An Experimental Study of Buyer-Seller Negotiation with One-Sided Incomplete Information and Time Discounting

An Experimental Study of Buyer-seller Negotiation with One-sided Incomplete Information and Time Discounting

Amnon Rapoport • Ido Erev • Rami Zwick
University of Arizona, Tucson, Arizona 85721
Technion–Israel Institute of Technology, Haifa 32000, Israel
The University of Auckland, Auckland, New Zealand

We study a multiperiod bargaining mechanism in which a seller negotiates with a buyer over the price of an indivisible good. It is common knowledge that the good has zero value to the seller. Its value to the buyer is privately known, distributed independently of the seller's value according to a distribution that is common knowledge. Bargaining proceeds as follows. The seller sets a price and offers the buyer an opportunity to purchase the good. The buyer either waits for at least one more period or agrees to purchase the good at the given price. If the buyer refuses the offer, then the process is repeated with the seller making a new offer on the next period. Our findings reveal several behavioral regularities, which do not support the sequential equilibrium for this bargaining mechanism. In line with recent developments in behavioral decision theory and game theory, which assume bounded rationality, we find that subjects follow simple rules of thumb in choosing strategies, reflected in the behavioral consistencies observed in this study.
(*Negotiation; Game Theory; Experimental Economics; Time Discounting; One-sided Incomplete Information*)

---

1. Introduction

Exchange activities and the manner in which the terms of exchange are established constitute a major concern of marketing. Arndt (1979) has observed that a growing number of markets are characterized by negotiated exchange (e.g., industrial product sales, negotiations between marketing channel members, media negotiations, etc.), and designated negotiation as a fundamental responsibility of marketing. In consumer markets the prices of many products recently have been subjected to negotiated exchange. Consumers may negotiate prices now in categories that traditionally were characterized by a fixed price trading format. For example, consumers can negotiate prices of airline tickets (*Business Week*, September 11, 1989) and vacations (*Business Week*, February 4, 1991). Some lenders and mortgage brokers negotiate interest rates selectively with customers who have other assets that can secure debt (*Business Week*, February 15, 1993). Developments in deregulating and computer-based communications have led Robert Kuttner to assert that, "In the electronic marketplace, the price of any relatively standard product would be negotiable" (*Business Week*, September 11, 1989, p. 17).

Noticing that the sale transaction is a central event in marketing, Neslin and Greenhalgh suggested more than ten years ago that market research get involved "in developing and testing theories that can predict the outcomes of these buyer-seller interactions" (1983, p. 368). Yet in a most recent comprehensive survey of mathematical models of group choice and negotiations, Corfman and Gupta have observed that "Despite the prevalence and importance of group decision making and negotiation in marketing, relatively few researchers are actively exploring this subject, and even fewer

0025-1909/95/4103/0377$01.25

concentrate on modeling group choice and negotiations" (1993).

Recently, there has been increasing interest in applying results from game theory to marketing negotiation situations. The research reported below extends the line of inquiry taken by Eliashberg et al. (1986), Green et al. (1967), Gupta (1989), McAlister et al. (1986), and Neslin and Greenhalgh (1983, 1986). It diverges from these studies by (1) testing a strategic model of the bargaining process, and (2) focusing on forces that drive the two parties to the bargaining process to reach an agreement rather than insist indefinitely on incompatible demands.

The noncooperative strategic approach to the bargaining problem, in which the outcome is an equilibrium of an explicit model of the bargaining process (Osborne and Rubinstein 1990), has been criticized on the grounds that the results it yields are strongly dependent on the particular rules imposed on the bargaining process (e.g., Gupta and Livne 1988; Corfman and Gupta 1992). Although acknowledging this dependence, we consider this particular feature of the model an advantage to marketing research. Theoretical and experimental studies of bargaining have taught us that bargaining outcomes depend on the institutional forms of the interaction as well as the parties' preferences and private information. The noncooperative approach highlights some of the rich strategic flavor of real-life bargaining through an explicit description of the bargaining process (Chatterjee et al. 1991). Because negotiations in real life are often conducted under official "rules of communication" or guided by unofficial rules often shaped by custom and tradition, it is important to study bargaining as a function of the specific institutions that guide the bargaining process.

The importance of specific trading rules is likely to increase in the future due to the advances in information system technology that has provided the tools for computer-mediated negotiations. Such systems, by necessity, have to impose at least a minimal level of structure on the communication process. For example, such systems are already in the test stage for media buying of advertisement (spot television, *Marketing and Media Decisions*, 1989), negotiation of air fares (*Business Week*, Sept. 11, 1989), and the on-line marketplace for the buying and selling of information and consulting services (AMIX).

The major aim of the present study is to investigate bargaining behavior with one-sided incomplete information and time discounting. We focus on the empirical properties of the "Tunisian Bazaar" mechanism used to structure bargaining under incomplete information. Our results should be of interest to both managers and consumers. Managers can gain insights to the consumers' decision rules in this context, as well as to the profitability of adopting the "Tunisian Bazaar" mechanism whenever sellers can select the bargaining format. Consumers can gain insight to sellers' expected price path and learn to utilize a better decision rule.

The paper proceeds as follows. Section 2 presents and motivates the salient features of the trading rule examined in this study. Section 3 describes the trading rule in detail and states several testable hypotheses. Section 4 describes an experiment designed to study the bargaining process, test one particular salient equilibrium of the mechanism and assess the effects of learning from experience. The results of the experiment are presented in §5. Section 6 concludes with a discussion of the experimental findings and their implications.

2. Salient Features of the Trading Rule

In this study we test a simple model of the negotiation between seller and buyer over the price of an indivisible good. Because the negotiation is bilateral, the context allows for both seller and buyer to have some monopoly power. A typical example is a vendor with a unique product that has special value for one industrial customer (Wilson 1987).

Following Rubinstein (1991), we adopt the view that a game is not a rigid description of the physical rules of the real world. Rather, a game-theoretic model should include only those factors that are perceived by the players to be salient. The key features of the model are: (1) private information on one side; (2) only the uninformed party makes offers; (3) the parties are impatient to enjoy the fruits of the agreement; and (4) no communication is allowed except price proposals, acceptance, and rejections.

The salient features of the trading rule we study capture some of the prevalent real-world characteristics of buyer-seller negotiation which are strategically important.

2.1. Private Information on One Side

Many negotiation activities are characterized by asymmetry of information. Such is the case, for example, when consumers negotiate the price of a new car with a dealer. In many cases, consumers can find out exactly what the dealer's invoice price is for a given car by consulting, for example, Consumer Reports Auto Price Service. On the other hand, the dealer is not informed of the buyer's valuation price (*Business Week*, August 30, 1993, p. 86).

2.2. Only the Uninformed Party Makes Offers

This is the case, for example, in department stores' "discount basement" where the seller sequentially posts new prices as time advances. Here only the seller, who is frequently the uninformed party, makes offers, and the buyer simply waits to accept some posted price.[1]

2.3. The Parties are Impatient to Enjoy the Fruits of the Agreement

The impatience can be interpreted as the "cost" of bargaining. As Cross (1969, p. 13) has observed, ". . . the passage of time has a cost in terms of both dollars and the sacrifice of utility which stems from the postponement of consumption, . . . it is precisely this cost which motivates the whole bargaining process. If it did not matter when the parties agreed, it would not matter whether or not they agreed at all."

[1] Ausubel and Deneckere (1992) provide theoretical justification for studying the sequential bargaining game with one-sided incomplete information in which only the uninformed party is permitted to make offers. They show that when the time interval between successive periods is sufficiently short, the informed party never makes any serious offers in the play of alternating-offer bargaining games. Furthermore, several examples suggest that the time interval required to assure silence is not especially brief. Hence, for the class of equilibria studied by Ausubel and Deneckere (1992), the outcome of the alternating-offer game is as if the extensive form permits offers only by the uninformed party (the Silence Theorem). Whether the Silence Theorem will hold in practice is an interesting question which deserves further study.

The influence of time upon bargaining may assume different forms. First, it is reflected in a discounting function if the players discount future benefits. Second, the utility of agreement may change with the calendar date. Finally, there is usually a fixed cost of bargaining that recurs at each stage of the negotiation (Cross 1969). In the present study we test the effect of discounting future benefits on the negotiated agreement.

2.4. Limited Communication—No Communication is Allowed Except Price Proposals, Acceptance, and Rejections

This feature of the model reflects transaction contexts characterized by the use of intermediaries who serve as communication channels between buyers and sellers. For example, real estate agents refrain from allowing buyers and sellers to communicate directly. Most automobile purchases are structured similarly in that the salesperson physically carries the consumer's price offer to the sales manager and vice versa (Evans and Beltramini 1987).

