Inventories and Public Information in Private Negotiation:
A Laboratory Market Study

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Abstract

Using laboratory markets, this research investigates the impacts of reporting different kinds of aggregated trade information to buyers and sellers who conduct transactions through bilateral/private negotiation. There are a limited number of bargaining rounds or matches between buyer and seller pairs. Sellers hold a perishable inventory before negotiations begin. We find that knowledge of trades, along with price, improves the coordination and bargaining position of buyers. Trade prices are lower and buyer earnings are higher, relative to the no-information treatment or when just-past quantities or just-past prices are reported. Market efficiency declines as public information is reported.

Keywords: information, laboratory markets, private negotiation

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Prices in many business-to-business transactions are not discovered through the simultaneous interaction of numerous sellers and/or buyers, such as in an auction or well-developed posted-price market. Instead, prices and possibly other terms of trade are decided through negotiation, for which histories and outcomes are proprietary. In some sectors of agriculture, such as fed cattle, private negotiation trading has become a dominant method of price discovery. For the period October 2002 – March 2005, Taylor et al. (2007) report that individually negotiated pricing was the most common (57.13% of head) method used to establish prices for fed cattle purchases. At another level of the beef supply chain, retailers privately negotiate terms of trade with packers for boxed beef. In other sectors of agriculture and for many commodities, it is common for producers and processors to bilaterally negotiate terms of trade.

An important feature of a trading institution is the amount of information it makes available (Smith 1962). Depending on whether it is single or double sided, an auction market typically is characterized by offers and/or bids being made in the presence of all traders who may immediately accept or counter a proposed price. Trade prices and units traded are public information known to all parties as they occur. Often, real-time information about prices and the quantities traded is provided through the trading institution, and market feedback is immediate. In this sense an auction-trading institution is information-rich. In posted-price markets as well, agents are aware of a menu of
available prices and their changes. This information allows buyers/sellers to search across product qualities and compare prices, before and while there is on-going exchange.

In private negotiation it is often the case that bids, offers, and product qualities are known only by the agents directly involved. Information is private. In this environment, which we take as our working model, price discovery is restricted to the bargaining parties. Information is not shared with other traders in the market, and the information that agents accumulate comes from a personal history of continued trading. This history can be truncated by a “matching” problem between agents. That is, a bargaining pair may be unable to trade or only make inefficient trades because differences between buyer marginal values and seller marginal costs are small or negative (Menkhaus et al. 2007a).

Limited matches between buyers and sellers in a trading period is a common feature of private negotiation and can be the result of high transaction costs, few traders on one or both sides of the market, and/or infrequent trading because of the production process. The number of matches may be reduced by a geographically-restricted trading area or increased industry concentration. Compared to auction trading, a limited number of sequential matches between buyers and sellers in private negotiation reduces the gains from trade.¹

Private negotiation frequently requires the advance production of goods; the seller must have inventories on hand when matched with a buyer.² Before negotiations begin, it is understood that an agreement means delivery of product for which the production process has begun or has been completed. Most or all of the costs of production are sunk. In many agricultural commodity markets, for example, processors negotiate with
producers for the delivery of livestock, produce, and grains after the production decision has been made. We believe that advance production characterizes many transactions in private negotiation. Further, many agricultural commodities inventories are perishable or storable for only a short period of time. In other cases, such as livestock, the production process becomes costly if the animals are not sold in a timely manner. There also could be price discounts associated with changing animal quality, as livestock are kept beyond the optimal sale weight. Together, these characteristics of agricultural commodities result in an advance production risk for sellers, measured by unsold or heavily-discounted inventory. This risk can be exacerbated by the matching problem in private negotiation trading. It leads to a bargaining advantage and higher earnings for buyers relative to sellers (Menkhaus, Phillips, and Bastian 2003).

The Case of Livestock Mandatory Price Reporting and Related Literature

Limited information resulting from reduced market feedback in private negotiation is thought to impair efficient trading. A possible remedy is to move the level of information that agents possess closer to that held in an auction or posted-price market institution. This can be done by making otherwise proprietary information about quantities traded and prices common knowledge. There is a practice of many government agencies and trade associations to collect price and sales information from negotiated transactions, aggregate the data, and then issue public reports (Areeda and Kaplow 1988). As privately-negotiated transactions increase in the agricultural sector, the provision of public information from these transactions has become an issue addressed by industry groups and policy makers. For example the Livestock Mandatory Price Reporting
(LMPR) Act of 1999 (U.S. Senate 1999) required private information from bilaterally-negotiated prices and livestock sales be made public. While the statutory authority of the 1999 LMPR ended in September 2005, the Agricultural Marketing Service of the USDA subsequently requested voluntary market information. In 2006, HR 3408 extended LMPR through September 2010 (Becker 2006). The belief is that the added information will equalize bargaining power between buyers and sellers and lead to more efficient trading.

