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Conspiracies and secret price discounts in the marketplace: evidence from field experiments

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and

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We explore collusion by using the tools of experimental economics in a naturally occurring marketplace. We report that competitive price theory adequately organizes data in multilateral decentralized bargaining markets without conspiratorial opportunities. When conspiratorial opportunities are allowed and contract prices are perfectly observed, prices (quantities) are considerably above (below) competitive levels. When sellers receive imperfect price signals, outcomes are intermediate to those of competitive markets and collusive markets with full information. Finally, experienced buyers serve as a catalyst to thwart attempts by sellers to engage in anticompetitive pricing: in periods where experienced agents transact in the market, average transaction prices are below those realized in periods where only inexperienced agents execute trades.

1. Introduction

■ Economists often disagree about the extent to which industry structure determines market performance. While it is generally agreed that explicit communication among sellers will lead to attempts at price fixing, little consensus exists as to the ultimate impact of such attempts on market prices. If the costs associated with enacting, monitoring, and maintaining collusive arrangements are prohibitive, then such agreements are ineffective. Others argue that collusive outcomes are relatively stable, with anticompetitive prices sustainable in concentrated markets or in markets where sellers engage in repeated interactions.

There are not a large number of empirical studies examining conspiracies in naturally occurring markets.[1] Experimental markets and laboratory studies provide a tool for analyzing explicit seller conspiracies (see, e.g., Isaac and Plott, 1980; Isaac, Ramey, and Williams, 1984; Davis and

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[1] Exceptions include the studies of Porter (1983), Lee and Porter (1984), and Ellison (1994), which examine cartel stability by analyzing behavior of the Joint Executive Committee, a legal freight cartel that controlled eastbound rail shipments from Chicago to the eastern seaboard during the 1880s. In the context of procurement bidding, Porter and Zona

Holt, 1998). The researcher can introduce explicit collusive activities while holding constant other elements of market structure. Experiments allow the researcher to study the effects of changes in market structure that are difficult to identify in field data. Yet it is important to note that much of the relevant research has examined collusive behavior using a student subject pool in an experimental laboratory market.

We take a new look at the structure/performance relationship by experimentally examining decentralized outcomes, in the spirit of Chamberlain (1948) as extended by List (2004), in a laboratory market set in a naturally occurring context—the sportscard marketplace. An advantage of this experimental design is that our laboratory is the marketplace: subjects would be engaged in buying, selling, and trading activities whether we ran an exchange experiment or were passive observers. An added advantage is that agents have endogenously selected certain roles within the marketplace—such as being a seller (dealer) or buyer (nondealer), experienced or inexperienced agent, etc. In this sense, the data are gathered in a laboratory market arranged in a naturally occurring context with self-selected buyers and sellers that maintains the necessary control to execute tests of relevant theory.[2]

Our experimental design consists of several market treatments with twelve buyers and either four or twelve sellers. Variations in underlying market structure and information settings are used to examine equilibrium outcomes. Each market treatment mimics Chamberlain's (1948) construct in that each buyer (seller) is given a reservation price for each unit demanded (supplied) and is allowed to engage in market bargaining and haggling until executing a contract or until the trading period terminates.[3]

Several insights emerge from our experiment. First, there is a tendency for convergence toward competitive predictions in markets without explicit seller conspiracy. Even in concentrated markets with four sellers each providing three units, competitive price and quantity levels are approximated in many market rounds.

Second, there is a persistent anticompetitive effect of explicit seller conspiracy in some multilateral decentralized bargaining markets, especially in markets with perfect information regarding transactions prices. This finding strengthens previous laboratory results from double-auction markets that find mixed evidence in support of anticompetitive behavior in conspiratorial sessions (Isaac and Plott, 1980; Isaac, Ramey, and Williams, 1984). Our experimental results suggest that in multilateral decentralized bargaining markets, sellers are able to extract rents in excess of those predicted under a joint-profit-maximizing strategy in markets with a single price: producer rents exceed the joint monopoly levels in over half of our collusive rounds. In such markets, the joint-profit-maximizing price and quantity levels are approximated in all market rounds.

Third, in collusive markets with imperfect price signals, outcomes lie between those of competitive markets and collusive markets with full information. Finally, market experience among buyers plays a critical role in market performance and the ability of sellers to engage in anticompetitive pricing. Buyers with substantial market experience are more likely to thwart attempts at anticompetitive pricing and earn greater rents than inexperienced counterparts.

The remainder of our article proceeds as follows. In Section 2 we provide a brief overview of previous studies and outline our experimental design. In Section 3 we discuss the empirical results. Section 4 concludes.

(1999) and Pesendorfer (2000) examine and describe the behavior of convicted cartel members. Porter and Zona (1993) and Bajari and Ye (2003) develop and employ empirical strategies to identify collusive bidding for highway construction contracts.

[2] Denoting our study as a "field experiment" might be viewed as liberal; we borrow the terminology of Harrison and List (2004), and therefore a more accurate description of our experimental design is that of a "framed" field experiment. For an example of a "natural" field experiment, see List and Lucking-Reiley (2002).

[3] Markets such as those used in our study are not uncommon in practice. Such markets have been examined in the laboratory using student subjects by Hong and Plott (1982), Joyce (1983), and Grether and Plott (1984).

2. Literature background and experimental design

■ Although empirical analyses of the impacts of explicit seller conspiracies on market outcomes are limited, there is an extensive literature testing the links between market structure, conduct, and performance measures.[4] A different methodological line of inquiry has examined explicit seller conspiracies using experimental markets. These studies, which primarily use students as experimental subjects, are designed to test the effect of market structure on conspiratorial outcomes and the stability of collusive arrangements. Isaac and Plott (1980) examine conspiracies in centralized, double-auction markets (i.e., markets where all bids, asks, and contracts are common knowledge) and find that despite explicit attempts by sellers to fix prices, such arrangements are unstable. Sellers in these markets were unable to affect profits above competitive predictions, and outcomes along other dimensions (i.e., prices and quantities) lie between collusive and competitive levels. Isaac, Ramey, and Williams (1984) analyze collusive behavior in posted-offer markets. Sellers in posted-offer markets consistently maintain prices above the competitive level. In a related study, Davis and Holt (1998) alter both the institutional arrangement and the informational setting. In their experimental markets, sellers are able to offer discounts from a posted-offer price that are either unknown or imperfectly signalled to other sellers. When such discounts are private information, prices are significantly lower and producer rents approach those expected under competitive behavior. *Ex post* signals of seller actions tend to facilitate conspiracies but dampen the impacts of such conduct.

