>
<td>85.40&lt;sup&gt;b&lt;/sup&gt; (0.218)</td>
<td>10.48&lt;sup&gt;b&lt;/sup&gt; (0.359)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>EA-PN Linked</td>
<td>90.13&lt;sup&gt;c&lt;/sup&gt; (1.118)</td>
<td>20.71&lt;sup&gt;a&lt;/sup&gt; (0.843)</td>
<td>20.87&lt;sup&gt;a&lt;/sup&gt; (0.426)</td>
<td>92.13 (7.702)</td>
<td>199.04&lt;sup&gt;a&lt;/sup&gt; (5.007)</td>
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<td>_EA1</td>
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<td>19.40</td>
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<td>93.82 (7.702)</td>
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<td>_PN2</td>
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<td>1.66</td>
<td>1.66</td>
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</tbody>
</table>

Regression assumes, cross-sectional correlation, heteroskedasticity, and AR1 serial correlation (no AR1 for seller earnings per specification testings). Normality of residuals was verified by Shapiro-Wilk tests.

a,b,c,d,e – Same letters indicate estimates within columns that are not significantly different at alpha=0.10 level.
Figure 3. Average trading prices in different markets
Figure 4. Average quantity traded in different markets
Figure 5. Average total earnings in different markets

![Graph showing average total earnings in different markets](image-url)
Figure 6. Average buyer earnings in different markets
Figure 7. Average seller earnings in different markets
INSTRUCTIONS (LINKED MARKETS)

Introduction

This is an experiment in the economics of market decision making. In this experiment, there is a market in which some of you are BUYERS and some of you are SELLERS. Whether you will be a buyer or a seller is randomly determined by the computer program.

The commodity you are trading is referred to as a "unit". Sellers earn money by producing units and selling the units to buyers at a price above the seller's production cost. Buyers earn money by purchasing units from sellers and then redeeming (or reselling) these units to the experimenter at a higher price (THE REDEMPTION VALUE). Earnings are recorded in a fictitious currency called tokens. Tokens are exchanged for cash at the rate of 100 tokens = $1.00. Earnings will be paid to YOU in CASH at the end of the experiment. To begin, every buyer and seller will be given an initial balance of 1000 tokens ($10.00). You may keep this money PLUS any you earn.

Sellers will produce units and then buyers and sellers will trade the units in a computerized market over a sequence of periods. Each trading period consists of an English auction followed by three one-minute bargaining rounds. In the English auction buyers bid on units as each unit comes up for sale. The buyer with the highest bid in the English auction wins. In the bargaining rounds buyers and sellers are randomly paired for 1 minute at the end of each one-minute round each buyer and seller will be randomly re-matched with another buyer or seller. During the one minute bargaining rounds a buyer and a seller can make bids and offers until the buyer and seller reach a trade price on each unit. Units can be traded until time expires.

Specific Instruction to Buyers

Buyers are free to purchase up to 8 units, each with a different redemption value. The computer screen will show the redemption value of each unit purchased on the screen labeled "Buyer Unit Information". This is the redemption value at which the experimenter redeems each of the buyer’s units at the end of the experiment. For the first unit that each buyer purchases, the buyer will receive the amount listed under VALUE for Unit 1. The redemption values for these and subsequent units will be displayed on the buyer computer screen.

The earnings from each unit that a buyer purchases are computed by taking the difference between the redemption value and purchase price of each unit. That is,

Your earnings for each unit = Unit Redemption Value – Purchase Price for that unit

Specific Instructions to Sellers

Sellers are free to produce and sell up to 8 units, each with a different unit production cost. Units are sold through an English auction or bargaining rounds. All units held for English auction will be offered
to buyers, but if buyers do not reach a minimum bid (a reserve price), they can be sold in the bargaining rounds. All unit production costs will be displayed on the computer screen in the production stage of the experiment.

The earnings from each unit that each seller produces are computed by taking the difference between the sale price and unit production cost of the unit sold. That is,

**Sellers Earnings for Each Unit = Sale Price for that Unit – Unit Production Cost.**

Suppose a seller chooses to produce a total of 5 units. The seller will be asked if there are units he or she wants to hold and sell through negotiations. If the seller holds 2 units for negotiations, then 3 units will be available for sale in the auction; if fewer than 3 units are sold in the auction because of low bids, leftover units go to the bargaining phase of the experiment.

A seller can take a loss on a unit sold in the English auction if the highest bid is above the reserve price but below the unit production cost. A seller also can take a loss in negotiations by accepting a bid below the cost of the unit, or not selling all units before time expires, in which case the seller’s loss is the cost of production. The unit production costs, sale prices, and profits will be displayed on the seller’s computer screen at the end of each period.