3. The Trading Rule

3.1. The Seller-Offer Game (The Tunisian Bazaar Mechanism

A single seller negotiates with a single buyer the price of an indivisible good. The value of the good to the seller (e.g., production cost), denoted by s, is common knowledge. The buyer imputes some value, denoted by v ($b_* \leq v \leq b^*$), to the good. The value of v is known to the buyer but not the seller. A probability distribution $F(v)$, which is common knowledge, represents the seller's belief about the buyer's reservation price, v. Bargaining has the following structure. Time is divided into discrete periods. At each period t, $t = 0, 1, 2, \ldots$, the seller sets a price p_t and offers the buyer an opportunity to purchase the good. The buyer can either wait (reject the present offer) or agree to purchase the good at the given price p_t. If the buyer rejects the offer, then the process repeats itself, with the seller making a new offer on the next period $t + 1$. If a price p_t is offered and accepted on period t, the seller's payoff is given by δp_t, and the buyer's by $\delta^t(v - p_t)$, where $\delta < 1$ is a common discount factor assumed to be common knowledge.

3.2. Main Results

The above trading rule has been studied by Sobel and Takahashi (1983), Fudenberg and Tirole (1983), Cramton (1984), Fudenberg et al. (1985), Gul et al. (1986), and Ausubel and Deneckere (1989a,b, 1992). Although the game appears to be very different at first sight, the bilateral bargaining situation described above is closely related to a durable monopoly market where a seller repeatedly makes offers to sell many units to a population of many buyers, with valuations known to be distributed according to the same distribution for the privately known valuation of the buyer in the bilateral bargaining situation (Wilson 1987). Behaviorally, the equivalence of these two situations appears doubtful (Güth and Ritzberger 1992; Güth et al. 1993); hence, we limit our discussion to the bilateral bargaining case.

The main theoretical results are that there exist sequential equilibria (SE), and that if the (continuous) distribution from which the buyer's value is drawn has a support that strictly exceeds the seller's value ($s < b_*$), the sequential equilibrium path is unique.

Whenever (1) the good has already been produced, (2) the seller cannot bargain with any other buyer ($s = 0$), and (3) the seller's prior beliefs about the buyer's valuation are uniformly distributed on the interval (0,1], the unique sequential equilibrium path has the following structure (if $v \in [0,1]$, this equilibrium is not unique):

The seller offers a sequence of prices, which decline geometrically over time, i.e.,

$$p_t = \gamma^t p_0, \quad t = 0, 1, \ldots \text{ where} \tag{1}$$

$$p_0 = \gamma(1 - \delta)/(1 - \gamma\delta), \quad \text{and} \tag{2}$$

$$\gamma = [1 - (1 - \delta)^{1/2}]/\delta. \tag{3}$$

The buyer's strategy is to accept p_t if and only if $p_t \leq p^*(v)$, where

$$p^*(v) = v(1 - \delta)/(1 - \gamma\delta). \tag{4}$$

Bargaining under the Tunisian Bazaar mechanism may be evaluated in terms of the sources of power controlled by the seller and buyer. The buyer derives power from her superior information, whereas the seller derives power from his role as the only player to make offers. Fudenberg et al. (1985, p. 85) use a similar terminology when providing intuition to the game-theoretical model:

> "The incentive to bargain is due to the destruction of the pie by discounting. By making offers, the seller makes the buyer responsible for destroying the pie if he rejects the offer. The seller uses this leverage to extort the buyer's surplus and, when there is incomplete information, price discriminate. With short time periods, higher-valuation buyers are more willing to free ride on lower-valuation buyers. The seller consequently loses his ability to price discriminate."

The equilibrium solution implies that the seller's bargaining power is severely eroded if the buyer has private information, has the option to pass, and is patient—at least if the buyer's strategy is stationary. This prediction has important practical applications; it is amenable for experimental testing (Wilson 1987).

3.3. Specific Predictions

The equilibrium solution implies several testable predictions, some of which are listed below.

1. First prices.

a. Regardless of the value of the discount factor, the seller's first offer is limited by $0 < p_0 < 0.5$. b. First prices should decrease as the value of the discount factor, δ, increases.

2. Price schedule. Equation (1) implies an exponentially descending price path.

3. Price discrimination. With a high discount factor, higher-valuation buyers are more willing to free ride on lower-valuation buyers. The seller consequently loses his ability to price discriminate when δ approaches 1.

4. Profit from trade. When the discount factor converges to 1, the seller's payoff converges to zero.

5. Efficiency of trade. When measured as the ratio of combined profit gain from trade to the total possible surplus, efficiency should increase with δ.

The next section describes our experimental design. We chose to test the bargaining mechanism under the condition in which the seller does not know with certainty that the value of the good for the buyer (v) is larger than his production cost (s). Thus, the experimental game simulates the multiple equilibria case (i.e.,

$s = 0$ and $v \in [0,1]$). This condition was chosen because it seems more natural. In most real world scenarios, sellers' costs are positive, and lowest-valuation buyers value the good less than the cost to the seller. Gul et al. (1986) have argued that because the equilibrium described above is the only one for which the buyer's strategy is continuous, such an equilibrium should be a salient predictor of market behavior.[2]

4. Method

4.1. Subjects

Forty-eight male and female students from the University of North Carolina at Chapel Hill participated in the experiment. Subjects were recruited through advertisements placed on bulletin boards on campus and printed in the students' daily newspaper. The announcements promised monetary reward contingent on performance for participation in a decision making experiment.

To test for the effects of experience, 16 of the original 48 subjects were chosen randomly, approached by the experimenter, and offered the opportunity to participate in the same experiment for two more sessions. Only one of these 16 subjects declined. He was replaced by another randomly chosen subject, who had participated in the first session.

4.2. Procedure

The experiment consisted of three sessions, with 48 subjects taking part in Session 1 and a subset of 16 subjects taking part, in addition, in Sessions 2 and 3. Session 1 lasted approximately two hours, and Sessions 2 and 3 lasted about one hour each. In all three sessions, the subjects participated in groups of four. To eliminate reputation effects across sessions (for "tough" or "soft" bargaining) and prevent collusion, unique groups were formed in each session.

Each subject in each session participated in 18 two-person bilateral monopoly games described in §3. To construct these games we used a 2-by-3-by-3 role by condition by iteration within-subject design. Each player was assigned the role of a seller in nine games and buyer in nine other games.[3] The three experimental conditions were different from one another in the value of the (common) discount factor: $\delta = 0.9$ in Condition H (high); $\delta = \frac{2}{3}$ in Condition M (medium); and $\delta = \frac{1}{3}$ in Condition L (low). Each condition was iterated three times. The pairing of the four group members was changed from game to game to limit sequential dependencies and reputation building. In each condition, each subject was paired twice with each of the remaining three members of his or her group, once as a seller and once as a buyer. Thus, in each condition each subject assumed the role of buyer in three games and seller in three other games.

The three conditions were played in order; subjects first completed six games under one condition, then six games under a second condition, and finally six more games under a third condition. The order of the three conditions was balanced: each of the six orderings (H,M,L), (H,L,M), (M,H,L), (M,L,H), (L,H,M), and (L,M,H) was assigned to two different groups.

At the beginning of the session the four group members were seated in separate booths and read the written instructions.[4] They remained in their booths until the end of the experiment. Subjects were told that in each game the experimenter would randomly pair them with another person in the group. It was emphasized that in each game they were likely to play against a different person, whose identity would not be revealed to them.

[2] Although the presence ($s < b_*$) or absence ($s \leq b_*$) of a "gap" between seller's and buyer's valuation is theoretically important, we do not expect such discontinuity in human behavior. Participants in competitive situations have some notion of which situations are similar and which are not. We proceed on the assumption that subjects perceive the above two conditions to be very similar to each other, leading to similar behavior.

[3] The model applies to a one-shot game. In the present experiment 18 games were played by groups of four players each. We have tried to limit reputation effects for "tough" or "soft" play (as opposed to within game buyer's reputation for having high or low valuation) by instructing subjects that in each game the experimenter would randomly pair them with another member of the group, whose identity is unknown, and that in each game they were likely to be matched with a different person. We cannot, however, discard the possibility that some subjects were motivated to gain "tough" reputation. It is difficult, though, to imagine how such status could have been achieved, given the anonymity of the experimental environment and the relatively small number of trials.

[4] Instructions used in this study and the data can be obtained by contacting any of the authors.

On each game the seller was asked to sell an indivisible good,[5] which had no value to the seller except its selling price. The value of the good to the buyer, v, was an integer between \$0 and \$100. It was actually determined by sampling a card from a deck of 101 cards numbered \$0, \$1, . . . , \$100. The seller's reservation price of 0 was known to both bargainers. The buyer knew the value of her own reservation price v, whereas the seller only knew that this value might assume any integer value between \$0 and \$100 with equal probability.[6] The discount factor, δ, was common knowledge.

Communication within dyad was conducted in the following way: On each period the seller listed his price for the good on an Offer Sheet. The experimenter delivered this offer sheet to the buyer, who either accepted the offer by writing "+" or rejected it by writing "−". If the offer was rejected, the experimenter returned the offer sheet to the seller to list another price for the next trial. If the offer was accepted on period t, the game terminated with the seller getting $\delta^t p_t$ and the buyer $\delta^t(v - p_t)$. Subjects were not required to calculate δ^t. Rather, the values of δ^t—referred to as "percentage of profit paid"—were listed for each condition separately. Thus, the (common) cost of delay for each condition was easily assessable.