The LMPR Act provides an interesting context through which to study the impacts of public information in private negotiation. In an information-related study just prior to LMPR, Anderson et al. (1998) examined the influence of a reduction in public cash market information on fed cattle markets. Their analysis supports prevalent policy thinking and suggests that reducing public information increases price variance and decreases pricing efficiency for fed cattle. Azzam (2003) developed a theoretical oligopolistic model to represent downstream firms (packers) and upstream firms (feedlots) and used comparative statics to investigate the impact of a change in transparency associated with mandatory price reporting. Azzam concludes that the increased transparency results in increased packer competition, output, and feeder cattle prices while reducing consumer prices. From this it can be inferred that aggregated data through policies such as LMPR would promote competition and increase market efficiency. In later works Fausti and Dierson (2004), Perry et al. (2005), Lensing and Purcell (2006), and Pendell and Schroeder (2006), all in a variety of different contexts, generally find support for LMPR promoting more efficient livestock markets.
The collective outcomes of these studies represent an endorsement of LMPR. A note of caution, however, is suggested by the survey results of Grunewald, Schroeder, and Ward (2004). They queried managers of feedlots in Kansas, Iowa, Texas, and Nebraska regarding the effectiveness of LMPR in their negotiations with packers. Overall, responses ranged from neutral to negative with respect to benefits of LMPR. Livestock sellers did not believe that LMPR helped them in negotiating good trades. These authors report that expectations about the potential benefits of information from LMPR may have been unrealistic.

Public information can have unintended impacts on market outcomes. Wachenheim and DeVuyst (2001), for example, argue that mandatory price reporting of bilaterally negotiated trades may decrease the price received by sellers in the livestock industry. Holding the aggregation of data to a regional level can help broader markets perform more efficiently. Higher prices in one area signal producers to move livestock to a different regional market, provided transport costs are not too high. Greater levels of aggregation will mask these regional differences. Reports that are sufficiently disaggregated, however, may help the tacit collusion of processors. Increased information about prices and quantities can allow agents to: (1) better monitor rivals; (2) decrease the time required to detect and punish non-cooperative behavior; and (3) increase processor ability to separate the market effects of demand from those due to non-cooperative behavior.

Morris and Shin (2002) model the relation between private and public information in order to assess the social value of public information. The results of the Morris and
Shin study are particularly relevant to the current study. Mandatory price reporting collects valuable private information from market traders, which is then given back to them as an average. Morris and Shin find that public information increases welfare when agents do not have socially valuable private information. On the other hand the impact of public information is ambiguous when agents have access to private information. The impact becomes an empirical question. The Morris and Shin model does not specify a trading institution. Specifically in a bilateral bargaining environment, how alternative forms of public information affect bargaining behavior and the relative power of agents seems particularly relevant because agents possess valuable private information. We believe that the study of bargaining behavior in well-controlled laboratory markets with different information treatments can measure the potential market impacts of public information.

**Study Objective**

The objective of this paper is to assess how selected reports of past trading behavior, such as prices and units traded released as common knowledge, influence market outcomes in private negotiation with advance production and limited bargaining matches. How are the relative bargaining positions, competitiveness, and earnings of buyers and sellers affected by alternative public information reports in this market environment? What are the driving forces that contribute to different market outcomes, should they exist, under alternative information scenarios?

A bilateral or private negotiation trading environment that was created in the laboratory is described. The laboratory market was designed to capture the important
features of the market environment in which many transactions in the food supply chain occur. Both buyers and sellers received the same price/trade reports in order to avoid asymmetry with regard to the public information. Sellers and buyers were randomly paired a limited number of times and negotiated for price after a production decision was made by sellers. Sellers could be forced to trade units at a discount or be left with unsold units at the end of a trading/production cycle. In essence at the end of a production/negotiation cycle, the commodity becomes perishable or has a prohibitively high storage cost. As already argued, we consider this a common trading environment, and a better understanding of bargaining behavior in this environment is important.

**Theoretical Discussion**

To help set the stage for our experimental results, in this section we highlight the bargaining power of buyers in repeated negotiations when there is advance production by sellers. We argue that common knowledge of prices that may be reported as an average, and the number of units available for sale (the level of inventory) in a trading cycle (a production and bargaining round) gives buyers a relatively strong bargaining position. Our case is made through backward induction and follows the discussion in Menkhaus et al. (2007a).

Consider the case of different sellers and perfectly-coordinated buyers who are matched $n$ times for the purpose of negotiating for price after the production decision by sellers in a trading cycle. Inventory therefore is in stock. Units of production cannot be carried over to the next trading cycle due to product perishability, prohibitive storage costs, costly production process, or quality deterioration. Sellers have the opportunity to
sell multiple units during each of \( n \) rounds of matches with buyers in a trading cycle. Left-over units become worthless at the end of the \( n \)th negotiating round. In the last round of bargaining, a buyer has the incentive to bid and pay virtually zero for remaining stock. Through backward induction, there is the incentive to pay zero in the \( n-1 \) round, then in the \( n-2 \) round, and so on for all negotiation pairings. A price of zero, therefore, is the predicted Nash equilibrium price for a single production/trading cycle. With repeated trading cycles this cannot be an equilibrium because sellers will not produce in future cycles. Nevertheless, this result demonstrates the bargaining advantage possessed by buyers in this trading environment.

Coordinated buyers in a multi-cycle game with \( n \) bargaining rounds or matches in a trading cycle seek to maximize their consumer surplus. Assuming no price discrimination and a uniform price, buyer surplus is maximized where marginal factor cost intersects the demand schedule, and price is from the supply schedule. Price and quantity sold are determined as if buyers held perfect monopsony power. This is a stylized multiple trading cycle Nash equilibrium.\(^3\) Sellers in general are not passive to negotiated prices that are relatively low. They can react by producing less in future periods, offsetting some of the bargaining advantage held by buyers.

