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Testing Neoclassical Competitive Theory in Multilateral Decentralized Markets

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Walrasian tâtonnement has been a fundamental assumption in economics ever since Walras' general equilibrium theory was introduced in 1874. Nearly a century after its introduction, Vernon Smith relaxed the Walrasian tâtonnement assumption by showing that neoclassical competitive market theory explains the equilibrating forces in "double-auction" markets. I make a next step in this evolution by exploring the predictive power of neoclassical theory in decentralized naturally occurring markets. Using data gathered from two distinct markets—the sports card and collector pin markets—I find a tendency for exchange prices to approach the neoclassical competitive model prediction after a few market periods.

I. Introduction

Conventional economic theory relies on two assumptions: utility-maximizing behavior and the institution of Walrasian *tâtonnement*. In a seminal study that made use of the Walrasian tâtonnement mechanism, Becker (1962) proved that several fundamental features of economics, such as correctly sloped supply and demand schedules, could result even when agents are irrational, serving to sufficiently relax the utility-maximizing assumption. Explorations to relax institutional constraints have taken a variety of paths, with traditional economic tools having limited empirical success partly due to the multiple simultaneously moving parts

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in the marketplace. Perhaps this obstacle was the genesis behind the article by Chamberlain (1948), who over a half century ago executed what is believed to be the first experiment to test neoclassical competitive market theory. Using Harvard students participating in decentralized one-shot bargaining markets, Chamberlain observed that volume was typically higher and prices typically lower than predicted by competitive models of equilibrium. Efficiency was also frustrated in these bilateral negotiating markets.

Smith (1962) later refined Chamberlain's work by varying two key aspects of the experimental design: (i) centrally occurring open outcry of bids and offers, similar to stock and commodity exchanges (commonly termed "double auctions"), and (ii) multiple market periods, allowing agents to learn. Empirical results from Smith's double auctions were staggering—quantity and price levels were very near competitive levels—and served to present the first evidence that Walrasian tâtonnement, conducted by a central auctioneer, was not necessary for market outcomes to approach neoclassical expectations. It is fair to say that this general result remains one of the most robust findings in experimental economics.

This study takes a fresh look at neoclassical price theory by experimentally examining decentralized outcomes, in the spirit of Chamberlain, within markets that have naturally occurred—the sports card and collector pin marketplaces.[1] My field experimental design consists of several market treatments with as few as six buyers and six sellers and as many as 12 buyers and 12 sellers. I also vary the underlying market structure to examine equilibrating tendencies across a variety of theoretically demanding, yet realistic, scenarios. Each market treatment mirrors Chamberlain's construct in that I give each buyer (seller) a reservation price for each unit he or she demands (supplies) and allow agents to engage in bilateral higgling until they make a contract or the trading period terminates. This feature of my design shares characteristics with early-organized marketplaces; yet bargaining maintains an important role in modern economies, as Camerer (2003, p. 151) notes: "Bargaining … is possibly the most basic activity in economic life. Even in thick, competitive markets where traders closely resemble 'price takers' of economic theory, haggling occurs over time of delivery, repairs, sidepayments, and quality, as well as price."

A key result is the tendency for exchange prices to approach the neoclassical competitive model predictions, especially in symmetric mar-

[1] The most closely related study to my knowledge is Hong and Plott (1982), which compared bilateral telephone negotiations with posted offer trading. Joyce (1983) examined student behavior in three experimental Chamberlain-like markets with posted transaction prices. Other related work includes Grether and Plott (1984) and Plott (1988). The interested reader should see Holt (1995) and Roth (1995) for reviews.

kets. Even under the most severe tests of competitive market theory (treatments with highly asymmetric rents) and in markets including only children, women, or men, the expected price and quantity levels are approximated in many market periods when agents have sufficient experience. These results suggest that in mature markets, very few of the "typical" assumptions, such as Walrasian tâtonnement or centrally occurring open outcry of bids and offers, are necessary to approximate the predicted equilibrium in the field. This finding also adds insights into the predictive ability of neoclassical theory in multilateral decentralized markets, since it shows that an indefinitely large number of market agents is not necessary for the existence of "pure" equilibrium.

A second insight is that market composition is important in the determination of rents and the trajectory of prices. For example, in all-female markets the tendency for buyers to demand rents causes neoclassical theory to be frustrated in markets in which buyers have perfectly elastic demand. This finding is consonant with the literature on the "fundamental problem of commerce," which suggests that on the basis of incomplete information considerations, there will be a tendency for buyers and sellers to understate their willingness to execute a transaction in hopes of obtaining a more favorable bargain (see, e.g., Myerson and Satterthwaite 1983). A third insight is that market experience plays a role in the distribution of rents: experienced market players earn more rents than inexperienced agents. While previous research suggests that structural and institutional features of the market are important, these results suggest that market composition also has important influences on equilibrating tendencies.

II. Experimental Design and Results I

My first series of tests of neoclassical competitive market theory depart from previous studies by examining individual behavior in a well-functioning marketplace—the sports card market. A few features of this particular market make it attractive to examine predictions of competitive theory in multilateral decentralized markets. First, I am observing behavior of agents who have endogenously chosen certain roles within the marketplace—such as being a buyer (nondealer) or seller (dealer). In this sense, I am gathering data in a natural environment while still maintaining the necessary control to execute a clean test of theory. Second, when the market opens, consumers mill around the marketplace, higgling and bargaining with dealers, who have their merchandise prominently displayed on their six-foot table; thus bargaining in a multilateral setting is natural for both buyers and sellers.

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. In step 1, before the market opened, a monitor approached dealers at the sports card show and inquired about their interest in participating in an experiment that would take about 60 minutes during the sports card show. To gather the nondealer subject pool, a monitor approached potential subjects entering the sports card show 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, in step 2 monitors thoroughly explained the experimental rules. The experimental instructions were standard and were taken from Davis and Holt (1993, pp. 47–55) with the necessary adjustments. Before proceeding, I should highlight a few key aspects of the experimental design. First, all individuals were informed that they would receive a $10 participation fee upon completion of the experiment. And, following Smith (1965), to ensure that marketers would engage in a transaction at their reservation prices, I provided a $0.05 commission for each executed trade for both buyers and sellers.

Second, nondealers were informed that the experiment consisted of five periods and that they would be buyers; dealers were informed that they would be sellers. In each of five periods, I used Smith's (1976) induced value mechanism by providing each buyer (seller) with a "buyer's card" ("seller's card"), which contained a number, known only by that buyer (seller), representing the maximum (minimum) price at which he or she would be willing to buy (sell) one unit of the commodity. Importantly, both buyers and sellers were informed that this information was strictly private and that reservation values would change each period. They were also told the number of buyers and sellers in the market (explained more fully below) and that agents may have different values.[2]

Third, the monitor explained how earnings (beyond the participation and commission fees) were determined: for buyers (sellers), the difference between the contract price and the maximum (minimum) reservation price determined market earnings. Fourth, the homogeneous commodities used in the experiment were 1982 Topps Ben Oglivie baseball cards, on which I had artfully drawn a moustache, making the cards valueless outside of the experiment. The cards and participating dealers were clearly marked to ensure that buyers had no trouble finding the

[2] The astute reader will notice that my use of "field experiment" is liberal; in the terminology of Harrison and List (in press), a more accurate description of my design is that of a "framed" field experiment. For an example of a "natural" field experiment that addresses a much different question, see List and Lucking-Reiley (2002). Also, note that I was careful to explain to buyers (in the presence of sellers) that sellers potentially have different reservation values. And, to avoid spillover effects, only one treatment was run per sports card show. In pilot treatments reported in List (2002), I learned that these were important characteristics of the market.