Bargaining was terminated by the buyer unless the highest possible discounted payoff to the buyer in the next round, $\delta^t(v - p_t)$, became smaller than \$1. In this case, the game was terminated by the experimenter to prevent lengthy haggling over an insignificant amount. Less than 6% of all the games were thus terminated.

To motivate the subjects, they were informed that three of the games would be chosen randomly at the end of the experiment and their mean earnings in these games would be paid to them.[7] In addition, each subject was paid \$5 for participation. On the average, subjects gained \$23.80 per session.[8]

[5] Bargaining in this study is about the division of a pie, whose actual size is unknown to the player making the offers. The other details are as described in 3.1. In the experimental implementation, and for the sake of reality, the proposer was labeled "seller" and the receiver "buyer." We must, of course, acknowledge that superfluous aspects of the experimental design might have affected the results. Context, scenarios (framing), and labeling have been found to influence the outcomes of bargaining experiments (e.g., Hoffman et al. in press). The only practical remedy is, of course, to replicate the experiment while controlling for the superfluous variables.

[6] Subjects were not informed of the termination rule in case the payoffs became too small. The theoretical model assumes infinite horizon, whereas the experimental implementation is finite but "long". Since infinite-horizon games cannot be directly implemented in a laboratory environment, this limitation is unavoidable unless a different interpretation of discounting is adopted (see for example Zwick et al. 1992). Infinite horizon games do not assume that the world is infinite. Rather, such models are meant to represent environments where players face a long-term process without assigning a specific termination period. In such environments, after each period, players expect that there will be many more periods, as in our game (Rubinstein 1991).

[7] While the use of randomly chosen games for payment might introduce some unnecessary complexities, it allows bargaining for a significant amount of money on each game, and eliminates the possible "wealth effect" that can be created by having payments accumulated from game to game. The current procedure has been implemented in related studies (see, for example, Bolton 1991, Ochs and Roth 1989, and Roth et al. 1991).

[8] Our reward structure satisfies Smith's (1982) four precepts for a controlled microeconomic experiment of Nonsatiation, Saliency, Dominance, and Privacy. Smith's notion of dominance defined as "The reward structure dominates any subjective costs (or values) associated with participation in the activities of an experiment" has been disputed recently by Harrison (1989, 1990) on the ground that dominance should be defined to consider the opportunity cost to a subject of suboptimal behavior. Harrison (1990) challenged experimentalists to report the cost of misbehavior along the assumptions underlying that calculation. Unfortunately, such computation in our context is not obvious. This difficulty is shared by most other "games of human interaction." In such games subjects may actually profit by adopting a suboptimal behavior (optimal vis-a-vis the theoretical model being tested) if other subjects do not adopt the strategies that they are expected to play according to the theoretical model being tested. This is actually what happened in our study, where sellers did better than expected based on the normative analysis.

Harrison (1990) has acknowledged this problem and suggested two possible solutions, neither of which makes much sense in our study.

(1) The natural benchmark assumption in situations of this kind is that all players other than the one being studied are adopting the strategies that are expected to play according to the theoretical model being tested. Under this assumption, it is easy to evaluate the payoff function that an individual faces. However, this assumption is clearly violated in our study; hence it does not make sense to evaluate the opportunity cost of suboptimal strategy choices based on this assumption.

(2) A second avenue is to write down a "sensible," or "rationalizable" model of subject behavior that accounts better for the empirical

Session 2 was conducted about three weeks after Session 1, and Session 3 within two weeks from Session 2. The procedure in these two sessions was exactly the same as in Session 1.

5. Results

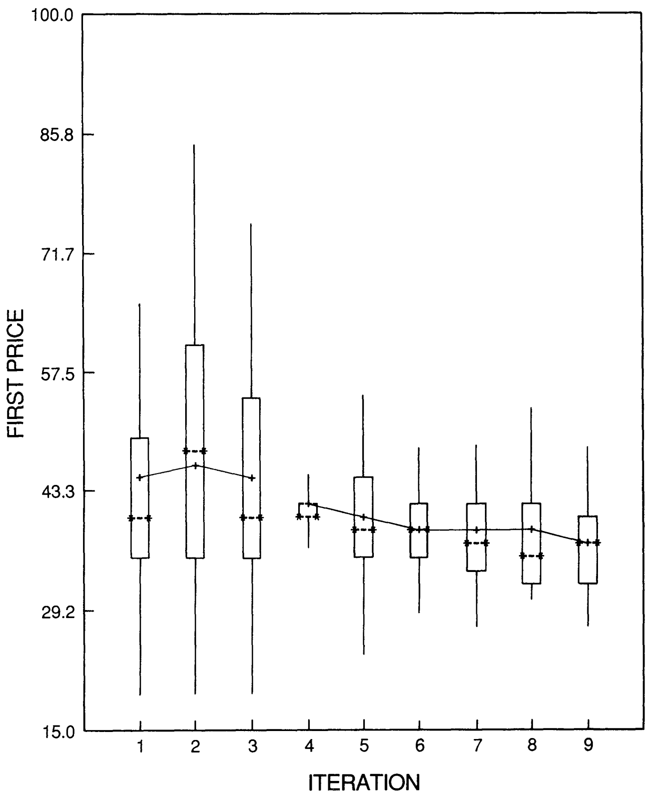
In reporting the results, we separate between games played by all 48 subjects in Session 1 (Iterations 1 to 3) and games played by the subset of 16 subjects in Sessions 2 and 3 (Iterations 4 to 9). Within session, we consider statistics which are common to both bargainers, characterize the price schedule of the seller, and characterize the decision rule of the buyer. In addition, to study the effect of experience we report session effects (mainly comparing Sessions 1 and 3) on the above statistics.[9]

5.1. First Prices

Figures 1a to 1c display for each condition separately side-by-side box plots of first prices by iteration. Mean first prices are represented by a centered plus sign (+) and are connected by a solid line. Medians are represented by a dashed line (*−*) within the body of the rectangle. The 25th percentile (75th percentile) is represented by the bottom (top) edge of the rectangle. The central vertical lines extend from the box as far as the data extend, to a distance of at most 1.5 interquartile ranges.

Inspection of Figures 1a to 1c reveals that first prices declined with the discount factor. They also show a weak but consistent decline in first prices with experience. However, first prices declined through the first three iterations, but did not fluctuate much thereafter.

Figure 1a **First Prices by Iteration ($\delta = 1/3$)**



We subjected the first prices in Session 1 (Iterations 1 to 3) to a 3 × 3 condition by iteration ANOVA with repeated measures on both factors.[10] The analysis yielded a significant condition effect ($F(2,46) = 52.8$, $p < 0.001$), a significant iteration effect ($F(2,46) = 3.75$, $p < 0.05$), and no interaction effect ($F(4,44) = 1.08$, $p > 0.3$). Post-hoc tests of the iteration effect within condition revealed a significant iteration effect in Condition H ($F(2,46) = 6.47$, $p < 0.01$), but not in the other two conditions ($F(2,46) = 0.67$, $p > 0.5$; $F(2,46) = 0.64$, $p > 0.5$, for Conditions L and M, respectively).

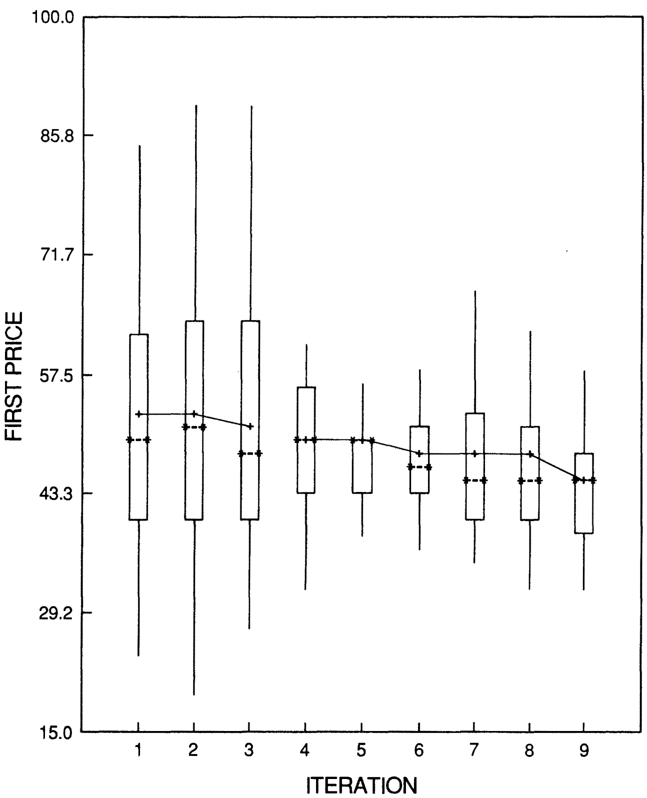
We repeated this analysis using the experienced subjects in Iterations 7 to 9 (Session 3). The analysis yielded a significant condition effect ($F(2,14) = 94.50$, p

distribution of opponent's behavior. This is what we do in 5.8 (Bounded rational behavior?). We found that both buyers and sellers deviate from the optimal behavior based on the observed distribution of opponent behavior. Here we can compute how much subjects did lose by their suboptimal behavior, but we do not find this information particularly interesting. Our goal is to investigate the normative solution and not the "bounded rationality" solution per se.