Davis and Wilson (2002) examine the role of communication and information structure on bidder behavior in markets resembling a procurement auction. Across both a set and endogenous cost regime, communication opportunities increase transaction prices and indices of monopoly effectiveness regardless of whether there was full disclosure of sales information. Feinberg and Snyder (2002) show that demand uncertainty alone had little effect on the stability of collusive outcomes. Yet the combination of secret demand shocks (uncertainty) and imperfect information about rival pricing generates static Nash outcomes in markets where collusion was sustainable using trigger strategies requiring but a single period of punishment. Aoyagi and Frechette (2003) examine collusion in an infinitely repeated game when the actions of opponents are observed via a noisy public signal. Cooperation is found across a wide level of noise in the public signal, but payoffs are found to be a decreasing function of this level.[5]

□ **Experimental design.** Our tests of collusive behavior depart from previous studies by examining individual behavior with participants in a well-functioning marketplace—the sportscard market. In this sense, our experimental design captures an element of naturally occurring settings: traders endogenously select into the market and are likely to have previous experience buying and selling. This experimental strategy may lead to different results than would an experiment with a subject pool unfamiliar with market exchange and where roles are exogenously assigned.

Each participant's experience typically followed four steps: (1) consideration of the invitation to participate in an experiment, (2) learning the market rules, (3) actual market participation, and (4) conclusion of the experiment and exit interview.[6] In step 1, before the market opened, a monitor randomly approached dealers at a sportscard show in a large Southern city and inquired about their interest in participating in an experiment that would take about 60 minutes during the show. Since most dealers are accompanied by at least one other employee, it was not difficult to obtain agreements after it was explained that money could be earned during the experiment. To gather the nondealer subject pool, a monitor randomly approached potential subjects entering the show

[4] For a summary of the literature, we point the interested reader to Michael Whinston's notes on antitrust at www.csio.northwestern.edu.

[5] There are a number of other studies that have examined the impacts of communication and information structure on cartel stability and collusive outcomes. Mason and Phillips (1997) show that symmetric duopoly markets are more cooperative when profitability is common knowledge. Sherstyuk (2002) shows that common knowledge of potential gains from collusion is sufficient to sustain collusive behavior in asymmetric auction markets.

[6] The general experimental design discussion closely follows List (2004).

and inquired about their level of interest in participating in an experiment that would last about 60 minutes.

Once the prerequisite number of dealers (sellers) and nondealers (buyers) agreed to participate, monitors thoroughly explained the experimental rules in step 2. The experimental instructions for the various treatments were standard and were adapted from Davis and Holt (1993, 1998). A few aspects of the experimental design should be highlighted. First, all individuals were informed that they would receive a $10 participation fee upon completion of the experiment. Following Smith (1965), to ensure transactions at reservation values, a $.05 commission for each executed trade was provided for both buyers and sellers.

Second, buyers (nondealers) were informed that the experiment consisted of five rounds and that they would be consumers. In each round, each buyer would be given a "buyer's card" that contained a number, known to only that buyer, representing the maximum price that he or she would be willing to pay for *one* unit. Dealers were informed that they would be sellers in the market. In each round, each seller would be given a "seller's card" that contained numbers, known to only that seller, representing the minimum for which he or she would be willing to sell their unit(s). Importantly, all agents were informed that this information was strictly private and that reservation values would change each round. They were also informed about the number of buyers and sellers in the market and that agents might have different reservation values.[7]

Third, the monitor explained how earnings (in excess of the participation and commission fees) were determined: for sellers, the difference between the actual contract price and the minimum reservation value determined producer rents. Likewise, buyers' earnings were determined by the difference between the contract price and the maximum reservation value. Several examples illustrated the irrationality associated with selling (buying) the commodity below (above) induced values.

Fourth, the commodities used in the experiment were 1982 Topps Ben Oglivie baseball cards upon each of which a moustache had been drawn, rendering them valueless outside the experimental market.[8] Thus, the assignment given to sellers was clear, and an everyday occurrence: sell the Oglivie "moustache" card for as much as possible. Likewise, the task confronting buyers was also clear: enter the marketplace and purchase the Oglivie "moustache" card for as little as possible. The cards and participating dealers were clearly marked to ensure that buyers had no trouble finding the commodity of interest. Fifth, buyers and sellers engaged in two five-minute practice periods to gain experience.

In step 3, subjects participated in the market. Each market session consisted of five market periods that lasted 10 minutes. After each 10-minute period, a monitor privately gathered with buyers and gave them a new buyer's card, while a different monitor privately gave sellers a new seller's card. It should be noted that throughout the competitive market sessions, careful attention was given to prohibit discussions between sellers (or buyers) that could induce collusive outcomes. In the collusive treatments, seller communications were permitted. We followed Davis and Holt (1998) in our information allowance. For example, subjects were not allowed to discuss nonpublic information such as unit costs, post-session side payments, or threats of a physical nature.[9] Step 4 concluded the experiment—after subjects completed a survey, they were paid their earnings in private (the Appendix contains the survey).

This procedure was followed in each of four treatments, which are summarized in column 1 of Table 1. Row 1, column 1 contains treatment *PC12*, denoting a competitive market with 12 buyers/sellers, who each have unit demand/supply. Figure 1 and Table A1 in the Appendix

[7] Following List (2002), it was carefully explained to buyers (in the presence of sellers) that sellers potentially have different reservation values.

[8] Note that this particular design choice differs from previous laboratory experiments that make use of "fictitious commodities" in the trading environment. We made this choice in an effort to make the trading environment more concrete to participants. To our knowledge, it is unknown whether this design choice affects behavior.

[9] In an effort to enforce these rules, monitors closely watched subjects during and after the sessions. We cannot guarantee that side payments and physical threats were not carried out after we departed the various sportscard shows on Sunday night.