TABLE 1
EXPERIMENTAL DESIGN

Demand/Supply Structure	Sports Card Market (1)	Sports Card Market (Children) (2)	Pin Market (3)
Symmetric	S12: 12 buyers, 12 sellers (3 sessions), $N=72$	S12rchildren: 12 buyers, 12 sellers (2 sessions), $N=48$ S6rchildren (1 session), $N=12$ S6echildren (1 session), $N=12$ S6ichildren (1 session), $N=12$	S6pin (2 sessions), $N=24$
Asymmetric:			
Perfectly elastic demand	PED12: 12 buyers, 12 sellers (3 sessions), $N=72$		PED6pin (2 sessions), $N=24$
Perfectly elastic supply	PES12: 12 buyers, 12 sellers (3 sessions), $N=72$		PES6pin (2 sessions), $N=24$

NOTE.—Each cell represents one unique treatment in which I gathered data in different sessions. For example, "S12" in row 1 of col. 1 denotes that one treatment (three sessions) had 12 buyers and 12 sellers competing in markets in which the demand and supply curves were symmetric. No subject participated in more than one treatment.

commodity of interest. Fifth, after completion of each contract, the exchange price was announced so that all buyers and sellers were made aware of the most recent transaction. Sixth, buyers and sellers engaged in two five-minute practice periods to gain experience with the market.

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; a different monitor privately gave sellers a new seller's card.[3] Throughout the market periods, careful attention was paid to prohibit discussions between sellers (or buyers) that could induce collusive outcomes. Step 4 concluded the experiment: after subjects completed a survey, they were paid their earnings in private (App. A contains the survey).

I follow this simple procedure in each of three treatments, which are summarized in column 1 of table 1 and can be read as follows: row 1, column 1, of table 1 contains treatment S12, denoting symmetric12. In this baseline treatment, the market is composed of 12 buyers (sellers), each with unit demand (supply). Figure 1 and table 2 present buyer-

[3] During the experiment, buyers approach various dealers, who are situated on the floor of a sports card show in a room the size of a typical gymnasium, in an attempt to buy the Oglivie card. This design aspect highlights one important difference between Smith's "double auction" and my multilateral bargaining market: the former has centralization and publicity of the array of bids and asks; the latter does not.

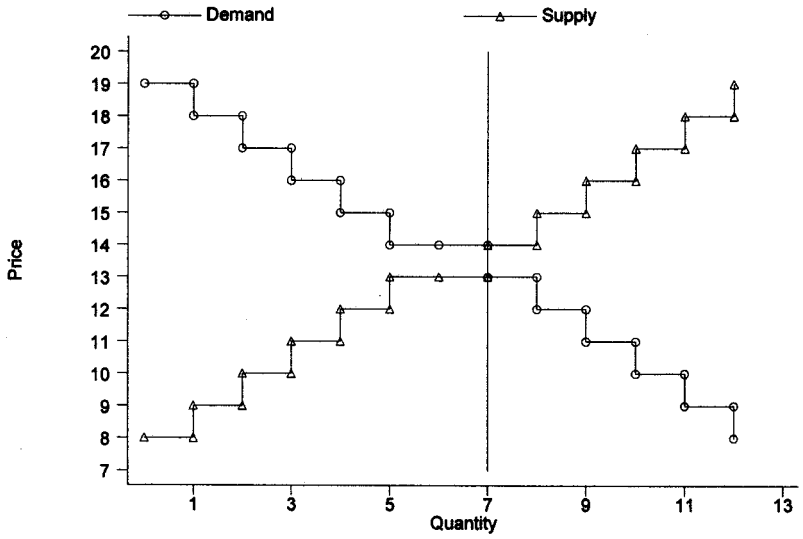

FIG. 1.—Supply and demand structure

and seller-induced values, which are taken from Davis and Holt (1993, pp. 14–15). In figure 1, each step represents a distinct induced value that was given to buyers (demand curve) and sellers (supply curve). The efficient perfectly competitive outcome in this treatment yields $37 in rents per period and occurs where competitive price theory predicts a tendency for the static price/quantity equilibrium of price = $13.00–$14.00 and quantity = 7 to be reached, which is the extreme point of the intersection of the buyer and supplier rent areas in figure 1. This treatment included three distinct market sessions with 72 different market participants.

Treatment PED12 (denoting perfectly elastic demand) is identical to S12 except for one important deviation: rather than a downwardly sloping aggregate demand schedule that is perfectly symmetric to the aggregate supply curve, I make demand perfectly elastic at a price of $13.50; thus buyers are told that if they purchase the commodity at a price above $13.50 in any market period, they will incur losses. In this case, the efficient perfectly competitive outcome yields $18.50 in rents per period, and competitive price theory predicts an equilibrium price of $13.50 and a quantity of seven. This particular test of neoclassical theory could well be the most severe test one could imagine, since it requires the entire rent to be allocated to sellers in equilibrium.

The final treatment, PES12 (denoting perfectly elastic supply), merely reassigns economic rents in equilibrium: transforming treatment S12 so that the supply schedule is perfectly elastic at $13.50. Thus each seller

TABLE 2
BUYER AND SELLER RESERVATION VALUES (in Dollars) BY MARKET PERIOD

	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

is informed that he cannot sell profitably at a price below \$13.50. In this treatment the efficient perfectly competitive outcome yields \$18.50 in rents per period, and competitive theory predicts that seven units will be traded at a price of \$13.50. Much like treatment PED12, this treatment represents a stringent test of theory, since in equilibrium the entire rents are allocated to buyers because of the five excess sellers.

Given that I executed three distinct five-period market sessions for each of the three treatments, experiment I includes data from 45 unique market periods. And since buyers and sellers competed in only one treatment, this experiment included 216 subjects: 108 consumers and 108 dealers. Of the 216 subjects, 14 were women and 202 were men, which highlights that the sports card market is male-dominated. The average participant was 31.5 years old, had two years of education beyond high school, earned nearly \$35,000 in annual income, and had nine years of sports card market experience.