[9] Each subject played eighteen consecutive games in each session. Potential learning effects and autocorrelation raise problems for analyzing the data. Econometric methods, transformation, and tests were used to handle the problem of heteroscedasticity and autocorrelation over periods.

[10] Each seller's nine first prices were first ranked and than converted to van der Waerden scores recommended for small samples. ANOVA tests were then performed on the van der Waerden scores.

Figure 1b **First Prices by Iteration ($\delta = 2/3$)**



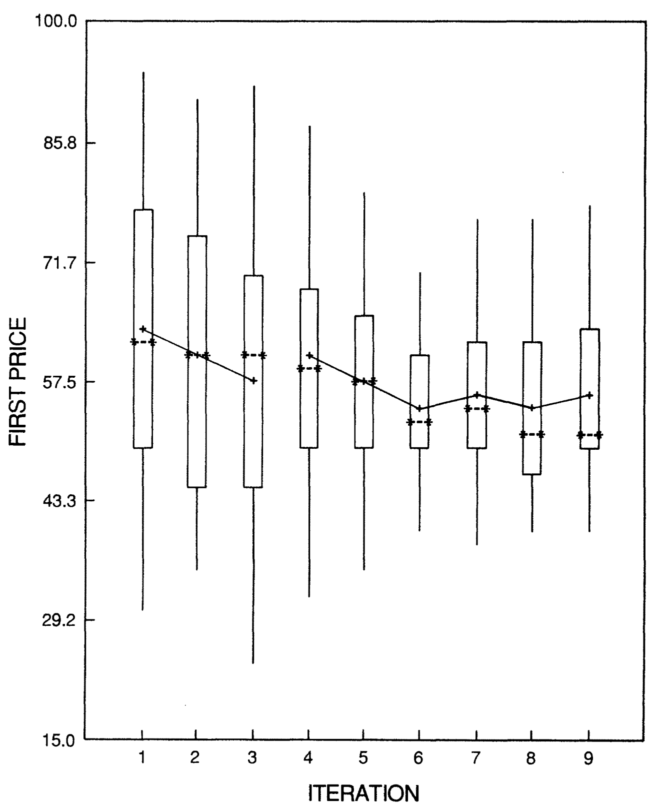
< 0.001) as before, no overall iteration effect ($F(2,14) = 2.97$, $p > 0.05$), and no interaction effect ($F(4,12) = 0.60$, $p > 0.5$).

The SE model predicts the exact value of first prices as a function of δ. It also predicts that $p_0 < 0.5$. This latter prediction holds only for Condition L in all iterations (the t values are −2.30, −1.46, −2.15, −4.35, −4.43, −8.46, −5.64, −4.33, and −6.2, for Iterations 1 to 9, respectively). Mean first prices were significantly higher than 0.5 in Condition H in all iterations except 8 and 9 (the t values are 5.86, 4.34, 3.51, 2.90, 2.13, 2.42, 2.35, 1.48, and 1.92, for Iterations 1 to 9, respectively), and were not significantly different from 0.5 in Condition M in all iterations (the t values are 1.4, 1.00, 0.24, −0.28, −0.09, −1.04, −0.80, −0.47, and −2.04, for Iterations 1 to 9, respectively).

On a more qualitative nature, the model predicts that mean first prices should decrease as the value of the discount factor, δ, increases. Figures 1a to 1c show that, in contrast, mean first prices follow the opposite trend, and the ANOVA results reported above indicate that this condition effect is statistically significant. Mean first prices increase from 45.8 in Conditions L through 52.1 in condition M to 60.9 in condition H in Session 1 (averaged over Iterations 1 to 3). The same pattern persists with experience. Mean first prices increase from 38.2 through 47.1 to 55.3 in Conditions L, M, and H, respectively, in Session 3 (averaged over Iterations 7 to 9).

Whereas the equilibrium prediction concerning the effect of δ on p_0 is violated by the trend of the mean results, it is possible that there is a substantial number of subjects for whom the prediction holds. We tested this hypothesis by checking the ordering of the three mean first prices, denoted by $p_0(\mathrm{H})$, $p_0(\mathrm{M})$, and $p_0(\mathrm{L})$, on the individual level. In Session 1, two of the 48 subjects exhibited the predicted ordering of $p_0(\mathrm{H}) < p_0(\mathrm{M}) < p_0(\mathrm{L})$, whereas 23 other subjects exhibited the op-

Figure 1c **First Prices by Iteration ($\delta = 0.9$)**



posite ordering $p_0(\text{H}) > p_0(\text{M}) > p_0(\text{L})$. The mean first offers of the remaining 23 subjects exhibited some other ordering. After considerable experience with the game, all of the 16 subjects in Session 3 exhibited an ordering of the three conditions, which is *diametrically opposed* to the equilibrium ordering. Thus, the analyses of first prices on both the group and individual levels provide no support to the equilibrium prediction about the effect of δ on p_0. Furthermore, there is no support in the data to the argument that with experience the results converge to the equilibrium prediction.

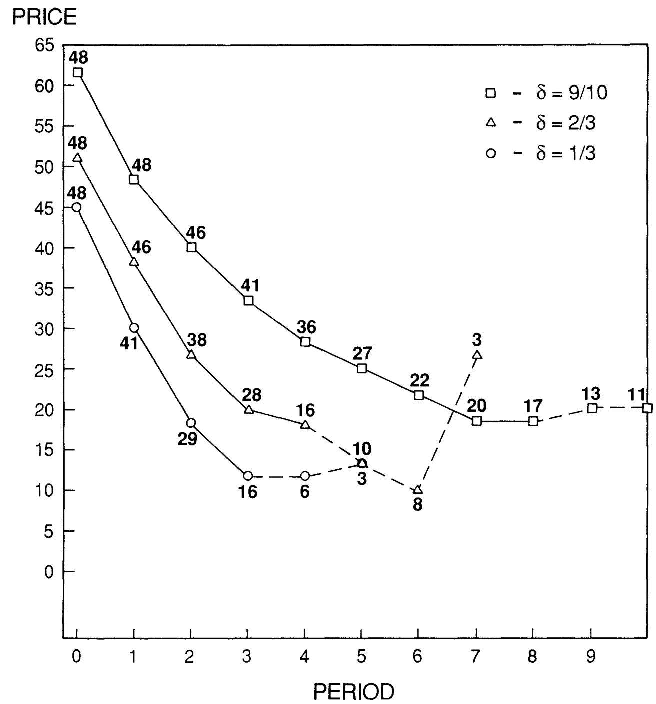
5.2. The Price Schedule

We have found that p_0 is poorly predicted by the SE solution. Yet it may be the case that once p_0 is determined, sellers follow the predicted "structure" of an exponentially descending price path. Figures 2a (Session 1) and 2b (Session 3) display mean prices on the vertical axis as a function of period on the horizontal axis, one curve for each condition. The number of subjects contributing to the calculation of each mean is written beside each point.[11]

A descending price path is clearly detected in Figures 2a and 2b. This is not an obvious finding because subjects could have adopted other common pricing strategies such as take-it-or-leave-it offers or multiple-step price paths (Ausubel and Deneckere 1989a).

First we tested the hypothesis that a descending linear trend is an adequate presentation of the data.[12] Using

Figure 2a **Mean Prices by Period (Session 1)**



the sequential sum of squares criterion (Freund and Littell 1986, p. 105), it was determined that a quadratic term adds significantly to the reduction in residual mean square in Session 1 ($F(1{,}132) = 10.59$, $p < 0.05$; $F(1{,}174) = 23.40$, $p < 0.01$; $F(1{,}303) = 70.94$, $p < 0.005$, for Conditions L, M, and H, respectively) but not in Session 3 ($F(1{,}30) = 3.49$, $p > 0.05$; $F(1{,}48) = 3.76$, $p > 0.05$; $F(1{,}66) = 3.81$, $p > 0.05$ for Conditions L, M, and H, respectively). The transition due to experience from nonlinear to a linear descending price path is clearly visible by comparing Figure 2a to 2b.