TABLE 1 Experimental Design

Rent Allocation	Sportscard Market Summary
Symmetric: 12 sellers	*PC12* 12 buyers, 12 sellers (3 sessions) $n = 72$
Symmetric: 4 sellers	*PC4* 12 buyers, 4 sellers (3 sessions) $n = 48$
Collusive: Perfect *ex post* price revelation	*CPK* 12 buyers, 4 sellers (3 sessions) $n = 48$
Collusive: Imperfect *ex post* price revelation	*CPS* 12 buyers, 4 sellers (3 sessions) $n = 48$

Notes: Each cell represents one unique treatment in which we gathered data in different sessions. For example, *PC12* in row 1, column 1, denotes that one treatment (three sessions) had 12 buyers and 12 sellers competing in markets where the rents were allocated symmetrically. No subject participated in more than one treatment. *PC12* data are from List (2004); all other data are new.

present buyer- and seller-induced values, which are taken from Davis and Holt (1993).[10] In Figure 1, each step represents a distinct induced value that was given to buyers (demand curve) and sellers (supply curve). The efficient competitive outcome yields \$37 in economic rents per round, with associated equilibrium price between \$13.00 and \$14.00 and a quantity of 7. This represents the extreme point of intersection of buyer and supplier rent areas in Figure 1. Under competitive behavior, producer surplus ranges from \$15–\$22, with the remaining value (\$22–\$15) accruing to buyers. As noted in Table 1, this treatment comes directly from List (2004) and included three distinct market sessions with 72 different market participants.

Treatment *PC4* is identical to *PC12* except for one important deviation: rather than having twelve sellers each providing a single unit of the good, aggregate supply is derived from four sellers each providing three units of the good. All remaining market parameters are identical to those in the *PC12* sessions, with the same competitive equilibrium (CE) prediction. This treatment allows tests of market concentration on performance. The treatment included three distinct market sessions with 48 different market participants. We should note that in both treatment *PC12* and treatment *PC4*, after each contract is completed, (i) a monitor posts the exchange price on a public board, and (ii) monitors inform all buyers and sellers of the exchange price in case they are removed from the public board.

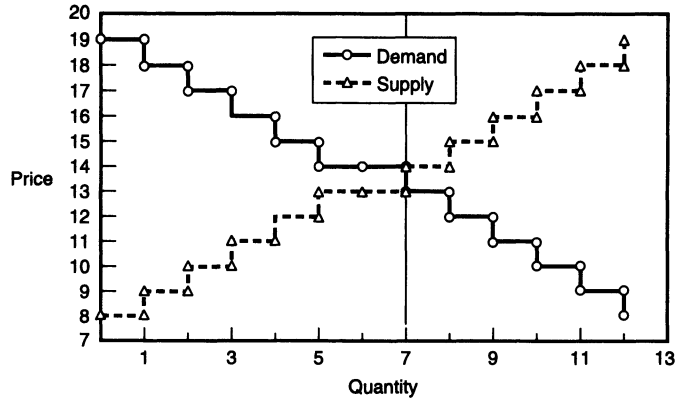
Treatments *CPK* (denoting collusion, with prices known) and *CPS* (denoting collusion, with price signals) are made up of twelve buyers each with unit demand and four sellers each with three units of supply.[11] Both markets allow explicit seller communication between rounds to induce

[10] It should be noted that (unbeknownst to buyers and sellers) within each session all agents received at least two reservation values that would place them "in the market" if competitive predictions prevailed. For the collusive sessions, each agent received at least a single reservation value that would place them "in the market" if monopoly predictions prevailed.

[11] The timing of each treatment was determined randomly to ensure appropriate randomization at the sportscard show—i.e., *CPK* session 1 was carried out on a Saturday morning, session 2 on a Sunday afternoon, etc.

FIGURE 1

SUPPLY AND DEMAND STRUCTURE



attempts to fix prices. The markets differ in the nature of the signal of exchange. In the *CPK* treatment, prices are revealed fully through *ex post* revelation, as in treatments *PC12* and *PC4*. Agents in the *CPS* treatment receive only an imperfect signal of contract prices: the signal they receive is the actual executed price plus an integer value randomly drawn on the interval $[-3, 3]$.

In the collusive treatments, efficient joint-profit-maximizing strategy yields \$32 in economic rents, with \$26 accruing to sellers.[12] The monopoly price is \$16.00, with four units sold. This outcome represents that which maximizes joint producers' profits.

In summary, the monitor gives each buyer and seller a reservation price for one (three) unit of the Oglivie "moustache" card and allows agents to engage in bilateral haggling and bargaining until they enact a contract(s) or the trading period terminates. After each contract is completed, (i) a monitor posts the exchange price (or signal) on a public board, and (ii) monitors inform all buyers and sellers of the exchange price (or signal) in case they are removed from the public board. Given that three distinct five-period market sessions were executed for each of the four treatments, the experiment includes data from 60 unique market periods. Since buyers and sellers competed in only a single treatment, our experiment included 216 subjects: 144 consumers and 72 dealers. Finally, all treatments were run in the spring of 2000, and the average payoff, including the participation fee, was \$19.74.

3. Experimental results

■ Table 2 provides summary statistics for the experimental data. Entries in Table 2 are at the period level and include average price and its standard deviation, quantity traded, total buyer and seller per-period profits, and measures of monopoly effectiveness (M) and efficiency (total rents captured divided by available rents).[13] Table 2 can be read as follows: on average, in period 1 of the *PC12* sessions, 7.3 card transactions occurred at an average trading price of \$13.53 (standard deviation = 1.9). Total buyer and seller profits were \$15.75 and \$17.25 respectively, monopoly effectiveness was $-.167$, and traders captured 89% of the available rents. The data summary for treatment *PC12* indicates our first result.

Result 1. Competitive price theory adequately organizes data in markets without conspiratorial opportunities.

This result is directly from List (2004). In every period, the average price is within the

[12] Monopoly prices and rents are based upon the setting of a single monopoly price. In our environment this is akin to sellers agreeing upon a single take-it-or-leave-it price. Such a strategy does not permit sellers to engage in price-discriminating behavior and may not necessarily reflect the optimal selling mechanism.

[13] M is calculated as the difference between producer surplus and the predicted producer surplus in a competitive market (\$18.50) divided by the difference between predicted monopoly rents (\$26) and competitive market rents.