Experimental Sports Card Results 1

Table 3 contains summary statistics for the experimental data. Entries in table 3 are at the period level and include average price and its

TABLE 3
EXPERIMENTAL RESULTS: SPORTS CARD EXPERIMENT I

	MARKET PERIOD				
	(1)	(2)	(3)	(4)	(5)
	A. S12 (N=72)				
Average price	13.53	13.86	13.71	13.77	13.12
Standard deviation	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	15.75	20.08
Sellers	17.25	16.58	18.65	16.42	14.92
Efficiency	89%	85%	88%	87%	95%
	B. PED12 (N=72)				
Average price	12.39	12.42	13.13	13.12	13.15
Standard deviation	1.1	1.1	.45	.34	.78
Quantity	5.7	6	6.6	7	6.3
Profits:					
Buyers	6.25	6.50	2.50	2.67	2.08
Sellers	9.91	10.17	15.83	15.83	14.58
Efficiency	87%	90%	99%	100%	90%
	C. PES12 (N=72)				
Average price	15.91	16.11	14.38	13.90	13.68
Standard deviation	1.3	1.4	.8	.30	.18
Quantity	3.6	4.3	6.3	7	6.3
Profits:					
Buyers	4.67	3.50	12.25	15.67	16.67
Sellers	8.83	11.33	5.58	2.83	1.16
Efficiency	73%	80%	96%	100%	96%

NOTE.—Figures in the table represent averages across the three sessions in each treatment. Summary statistics are provided for period price, standard deviation of period price, quantity traded in period, and total buyer and seller profits in each period. For example, in the S12 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, and total buyer (seller) profit was $15.75 ($17.25) for the period. Overall efficiency was 89 percent.

standard deviation, quantity traded, total buyer and seller profits per period, and a measure of efficiency (total rents captured divided by available rents). Table 3 can be read as follows: on average, in period 1 of the S12 sessions, 7.3 cards were purchased at a trading price of $13.53 (standard deviation of 1.9). Total buyer and seller profit was $15.75 and $17.25, and traders captured 89 percent of the available rents for the period. Perusal of the data summary for treatment S12 yields a first result.

RESULT 1. Competitive theory adequately organizes data in symmetric markets.

This result can be seen most vividly by observing average trading prices across the five market periods in row 1 of table 3. In every period, the average price is within the neoclassical prediction range, and quantity levels are close to neoclassical expectations. Average efficiency rates are

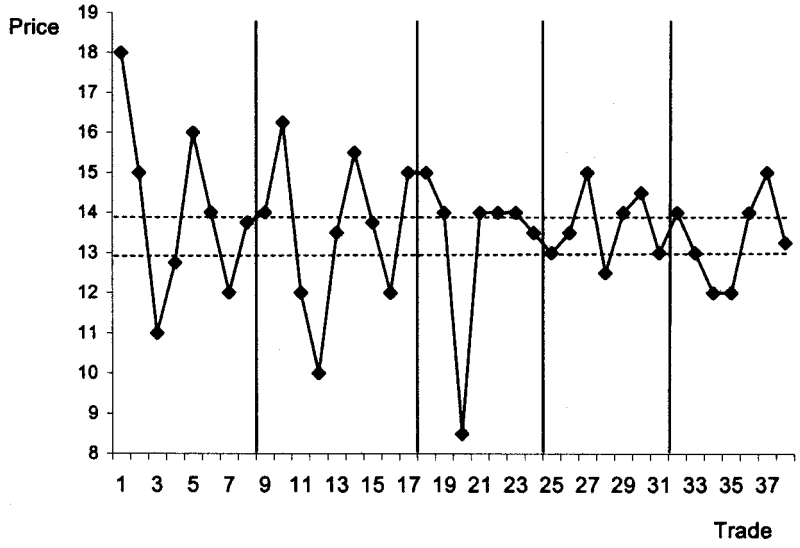

FIG. 2.—Price path S12, session 1

also quite high, reaching 95 percent in the final period, as traders learn particulars about the market. Figure 2 provides sequential transaction prices for S12 session 1 and uses vertical demarcation lines to denote periods.[4] The figure reveals that after a few periods, prices converge to the competitive level, and in the final two periods, prices "settle down" to approximate neoclassical expectations: eight of 14 trades are in the competitive range in the final two periods and the other six trades occur at prices near the competitive prediction.

Overall I do not observe the persistent pattern of results found in Chamberlain's article (volume consistently too high and price consistently too low). I suspect that the level of market experience among my subjects is the reason why Chamberlain's anomaly is not observed herein: it was clear that in this setting, market participants' bargaining behavior made the decentralized setting resemble Smith's double auctions, as consumers were unrelenting in their pursuit of profits—rapidly moving from dealer to dealer in search of the lowest price. This experience conjecture will be revisited later in the experiments performed with children as subjects.

While these results extend the work of Chamberlain (1948) and Smith (1962), it would be comforting to observe similar data patterns in mar-

[4] As a complement to fig. 2 (and figures discussed below), figures for each session and the overall treatment mean (figs. B1–B7) appear in App. B in the online edition of this article.

kets that are more demanding of neoclassical theory. Two such markets include treatments PED12 and PES12, where in equilibrium the entire rents are allocated to one side of the market. Data from these six sessions suggest the following insight.

RESULT 2. Even in highly asymmetric settings, competitive theory organizes the data satisfactorily.

One can glean this result from panels B and C in table 3, which summarize market outcomes across the three sessions in each treatment. When demand is perfectly elastic, the average price in market period 1 is \$12.39; while prices exhibit a degree of upward stickiness, as the market progresses, the average price approaches \$13.50 and buyer rents approach zero. Indeed, estimating a Tobit panel data model at the market level that uses $P_n - P_i$ (where P_n is the neoclassical price prediction and P_i is the executed market price) as the dependent variable and session- and period-specific effects as the independent variables, I find that there is evidence of prices converging to neoclassical expectations, since the coefficient on the period 5 dummy variable is significantly smaller than the coefficient on the period 1 dummy variable at the $p < .05$ level.[5] Furthermore, considering that more than 50 (90) percent of trades in period 5 occurred at the equilibrium price (within \$0.50), whereas less than 11 (52) percent occurred at the equilibrium price (within \$0.50) in period 1, the data suggest a tendency toward the neoclassical prediction. This insight is highlighted in figure 3, which plots sequential transaction prices for session 1 of treatment PED12. Figure 3 highlights the convergence at work: in the first two periods the competitive price prediction was never attained, yet of the last five transactions in the terminal period, four were exactly at the competitive prediction of \$13.50.

Results for the PES12 treatments provide stronger evidence of convergence: the average price in period 1 is \$15.91, yet by period 5 the average price decreases to \$13.68. Again, when a Tobit panel data model is used, these price realizations are different from one another at the $p < .05$ level, suggesting that exchange prices are moving toward neo-

[5] Similar insights are obtained when I use a time trend rather than time period dummies. An alternative market-level approach is to use a matched-pairs *t*-test, in which to control for data dependencies one can compare the series of price realizations within each session. When I match price realizations in the first and fifth periods and examine whether the fifth period's price realizations are closer to theoretical predictions than the first period's price realizations, I find that there is evidence of prices converging to neoclassical expectations ($t = 3.70$; below I shall present only Tobit panel data results, but I should stress that matched-pairs *t*-tests are always consistent unless otherwise noted [see App. B in the online edition]). Note that the matched-pairs *t*-test assumes that price realizations are independent within any given period of a session, an assumption likely not met in practice. To supplement these parametric results, when appropriate, I also conduct nonparametric tests, which again rely on the independence assumption. Results from all nonparametric tests are presented in App. B in the online edition.