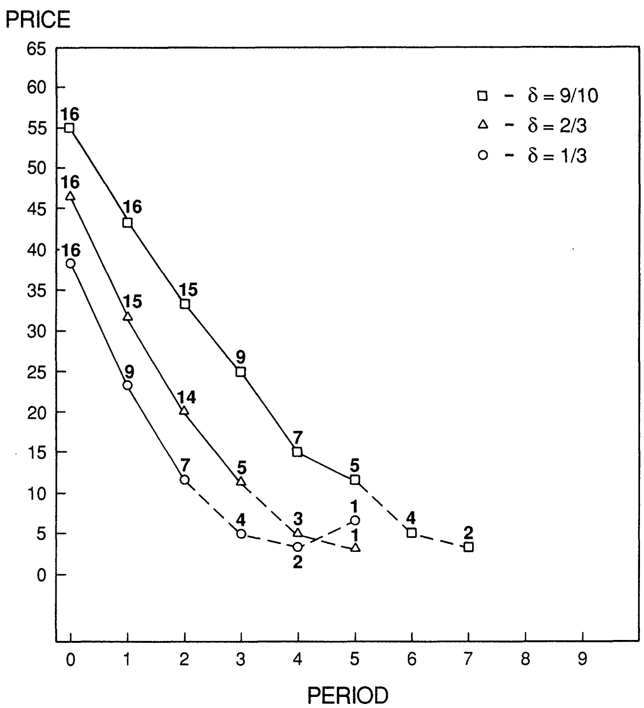
Having found that a nonlinear price path fits Session 1's mean offers better than a linear path, we tested the

[11] In testing the SE prediction, care should be taken of the fact that, due to the differences in the buyer's reservation price, different subjects contributed different numbers of observations in a given period. Furthermore, dyads including sellers reducing their prices relatively slowly or buyers setting up their decision criterion relatively low require more rounds to make a transaction. This phenomenon, known as the "selection bias," appears in learning experiments where slow learners contribute more data points than fast learners. Wishing to assign the same weight to subjects, not observations, the mean price by period was first computed for every subject and only then averaged across subjects (in Figures 2a and 2b). Furthermore, a period of negotiation was included in all subsequent analyses only if at least $\frac{1}{3}$ of the subjects contributed observations to this period.

[12] To test for heteroscedasticity we used White's test (White 1980). The test statistics are 0.76 (1.72), 0.41 (1.65), and 0.48 (2.03) for conditions L, M, and H, respectively in Session 1 (3). Since the critical value is $\chi^2\,(0.95;2) = 5.99$, no heteroscedasticity is detected in our data.

However, as expected from the time series nature of the price paths, the Durbin-Watson tests for the existence of first order autoregressive process are significant for all conditions and sessions (estimated first order autocorrelations are 0.51 (0.31), 0.69 (0.63), and 0.69 (0.75) for conditions L, M, and H, respectively, in Session 1 (3)). Given the significant autoregressive process, the following regressions were computed using the AUTOREG procedure (SAS/ETS User's Guide, p. 183).

Figure 2b **Mean Prices by Period (Session 3)**



fit of Session 1's data to an exponentially descending price path using a log-linear model. The model fits the data rather well but not significantly better than a linear model with a quadratic term. The estimated (predicted by SE) γ parameters are equal to 0.55 (0.55), 0.68 (0.63), and 0.81 (0.76), in Conditions L, M, and H, respectively. However, only in Condition L the estimated parameter is not significantly different from the predicted value ($F(1,129) = 0.23$, $p > 0.7$; $F(1,171) = 2.99$, $p < 0.05$; $F(1,300) = 6.80$, $p < 0.005$, for Conditions L, M, and H, respectively).

5.3. The Buyer's Decision Rule

A rational buyer should accept an offer at a time (price) which maximizes $\delta^t(v - p_t)$. This implies that

$$\delta^t(v - p_t) \leq \delta^f(v - p_f) \quad \text{for all} \quad t < f, \qquad (5)$$

where f designates the period of agreement and p_f designates the accepted price.

To test this qualitative prediction, we scrutinized all the games with at least two rounds in which a transaction was made. Altogether, 257 games satisfied this requirement in Session 1. In only 13 (5%) of these 257 games was the inequality in Equation (5) violated. Most of the violations—10 out of 13—occurred when the buyer's reservation price, v, exceeded 50. Presumably, the buyer expected a high profit in these games. When the seller's offers did not decrease fast enough, in some games buyers seemed to "punish" the seller by rejecting the "too late" offers.

With experience, the frequencies of violation of Equation (5) decreased to 3.3% in Session 2 (3 out of 91) and 1.2% in Session 3 (1 out of 84).

5.4. Price Formation

Table 1 presents predicted (P) versus mean final accepted prices by condition, buyer's valuation, and session. The table presents results for which there are at least three data points in a cell for at least one session. Table 1 shows that the Tunisian Bazaar mechanism generated, on the average, prices that are higher than predicted by the equilibrium theory. The high prices persist even after considerable experience in Session 3, and exist in almost all the buyer's valuation ranges.

The high prices are advantageous, of course, to the seller, and are reflected in the profit from trade discussed in §5.6.

5.5. Price Discrimination

The equilibrium model predicts that with a high discount factor, higher-valuation buyers will be more willing to free ride on lower-valuation buyers. Consequently, the seller should lose his ability to price discriminate when δ approaches 1.

Moreover, for a fixed discount factor, the model predicts that sellers cannot price discriminate between buyers whose valuation lies within certain ranges. Table 1 presents these ranges for each condition. For example, the model predicts that with a discount factor of 0.9, sellers cannot price discriminate between buyers whose valuation lies between 32 and 100. Similarly, when the discount factor is $\frac{2}{3}$, sellers cannot price discriminate between buyers whose valuation lies between 58 and 100. The fact that sellers lose their ability to price discriminate as δ gets higher is reflected in the fact that the v range bounded above by 100 includes most of the v values when $\delta = 0.9$.

Table 1 Predicted (*P*) versus Mean Actual Prices, and Price Discrimination (CORR) by Condition, Buyer's Valuation, and Session

			Session					
			1			3		
Condition	*v* Range	(*P*)	*N*	Mean	CORR	*N*	Mean	CORR
L	<8		6			2		
	8–13	(4.14)	8	7.63*	0.86@	5	5.20	−0.76
	14–24	(7.51)	15	12.13*	0.26	4	16.75*	0.94@
	25–44	(13.63)	29	22.00*	0.53@	6	24.50*	−0.53
	45–81	(24.74)	49	41.00*	0.28@	17	35.76*	−0.11
	82–100	(44.90)	31	46.35	0.00	13	38.08⁻	0.60@
M	<15		12			3		
	15–23	(9.33)	15	11.93*	0.40	5	15.80*	0.24
	24–36	(14.71)	15	22.60*	0.42	9	17.00	0.13
	37–57	(23.20)	27	30.19*	0.14	10	34.20*	0.59
	58–100	(36.60)	67	45.69*	0.36@	20	42.80*	−0.08
H	<14		13			6		
	14–18	(10.53)	12	9.46	0.40	1	6.00	—
	19–24	(13.86)	3	10.67	0.87	0	—	—
	25–31	(18.24)	4	21.25	0.11	5	20.80	0.31
	32–100	(24.00)	102	37.81*	0.60@	36	37.94*	0.69@

* : Actual price is significantly higher than predicted ($p < 0.05$).
⁻ : Actual price is significantly lower than predicted ($p < 0.05$).
@ : The hypothesis CORR = 0 is rejected ($p < 0.05$).

Table 1 presents Spearman correlation coefficients (CORR) between final accepted prices and buyers' valuations, by condition, within each of the v ranges. The equilibrium theory predicts, of course, zero correlation. Table 1 indicates that buyers did not take full advantage of their strategic privilege of being the fully informed party. For the most part, higher-valuation buyers did not free ride on lower-valuation buyers. This is mainly apparent in the upper v range in Condition H.

5.6. Profit from Trade

The SE solution predicts that when the discount factor converges to one, the seller's payoff converges to zero. In other words, the seller should lose his ability to price discriminate when the discount factor approaches unity.

The values of the discount factors in the present experiment are such that, based on the SE solution, the seller's expected profit in Condition L is higher than the buyer's expected profit (22.5 vs. 16.6), and is smaller in Conditions M (18.4 vs. 22.9) and L (12.2 vs. 32.4). The seller's profit is expected to decline as the discount factor grows larger, whereas the opposite trend is expected with regard to the buyer's profit. In all conditions, the profit is expected to be a positive function of the buyer's valuation.

Table 2 presents means and standard deviations of profit by role, condition, and session. In Session 1, there is a small increase in both the buyer's and seller's profit as δ increases. A 3×3 condition by iteration ANOVA[13] with repeated measures on both factors reveals that the increase is significant for buyers ($F(2,45) = 3.60$, $p < 0.05$), but only marginally so for sellers ($F(2,45) = 2.76$, $p < 0.08$). The iteration effect and the interaction were not significant. In all three conditions, the seller

[13] These ANOVA procedures were performed on the van der Waerden scores of the buyers' and sellers' profits as a proportion of the available pie.

Table 2 Means (Standard Deviations) of Profit by Role, Condition, and Session

		Condition		
Session	Role	H	M	L
1	Seller	25.51 (18.2)	25.39 (19.9)	24.97 (21.4)
	Buyer	20.12 (16.3)	19.46 (19.2)	17.75 (19.7)
3	Seller	27.11 (16.2)	24.35 (17.1)	25.77 (16.5)
	Buyer	19.50 (14.5)	16.87 (17.1)	26.53 (21.4)

outperformed the buyer; the sign statistic for testing the hypothesis that the difference between seller's and buyer's profits is significant in each of the three conditions are M(sign) = 22, $p < 0.001$; M(sign) = 27.5, $p < 0.001$; and M(sign) = 19.5, $p < 0.001$, for Conditions L, M, and H, respectively. As predicted, there is a high positive (Spearman) correlation between the buyer's valuation and the buyer's profit (0.87) as well as the seller's profit (0.83).