In actual market trading like that constructed in our laboratory market with several buyers and sellers, buyer coordination can be difficult. Both buyers and sellers face a “matching risk.”\(^4\) During late matches, it is possible that a buyer may be paired with a seller who has no inventory for sale. Further, traders may be disadvantaged due to the relative difference between their respective marginal benefits and marginal costs. In
the case of limited matches during a trading cycle (i.e. n is small), traders have an incentive to trade early. This will dilute some of the buyer’s bargaining power associated with advanced production. Wishing to avoid a later mismatch, buyers are expected to bid the price above the pure monopsony level.

On the other hand information about prices in the market will help buyers coordinate themselves in the direction of the monopsony equilibrium. If reported prices, either an average or all trade prices, show that an individual buyer makes bargains at relatively lower prices, it is a signal that other buyers are more aggressive in their bargaining. The trader needs to trade earlier at higher prices or risk matches later in the trading cycle with limited profitability. Trades made by an individual buyer at relatively higher prices signal that he or she is paying a premium and could be more patient in trading. Profits to this buyer can increase by making bargains later in the trading cycle at lower prices.

Also, knowledge of quantities produced/traded allows buyers to form better subjective probabilities over future transactions. Knowing the number of matches, perhaps learned through repeated trading cycles, traders can overcome matching risk. More information about the number of trading opportunities, along with knowledge of the number of units that can be traded, allows buyers to become more patient and conservative in their negotiations.

We believe additional information, given the strategic opportunities and reactions of traders in the trading environment described, will give buyers a negotiation advantage relative to sellers. Quantity information will allow buyers to be more patient in their
negotiations, and price information signals buyers to be more aggressive or patient in
their offers and counteroffers – together helping buyers coordinate and placing sellers at a
bargaining disadvantage. We emphasize that it is both types of information together that
help buyers coordinate. An absence of information about average prices or quantities
traded creates sufficient uncertainty about the behavior of other buyers, thus they are
unable to achieve any tacit coordination over themselves.

Because of advance production and limited matches, sellers are not helped by
backward induction from the end of a trading cycle. They will find it difficult to
coordinate in private negotiation trading, with or without information about prices and
the quantities traded. In the trading environment constructed, sellers remain competitive
in the absence of formal agreements.

Two testable propositions summarize this discussion. Advance production and
limited matches lay the foundation for buyers to coordinate from the last trading round to
earlier trading rounds. Buyer coordination can be aided by “injections” of public
information into the bargaining environment. Testable propositions to this effect are:
Proposition 1: Bargaining outcomes will not be impacted by the public reporting of
information on just trade prices or just quantities traded.
Proposition 2: Bargaining outcomes will favor buyers if trade information is reported on
prices and quantities traded.

In the experimental setup described below, we devise two ways public reports can
inject price and quantity information into the market. One is to report an average price
for the number of units traded, and the other is to report the price of each unit sold, which
also informs agents of the number sold. There may be other ways to publicly report
information through which information about prices and quantities traded is conveyed.
These propositions have implications for total market efficiency that will be discussed as
the data are analyzed.

**Experimental Methods and Treatments**

All trading was conducted over a computer network in a university computer laboratory.
An experimental session consisted of 20 three-minute trading cycles, each following a
production decision by sellers. A trading cycle may be thought of as a production and
marketing period. Twenty trading cycles allowed for ample time for learning to occur by
experiment participants along with convergence of trade prices, quantities traded and
earnings. Each trading cycle had three one-minute bargaining rounds in which randomly
matched buyers and sellers negotiated for price. Thus, if negotiations failed with a buyer-
seller match, another match might be possible, although randomly determined. We chose
a limited number of matches to reflect the market setting previously described.
Following previous research (Plott 1982), four buyers and four sellers participated in
each laboratory market session. Subjects were recruited primarily from upper-level and
graduate business and economics classes. They were randomly assigned the role of buyer
or seller. The basic experimental design follows Davis and Holt (1993) and Menkhaus et
al. (2007a).

Multiple designs could have been used for the private negotiation institution. We
chose a design to capture the essence of bargaining, without verbal communication or the
sending of explicit messages. Private negotiation is a complicated and usually involves
strategic behavior that is fostered through repeated encounters with other agents. Reputation building would necessarily appear if we permitted subjects to choose a trading partner and communicate. We were not interested in investigating a repeated game between two agents, and our design eliminated this for the purpose of control. Buyers and sellers were randomly matched in each of the private negotiation bargaining rounds. In these bargaining rounds matched pairs were given one minute to trade and then another random match was made, for three matches during a three minute trading cycle. This amount of time allowed for a transaction cost associated with taking too much time to negotiate a price as well as created a matching problem that exists in many agricultural commodity markets. The trading procedures in the private negotiation sessions essentially followed those of the double auction except for the number of traders.

Buyers (sellers), when paired, were allowed at any time to submit bids (offers) for a single unit. Bids (offers) were submitted by typing the numerical value into the computer. The best bid (offer) was displayed on each individual’s computer screen. Valid bids (offers) were made to follow an “improvement” rule (i.e. the bid [offer] to be displayed to the market was required to be higher [lower] than that previously displayed as the best bid [offer]). Also, following common practice, a valid bid (offer) in our experiments was not allowed to exceed (be lower) than the asking (bid) price currently displayed if one existed. A trade occurred when a best bid (offer) equaled the best offer (bid), or either party accepted the currently displayed bid (offer). After a trade was made, the buyer-seller pair continued negotiations for the next trade, if time had not expired and
a unit was available to trade. Communication between agents was not permitted during bargaining rounds.