TABLE 2 Experimental Results

Treatment	Market Period (1)	(2)	(3)	(4)	(5)
PC12					
Average price	13.53	13.86	13.71	13.77	13.12
	(1.9)	(1.7)	(1.9)	(1.5)	(1.3)
Quantity	7.3	8	7	7	7.3
Profits					
Buyers	15.75	14.75	14.02	16.25	20.08
Sellers	17.25	16.58	18.05	16.42	14.92
M	−.167	−.256	−.06	−.277	−.477
Efficiency (%)	89	85	87	88	95
PC4					
Average price	13.85	13.88	13.88	13.76	13.46
	(1.5)	(1.1)	(1.0)	(1.1)	(1.0)
Quantity	6.7	7.7	7.7	7.7	7.3
Profits					
Buyers	15.00	15.90	15.25	15.83	17.64
Sellers	20.33	20.43	20.40	20.50	17.03
M	.244	.257	.253	.267	−.196
Efficiency (%)	95	98	96	98	94
CPK					
Average price	15.49	15.46	15.28	15.28	15.85
	(1.0)	(.9)	(.59)	(.64)	(1.4)
Quantity	4.7	4.3	5	4.7	5
Profits					
Buyers	7.37	8.00	8.25	8.37	5.08
Sellers	23.63	23.00	23.75	23.63	28.25
M	.684	.6	.7	.684	1.3
Efficiency (%)	84	84	86	86	90
CPS					
Average price	15.94	15.20	14.59	14.55	14.80
	(1.6)	(1.6)	(1.4)	(1.5)	(1.2)
Quantity	5.3	5.7	5.7	6.3	5.7
Profits					
Buyers	4.65	7.88	10.62	9.83	9.78
Sellers	31.35	26.12	20.38	23.83	24.22
M	1.71	1.02	.251	.711	.763
Efficiency (%)	97	92	84	91	92

Notes: Figures in the table represent averages across the three sessions in each treatment. For example, in the *PC12* sessions, period 1 had an average trading price of $13.53 with a standard deviation of $1.9. On average, seven and one-third cards were purchased/sold, and total buyer (seller) profit was $15.75 ($17.25) for the period. Overall efficiency was 89%. *PC12* data are from List (2004). Indices of monopoly effectiveness, *M*, are calculated as (producer rent − 18.50)/(26 − 18.50), rents in excess of competitive rents, as a fraction of potential monopoly gains. Standard deviations are in parentheses.

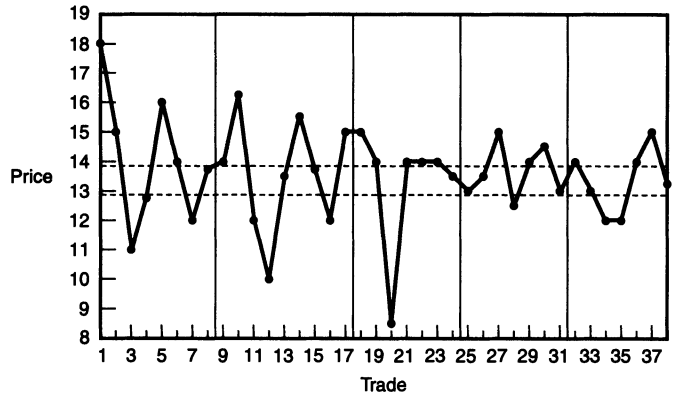
competitive prediction range ($13–$14) and quantity levels are within a single unit. Efficiency rates, which average 95% in the final period, are also quite high. Average producer profits range from $14.92 to $18.05 and fall within $.08 (.5%) of the competitive prediction range in all periods.

Figure 2 plots transaction prices for *PC12* session 1; the patterns in the other two sessions are similar. After a few periods, prices converge rapidly toward the competitive equilibrium level and "settle" in that range over the final three periods. Sixty-two percent (13 of 21) of executed trades in periods 3, 4, and 5 occurred within the competitive range.[14] Twenty-nine percent (5 of

[14] Overall, 18 of 38 trades executed in session 1 fall within the competitive equilibrium level, with two others occurring within $.50 of the competitive range.

FIGURE 2

PRICE PATH *PC12* SESSION 1



17) of executed trades fell within the competitive range in the first two periods. Consistent with early laboratory studies testing competitive price theory using other institutions (e.g., Smith, 1962, 1965), these data suggest that after a few trials the observed price and quantity levels approximate competitive predictions.[15]

Overall the data do not display the persistent pattern found in Chamberlain (1948)—volume consistently too high and executed prices consistently too low. Instead, the results are more consonant with Joyce (1983), who found average prices and average trading volume close to competitive predictions in three experimental Chamberlain-like markets with posted transaction prices.

While these results serve to extend the work of Chamberlain (1948) and Smith (1962, 1965), it would be comforting to observe similar data patterns in more concentrated markets. In treatment *PC4*, the number of sellers is reduced from twelve to four, each of whom can provide three units of the good. Data from these three sessions suggest the following insight.

Result 2. Seller concentration does not unduly affect prices and quantities, but it does result in small increases in market efficiency and producer rents.

The second panel in Table 2 summarizes market outcomes at the period level for the three *PC4* sessions. Average prices fall within the competitive range in all market periods, and quantities fall within .7 of competitive predictions. Average seller profits are 13%–25% greater in the concentrated markets than in the *PC12* markets, ranging from a low of \$17.03 to a high of \$20.50. Efficiency measures lie between 94% and 98% in all market periods.

Figure 3 plots transaction price paths for *PC4* session 1; the patterns displayed in the other two sessions are similar. The pattern of behavior is similar to that observed in the *PC12* sessions. Aggregating across all three *PC4* sessions, 53% (61 of 115) of the transactions occur within the competitive range, and 58% (38 of 68) in the final three market periods. Of the transactions occurring outside the CE range, prices in 50% (15 of 30) of the cases lie within \$.50.

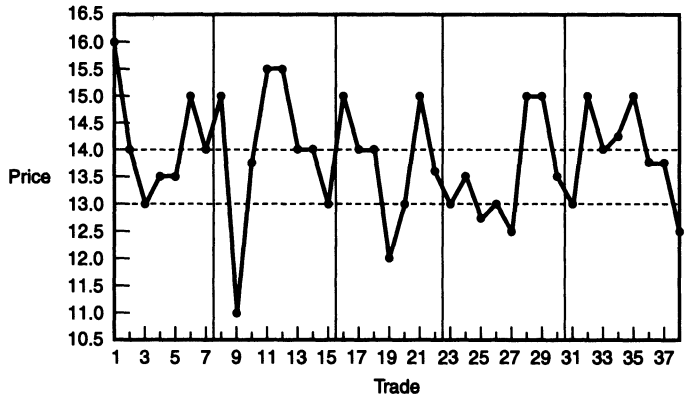
To complement these ocular insights, we estimate empirically an equation of individual transaction prices (and consumer surplus measures). To gain insights on factors that influence both the decision to purchase and the price paid, we follow List (2002) and apply a two-step selection model. In the first step, we make use of Butler and Moffitt's (1982) random-effects probit model to estimate the purchase decision of each buyer. Specifically we estimate

$$T_{ij} = \beta' X_{ij} + e_{ij}, \qquad e_{ij} \sim N[0, 1], \tag{1}$$

[15] Empirical findings are also consistent with those of Hong and Plott (1982) and Grether and Plott (1984), who find a tendency for "telephone" markets that operationalize the bilateral give and take of the original Chamberlain (1948) experiments to converge near competitive equilibrium.