Repetition of the above analysis for Session 3 reveals a marginally significant condition effect for buyers' profit ($F(2,13) = 3.19$, $p < 0.08$), but not for sellers' profit ($F(2,13) = 2.42$, $p > 0.1$). The buyers' profit in Condition L is significantly higher than in Conditions M and H, which in turn are not significantly different from each other. The seller outperformed the buyer in Conditions H and M but not L (M(sign) = −2.5, $p > 0.5$; M(sign) = 11, $p < 0.001$; and M(sign) = 7, $p < 0.05$, for Conditions L, M, and H, respectively). As predicted, there is a high and positive (Spearman) correlation between the buyer's valuation and the buyer's profit (0.94) as well as the seller's profit (0.83).

5.7. Efficiency of Trade

When efficiencies are measured as the ratio of combined profit gain from trade to the total possible surplus (v), their means in Session 1 (Session 3) across all subject pairs are equal to 0.62 (0.73), 0.66 (0.69), and 0.74 (0.81), in Conditions L, M, and H, respectively. As predicted, the efficiency of trade increased with δ. Experience clearly improved the efficiency of trade. Furthermore, it is interesting to note that after gaining experience, in Session 3, the observed efficiencies in all conditions are *higher* than the expected efficiencies based on the SE solution (0.55, 0.64, and 0.76, for Conditions L, M, and H, respectively).

5.8. Boundedly Rational Behavior?

Whereas most of the tests conducted above have focused on the sequential equilibrium, the analyses reported in this section are driven by a thesis advocated by Kreps, who argues that

> "We must come to grips with the behavior of individual agents who are boundedly rational and who learn from the past—who engage in retrospection—if we are to provide answers to questions like: When is the equilibrium analysis appropriate? How do players select among equilibria? How do players behave when equilibrium analysis is inappropriate?" (Kreps 1990, pp. 150–151)

The approach that we adopt places the player in a dynamic context and assumes that in choosing her actions in the short run, the player builds a cognitive model of the choice problem, which is typically a simplification, misperception, or both of the "true situation" (see, e.g., the work of Tversky and Kahneman on biases and framing effects). The player is assumed to act optimally in the short run, given her cognitive model, while continuing to gather information from her experience and to use it to update the model employed in the short run. Examples of this general approach to bounded rationality in interactive situations include the work of Cournot (1838) on reaction functions in duopoly, the method of fictitious play suggested by Brown (1951), and the model of Bray (1982) on learning rational expectations equilibrium. While not driven by a particular learning model, the analyses reported below were conducted within this very general approach.

According to this approach, a buyer should attempt to maximize $\delta^t(v - p_t)$, given her beliefs (based on her past experience) about the seller's price path. The following analysis is based on our previous finding that an exponentially descending price path fits the seller's offers rather well in Session 1, and a linear descending price path fits the seller's offers in Session 3. Not knowing the buyer's beliefs, we *assume* that they correspond to these descending price paths.

Given the observed initial prices and rate of descent (geometric in Session 1 and linear in Session 3), we calculated for each condition separately the period in which $\delta^t(v - p_t)$ is maximized. Hereafter, we refer to these periods as the "fictitious" periods. The computation was based on the following values: initial prices (geometrically descent rate) of 45.7 (0.55), 50.6 (0.68), and 54.5 (0.81) for Conditions L, M, and H, respectively, in Session 1, and initial prices (linear descent rate) of 37.8 (−13.4), 45.6 (−12.7), and 53.2 (−9.2) for Conditions L, M, and H, respectively, in Session 3. The above parameters are the coefficients of the best exponential (Session 1) and linear (Session 3) regressions computed on the observed price paths in Sessions 1 and 3, respectively (see §5.2).

For example, given the observed price path in Session 1, first price offers should have been accepted immediately in Condition L if $56 \leq v \leq 100$; in Condition M if $81 \leq v \leq 100$; and in condition H if $79 \leq v \leq 100$. Similarly, in Session 1, agreements should have been reached in period 3 in Condition L if $10 \leq v \leq 17$; in Condition M if $27 \leq v \leq 38$; and in Condition H if $80 \leq v \leq 96$. Similar v ranges can be constructed for other predicted periods of agreements based on the observed price path.

Table 3 presents "fictitious" vs. actual (mean and median) period of agreement by condition and session. N indicates the number of games in which the v value is included within the appropriate range corresponding to the predicted period of agreement. For example, in 66 games the v value in Condition L in Session 1 was bounded below by 56, and in 45 games the v value in Condition M in Session 1 was bounded below by 81. For categories where $N > 10$, the percentage of games that ended at or before the predicted period of agreement is presented in parentheses beside the median indicator.

The percentage indicator shows that most games ended *at* or *before* the "fictitious" period of agreement. The mean and median indicators show a close correspondence in Conditions L and M between "fictitious" and actual period of agreements for games that were predicted to last for only one or two periods. The agreement is better with experience. For example, of the 66 games in Condition L in Session 1 that were expected to end in period zero, 59 games (89%) ended in that period. Compare this to the 100% accuracy of games expected to end in period zero in Condition L in Session 3.

In Condition H, and in all games in Conditions L and M that were expected to last for more than two periods, buyers accepted the price offer "too soon." For example, 44 games in Condition H in Session 3 were expected to end in period 5. Table 3 shows that on the average games lasted only 1.8 periods.

What was, then, the most common buyer's strategy? A strategy that guarantees that a price offer will not be accepted "too late" but may be accepted "too soon." The simplest such strategy, given a monotonically descending price path, is for the buyer to accept the first price that is equal to or smaller than her reservation price.

Table 4 presents frequency distributions—one for each condition—of the number of offers (m) equal to or smaller than v *before* agreement was reached. Thus, $m = 0$ means that the buyer accepted the first price equal to or smaller than her reservation price, $m = 1$ means that the buyer accepted the second offer equal to or smaller than her reservation price, etc. (The frequencies for each condition do not sum up to 144 in Session 1, or 48 in Session 3, because games that ended without an agreement were deleted from this analysis.) Table 4 shows that the simple strategy of accepting the first ($m = 0$) or the second ($m = 1$) price offer that is equal to or below the buyer's valuation describes the data quite well. With experience, subjects adopted this strategy more frequently. Accepting the first or second price offer that is below v accounts for 99.3%, 93.4%, and 72.4% of the accepted prices in Conditions L, M, and H, respectively, in Session 1. The corresponding percentages for Session 3 are 100%, 100%, and 79.1%. Inspection of individual data reveals that seven subjects in Session 1 adopted the above strategy by always accepting the first price offer below their reservation value ($m = 0$) in all nine games in which they were buyers. Sixteen more subjects never waited longer than one more period ($m \leq 1$) in all nine games. The remaining 25 subjects waited occasionally longer, but almost always less than two more periods ($m \leq 2$). Experience caused buyers to accept price offers sooner mainly in Conditions M and L. Inspection of individual results of the 16 experienced subjects reveals that, on the average, 11 of them accepted price offers sooner in Session 3 than in Session 1.

Table 3 Predicted (Based on Observed Price Path) Versus Actual Period of Agreement

	Condition								
	L			M			H		
Predicted	*N*	Mean	Median	*N*	Mean	Median	*N*	Mean	Median
Session 1									
>7	0			9			23		
7	2	4.0	4.0	2	4.5	4.5	10	3.0	3.0 (100)
6	2	3.0	3.0	6	3.8	3.5	13	2.8	3.0 (100)
5	2	3.0	3.0	9	2.9	3.0	16	2.5	2.5 (100)
4	6	3.5	3.5	8	2.7	3.0	22	1.6	1.0 (100)
3	13	2.4	2.0 (100)	16	1.9	2.0 (94)	29	1.2	1.0 (90)
2	16	1.6	2.0 (94)	25	1.9	1.0 (76)	7	0.7	0.0
1	37	0.9	1.0 (84)	24	0.6	0.0 (87)	—	—	—
0	66	0.1	0.0 (89)	45	0.4	0.0 (80)	—	—	—
Overall	144	0.9	0.0	144	1.6	1.0	144	3.7	3.0
Session 3									
>5	5			4			4		
5	0	—	—	0	—	—	44	1.8	1.5 (98)
3	0	—	—	19	1.7	2.0 (100)	0	—	—
2	8	1.9	2.0 (75)	5	0.8	0.0	0	—	—
1	5	0.6	1.0	6	0.7	0.5	0	—	—
0	30	0.0	0.0 (100)	14	0.1	0.0 (86)	0	—	—
Overall	48	0.7	0.0	48	1.2	1.0	48	2.2	2.0

Applying the same "boundedly rational" approach to the sellers, we note that with experience (Session 3) sellers in Conditions M and L could have expected with high confidence that buyers would accept the first price that is equal to or below their valuation (buyers did so in 78.8% and 91.5% of the time, respectively). Simple technical manipulation shows that the optimal sequence when $\delta = \frac{2}{3}$ is 64, 41, 26, 16, 10, 6, 4, 3, 2, 1. The optimal sequence for $\delta = \frac{1}{3}$ is 56, 31, 17, 9, 5, 3, 2, 1. Although these sequences are declining, they are clearly different from the observed price paths portrayed in Figure 2b.