Reservation values, unit costs, and earnings were denoted in a monetarily convertible currency called tokens. The exchange rate used in the experiments was 100 tokens = 1 dollar. At the beginning of each session, each participant was given an initial token balance of 700 tokens. Participants were told that they could keep this money plus any they earned from trading. Buyers were privately given a table that listed the maximum reservation (resale) values for each unit purchased. Sellers were similarly provided with unit costs. Unit values and unit costs were identical for each buyer and each seller, respectively, and for control purposes unit values and costs remained the same across replications and treatments. The schedules used in the experiments are reported in table 1. In aggregate as presented below, these translate into induced supply and demand and in equilibrium, equal earnings result for buyers and sellers. Each buyer was allowed to purchase one at a time, up to eight units during each trading cycle. The first unit purchased was the highest value unit, the second purchased was the second highest value unit, and so on. Likewise, each seller was allowed to produce up to eight units and to sell them, one at a time, in a trading cycle. The first unit produced (sold) was the lowest cost unit; the second unit was the second lowest cost, and so on. Eight units proved to be sufficient to allow for ample trading activity during each cycle.

Relying on induced value theory (Smith 1982; Plott 1982), the values and costs used in the experiment (table 1) constitute individual demand and supply for each trading cycle. When summed horizontally over four sellers and four buyers, the aggregate
supply and demand curves are derived. Competitive price theory predicts an equilibrium price of 80 tokens, units traded between 20 and 24 units per cycle, buyer and seller earnings each 150 tokens, and total earnings of 1,200 tokens. For comparison the monopsony solution is a price of 60 tokens and 16 units traded per period.

Earnings for a buyer on each unit purchased were equal to the redemption value of the particular unit less the price paid to the seller. Earnings for a seller on each unit sold were equal to the price received by the seller less the production cost of the particular unit. Earnings accumulated over the sequence of trading cycles were displayed on the computer screen at the end of each trading cycle. At the end of the experiment, participants were paid the cash equivalent of their earnings. Each experiment session lasted from 2 to 2 1/2 hours, and the earnings per participant were about $20 to $30.

Figure 1 illustrates the design of the trading cycle for each session. After the instructions for the experiment were presented, and before the actual experiment began, participants were given the opportunity to acquaint themselves with mechanics of the computer trading (Phase 1) using unit costs and values different from those in the actual experiment. Sellers made a production decision (Phase 2), thereby providing units for sale once negotiation commenced (Phase 3). Note that production costs were incurred before trading begins, reflecting the advance production nature of a spot market. Sellers were allowed to sell only the number of units they produced, and there was no inventory carryover. As soon as the seller produced units, the production costs were sunk. The unit cost of production was lost for unsold units, reflecting commodity/product perishability. The seller could avoid losing the entire unit cost of production by selling units at a
discount. We, therefore, purposely assigned more risk to the seller than to the buyer to reflect the market environment described above and to highlight how alternative types of information might impact the relative bargaining power of buyers and sellers in such a market setting. At the end of every trading cycle, earnings were reported as private information (Phase 4), and a new production/trading cycle then began after selected public information was presented, depending on the treatment (Phase 5).

Our research focuses on how alternative types of public information affect bargaining outcomes in private negotiation trading with spot delivery. How these alternative types of information impact trading results in private negotiation exchange with spot delivery distinguishes this research from previous efforts that primarily address how market outcomes are affected across trading institutions and methods of delivery (Menkhaus et al. 2003; Menkhaus, Phillips, and Bastian 2003). Five types of public market information are investigated in this study (Phase 5 in figure 1):

- Treatment 1: No market information is reported. We refer to this baseline treatment as NMI.

- Treatment 2: After the trading was completed and earnings reported and recorded, we provided agents with the average market price from all trades in the cycle, which we refer to as the market price. This information also was recorded on a record sheet that was provided to the participants. This is labeled as the Market Price (MP) treatment.
- Treatment 3: The number of trades in the cycle was reported in the same manner as the market price in treatment 2, after which a new trading cycle began. This is the Quantity Traded (QT) treatment.

- Treatment 4: After the trading cycle was completed, we provided agents with the average market price and total units traded in the cycle. For reference the label is the Market Price/Quantity Traded (MPQT) treatment.

- Treatment 5: Every trade price was displayed to all participants in the session immediately after a trade had been made. The treatment is labeled All Trade Prices (ATP).

Three replications of each treatment, for a total of 15 experimental sessions, provided the data for analyses. Note information was not available in treatments 2, 3, and 4 for the first trading cycle.

**Data Analysis**

A description of the characteristics of the data generated in the experiments (prices, trades, buyer and seller earnings, and total earnings) is provided graphically and by means of a convergence model (Ashenfelter et al. 1992; Noussair, Plott and Reizman 1995). The latter also provides a convenient method to describe the data and supplements the former with tests of statistical differences between the various treatments for each market outcome, effectively testing the propositions set forth above. The data generated over several time cycles, pooled with cross section data (for example across the treatments described in the presentation of the experimental design) may be serially correlated and heteroscedastic. Data also may be contemporaneously correlated between
cross sections due to the same unit values/costs being used, as an example, between and among alternative treatments. These complications, in the absence of a well-developed theory of the convergence process in markets, create problems with statistical analyses.