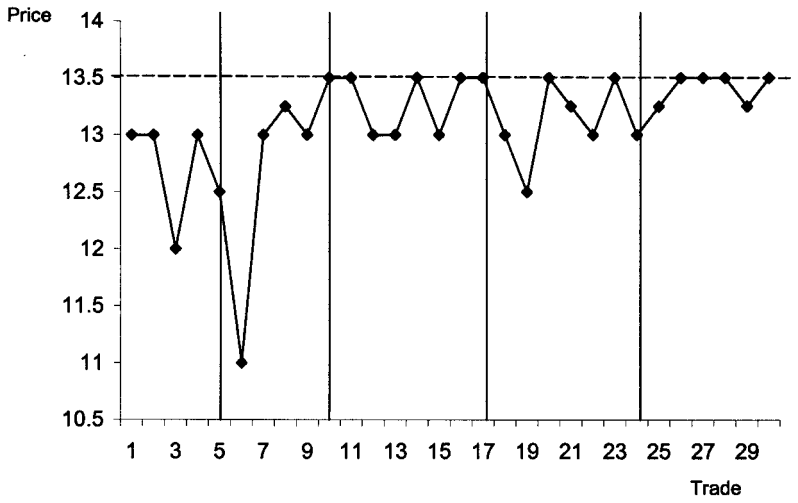

FIG. 3.—Price path PED12, session 1

classical expectations. In addition, the allocation of rents is almost entirely favoring buyers: of the \$17.83 in rents, buyers garnered \$16.67, or 94 percent. This tendency toward neoclassical expectations yields nearly 50 (85) percent of the executed trades at the equilibrium price of \$13.50 (within \$0.25 of the equilibrium price) in period 5. This insight is highlighted in figure 4, which plots transaction prices for treatment session 1 of PES12. Figure 4 shows that prices tend to be a shade above the equilibrium price, but in the terminal period, three of the final four transactions occur at the expected price, \$13.50.

While these results highlight that the static equilibrating tendencies depend not only on the intersection of the demand and supply curves but also on the underlying shape of the curves, the data are sufficiently rich to provide an examination of whether individual-specific attributes influence the allocation of rents. A problem in estimating such a relationship with the data herein is that complete data are not available for all subjects because everyone does not trade in each period. Because data are missing with greatest frequency for agents who have little market experience, resulting sample truncation can cause biased and inconsistent estimates. This situation is handled by applying Heckman's (1979) two-step selection model, which treats truncation as an omitted variable problem. In the first step, I estimate a random-effects probit model:

$$T_{it} = \boldsymbol{\beta}'\mathbf{X}_{it} + e_{it}, \quad e_{it} \sim N[0, 1], \tag{1}$$

where T_{it} equals unity if agent i executed a trade in period t and equals zero otherwise; $\mathbf{X}_{it}$ includes subject-specific characteristics and a time

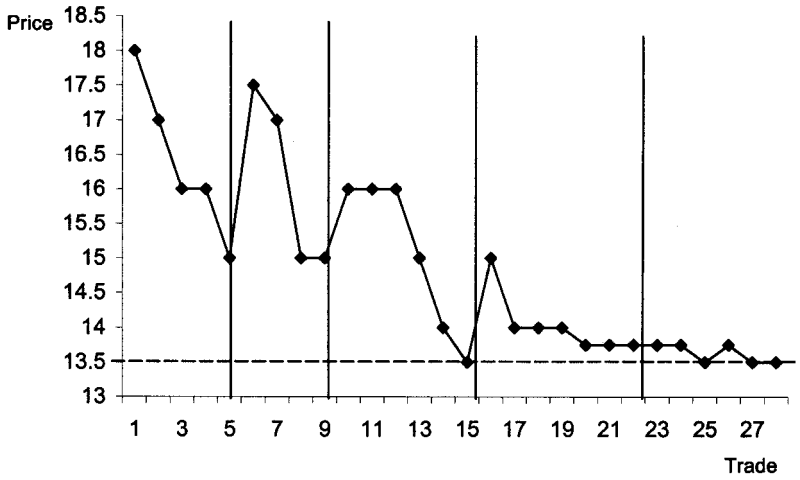

FIG. 4.—Price path PES12, session 1

trend to control for learning over the market session. I specify $e_{it} = u_{it} + \alpha_i$, where the two components are independent and normally distributed with mean zero; thus $\text{Var}(e_{it}) = \sigma_u^2 + \sigma_\alpha^2$. In $\mathbf{X}_{it}$, I use information from the survey: gender, a measure of market bargaining experience (which is equal to the product of years of market experience and the number of trades in a typical month), age, income, treatment dummy variables, and a dichotomous variable indicating whether the agent received an induced value that placed him "in the market." For buyers (sellers), this dichotomous variable equals one if the induced value is \$14 (\$13) or greater (less).[6] I estimate equation (1) using the maximum likelihood approach derived in Butler and Moffitt (1982).[7]

In the second step, the inverse Mills ratio is recovered from equation (1) and used as a regressor in estimating

$$P_{it} = v(\mathbf{Z}_{it}) + \epsilon_{it}, \tag{2}$$

where P_{it} is the price the ith buyer (seller) paid (received) in period t. Like $\mathbf{X}_{it}$, $\mathbf{Z}_{it}$ includes subject-specific characteristics—gender, a measure of market bargaining experience (years of market experience × intensity of market experience), age, and income—as well as treatment dummy

[6] I attempted to use the actual induced value as a regressor, but convergence was never achieved.

[7] The likelihood function can be succinctly written as

$$L = \prod_i L_i = \int_{-\infty}^{\infty} (2\pi)^{-1/2} \prod_t \exp(-e_{it})^2 \Phi(g_{it} q_{it}),$$

where $g_{it} = 2nc_{it} - 1$, and $q_{it} = \boldsymbol{\beta}' \mathbf{X}_{it} + \{\text{corr}(e_{it}, e_{is})/[1 - \text{corr}(e_{it}, e_{is})]\}^{1/2} e_i$.