Table 4 Frequency Distributions of Number of Offers (*m*) Equal to or Smaller than *v* Before Agreement Was Reached

	Condition					
	H		M		L	
m	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.
Session 1						
0	55	41.1	99	72.8	123	89.2
1	42	31.3	28	20.6	14	10.1
2	20	14.9	8	5.9	1	0.7
3	11	8.2	—	—	—	—
4	4	3.0	1	0.7	—	—
5	1	0.7	—	—	—	—
6	1	0.7	—	—	—	—
Total	134	100.0	136	100.0	138	100.0
Session 3						
0	23	47.9	37	78.8	43	91.5
1	15	31.2	10	21.3	4	8.5
2	7	14.6	—	—	—	—
3	3	6.3	—	—	—	—
Total	48	100.0	47	100.0	47	100.0

6. Discussion

In his editorial discussion on the role of game theory in modeling competition, Weitz (1985) states that:

> "The usefulness of the game theoretic approach is determined by the quality of the insights derived and the degree to which those insights can be substantiated through empirical research" (Weitz 1985, p. 232).

This statement applies to the game theoretic approach to model buyer-seller negotiation with one-sided incomplete information and time discounting. Our experiment suggests that there remains considerable room for improvement in our ability to predict subjects' behavior in this context. The equilibrium predictions capture very little of the qualitative features of the data. In line with recent developments in behavioral decision theory and game theory, which assume bounded rationality, we find that subjects follow simple rules of thumb in choosing strategies, reflected in the behavioral consistencies revealed in the study. These are summarized below.

(1) The seller's mean profit is remarkably consistent at about \$25 over different discount factors and sessions. This amount is exactly half the expected value of the good, and is the expected profit from a \$50 take-it-or-leave-it strategy.[14] Note that, theoretically, all the possible surplus is obtained and goes to the buyer when δ approaches one. Thus, as bargaining costs go to zero in the infinite horizon model, the seller loses the ability to make sales at positive prices. Yet, we have found that even after considerable experience, higher-valuation buyers do not take full advantage of the information superiority by free riding on lower-valuation buyers even when the cost of bargaining is rather low (Condition H). The most frequent decision rule used by the buyers is to accept the first or second price which is equal to or smaller than her valuation regardless of the discount factor. As a result of the above strategy, buyers typically accept offers "too soon" and consequently obtain smaller profits than expected.

(2) Our results show that first prices increase as the discount factor increases; the SE model predicts the opposite relationship.

(3) The bargaining mechanism performs quite well. As in the experiment of Radner and Schotter (1989), with experience the deviations from equilibrium resulted in a higher than predicted efficiency of bargaining, which in this case means that agreements were reached sooner than predicted.

(4) Whereas relatively inexperienced sellers set a nonlinear descending price path, with experience a simpler strategy of linear descending price schedule was adopted.

Despite the major change in experimental design, our conclusions support the conclusions of earlier experiments of two-person sequential bargaining behavior with complete information. In most of these earlier studies (Roth, 1995), the equilibrium predictions capture at least some of the qualitative features of the data, but fall considerably short of being perfect predictors.

In general, equilibrium solutions may be expected to account for interactive behavior if the solutions are transparent so that players may adopt them naturally, or if, as a result of much practice with the game (or similar games that allow positive transfer of experience), behavior converges to an equilibrium solution (Kreps 1990). Neither of these conditions was satisfied in the present study. The large and systematic discrepancies in Session 1 between observed and predicted first prices suggest that inexperienced bargainers who use the Tunisian Bazaar mechanism do not bargain according to the SE model. A comparison of Sessions 1 and 3 shows no indication of convergence to the equilibrium solution. In fact, an opposite trend was detected when the ordering of the first prices over the three different discount values was examined. Two of the 48 sellers in Session 1 exhibited the predicted ordering (highest first offer in Condition L and lowest in Condition H) compared to 23 sellers (48%) who exhibited the reverse ordering. In Session 3, after the players had gained considerable experience with the task, all 16 sellers exhibited the reverse ordering.

In a similar vein, there is no evidence that subjects adapt to the empirical realities of the game. Rather, the decision rules adopted by buyers and sellers violate any possible sequential equilibrium of the mechanism under investigation, or described by fictitious strategies.

It seems unlikely that the SE solution will prove to be more successful in natural settings than it was in the laboratory. Even if the SE model will provide a better description of bargaining behavior in another approximation of the theoretical mechanism, the predictions are not sufficiently robust to be much practical value.

[14] A seller who follows this strategy asks for a fixed price of \$50 on each round. The buyer's best response is to accept the first offer if $v > 50$. Since the probability of this event is about $\frac{1}{2}$, the seller's expected profit is \$25.

6.1. Possible Reasons for the Models' Failure

Standard economic analysis assumes that economic agents are rational, selfish, impatient, and have unchanging tastes. In addition, in any game in which the players interact strategically, game theory assumes that the rules of the game are common knowledge, which include, in particular, the exact procedural rules, other players' preferences (e.g., impatience, risk posture, outside opportunities, etc.), and the probabilities of private information. Finally, sequential equilibrium assumes that each party's strategy is optimal against other's strategy *in every contingency*.

It is hard to determine which assumptions have been violated in our study. Theories of incomplete information present special problems of experimental control, since they depend on the beliefs that players maintain. Our study deals with subjects' initial beliefs by beginning the game with an objective probability distribution known to all the players, so that the analysis of the experiment can proceed by taking each player's prior probability distribution to be equal to this objective distribution. We believe that the common knowledge assumption about the rules of the game and the initial probabilities of private information hold, given the extensive instructions to subjects, and the considerable experience with the procedure for at least the subjects who participated in three sessions.

It is more likely that since bargainers' preferences were not completely controlled in our study, the bargainers could not have common knowledge of one another's preferences. In addition, subjects' ability to update beliefs according to Bay's Rule and compute an optimal strategy is questionable.

The subgame perfect equilibrium solution predicts that risk aversion is disadvantageous in bargaining (Roth 1989). The theoretical model tested here assumed that bargainers' utility is measured by their monetary payoffs (risk neutrality). Since buyers, in general, accepted prices that are higher than predicted by the SE model, it can be argued that buyers exhibited risk aversion. Sellers, on the other hand, stated prices that are higher than expected, demonstrating risk-seeking behavior. Since the same subjects were assigned the roles of both buyer and seller, it is difficult to explain why subjects' attitude toward risk would vary with their role in the game. We suspect that risk posture cannot account for the behavioral regularities found in our study.

Clearly, our subjects deviated from game-theoretic rationality, or even from the most simple type of bounded rationality described by fictitious play. In line with recent developments in behavioral decision theory and game theory (e.g., Tietz 1986), which assume bounded rationality, we found that subjects followed simple rules of thumb in choosing strategies, reflected in the behavioral consistencies reported in this study.

6.2. Sellers' Advantage

One feature of our findings is particularly puzzling. We have found sellers' advantage in an environment that theoretically favors the buyer. Several studies have shown that bargainers appear to desire fairness for themselves, treating fairness for their partner as their partner's problem (Bolton 1991; Thompson and Loewenstein 1992). Because sellers lacked information about the values of buyers, they could not judge the "fairness" of the final agreement. Hence, we could have expected that buyers would take full advantage of their position as the only informed party. Contrary to expectation, in all conditions except Condition L in Session 3, buyers accepted prices that resulted in lower profits to themselves compared to the sellers' profits. Although they were the only fully informed party, and hence in a position to make comparative judgments, buyers accepted divisions of the pie that were favorable to the theoretically weaker player.

It is possible that the sellers' observed advantage in situations that theoretically favor the buyer (Conditions L and M) is due to social norms about "fair" division of surplus between buyers and sellers. Since sellers have the property rights to the good before the exchange, it is considered "fair" for them to benefit more. Indirect support for this hypothesis is found in Hoffman et al. (1994), who found that naming the first mover in an ultimatum game a "seller" generates higher demands compared to a condition in which subjects were named Player 1 and Player 2. When named "seller," Player 1 was more likely to take advantage of his/her superior strategic position. The importance of others' welfare was found to be significant in related marketing negotiation contexts (Corfman and Lehmann, 1993) and in determinants of consumer satisfaction (e.g., Oliver and Swan 1989). Based on our findings we suspect that the importance of others' welfare is not symmetric: buyers are expected to care more about the seller's welfare than vise versa. Future research should examine this hypothesis in more detail.

6.3. Conclusions

The managerial implications of our research and the usefulness of game theory in this context must be based on the laboratory study. Extrapolation to the "real world" is probably not appropriate at this juncture. However, to the extent that the Tunisian Bazaar mechanism approximates real-life bargaining, our results can provide some useful insights to managers and consumers alike.

(1) The relative advantage of sellers, found in our study, in situations in which the seller is the less informed party is very significant. Note that posting a fixed price is the optimal strategy for a monopolist seller of a single good when he faces a single potential buyer (Bester 1993). Our findings might explain why, nevertheless, a bargaining mechanism is frequently adopted in markets in which the sellers have the ability to choose the selling format. Although many consumers feel uneasy about the negotiation process and prefer set pricing, others not only expect to haggle with, say, a car salesman, but they actually like it (survey finding cited in *Brandweek*, March 22, 1993). Our results might suggest that when facing such consumers, salesmen who adopt a flexible price strategy contribute to consumers' satisfaction, and at the same time to their profitability.