We estimated variations of the following general convergence model:

\[ P_i(t) = B_0 rac{(t-1)}{t} + B_1 \frac{1}{t} + \sum_{j=1}^{i-1} \alpha_j D_j \frac{(t-1)}{t} + \sum_{j=1}^{i-1} \Gamma_j D_j \frac{1}{t} + u_{it}, \]

where \( P_{it} \) = average sale price (or units traded or earnings) across all replications, and all trades for each of \( t \) cycles in cross section (treatment) \( i \); \( B_0 \) = the predicted asymptote/convergence of the dependent variable for the base category; \( B_1 \) = predicted starting level of the base data; \( t \) = trading cycles \( 1, \ldots, 20 \); \( i = treatment \ 1, \ldots, 5 \), where the no market information treatment (NMI) is the base, and the other subscripts represent in order MP, QT, MPQT, and ATP; \( D_j, \alpha_j, \) and \( \Gamma_j \) = dummy variables and associated regression parameters representing treatments; and \( u_{it} \) = error term. The asymptote/convergence values are of primary interest in this study, particularly how they differ across treatments. Given this and the fact that learning occurs in early cycles, we opted to include data from trading cycle one in the analysis, even though information was not available in the first trading cycle in treatments 2 through 4. Sale prices (and units traded and earnings) for a treatment were averaged across the replications to reduce the influence of individual agents.

The Parks method (1967) was used to estimate the model (equation 1). This is an autoregressive model in which the random errors \( u_{it}, i=1, 2, \ldots, 5 \) and \( t=1, 2, \ldots, 20 \), have the structures (SAS 1993) \( E(u_{it}^2) = \sigma_{ii} \) (heteroscedasticity); \( E(u_{it} u_{jt}) = \sigma_{ij} \)
(contemporaneously correlated); and \( u_{it} = \rho u_{i,t-1} + \varepsilon_{it} \) (autocorrelation). The Parks method assumes a first-order autoregressive error structure with contemporaneous correlation between cross sections. The covariance matrix is obtained by a two-stage procedure leading to the estimation of model regression parameters by generalized least squares. The use of the Parks method takes into account the unique statistical problems resulting from the panel data sets that consist of time series observations on each of the several cross-sectional units generated in the experiments. The method requires the number of observations per cross-section to be balanced and the number of time series observations to be greater than the number of cross-sections. Buyer earnings minus seller earnings were used as the dependent variable in the convergence model to analyze the relative magnitudes of buyer and seller earnings.

We now report the results of our experimental treatments and test for statistical differences. Differences are considered statistically different at the 99 percent confidence level. These observations and tests provide the support, if any, for the propositions outlined above.

*Prices*

Average prices across the three replications for each treatment and production/trading cycle are presented in figure 2. Price levels in the no market information (NMI), market price (MP), and quantity traded (QT) treatments track closely during latter trading cycles and are the highest among all treatments. The estimated asymptotes from the convergence model are not significantly different (table 2) for the NMI, MP, and QT treatments. Hence, providing information to market agents about only the average price
from trades or only the quantity traded in the previous trading cycle neither lowered nor raised prices in private negotiation trading relative to the no information treatment.

The data in figure 2 show that average negotiated prices in the MPQT and ATP treatments are lower than prices in the other three treatments. Table 2 further reports that these prices are significantly lower than those in the other three treatments and not statistically different from each other. Prices in the MPQT and ATP treatments are well below the predicted competitive level of 80 tokens and above the predicted monopsony level of 60 tokens (figure 2). A downward drift in prices during the 20 cycles is apparent for the ATP treatment. The additional information associated with announcing the average trade price and quantity traded together, or the price as it occurred for each unit traded, in the MPQT and ATP treatments, respectively, lowered price by as much as 7.7% from the NMI treatment. These results are consistent with the propositions stated earlier. Such information practices appear to have helped the bargaining power of buyers.

Quantities Traded

Average quantities traded across the three replications for each of the 20 cycles by treatment are presented in figure 3. The NMI and the QT treatments exhibit the most trades during the latter trading cycles. Trades in the QT treatment are significantly higher than trades in other treatments, including the NMI treatment (table 2). The MPQT treatment resulted in significantly lower trades, as compared to the no information treatment. Units traded converged to levels ranging from about 12.60 units in MPQT to about 15.86 units in the QT treatment.
As reported in table 2, the ATP treatment does not show quantities traded to be significantly different from the NMI baseline. Figure 2 shows that these prices begin to fall after cycle 10. Viewing the trade data after cycle 10 shows a significant difference in trades between the NMI and ATP treatments. It is noteworthy that fewer trades in the MPQT and ATP environments did not result in higher prices. This supports the argument that buyers are able to tacitly coordinate in the MPQT and ATP information treatments. The experimental results favor propositions 1 and 2.

A comparison of the number of units traded with average price indicates that fewer units were traded in each treatment than would be expected based on the unit cost schedule. For example the average price in NMI is about 73 tokens, signifying that five units could be traded (produced) profitably by each seller, on average. Hence trades in all treatments are below the predicted competitive level of 20 to 24 units, suggesting that producers are responding to risk from advance production and limited matches. This is the first indication that the bargaining environment in general leads to less efficiency than would be possible from the market operating at the intersection of supply and demand.