TABLE 4
TWO-STAGE SAMPLE SELECTION REGRESSION ESTIMATES

	BUYERS		SELLERS	
	First-Stage Random Effects Probit (1)	Second-Stage Random Effects (2)	First-Stage Random Effects Probit (3)	Second-Stage Random Effects (4)
Gender	1.16**	−.09	.29	.60*
	(.21)	(.34)	(.41)	(.36)
Market experience	.001**	−.0008**	.0005**	.00001
	(.0003)	(.0004)	(.0001)	(.00001)
Income	.03	−.01	−.08**	.04
	(.03)	(.03)	(.04)	(.04)
Age	−.004	.005	.005	−.006
	(.004)	(.005)	(.004)	(.004)
Induced value	2.65**	.41**	2.64**	.38**
	(.21)	(.04)	(.19)	(.04)
Period	.10**	−.14**	.10**	−.14**
	(.05)	(.05)	(.05)	(.05)
PED12	−1.24**	.24	−.43**	−.51**
	(.18)	(.18)	(.19)	(.17)
PES12	−.60	.72**	−1.76**	.25
	(.18)	(.17)	(.20)	(.22)
Constant	−2.62**	7.45**	−1.64**	10.35**
	(.35)	(.80)	(.50)	(.59)
Observations	540	287	540	287

NOTE.—Dependent variable equals one if the subject chose to trade, zero otherwise in the first stage. In the second stage, the dependent variable is market price. Standard errors are in parentheses beneath coefficient estimates. Market experience is the product of the number of trades made in a typical month and the years of market experience. Income denotes categorical variable (1–8): (1) less than $10,000, (2) $10,000–$19,999, (3) $20,000–$29,999, (4) $30,000–$39,999, (5) $40,000–$49,999, (6) $50,000–$74,999, (7) $75,000–$99,999, and (8) $100,000 or over. Age denotes actual age in years. Gender denotes categorical variable: 0 if female, 1 if male. PED12 and PES12 represent treatment dummies.

* Significant at the $p < .10$ level.

** Significant at the $p < .05$ level.

variables. In $\mathbf{Z}_{it}$, however, I include the actual induced value the agent was given for that period since convergence was achieved in each case. The term $\epsilon_{it} = \alpha_i + u_{it}$; $\mathrm{E}[\alpha_i] = 0$, $\mathrm{E}[\alpha_i^2] = \sigma_\alpha^2$, and $\mathrm{E}[\alpha_i \alpha_j] = 0$ for $i \neq j$; and α_i and u_{it} are orthogonal for all i and t.[8]

Empirical estimates from models treating buyer and seller data in separate regression specifications are presented in table 4. On the buyer side of the market, a first insight from the two-stage model contained in columns 1 and 2 is as follows.

RESULT 3*a*. Male buyers execute more trades than female buyers; yet conditional on making a trade, women and men garner similar rents.

Evidence for the first part of this result is contained in column 1, which summarizes the first-stage probit estimates and indicates that at

[8] Education's level of correlation with income persuaded me to omit it from the specification. All the reported results hold when education is included, however.

the $p < .01$ level, men execute more trades than women, ceteris paribus. This result may hold for a variety of reasons; hence I shall not dwell on it here other than to note that it raises an interesting query: Do female-dominated markets equilibrate in the same fashion as male-dominated markets? This question will be addressed below. Evidence of the latter part of result 3*a* can be gleaned from second-stage regression estimates in column 2, which suggest that conditional on making a trade, women pay a higher price for the moustache card, but the difference is not statistically significant at conventional levels. Or likewise, consumer surplus is not influenced by gender conditional on executing a trade. A second insight gained from the buyers' regression estimates is as follows.

RESULT 3*b*. Experienced agents execute more trades than lesser experienced agents and earn more rents conditional on making a trade.

The first half of this finding follows from column 1, which suggests that experienced bargainers are significantly more likely to execute a transaction at the $p < .01$ level. Empirical estimates in column 2 provide evidence of the second half of this result, namely that market experience is a significant determinant of prices. In this case, via the bargaining process, experienced agents negotiate lower prices and therefore receive higher economic rents than their lesser experienced counterparts.[9]

Considering the seller side of the market, I find the following result.

RESULT 3*c*. Male and female sellers execute a similar number of trades; yet conditional on making a trade, women receive lower prices.

This result can be observed in columns 3 and 4 of table 4. Column 3 suggests that the dealer's gender is not an important determinant of whether a trade is executed, but column 4 indicates that women who do make a sale receive lower prices and therefore lower producer surplus than men. This comparative static finding is significant at the $p < .10$ level, but it should be viewed with caution since only four of the sellers were women in these sessions. These empirical results serve to highlight that individual attributes influence market outcomes.[10] In this regard, the empirical results point to at least two outstanding questions: (i) Do naturally occurring markets dominated by inexperienced buyers and sellers generate results consonant with neoclassical expectations in mul-

[9] Other empirical results contained in cols. 1 and 2 imply that the number of trades increases over the market periods and prices fall, which is consistent with the notion that players "warm up" in the market and execute a greater number of trades in the later periods, as they learn the nuances of the market and explore optimal bargaining strategies. Finally, buyers who had induced values that placed them "in the market" were more likely to execute a trade than those with induced values below the competitive prediction. And, higher induced values led buyers to pay a higher price for the Oglivie card.

[10] Other parameter estimates are consonant with expectations: previous bargaining experience, the time trend, and whether the dealer was given an induced value that would place him "in the market" are each significant at conventional levels. One (potentially) unexpected result is that sellers with higher incomes execute fewer trades than their lower-income-earning counterparts.

tilateral bargaining markets? And (ii) do other naturally occurring markets, such as those dominated by women rather than men, yield similar equilibrating tendencies?

Experimental Design and Sports Card Results 2

While the above treatments provide field evidence that centralization, via either the Walrasian tâtonnement or double-auction mechanism, is not necessary for market outcomes to approach neoclassical expectations, it remains an open issue whether in naturally occurring markets inexperienced buyers and inexperienced sellers will generate similar results. Gode and Sunder (1993) illustrate the value of such an exercise, since their simulation results suggest that efficiency of the double-auction institution derives largely from its structure rather than from individual learning.

In an effort to synthesize the results in the received literature, I conducted several additional market sessions. One major difference from the sports card experimental design above, however, is market composition. In these three new treatments, to focus more exclusively on market experience, I examine markets that are populated by children under the age of 13. That is, children under the age of 13 are the only participants allowed to be buyers and sellers. This exploration provides an avenue to explore behavioral differences across inexperienced agents and their experienced counterparts. More broadly, it is important to understand children's behavior in such exercises because popular explanations of economic behavior model familial decision processes as a part of a household bargaining process, in which children are engaged.

To begin the analysis, I replicate the S12 sports card treatment with its children analogue: S12rchildren (S12rchildren denotes 12 randomly drawn children buyers and sellers in symmetric markets). These three sessions are summarized as the first entry in column 2 of table 1. I also examine data from sessions that include only six buyers and six sellers competing in the market. To maintain unitary supply and demand, in these markets I give sellers a value of \$9, \$11, \$13, \$13.50, \$16, or \$18 and give buyers a value of \$19, \$17, \$14, \$13.50, \$12, or \$10. In this case, neoclassical theory predicts a price of \$13.50 and a quantity of four; the efficient outcome yields \$17 in rents per period. This is a more difficult task for neoclassical theory, since with certain assortments of buyers and sellers, one trade needs to occur at zero economic profits.