FIGURE 3

PRICE PATH *PC4* SESSION 1



where T_{ij} equals unity if buyer i executed a transaction in period j, and equals zero otherwise; X_{ij} includes the treatment effect dichotomous variables (where the *PC12* treatment is the baseline) and the interaction of the treatment indicators with the induced value for buyer i in period j. We specify $e_{ij} = u_{ij} + \alpha_i$, where the two components are independent and normally distributed with mean zero. It follows that the variance of the disturbance term e_{ij} is $\text{Var}(e_{ij}) = \sigma_u^2 + \sigma_\alpha^2$. By construction, the individual random effects α_i will capture important heterogeneity across buyers that would be left uncontrolled in a standard cross-sectional model. We estimate equation (1) using the maximum-likelihood approach derived in Butler and Moffitt (1982).[16]

In the second step of our estimation approach, we recover the inverse Mills ratio from equation (1) and estimate equation (2),

$$P_{ij} = v(Z_{ij}) + \varepsilon_{ij}, \tag{2}$$

where P_{ij} is the transaction price for the ith buyer in the jth period, and $v(Z_{ij})$ is a linear function of the vector Z_{ij}, which includes dichotomous indicator variables for our experimental treatments and the inverse Mills ratio; $\varepsilon_{ij} = \alpha_i + u_{ij}$; $\text{E}[\alpha_i] = 0, \text{E}[\alpha_i^2] = \sigma_\alpha^2, \text{E}[\alpha_i \alpha_\ell] = 0$ for $i \neq \ell$; and α_i and u_{ij} are orthogonal for all i and j. Similar to equation (1), the random effects α_i capture important heterogeneity that would be left uncontrolled in a standard cross-sectional model.

Empirical estimates from our model are presented in columns 1 and 2 of Table 3. Column 2 of Table 3 provides insights consistent with the price realizations in Result 2: average transaction prices in the *PC4* treatment are statistically indistinguishable from those in the baseline *PC12* treatment (−.07 is statistically insignificant). Concerning overall market efficiency and the allocation of rents, we must turn to the selection equation results in column 1, which can be used to compute predicted probabilities of transacting conditional on induced value. As indicated in Table 4, a representative agent with an induced value below \$13 (i.e., someone who should not be in the market) is less likely to execute a transaction in the *PC4* treatment than in the *PC12* treatment. For example, an agent with an induced value of \$12 is roughly 13% less likely to execute a trade in our *PC4* treatment compared to the baseline *PC12* treatment. Given that quantity levels are roughly similar across *PC4* and *PC12*, such transactions serve to "crowd out" potentially profitable trades by agents with higher induced values (largely those with values of \$14). Such "crowding out" serves to generate the lower levels of producer surplus and overall market efficiency recorded in

[16] The likelihood function for this model can be written as $L = \prod_i L_i = \int_{-\infty}^{\infty} (2\pi)^{-1/2} \prod_t \exp(-e_{it}) \phi(g_{it} q_{it})$, where $g_{ij} = 2T_{ij} - 1$; and $q_{ij} = \beta' X_{ij} + [\text{corr}(e_{ij}, e_{is})/(1 - \text{corr}(e_{ij}, e_{is}))]^{1/2} e_i$. Estimation of this particular model is quite complex but is amenable to Hermite integration. To estimate the model, we use an eight-point quadrature and employ the Berndt et al. (1974) estimator to compute the covariance matrix.

TABLE 3 Heckman Selection Model: Individual Prices and Consumer Surplus

	Specification A: No Control for Experience			Specification B: Control for Experienced Agents		
	Selection (1)	Price (2)	Surplus (3)	Selection (4)	Price (5)	Surplus (6)
Constant	−8.05**	14.17**	2.61**	−8.29**	14.29**	2.55**
	(1.10)	(.21)	(.15)	(1.15)	(.23)	(.17)
PC4 treatment	−5.78**	−.07	−.23	−6.92**	.19	−.43*
	(2.52)	(.29)	(.20)	(2.84)	(.34)	(.25)
CPK treatment	−14.15**	1.70**	−.74**	−13.73**	1.59**	−.90**
	(4.36)	(.32)	(.23)	(4.42)	(.38)	(.28)
CPS treatment	−3.60*	1.45**	−.67**	−3.62*	1.42**	−.47*
	(2.17)	(.30)	(.21)	(2.20)	(.35)	(.26)
Induced value * *PC12*	.63**			.64**		
	(.08)			(.09)		
Induced value * *PC4*	1.07**			1.14**		
	(.17)			(.19)		
Induced value * *CPK*	1.49**			1.48**		
	(.29)			(.29)		
Induced value * *CPS*	.82**			.82**		
	(.013)			(.13)		
Exp * Induced value * *PC12*				.05		
				(.03)		
Exp * Induced value * *PC4*				.07**		
				(.03)		
Exp * Induced value * *CPK*				−.01		
				(.03)		
Exp * Induced value * *CPS*				.06**		
				(.03)		
Exp * *PC12*					−.89*	.37
					(.53)	(.39)
Exp * *PC4*					−1.01**	.59*
					(.41)	(.30)
Exp * *CPK*					−.03	.57
					(.51)	(.38)
Exp * *CPS*					−.38	−.43
					(.46)	(.35)
Number of observations	720	378	378	720	378	378

** Significant at $p < .05$ level.
* Significant at the $p < .10$ level.
Note: Entries are parameter estimates for a two-stage Heckman sample-selection model. Standard errors are in parentheses. Columns 2 and 5 examine individual transaction prices. Columns 3 and 6 examine individual measures of consumer surplus.

the *PC12* treatment relative to the *PC4* treatment, but it has no effect on the relative volume of trade across the two treatments.

To examine consumer surplus measures across *PC12* and *PC4*, we simply replace P_{ij} in equation (2) with C_{ij}, which is an indicator of consumer surplus for the ith buyer in the jth period. We present these empirical estimates in column 3 of Table 3. While consumer surplus is lower in *PC4* compared to *PC12*, the point estimate of −.23 is not statistically significant at any conventional level.