*Buyer/Seller Earnings Differences*

Supply and demand are set up in the experimental design so that if the market operates at the intersection of supply and demand, buyers as a group and sellers as a group have equal earnings of 600 tokens. There should be no difference in earnings.

The average differences in buyer and seller earnings for each treatment are presented in figure 4. From figure 4 buyers earned more than sellers in all treatments, with buyers earning the most in MPQT. The difference in earnings is lowest in the MP
treatment, indicating buyer (seller) earnings are least (greatest) in this treatment as compared with other treatments. Statistically, however, the estimated convergence levels for buyer-seller earnings differences for the MP, QT, and ATP treatments are no different from the base (NMI) treatment (table 2) and each other. The earnings difference is significantly higher from the base for the MPQT treatment, with buyers earning about 18 tokens more than sellers.

Information generally was not successful in yielding price levels that resulted in an equitable distribution of earnings to buyers and sellers and did not improve the earnings position for sellers relative to buyers. These observations are further support of propositions 1 and 2. There is evidence that the MPQT information treatment was of greater benefit to buyers than the ATP treatment. It may be that reporting the average price rather than listing all trade prices was more transparent and focal for buyer coordination than a list of trade prices.

Total Earnings

Market efficiency (the sum of buyer and seller earnings) was adversely affected in each of the private negotiation trading treatments, regardless of information given to the agents. This is primarily due to fewer units traded, compared to the predicted competitive level of 20 to 24 units. Figure 5 illustrates that compared to the competitive prediction of 1200 tokens in total surplus, bilateral bargaining efficiency fell by about 16% in the NMI, MP, and QT treatments and by about 20 and 22% in the ATP and MPQT treatments, respectively. Only MPQT, however, exhibited a level of total surplus significantly below the NMI treatment (table 2). Bilateral trading generally resulted in
fewer units traded, as previously discussed, which reduced total earnings to market participants.

Most market institutions become more efficient as traders gain experience. Figure 5, however, shows a declining trend in efficiency for the bargaining treatments. Indeed, table 2 shows that by comparing starting levels with asymptotes, the baseline NMI exhibits slightly increasing efficiency. Treatments MP, MPQT, and ATP, with some additional information added to the environment, show declining efficiency as subjects go through trading cycles. Thus, not only are average earnings for these treatments well below the 1,200 token mark at the start of experiments, the difference increases over time. The negative impact of the information on bargaining behavior appears to be robust.

Pattern of Trades and Prices

Quantities and prices for bargaining rounds 1 through 3 across all replications and for cycles 16 through 20 are reported in table 3. Data in this table show the distribution of trades and prices across bargaining rounds. Most trades were made in bargaining round 1, and about 70-75% of the trades occurred in rounds 1 and 2. The percents of trades are lower in round 3 as compared to round 1, for all treatments (table 3). This pattern is expected since marginal costs are higher for sellers and marginal values are lower for buyers as they work through unit values and costs (table 1).

There is a tendency for the lowest prices to be in round 3 across all treatments (table 3), but prices in the MPQT and ATP treatments are lower than in the other three treatments across all bargaining rounds. Data in table 3 suggest that buyers in the MPQT
and ATP treatments were coordinating relatively well in the sense that prices were kept consistently low across bargaining rounds. Because of this, buyers were able to confidently trade early with more than 40% of the trades made in the first round.

Coefficients of price variability across treatments tend to be higher in round 3, with the exception of the ATP treatment, which had its highest variability in the first round and had higher variability than the other treatments in each round. We expect variability to increase across trading rounds because of poorer matches between traders in later bargaining rounds. It is an anomaly for the ATP treatment to have its highest variability in the first round. We believe that this high variability is the result of a list of reported trade prices being less transparent and less focal than a reported average. When buyers, for example, received this list, they may have tried to beat the lowest trade price, or they may have wanted to trade at prices roughly comparable to the lowest quartile or the lowest half of the reported bargain prices. A list of prices creates multiple anchors that buyers can use to negotiate in later transactions.

We note variability in prices across the information treatments and bargaining rounds generally are higher than price variability for the NMI treatment. This indicates to us that public information in general enhances strategic behavior between traders; the information encourages more intense bargaining which, as we have already observed, does not improve market efficiency.

**Summary and Conclusions**

This research investigates the impacts of selected public information on laboratory market outcomes when there is private negotiation with advance production, perishable
inventories, and limited buyer-seller matches. We have argued that many agricultural products/commodities are traded in such a market environment. Will public information enhance market efficiency by creating more surplus? Is it possible for the public information to shift surplus between buyers and sellers? Information treatments included: no information (NMI); providing average market price from the trades in the previous production/trading cycle (MP); reporting the number of trades from the previous cycle (QT); making available average market price and quantity traded from the previous cycle (MPQT); and reporting all trade prices (ATP) as they occur.