To delineate across individual market experience levels in these six-buyer/six-seller markets, I run three market sessions, as summarized in the top panel of column 2 of table 1. In the session labeled S6rchildren (denoting six randomly drawn children buyers and sellers in symmetric markets), I recruit children under the age of 13 to participate in market

trading sessions identical to the sports card market sessions described above. Sessions S6echildren and S6ichildren are identical, but in these markets all buyers and sellers are either experienced (S6echildren) or inexperienced (S6ichildren). In defining levels of experience, I consider the intensity of previous bargaining activity over the past several years. In particular, with List's (2003) data used as a benchmark, experienced (inexperienced) nondealers are those consumers who have traded more (less) than 12 (one) times per month in the past two years (these figures are plus or minus one standard deviation from his mean trading rate of 5.66). Using similar selection criteria, I label a seller experienced (inexperienced) if he had made more (fewer) than 25 (three) trades per month in the past two years. Other than the selection criteria, the general rules and instructions for these treatments were identical to those above. In these treatments, the average participant age was 9.50, and the market sessions included 100 boys and eight girls.

Empirical results, summarized in table 5, suggest a first finding.

RESULT 4. In markets populated by children, competitive price theory adequately organizes the data when participants have sufficient market experience.

The first sign of this result occurs in the data from treatment S12rchildren, where 12 randomly selected buyers are paired with 12 randomly selected sellers in the decentralized bargaining market. While the data summarized in the first row of table 5 reveal that the average price across the three sessions is at, or near, the competitive market price prediction for each trial, the key result is the standard deviation of price. In the early periods, price is quite variant, but by the terminal period the variation is quite low, even lower than the variation observed in the S12 sessions. This insight can be gleaned from figure 5, which provides sequential transaction prices for session 1 of S12rchildren. The figure reveals that after a few periods, prices converge to the competitive level, and in the final two periods, prices "settle down" to approximate neoclassical expectations.

Observed quantity levels also approximate neoclassical expectations, since on average, 6, 6.3, and 7.7 units were traded in periods 3, 4, and 5; efficiency rates are quite high and increase throughout the market session—reaching 95 percent by period 5. These findings suggest that even in markets populated entirely by children, there is a tendency toward neoclassical expectations after a few periods of market experience.

The six-buyer/six-seller markets reinforce this finding and shed light on the relationship between experience and market outcomes. For example, while markets with randomly drawn participants (S6rchildren) and experienced participants (S6echildren) yield insights consonant with neoclassical expectations (see, e.g., fig. 6 and table 5), markets with

TABLE 5
EXPERIMENTAL RESULTS: CHILDREN'S SPORTS CARD EXPERIMENT

	Market Period				
	(1)	(2)	(3)	(4)	(5)
	A. S12rchildren (N=72)				
Average price	13.17	14.27	13.72	13.72	12.96
Standard deviation	3.55	2.64	2.03	1.41	1.21
Quantity	3	3.7	6	6.3	7.7
Profits:					
Buyers	9.17	8.33	15.83	15.33	21
Sellers	6.83	6.33	10.33	15.67	14
Efficiency	43%	40%	71%	84%	95%
	B. S6rchildren (N=12)				
Average price	15.00	12.50	13.25	12.88	13.00
Standard deviation	…	3.5	1.7	1.31	1.73
Quantity	2	3	4	4	3
Profits:					
Buyers	4.00	1.50	9.00	12.00	11.00
Sellers	6.00	1.50	6.50	5.00	5.50
Efficiency	59%	18%	91%	100%	97%
	C. S6echildren (N=12)				
Average price	14.00	12.37	13.83	13.88	13.83
Standard deviation	2.65	1.7	.29	.63	.29
Quantity	3	4	3	4	3
Profits:					
Buyers	8.00	14.00	8.00	8.00	8.50
Sellers	3.50	3.00	6.00	9.00	8.00
Efficiency	68%	100%	82%	100%	97%
	D. S6ichildren (N=12)				
Average price	19.00	14.16	15.00	16.17	17.00
Standard deviation	…	3.62	2.65	2.75	…
Quantity	1	3	3	3	2
Profits:					
Buyers	.00	3.50	3.00	1.00	2.00
Sellers	6.00	7.00	5.00	4.00	10.00
Efficiency	35%	62%	47%	29%	71%

NOTE.—Figures in the table represent averages across the sessions in each treatment. Summary statistics are provided for period price, standard deviation of period price, quantity traded in period, and total buyer and seller profits in each period. For example, in the S12rchildren sessions, period 1 had an average trading price of $13.17 with a standard deviation of $3.55. On average, three cards were purchased, and total buyer (seller) profit was $9.17 ($6.83) for the period. Overall efficiency was 43 percent.

inexperienced subjects (S6ichildren) yield quite different insights.[11] Data from the bargaining session with inexperienced children are akin to a martingale process, whereby prices follow no apparent trajectory

[11] I do not include a graphical depiction of S6rchildren, but note that it is generally consistent with S6echildren with added noise (see the standard deviations in table 5). It is interesting to note the tight range of observed prices in the S6echildren session. As summarized in table 5, the standard deviation in period 1 is relatively large, but by the terminal period the variance is quite small.

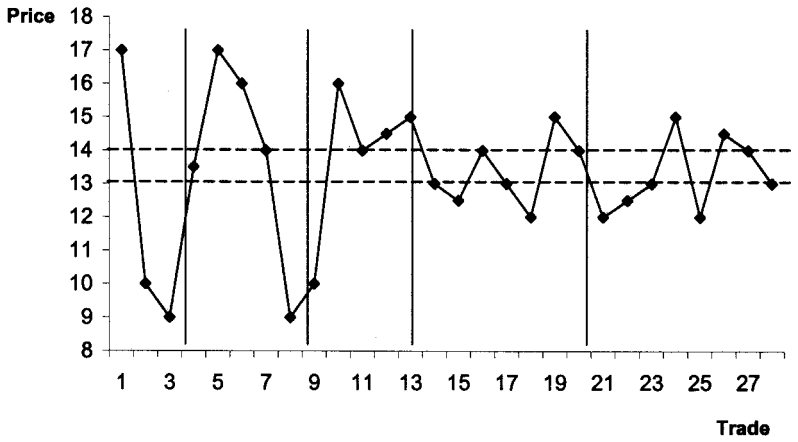

FIG. 5.—Price path S12rchildren, session 1

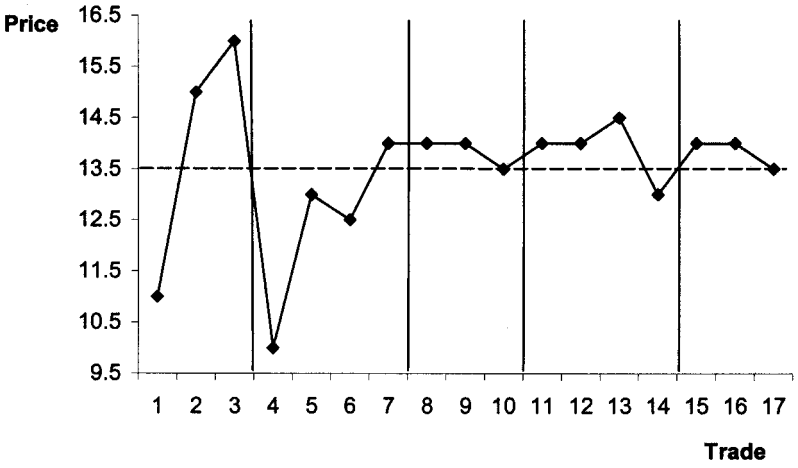

FIG. 6.—Price path S6echildren

or trend. Indeed, perusal of figure 7 and the data in panel D of table 5 suggests that markets including only very inexperienced agents are inefficient, yield rent allocations that favor sellers, and provide price signals that do not represent the underlying (static) demand and supply structures.