□ **Seller conspiracies with perfect price revelation.** The third panel of Table 2 summarizes market outcomes for treatment *CPK*. Average prices for these three sessions lie substantially

TABLE 4 Predicted Probability of Trade (%)

Value	*PC12* Treatment	*PC4* Treatment	*CPK* Treatment	*CPS* Treatment
11	12	2	0	.04
12	29	16	0	3
13	53	53	.02	16
14	78	87.5	9	43
15	91	99	56	74
16	98	100	95	93
17+	100	100	100	100

Note: Entries are the predicted probability that an agent with a given induced value executes a trade for each of the four experimental treatments. Probabilities are calculated using the parameter estimates from column 1 in Table 3. For example, row 1 in column 1 indicates that an agent with an induced value of \$13 in the *PC12* treatment is predicted to execute a trade in approximately 53% of the periods.

above competitive levels and are within 5% (\$.72) of the joint-profit-maximizing level of $p = \$16$ in all periods. On average, quantities exchanged are at least two units below the levels associated with a competitive outcome and are no more than a single unit above the collusive prediction ($Q = 4$). In all five periods, producer rents exceed the predicted rents in a competitive market by at least \$1.00, and in period 5, producers garner rents in excess of those predicted for a single price monopolist ($M = 1.3 > 1$).

Figure 4 plots price paths for *CPK* session 1; the patterns in the other two sessions are similar. Similar to Isaac and Plott (1980) and Isaac, Ramey, and Williams (1984), who analyzed different institutions, the data display a marked decline in transaction prices at the end of each trading period.[17] Indeed, in only a single trading period (*CPK* session 3, round 1) were sellers successful in setting a fixed price from which no deviations occurred. In the remaining 14 market periods, the contracted price for the final unit sold was at or below the level reported on the prior transaction. In 11 of these periods there is a decline of at least \$.50, with an average decline of \$.82 across all trading periods.

One striking pattern illustrated in Figure 4 is that pricing strategies in the final period mimic those employed by a first-degree price discriminator. Summarizing over all CPK sessions, 47% of the transactions in the final period (7 of 15) take place at prices above the joint-profit maximizing level, with an additional two transactions occurring at the joint-profit maximizing price. Of the remaining six transactions, all occur at prices at or below \$15, with half of these contracts executed at a price of \$14.50 or less. This pricing strategy results in producers extracting rents in excess of those obtained under joint-profit maximizing behavior: in the final round, measures of monopoly effectiveness are 130. We return to this observation later.

Summarizing over all CPK market data, we find persistent anticompetitive pricing. Approximately 41% of all market transactions (29 of 71) occur at or above the single joint-profit maximizing price. In comparison, only 5.6% of all market transactions (4 of 71) occur at prices that lie within or below the CE level. This leads to our third insight.

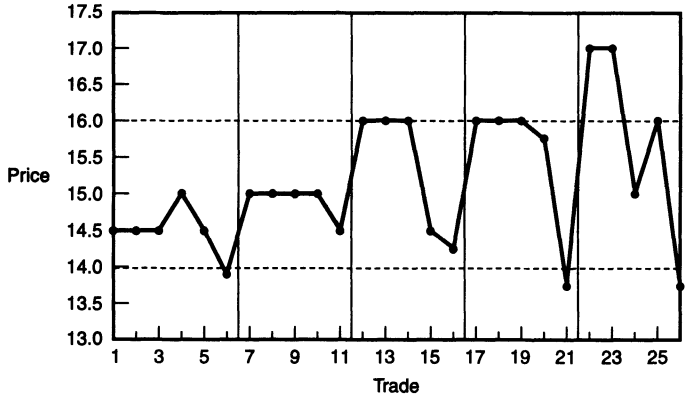
Result 3. Seller communication serves to raise prices above CE levels and restrict quantities sold, resulting in greater producer surplus and lower market efficiency.

To provide statistical support for this result, we return to the empirical estimates provided for equations (1) and (2). As illustrated in column 2 of Table 3, conditional transaction prices in our *CPK* treatment are on average \$1.70 greater than in either *PC12* or *PC4*, with this difference statistically significant at the $p < .05$ level. Furthermore, as indicated in column 3 of Table

[17] Yet these data are not entirely consonant with Isaac and Plott's (1980) findings—for example, they report that individuals deviate from a collusive strategy. While we cannot pinpoint exactly why this difference exists, it is most likely due to either the nature of the sample pool or the multilateral decentralized bargaining market institution. This merits future research, as such behavior may be optimal for a discriminating monopolist in our environment.

FIGURE 4

PRICE PATH *CPK* SESSION 1



3, average consumer surplus per transaction in the *CPK* treatment is approximately \$.74 (\$.51) lower than that realized in the *PC12* (*PC4*) treatment, with both of these differences significant at conventional levels.

Exploring these results in greater detail, we find that higher prices (and reduced market efficiencies) are driven almost entirely by reduced participation rates by both marginal and infra-marginal buyers (i.e., buyers with induced values of \$14 or \$15, respectively).[18] For example, as indicated in row 5 of Table 4, agents with an induced value of \$15 are approximately 35% (43%) less likely to execute a trade in our *CPK* sessions than would a similar agent in a *PC12* (*PC4*) session. By excluding such buyers from the market, sellers in our *CPK* sessions are able to restrict overall trading volume, which generates a reduction in market efficiency. Furthermore, by excluding buyers with lower induced values from trading, sellers are able to maintain prices above competitive levels and extract greater rents on all units sold.

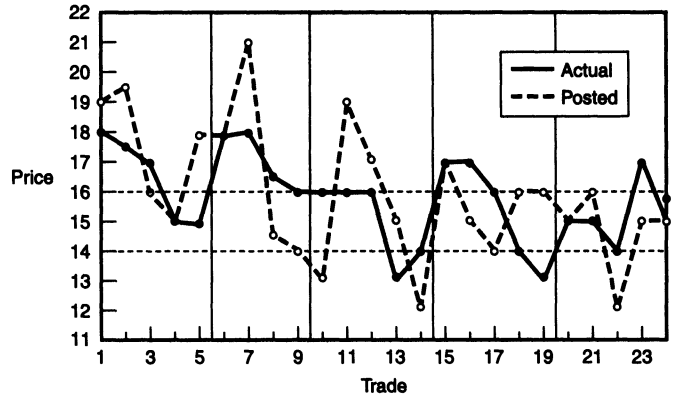
□ **Seller conspiracies with imperfect price signals.** The lowermost panel of Table 2 provides mean performance measures at the period level across our three *CPS* sessions. The outcomes in collusive markets with imperfect price signals lie between those of the *PC12* and *PC4* treatments and the collusive markets with full price revelation (*CPK*). Prices are at least \$.55 (4%) above competitive levels in all market periods, but lie below those in treatment *CPK* in all but the first trading period. Additionally, prices tend to be more volatile in these sessions than in either of the other four-seller markets, as reflected by higher standard deviations in prices across four of the five periods. Across all market periods, quantities sold lie between those exchanged in the *PC4* and *CPK* treatments. Additionally, in four of the five market periods, efficiency measures are 91% or greater, above those achieved in the *CPK* sessions but below those observed in the *PC4* sessions.