Compared to the baseline NMI treatment, the four treatments in which information was reported in our experiments did not improve market efficiency (total earnings), and in one case (MPQT) made it significantly worse than if no information were provided. In the market environment described, the added information can improve the bargaining position of buyers, relative to that of sellers, putting sellers in a worse position than in the NMI treatment, as in the MPQT treatment. The negotiating position of sellers for price especially deteriorated when both price and quantity were known, either explicitly (MPQT) or implicitly (ATP). Price and quantity information together allowed buyers to coordinate in their negotiations with sellers. Seller earnings were at best no better in the information treatments (MP, QT, and ATP) and were significantly lower in the MPQT treatment, relative to the NMI treatment. When the quantity available for sale and price from earlier production decisions were known, bargaining power favorable to buyers was created.
Related research (Phillips, Menkhaus, and Coatney 2003) reports that knowledge of quantity for sale in a multiple unit English auction (e.g. a wine or cattle auction) allowed buyers to coordinate bids. Coordination was observed for as many as four bidders. This finding is consistent with that reported in the current study recognizing that price, in fact, is public knowledge in an English auction. Hence, when the quantity for sale was known before bidding began, buyers were made aware of both prices and remaining units for sale as the auction was conducted. Previous research, therefore, supports the result that price and quantity information together is an important facilitating influence for coordinating buyers in the price negotiation process.

Institutions, such as those that govern trading rules and the environment in which trading occurs, can impact market feedback. Information that is available to market agents in a private negotiation trading environment is different than when buyers and sellers interact simultaneously, say through an auction, to determine market outcomes. Market feedback in auctions generally results in efficient exchange. The results of this study indicate that this market feedback may not be duplicated by publicly reporting market outcomes from private negotiation trading with advance production of a perishable commodity and with limited bargaining matches. Market outcomes in such a setting depend on the relative bargaining positions of market agents. The changing market environment in the food and fiber sector requires policy makers and analysts to tailor their thinking and analyses to the relevant trading institution under consideration. Continued research is required to evaluate the sensitivity of bargaining behavior to the institutional changes occurring in agricultural commodity and product markets.
Based on this research, additional focus on alternatives that might improve a seller’s negotiating position and equity in returns between buyers and sellers in private negotiation trading with spot delivery is warranted. Alternatives that generally would improve the bargaining position of sellers relative to buyers are possible avenues for future research. Cooperative agreements for sellers through controlling a greater production and effectively increasing the number of matches between buyers and sellers could increase their bargaining power in private negotiation. Negotiating power of sellers also could be increased by: (1) relaxing the advance production requirement either through the carryover of inventories when feasible or through production-to-demand arrangements such as forward contracting before production costs are sunk or (2) allowing for multilateral contracting. The first measure makes it more difficult for buyers to judge available supplies and coordinate, while the second increases buyer and seller contact.

Finally, the results of this research suggest that mandatory reporting aggregate negotiated price, by itself, under LMPR may neither help nor hinder the bargaining position of cattle producers relative to buyers (processors). The combination of quantity and price information seems to be most critical in providing a bargaining advantage to buyers in the market environment described. Given that much of the previous research provides support for LMPR, although these studies did not address the issues of market efficiency or equity in returns between buyers and sellers, we do not recommend abolishing LMPR. Instead, based on the results of this research, consideration should be given to supplementing the information base under LMPR with measures such as those
previously presented that would alleviate risks borne by sellers (producers) associated with advance production and limited matches in private negotiation trading.
Endnotes

1 In this context Bulow and Klemperer (1996) analytically demonstrate that sellers will do better selling in an English auction than trading through private negotiation. They write (p. 180) that the “value of negotiation skill is small relative to the value of additional [bidding] competition.”

2 Advance production also is known as spot delivery. Having inventory available for immediate delivery is a primary component of a spot market. Production-to-demand delivery is descriptive of a forward contract and also is known as forward delivery.

3 Sexton and Zhang (1996) provide empirical evidence of this type of control giving buyers an advantage “when the sellers’ asset is sunk and highly perishable” (p. 932). These authors document a decline in spot lettuce prices related to greater advance production.

4 Matching risk can be demonstrated with two rounds of trading. Suppose a buyer purchases one unit and has a reservation price of \( r_B \). In round 1 a trade can occur at \( r_B - p_{1B} \), where \( p_{1B} \) is the negotiated price, or the buyer can reject the deal and wait until round 2. In round 2 three random events are possible. The buyer may not be able to locate a seller who will sell at a price above \( r_B \), in which case no trade occurs. In two other scenarios a trade may occur, and it could be better or worse than the round 1 deal. Probabilities can be assigned to the outcomes in round 2 that would make expected payoffs lower than \( r_B - p_{1B} \). The expected payoffs could be low enough that the buyer would agree to a trade in round 1 at a higher price (Menkhaus et al. 2007b).
We used tokens as the monetary unit for generality and convenience. For example, we have run these experiments in other countries and could easily change the exchange rate for payoffs to be comparable across countries.

The initial balance was deemed necessary in our spot market experiments because sellers must incur production costs prior to being given the opportunity to earn profit from sales. An additional concern is that the initial endowment should be large enough to preclude the possibility of individual bankruptcy early in the session, particularly for sellers. In order to maintain symmetry between buyers and sellers, the initial balance was given to both buyers and sellers.