While these results do not map directly into what Chamberlain (1948) observed, they do parallel his main message: neoclassical theory does not do well in organizing behavior in markets populated by agents with little market experience. And, they lend insights into the generality of

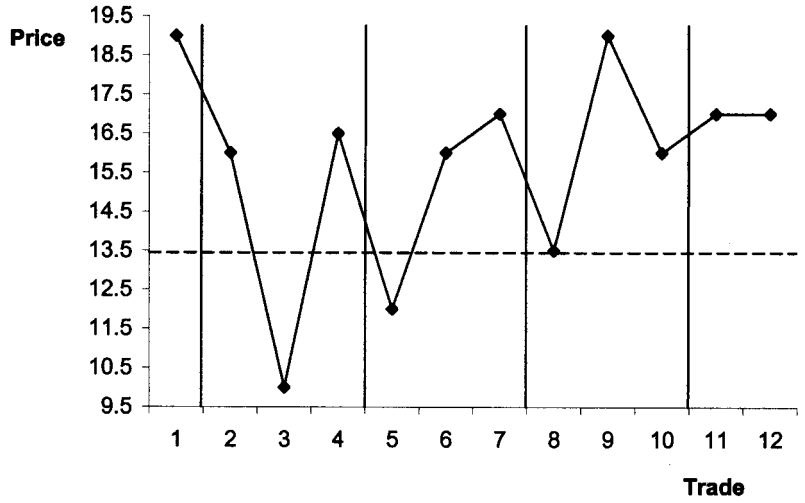

FIG. 7.—Price path S6ichildren

Gode and Sunder (1993), in that if one considered the inexperienced children as having "zero market intelligence," these results suggest that the institution itself is not driving equilibrium outcomes and highlights the import of market experience (in this spirit, see Brewer et al. [2002]).

III. Experimental Design and Results II

Insights gained from the sports card market provide conclusions concerning neoclassical competitive market theory and its ability to explain the equilibrating forces operating in decentralized haggle markets. Yet, it would be comforting if similar behavior could be detected in other naturally occurring markets. And since few women participate in the sports card market, any subtle gender differences observed were difficult to detect statistically because the sample sizes were quite small. With the dual goal of providing a robustness test in a new market and examining behavior in markets dominated by women, I began searching for naturally occurring markets that satisfied these criteria. My search ended when I found the collector pin market in Walt Disney World's Epcot Center in Orlando, Florida.

While there are numerous designated trading sites throughout the Walt Disney World Resort in Orlando, I chose to execute my field experiment at the Millennium Central Pin Trading Station in Walt Disney World's Epcot Center, where I was told a significant number of traders would meet on any given day. To maintain consistency with the sports

market experiment, I used a damaged good: a chipped cloisonné pin of Mickey Mouse that was issued on St. Patrick's Day, 2000.

The pin field experiment uses markets composed of six buyers and six sellers. The major difference between these treatments and those above is that in the pin sessions women, rather than men or children, dominate the market: of the 72 participants, only four men competed. The buyers and sellers were randomly allocated to one of three treatments, as summarized in column 3 of table 1. It was necessary to focus on six-buyer/six-seller market sessions because of the limited number of participants available at any given time. Treatment S6pin is similar to the S6rchildren treatment in that I use symmetric demand and supply curves for six one-unit demanders and six one-unit suppliers. Treatments PED6pin and PES6pin are the six-buyer and six-seller analogues to PED12 and PES12: in PED6pin (PES6pin) the six buyers (sellers) have perfectly elastic demand at \$13.50 and the six sellers (buyers) have a value of \$9, \$11, \$13, \$13.50, \$16, or \$18 (\$19, \$17, \$14, \$13.50, \$12, or \$10). Thus the total rents available in PED6pin (PES6pin) are \$7.50 (\$9.50). Every other aspect of the design is identical to the procedures described above.

Summary experimental results are presented in table 6 and suggest the following result.

RESULT 5. In female-dominated markets, competitive price theory adequately predicts data patterns in symmetric markets.

Evidence to support this finding is contained in the first row of table 6 as well as in figure 8, which charts sequential transaction prices for session 1 of S6pin. In this treatment, what one observes is a low level of trading and very sporadic prices in the early periods; but after a few periods, traders begin to explore market opportunities more fully, and in period 5, six of the seven observed trades are within \$0.50 of the neoclassical expectation and efficiency rates are quite high, never falling below 90 percent after period 3.

While neoclassical theory adequately organizes the data in symmetric markets after a few trading periods, other summary results contained in table 6 suggest the following result.

RESULT 6. In female-dominated markets, competitive price theory satisfactorily predicts data patterns in *some* asymmetric markets.

Data from treatment PES6pin (panel B) in table 6 show that in markets with perfectly elastic supply, prices tend toward the theoretical prediction: in the early periods, prices are quite different from neoclassical expectations; yet by the terminal period the average trading price of \$13.63 approaches neoclassical expectations. Indeed, estimated price realizations in period 5 are significantly different from those in period 1 in a Tobit panel data model at the $p < .05$ level, and in both sessions the expected quantity level is achieved in period 5. Figure 9

TABLE 6
EXPERIMENTAL RESULTS: PIN EXPERIMENT

	MARKET PERIOD				
	(1)	(2)	(3)	(4)	(5)
	A. S6pin (N=24)				
Average price	16.50	14.50	14.07	14.07	13.64
Standard deviation	1.32	1.00	.67	.93	.38
Quantity	1.5	2	3.5	3.5	3.5
Profits:					
Buyers	1.75	5.50	7.50	7.50	9.00
Sellers	4.75	6.25	9.50	8.00	8.00
Efficiency	38%	69%	100%	91%	100%
	B. PES6pin (N=24)				
Average price	17.67	17.00	14.75	14.00	13.63
Standard deviation	1.15	2.00	1.25	.70	.23
Quantity	1.5	1.5	3	3.5	4
Profits:					
Buyers	1.00	2.00	5.50	7.75	8.95
Sellers	6.25	5.25	3.75	1.75	.50
Efficiency	76%	76%	97%	100%	99%
	C. PED6pin (N=24)				
Average price	11.70	12.00	12.36	12.64	12.64
Standard deviation	.84	.87	.99	.69	.63
Quantity	2.5	2.5	3.5	3.5	3.5
Profits:					
Buyers	4.50	3.75	4.00	3.00	3.00
Sellers	2.75	3.25	3.50	4.50	4.50
Efficiency	97%	93%	100%	100%	100%

NOTE.—Figures in the table represent averages across the sessions in each treatment. Summary statistics are provided for period price, standard deviation of period price, quantity traded in period, and total buyer and seller profits in each period. For example, in the S6pin sessions, period 1 had an average trading price of $16.50 with a standard deviation of $1.32. On average, one and one-half cards were purchased, and total buyer (seller) profit was $1.75 ($4.75) for the period. Overall efficiency was 38 percent.

reveals the strength of this insight, as the last seven trades in session 1 are executed at $13.50. Furthermore, efficiency levels as well as the allocation of rents both approach neoclassical expectations in later periods.