One striking feature of these data is the level of rents captured by producers. Despite an increase in trading volume and a reduction in prices from the joint-profit-maximizing levels, average producer profits exceed those predicted under joint monopoly pricing in both the first and second trading periods. Overall, in 60% (9 of 15) of the trading periods, values of monopoly effectiveness exceed 100%, the level obtained from a joint-profit-maximizing strategy. Sellers extract excess rents by selling the first few units in any period at prices above the collusive level and then allowing prices to decay throughout the trading period along the demand curve. This

[18] Excluding such buyers from the market is a necessary condition for sellers to engage in anticompetitive pricing since, by design, buyers do not pay a price that is greater than the buyer's induced value. Transactions by buyers with induced values of \$14 or \$15 would thus necessarily put downward pressures on prices and serve to limit conspiratorial gains.

FIGURE 5

PRICE PATH *CPS* SESSION 1



results in price paths that mimic (albeit quite imperfectly) those obtained by a first-degree price discriminator.

Figure 5 plots price paths for *CPS* session 1; the patterns in the other two sessions are similar. The data display a pattern of price deterioration over a trading period similar to that observed in our *CPK* sessions, and noted in Isaac, Ramey, and Williams (1984); in each instance but period 5, initial transactions occur at or above the monopoly price and deteriorate steadily throughout the period, as would be expected from a first-degree price discriminator. These data produce our fourth result.

Result 4. When sellers receive only an imperfect price signal, price realizations lie between those of competitive markets and collusive markets with full information.

Empirical support for this result is provided in column 2 of Table 3. Average transaction prices in our *CPS* treatment are approximately \$1.45 greater than those in our competitive treatments, but they are slightly less than realized prices in collusive markets with perfect price revelation. Nevertheless, both of these differences are statistically significant at the $p < .05$ level. Exploring these differences in greater detail, we find that the empirical results are driven largely by disparities in the participation rates of buyers with induced values of \$14 and \$15 across our various experimental treatments. For example, as indicated in Table 4, buyers with an induced value of \$15 are approximately 17%–25% less likely to purchase in our *CPS* treatment than they would be in our competitive markets. However, such a buyer is 18%-34% more likely to trade in treatment *CPS* than in treatment *CPK*. Such differences generate prices in our *CPS* markets that are above those realized in competitive market sessions, but lower than those in collusive markets with perfect price revelation.

□ **Experience effects.** Our data are sufficiently rich to examine whether, and to what extent, individual market experience on the buyer side attenuates the effectiveness of collusion among sellers. In particular, our data enable us to address whether market experience is a catalyst to thwart collusive schemes. For every agent in our dataset, we generate an indicator of prior market experience based upon the number of years a buyer has participated in the sportscard market and the average number of transactions (purchase or sale of sportscards) the agent engages in during a typical month. The market experience indicator is set equal to one if the product of the number of trades in a typical month and the years of market experience is more than one standard deviation above the sample mean, zero otherwise.[19]

[19] Specifying market experience using other measures, such as including the number of trades in a typical month and years of market experience as separate measures, yields similar insights to those presented below.

In this subsection we explore whether the presence of experienced buyers in the market is correlated with aggregate market outcomes. In this spirit, we return to equations (1) and (2) and augment the two-stage price and consumer surplus models by expanding X_{ij} and Z_{ij} to include (i) the interaction of our experience indicator with induced values in the first-stage selection equation and (ii) the interaction of our experience and treatment indicators in the second-stage price (surplus) equations. Empirical estimates from this model are presented in columns 4–6 of Table 3. From column 5 we learn that buyers denoted as "experienced" pay prices that are on average \$.89 to \$1.01 less in our competitive markets than their inexperienced counterparts (with these differences significant at the $p < .05$ level). In collusive markets (*CPK* and *CPS*), however, there is no discernable correlation between buyer experience and executed price at the individual transaction level.

Exploring the effects of buyer experience on aggregate market outcomes, however, leads to an interesting asymmetry across competitive and collusive treatments: in those periods in *CPK* and *CPS* where an experienced buyer transacts, average market prices are lower than in cases when they do not transact. For example, average transaction prices in *CPK* and *CPS* market periods when at least one experienced buyer transacts are \$.83 lower than average prices in periods where only inexperienced buying agents transact (even though, as described above, there are no individual price differences across experienced and inexperienced buyers).[20] Furthermore, 69.8% of the transactions in periods where an experienced buyer participates occur below the single-price monopoly level. In periods where only inexperienced agents participate, only 32.3% of the recorded transactions occur at prices below the monopoly benchmark. Alternatively, in *PC12* and *PC4*, average prices are not different when experienced buying agents transact (but individual prices are different). We therefore gain the following insight.

Result 5. Market experience is a catalyst to thwart anticompetitive pricing by sellers in markets with conspiratorial opportunities.

To provide further evidence of this result, we estimate a linear random-effects model of average period transaction prices of the form

$$P_{jt} = \beta' X_{jt} + \varepsilon_{jt}, \tag{3}$$

where P_{jt} is the average transaction price in the jth period for the tth market session, X_{jt} is a vector of model covariates that includes dichotomous indicator variables for our experimental treatments and the interaction of these treatments with a dichotomous indicator variable for any period where an experienced agent purchases; $\varepsilon_{jt} = \alpha_j + u_{jt}$; $\mathrm{E}[\alpha_j] = 0, \mathrm{E}[\alpha_j^2] = \sigma_\alpha^2, \mathrm{E}[\alpha_j \alpha_\ell] = 0$ for $j \neq \ell$; and α_j and u_{jt} are orthogonal for all j and t. Similar to equation (1), the random effects α_j capture important heterogeneity across sessions that would be left uncontrolled in a standard cross-sectional model.