While sellers can lose the unit cost for unsold units in advance production, buyers give up the marginal profit if they do not purchase. If we deemed it to be appropriate, it is a simple matter to create a risk for the buyer identical to that facing the seller who does not sell all units produced. This involves creating a mandatory buy-order for the buyer, and if it is not met, the buyer must purchase unfilled units in a “secondary market” for 160 tokens each and sell each at the designated redemption value. We believe, however, that it is more realistic in many agricultural markets to assign more risk to producers. Buyers can usually meet plant capacities, for example, given the large inventories of products available for sale. Further, a design that gives equal risk to buyers and sellers would be expected to generate results reflecting nearly equal bargaining power between buyers and sellers (Menkhaus, Phillips, and Bastian 2003). Circumstances that give bargaining power to one side of the market or the other are important considerations, along with how public information might impact the relative bargaining power under such circumstances.
The convergence model was estimated using data from the last ten cycles to confirm the statistical significance of differences in trades between the NMI and ATP treatments observed in figure 3.
References


<table>
<thead>
<tr>
<th>Instructions</th>
<th>Actual Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1</strong></td>
<td><strong>Phase 2</strong></td>
</tr>
<tr>
<td>Buyers (4)</td>
<td>Production</td>
</tr>
<tr>
<td></td>
<td>Wait</td>
</tr>
<tr>
<td></td>
<td>Sellers (4)</td>
</tr>
<tr>
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<td>Private Negotiation (Three Bargaining Rounds-Random B/S Matches)</td>
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<td>-All Trade Prices</td>
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Figure 1. Organization of experimental session and trading cycles for buyers (B) and sellers (S)
Figure 2. Prices - alternative public information treatments
Figure 3. Trades - alternative public information treatments
Figure 4. Buyer earnings minus seller earnings - alternative public information treatments
Figure 5. Total earnings - alternative public information treatments
Table 1. Unit Values and Unit Costs (Tokens)

<table>
<thead>
<tr>
<th>Unit(s)</th>
<th>Unit Values (Buyers)</th>
<th>Unit Costs (Sellers)</th>
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<tr>
<td>1</td>
<td>130</td>
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<tr>
<td>2</td>
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<td>70</td>
<td>90</td>
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<tr>
<td>8</td>
<td>60</td>
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Table 2. Estimated Convergence Models and Related Statistical Tests for Price, Quantity Traded, Buyer Minus Seller Earnings, and Total Earnings

<table>
<thead>
<tr>
<th>Variable</th>
<th>Price</th>
<th>Quantity Traded</th>
<th>Buyer-Seller Earnings</th>
<th>Total Earnings</th>
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<tr>
<td><strong>Asymptotes</strong></td>
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<tr>
<td>NMI - Base</td>
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<td>55.28</td>
<td>1009.77</td>
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<td>(0.20)</td>
<td>(4.97)</td>
<td>(12.90)</td>
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<tr>
<td>MP</td>
<td>0.45a</td>
<td>-0.43a</td>
<td>-9.68a</td>
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<td>(0.33)</td>
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<tr>
<td>QT</td>
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<td>1.23*a</td>
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<td>-2.00*b</td>
<td>18.19*b</td>
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<tr>
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<td>(0.86)</td>
<td>(0.36)</td>
<td>(6.52)</td>
<td>(17.18)</td>
</tr>
<tr>
<td>ATP</td>
<td>-4.57*b</td>
<td>-0.77ab</td>
<td>-2.10a</td>
<td>-52.43bc</td>
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<td>(1.20)</td>
<td>(0.50)</td>
<td>(6.60)</td>
<td>(22.81)</td>
</tr>
</tbody>
</table>

<p>| <strong>Starting Levels</strong> |        |                 |                       |                |
| NMI - Base         | 69.78  | 14.94           | 93.18                 | 963.54         |
|                   | (1.35) | (0.62)          | (12.53)               | (38.13)        |
| MP                | 4.29a  | 2.63<em>a          | -42.04</em>a              | 139.99*a       |
|                   | (1.82) | (0.85)          | (12.34)               | (40.84)        |
| QT                | 1.05a  | 1.25a           | 1.76ac                | 7.00a          |</p>
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<td>(1.09)</td>
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* Significantly different from no information base asymptote (stating level), 99 percent confidence level. Standard errors are reported in parentheses. a, b, c - Same letter indicates no significant difference between estimated asymptotes (starting levels) in the respective equations. A different letter indicates a significant difference between estimated asymptotes (starting levels), 99 percent confidence level.
Table 3. Average Percent Trades and Average Trade Prices and Coefficients of Variability for Each Bargaining Round by Treatment across Replications and Trading Cycles 16-20

Average Percent Trades

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Bargaining Match Round 1</th>
<th>Bargaining Match Round 1</th>
<th>Bargaining Match Round 1</th>
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<tr>
<td>NMI</td>
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<td>35.55</td>
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<td>36.59</td>
<td>37.81</td>
<td>25.59</td>
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<tr>
<td>QT</td>
<td>40.80</td>
<td>30.96</td>
<td>20.24</td>
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<tr>
<td>MPQT</td>
<td>45.18</td>
<td>29.53</td>
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<td>ATP</td>
<td>42.77</td>
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<td>31.85</td>
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Average Trade Prices and (Coefficients of Variability)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average Trade Price (Coefficient of Variability)</th>
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<tbody>
<tr>
<td>NMI</td>
<td>76.36 (13.98) 74.37 (12.55) 69.36 (14.84)</td>
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<tr>
<td>MP</td>
<td>73.49 (15.55) 76.68 (16.65) 66.75 (20.65)</td>
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<tr>
<td>QT</td>
<td>78.28 (12.53) 76.92 (9.10) 66.14 (21.11)</td>
</tr>
<tr>
<td>MPQT</td>
<td>69.09 (15.24) 69.36 (13.47) 64.07 (19.26)</td>
</tr>
<tr>
<td>ATP</td>
<td>73.31 (31.07) 75.65 (23.99) 63.98 (24.48)</td>
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