As well as neoclassical theory explains data in PES6pin, its predictive power is reduced in PED6pin. Panel C of table 6 and figure 10 reveal that in markets with perfectly elastic demand, prices are sticky upward, and this stickiness causes theoretical point predictions to be frustrated. While certainly price is tending toward the neoclassical level of $13.50, as suggested by empirical results from a Tobit panel data model,[12] price realizations appear to have difficulty breaking the $13 level. This finding

[12] Yet a matched-pairs t-test is not consistent with this finding, since transaction prices in period 5 are not significantly different from the period 1 price realizations at the $p < .05$ level.

FIG. 8.—Price path S6pin, session 1

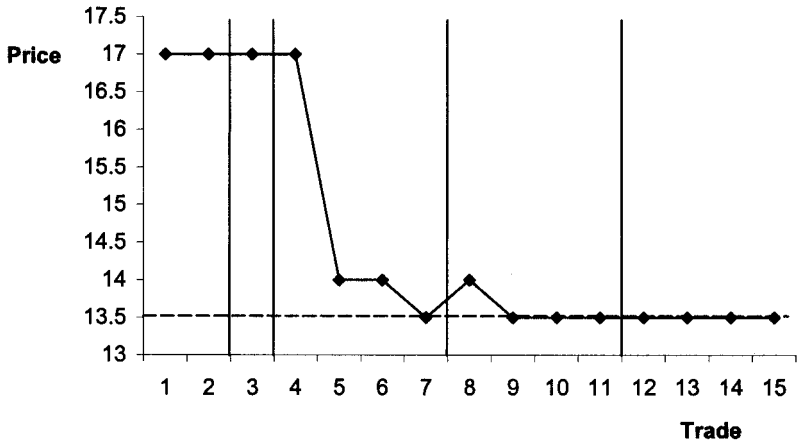

FIG. 9.—Price path PES6pin, session 1

is consistent with the "fundamental problem of commerce" literature, which suggests that on the basis of incomplete information considerations, there will be a tendency for buyers and sellers to understate their willingness to execute a transaction in hopes of obtaining a more favorable bargain (see, e.g., Myerson and Satterthwaite 1983). Combining this insight with results in PES6pin suggests that this finding is driven by female buyers' avoidance of transactions that will provide them with minuscule economic profits.

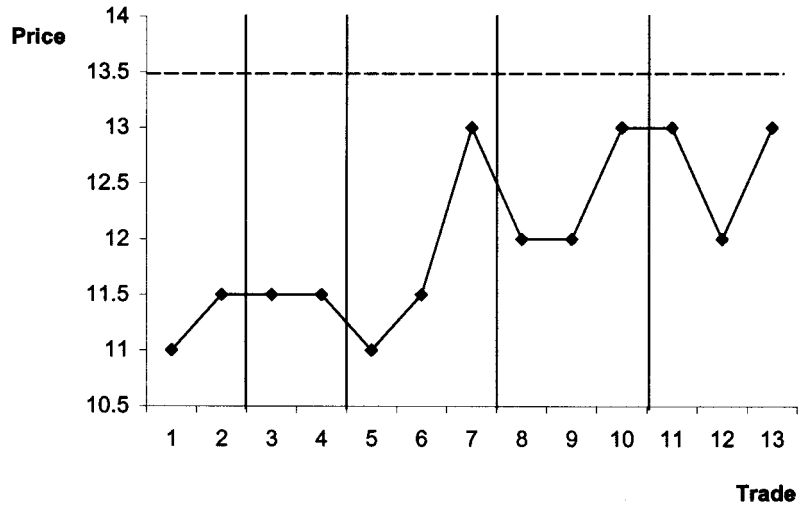

FIG. 10.—Price path PED6pin, session 1

Another interesting feature of these data is that in female-dominated markets, rents are shared more equally than in male-dominated markets: 43 (35) percent of trades split the rent equally in symmetric all-female (male) markets and 14 (11) percent of trades split the rent equally in asymmetric all-female (male) markets. While certainly institutional features may be driving some portion of this insight, it is interesting to note that more equal sharing of rents among women is consonant with the results of Andreoni and Vesterlund (2001), who study behavior in a laboratory dictator game and find that women are much more likely than men to be "equalitarians": choosing a division that gives equal payoffs. Yet this tendency of more equal rent splitting, which is observed throughout the female market sessions, does not influence the price trajectory in female markets in which sellers must accept transactions that will give them minuscule economic profits, PES6pin.

IV. Concluding Remarks

Markets are ubiquitous. Yet the extent to which neoclassical competitive market theory explains the equilibrating forces operating in markets remains underresearched. In this study, I depart from a traditional experimental investigation of neoclassical competitive theory by using the tools of experimental economics in an actual marketplace. The tests of neoclassical theory carried out are quite stringent, since the experimental conditions do not allow the marketer to obtain knowledge of

the offers and bids that are tendered, and whether or not they are accepted. Indeed, Smith (1962, p. 134) notes that "there are strong tendencies for … competitive equilibrium to be attained as long as one is able to … maintain absolute publicity of *all* bids, offers, and transactions" (italics added). This study sufficiently relaxes this informational assumption and finds that centralization and publicity of the array of bids and asks are not necessary for markets to equilibrate according to neoclassical expectations. In this sense, the data suggest that Adam Smith's invisible hand is quite powerful: competitive expectations are oftentimes met in multilateral contexts. A second insight is that market composition matters. While the early work in this literature has shown that structural and institutional features of the market are important, the results herein indicate that the composition of the market also influences outcomes.

Finally, as with any research endeavor, this study undoubtedly raised more issues than it settled. For example, merely by varying demand and supply parameters, one could gain considerable insights about the market adjustment process. In this regard, an appropriate field experimental design would permit a test to distinguish between the Walrasian hypothesis and the "excess rent" hypothesis (Smith 1965). And, by varying the rules of the marketplace, one could compare and contrast market institutions, examine collusive scenarios, and provide insights into customer markets heretofore unexplored in the marketplace. I leave these explorations for another occasion.

Appendix A

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 Pokemon cards, sportscards, other trading cards, and sports memorabilia.
3. Are you a sportscard or sports memorabilia professional dealer? —— If yes, how many shows per month do you attend in Tucson? ——
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 2) High School 3) 2-Year College 4) Other Post–High School 5) 4-Year College 6) Graduate School Education

7. What is your approximate yearly income from all sources, before taxes? 1) Less than $10,000 2) $10,000 to $19,999 3) $20,000 to $29,999 4) $30,000 to $39,999 5) $40,000 to $49,999 6) $50,000 to $74,999 7) $75,000 to $99,999 8) $100,000 or over
8. Approximate height and weight: ——.

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