Empirical estimates for (3) are contained in column 1 of Table 5 and provide statistical support for Result 5. In collusive market sessions with perfect (imperfect) price revelation, average period prices are \$.57 (\$1.16) lower whenever at least one experienced buying agent transacts, a difference that is statistically significant at the $p < .10$ ($p < .05$) level. In this sense, purchases by experienced agents in collusive markets act as a catalyst to break attempts by sellers to fix prices and serve to thwart anticompetitive behavior. In contrast, purchases by experienced agents in competitive markets have no overall effect on average transaction prices. Furthermore, the results in column 2 of Table 5 highlight that in treatment *CPS*, consumer surplus is also enhanced when an experienced buying agent transacts.

[20] In total, experienced agents trade in 23 of 30 collusive market periods. Average transaction prices in those periods where an experienced agent buys at least one unit are \$15.14. In periods where only inexperienced agents trade, average transaction prices are \$15.97.

TABLE 5 Experience Effects: Period-Level Average Prices and Consumer Surplus

	Average Period Prices	Total Consumer Surplus
Constant	13.65**	15.87**
	(.22)	(1.16)
PC4 treatment	.12	−.01
	(.27)	(1.41)
CPK treatment	2.24**	−9.81**
	(.34)	(1.81)
CPS treatment	2.49**	−11.04**
	(.47)	(2.47)
PC12 when experienced agent transacts	−.10	.57
	(.30)	(1.59)
CPK when experienced agent transacts	−.57*	2.15
	(.32)	(1.69)
CPS when experienced agent transacts	−1.16**	4.30*
	(.44)	(2.34)
R^2	.71	.67
Number of observations	60	60

** Significant at the $p < .05$ level.
* Significant at the $p < .10$ level.
Note: Entries are parameter estimates of a linear-regression model examining period-level performance measures. The model explicitly controls for individual session effects using a random-effects specification for the assumed error structure. In the *PC4* sessions, an experienced agent traded in every market period. We are thus unable to separately identify the treatment indicator and its interaction with our market experience indicator.

4. Concluding remarks

■ This study explores behavior in multilateral decentralized bargaining markets and finds that seller communication can prove effective in raising prices above competitive levels. Yet collusive outcomes are not ensured when communication is allowed—our data highlight the fragility of such arrangements. For example, we find that when price signals are imperfect, outcomes lie between those of competitive markets and collusive markets with full price information.[21] A related finding of interest is that conspiratorial success is critically linked to market composition. While the early work in this literature has shown that structural and institutional characteristics are important determinants of performance measures, the results herein regarding buyer-side experience indicate that the composition of agents in a marketplace may also influence outcomes. For example, when experienced buyers enter the market, average prices are significantly lower than in periods when only inexperienced agents execute a trade.

We would be remiss not to stress that consistent with other lab and field experiments, one must take care in applying inferences from these results to other environments. For example, Levitt and List (2005) highlight that extrapolation of experimental results to broader world situations depends critically on numerous dimensions, such as the fact that in experiments subjects know that they are being scrutinized; special emphasis is placed on the process by which decisions are made and final allocations are reached; the stakes are typically small; and the participants are self-selected. In our framed field experiment it might be the case, for example, that sellers are willing to uphold collusive agreements because they are part of an experiment and wish to signal trustworthiness to

[21] In a related set of experiments, we examine the effect of group composition on the stability of collusion in Chamberlain markets and find that adding "outside" dealers (i.e., a dealer from a nonlocal market) to a collusive ring serves to limit the effect of conspiratorial opportunities. The data from these experiments are available from the authors upon request.

other sellers, or even to the experimenter. The general point we are making with this caveat, and which Levitt and List (2005) discuss more broadly, is that to make broader inferences we need a model of experimental behavior to inform us about the data-generating process and how it is related to other contexts of interest. Much like theory is the tool that permits us to use empirical results in one instance to make predictions about another, laboratory generalizability should be no exception.

Undoubtedly our research has raised more questions than it has answered. For example, do the results from the lab concerning posted-offer and double-auction mechanisms transfer to the field? In addition, whether seller conspiracies work under varying degrees of market power remains an important question that is largely unanswered in the literature. Also, whether collusive markets tend to equilibriate according to the Walrasian hypothesis or the "excess rent" hypothesis (Smith, 1965) remains largely an open issue. We suspect that research in these areas will likely lead to insights hitherto uncovered.

Appendix

■ The survey used in the experiment follows.

Confidential survey. These questions will be used for statistical purposes only. THIS INFORMATION WILL BE KEPT STRICTLY CONFIDENTIAL and WILL BE DESTROYED UPON COMPLETION OF THE STUDY.

1. How long have you been active in the sportscards and memorabilia market? _____ yrs
2. Approximately how many trades (cards or memorabilia) do you make in a typical month? _____ . Note that trades could include Pokeman cards, sportscards, other trading cards, and sports memorabilia.
3. Are you a sportscard or sports memorabilia professional dealer? _____
4. Gender: 1) Male 2) Female
5. Age _____ Date of Birth _____
6. What is the highest grade of education that you have completed? (Circle one)

1) Eighth grade	3) 2-Year College	5) 4-Year College
2) High School	4) Other Post-High School	6) Graduate School Education

7. What is your approximate yearly income from all sources, before taxes?

1) Less than $10,000	5) $40,000 to $49,999
2) $10,000 to $19,999	6) $50,000 to $74,999
3) $20,000 to $29,999	7) $75,000 to $99,999
4) $30,000 to $39,999	8) $100,000 or over

8. Approximate height and weight: _____

TABLE A1 **Real Buyer/Seller Reservation Values (in dollars)**

	Period 1	Period 2	Period 3	Period 4	Period 5
Buyer 1	19	14	17	13	14
Buyer 2	18	9	10	17	11
Buyer 3	17	10	11	16	13
Buyer 4	16	11	12	15	9
Buyer 5	13	12	16	14	18
Buyer 6	14	13	14	19	15
Buyer 7	15	16	14	12	19
Buyer 8	12	14	15	11	16
Buyer 9	11	15	13	10	17
Buyer 10	10	17	18	9	14
Buyer 11	9	18	19	14	10
Buyer 12	14	19	9	18	12
Seller 1	13	18	9	12	13
Seller 2	9	17	13	11	14
Seller 3	10	16	13	9	15
Seller 4	11	15	8	10	16
Seller 5	12	14	10	13	17
Seller 6	8	13	11	13	18
Seller 7	13	13	12	14	8
Seller 8	14	12	14	15	9
Seller 9	15	11	15	16	10
Seller 10	16	10	16	17	11
Seller 11	17	9	17	18	12
Seller 12	18	8	18	8	13

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