Sellers are not allowed to incur production costs greater than the beginning token balance. Producing too many units can result in a loss on a sale, or units not sold at all. Conversely, if too few units are produced, a seller could be losing profit on units that could be profitably sold. If a seller does not produce units, profits are zero.

**Trading Rules for English Auction**

Units held for English auction are sold one at a time beginning with the lowest cost unit. If the sellers have equally low production cost units available, the unit that is auctioned first is determined randomly.

During the auction, sellers watch their screens to monitor how buyers are bidding for the units produced for the auction. The prices and quantities sold per period should help sellers decide how many units to produce in future periods. The computer serves as the auctioneer in this part of the experiment. The auctioneer will begin by setting a token amount at which bidding begins. If this initial bid is too high for buyers, the auctioneer will lower the unit price until a buyer clicks on the “Place Bid” box. If a buyer wants to bid, simply click on the “Place Bid” box displayed on the screen. The bid amount will go up by 1 token every time a buyer clicks on the “Place Bid” box. A buyer can also increase the bid by an amount greater than one token by typing an amount in the “Enter Bid” box and clicking Enter.
Buyers continue to bid against others until the bidding stops. When bidding pauses the computer screen will flash the message: going once, going twice. During this time if there are no additional bids, the unit is awarded to the highest bidder and the screen will flash sold. The sale price for that unit is displayed in the listing of unit trade prices. The auctioneer moves down to the next unit on the unit value schedule until all the available units are presented to buyers. The current unit being auctioned will be highlighted on the auction screen. Buyers will not be allowed to purchase units for more than the redemption value given for that unit.

If buyers do not bid as the auctioneer lowers the price of a unit, there is a price (called a reserve price) at which the unit cannot be sold if the price drops below the set reserve price. The unit then becomes a “no sale”. “No sale” units are added to a seller’s total units available for bargaining. The computer screen will inform all buyers and sellers of a “no sale”. The next unit for sale will then enter the auction at a starting bid set by the auctioneer. Starting bids can vary. Once all units have been auctioned, each buyer and seller will be shown a period recap screen. The experiment then moves to the bargaining phase.

**Trading rules for the bargaining rounds**

Only one unit may be bought and sold at a time. Buyers and sellers submit prices at which they are willing to purchase or sell. A buyer’s bid cannot be higher than the seller’s OFFER and a seller’s offer cannot be lower than the buyer’s BID. Counteroffers are made until both parties reach a price agreement for that unit, thus executing a trade.

A bid is initiated by the buyer when the buyer types a bid amount in the space labeled “Enter Any New Bid Amount” and presses the ENTER key or clicks on “Place Bid”. An offer is made by the seller when the seller types an offer amount in the space labeled “Enter Any New Offer Amount” and presses the ENTER key or clicks “Enter Offer”. Once a bid has been made, a buyer can increase a bid by 1 token by clicking on the “Place Bid” box. A seller can decrease an offer by 1 token by clicking on the “Enter Offer” box.

If a buyer decided to purchase the unit at the offered price, he or she would simply click on the “Accept Offer” box displayed at the bottom of the computer screen. Likewise, a seller can click on the “Accept Bid” box. After a buyer and seller have made a trade, the trading price will be displayed, and the buyer and seller move to the next unit and begin bargaining for the unit highlighted on both the buyer and seller screens. A buyer and seller pair may continue to bargain and make trades for one minute. After a minute has elapsed, buyers and sellers are randomly paired again.

There are three one-minute bargaining rounds in a trading period. The time remaining in the round is provided in the “Clock” displayed in the top right corner of the screen. A round may be terminated sooner than the full one minute if no more profitable trades are possible for either the buyer or the seller. A terminated round will show a blank screen. At the end of the 3- one-minute bargaining rounds, buyers
and sellers will be shown a full period recap on earnings for the period and total earnings for all production periods to this point.

This experiment will consist of at least 10 trading periods. The trading period and round numbers are provided in the top of the trading screen. We will conduct a practice run to familiarize each you with the mechanics of the computerized market before the actual experiment begins. The practice round will have different values and unit production costs then the values and production costs during the real experiment periods.

**Your Name and W Number**

Before beginning the experiment, the computer will ask for your name and W Number. This information is kept confidential, but it is important to the funding agency as proof of your participation. The bids and earnings of people in the experiment are confidential. Please do not look at someone else’s screen and do not speak to another participant once the experiment begins. You may ask the experimenter questions at any time. Are there any questions before we conduct the practice session?