(2) The more patient the sellers and buyers are, the higher prices are for $t > 2$, as predicted by SPE and verified in our study. Thus consumers who do not mind waiting make it easier for the seller to let prices drop more slowly. The critical test of this implication, however, will be when it is taken into the field and used to predict the outcomes of buyer-seller negotiation. We do not claim to have captured the true levels of intensity, interdependency, and trust of long-term, on-going buyer-seller relationships. Patient consumers are willing to wait longer before accepting a price. These two forces balance each other, delivering consistent profits to the seller over the different discount factors. Our results suggest that when the discount factor is equal and common knowledge, its actual value is irrelevant in determining the seller's profit. The same is not true for buyers. Under the same circumstances, buyers should prefer the low discounting environment.

(3) Our results should facilitate the prediction of prices in buyer-seller negotiation in the Tunisian Bazaar mechanism. If our results represent sellers' behavior in the real world, consumers' purchase-timing decisions should adapt to the empirical realities of the price schedule.

References

Arndt, J., "Toward a Concept of Domesticated Markets," *J. Marketing*, 43 (1979), 69–75.

Ausubel, L. M., and R. J. Deneckere, "A Direct Mechanism Characterization of Sequential Bargaining with One-sided Incomplete Information," *J. Economic Theory*, 48 (1989a), 18–46.

—— and ——, "Reputation in Bargaining and Durable Goods Monopoly," *Econometrica*, 57 (1989b), 511–531.

—— and ——, "Bargaining and the Right to Remain Silent," *Econometrica*, 60 (1992), 597–626.

Bester, H., "Bargaining Versus Price Competition in Markets with Quality Uncertainty," *American Economic Review*, 83 (1993), 278–288.

Bolton, G. E., "A Comparative Model of Bargaining: Theory and Evidence," *American Economic Review*, 81 (1991), 1096–1136.

Bray, M., "Learning, Estimation, and the Stability of Rational Expectations," *J. Economic Theory*, 26 (1982), 318–339.

Brown, G., "Interactive Solution of Games by Fictitious Play," in *Activity Analysis of Production and Allocation*, John Wiley and Sons, New York, 1951.

Chatterjee, K., G. Kersten, and M. Shakun, "Introduction to the Focussed Issue on Group Decision and Negotiation," *Management Sci.*, 37 (1991), 1219–1220.

Corfman, K. P., and S. Gupta, "Mathematical Models of Group Choice and Negotiation," in J. Eliashberg and G. L. Lilien (Eds.), *Handbooks in OR & MS*, Vol. 5, Elsevier Science, Amsterdam, 83–142, 1993.

——, and Lehmann, D. R., "The Importance of Others' Welfare in Evaluating Bargaining Outcomes," *J. Consumer Res.*, 20 (1993), 124–137.

Cournot, A., *Recherches sur les Principes Mathématiques de la Théorie des Richesses*, 1838, translated into English by N. Bacon as *Research in the Mathematical Principles of the Theory of Wealth*, Haffner, London, 1960.

Cramton, P., "Bargaining with Incomplete Information: An Infinite-horizon Model with Continuous Uncertainty," *Review of Economic Studies*, 51 (1984), 579–593.

Cross, J., *The Economics of Bargaining*, Basic Books, New York, 1969.

Eliashberg, J., S. A. LaTour, A. Rangaswamy, and L. W. Stern, "Assessing the Predictive Accuracy of Two Utility-based Theories in a Marketing Channel Negotiation Context," *J. Marketing Res.*, 23 (1986), 101–110.

Evans, K. R., and R. F. Beltramini, "A Theoretical Model of Consumer Negotiated Pricing: An Orientation Perspective," *J. Marketing*, 51 (1987), 58–73.

Freund, R. J., and R. C. Littell, "SAS System for Regression." SAS Institute Inc., Cary, NC, 1986.

Fudenberg, D., and J. Tirole, "Sequential Bargaining with Incomplete Information," *Review of Economic Studies*, 50 (1983) 221–247.

——, D. Levine, and J. Tirole, "Infinite-horizon Models of Bargaining with One-sided Incomplete Information," in A. E. Roth (Ed.), *Game-Theoretic Models of Bargaining*, Cambridge University Press, Cambridge, MA, 1985, 73–98.

Green, P. E., I. Gross, and P. J. Robinson, "Behavioral Experiment in Two-person Bargaining," *J. Marketing Res.*, 4 (1967), 374–379.

Gul, F., H. Sonnenschein, and R. Wilson, "Foundations of Dynamic Monopoly and the Coase Conjecture," *J. Economic Theory*, 39 (1986), 155–190.

Gupta, S., "Modeling Integrative, Multiple Issue Bargaining," *Marketing Sci.*, 35 (1989), 788–806.

——, and Z. A. Livne, "Resolving a Conflict Situation with a Reference Outcome: An Axiomatic Model," *Management Sci.*, 34 (1988), 1303–1314.

Güth, W., and K. Ritzberger, "On Durable Goods Monopolies and the (anti-) Coase-Conjecture," Discussion Paper No. 9215, Center, Tilburg University, The Netherlands, 1992.

——, P. Ockenfels, and K. Ritzberger, "On Durable Goods Monopolies: An Experimental Study of Intrapersonal Price Competition and Price Discrimination Over Time," Working Paper, 1993.

Harrison, G. W., "Theory and Misbehavior of First-price Auctions," *American Economic Review*, 79 (1989), 749–762.

——, "The Payoff Dominance Critique of Experimental Economics," Working Paper, University of South Carolina, 1990.

Hoffman, E., K. McCabe, K. Shachat, and V. Smith, in press, "Preferences, Property Rights and Anonymity in Bargaining Games," *Games and Economic Behavior*, 7 (1994), 346–380.

Kreps, D. M., *Game Theory and Economic Modeling*, Clarendon Press, Oxford, England, 1990.

McAlister, L., M. H. Bazerman, and P. Fader, "Power and Goal Setting in Channel Negotiation," *J. Marketing Res.*, 23 (1986), 228–236.

Neslin, S. A., and L. Greenhalgh, "Nash's Theory of Cooperative Games as a Predictor of the Outcomes of Buyer-Seller Negotiations: An Experiment in Media Purchasing," *J. Marketing Res.*, 20 (1983), 368–379.

——, and ——, "The Ability of Nash's Theory of Cooperative Games to Predict the Outcomes of Buyer-Seller Negotiations: A Dyad-level Test," *Management Sci.*, 32 (1986), 480–498.

Ochs, J., and A. E. Roth, "An Experimental Study of Sequential Bargaining," *American Economic Review*, 79 (1989), 355–384.

Oliver, R. L., and J. Swan, "Equity and Disconfirmation Perceptions as Influences on Merchant and Product Satisfaction," *J. Consumer Res.*, 16 (1989), 372–383.

Osborne, M. J., and A. Rubinstein, *Bargaining and Markets*, Academic Press, New York, 1990.

Radner, R., and A. Schotter, "The Sealed-bid Mechanism: An Experimental Study," *J. Economic Theory*, 48 (1989), 179–220.

Roth, A. E., "Risk Aversion and the Relationship Between Nash's Solution and Subgame Perfect Equilibrium of Sequential Bargaining," *J. Risk and Uncertainty*, 2 (1989), 353–365.

——, "Bargaining Experiments," in J. Kagel and A. E. Roth (Eds.), *Handbook of Experimental Economics*, Princeton University Press, Princeton, NJ, 253–348, 1955.

——, V. Prasnikar, M. Okuno-Fujiwara, and S. Zamir, "Bargaining and Market Behavior in Jerusalem, Ljubljana, Pittsburgh, and Tokyo: An Experimental Study," *American Economic Review*, 81 (1991), 1068–1095.

Rubinstein, A., "Comments on the Interpretation of Game Theory," *Econometrica*, 59 (1991), 909–924.

Smith, V. L., "Microeconomic Systems as an Experimental Science," *American Economic Review*, 72 (1982), 923–955.

Sobel, J., and I. Takahashi, "A Multistage Model of Bargaining," *Review of Economic Studies*, 50 (1983), 411–426.

Thompson, L., and G. Loewenstein, "Egocentric Interpretations of Fairness and Interpersonal Conflict," *Organizational Behavior and Human Decision Processes*, 51 (1992), 176–197.

Tietz, R., "Experimental Economics: Ways to Model Bounded Rational Bargaining Behavior," in R. Tietz, W. Albers, and R. Selten (Eds)., *Bounded Rational Behavior in Experimental Games and Markets*, Springer-Verlag, Bielefeld, West Germany, 3–10, 1986.

Van Damme, E., R. Selten, and E. Winter, "Alternating Bid Bargaining with a Smallest Money Unit," *Games and Economic Behavior*, 2 (1990), 188–201.

Weitz, B. A., "Introduction to Special Issue on Competition in Marketing," *J. Marketing Res.*, 22 (1985), 229–236.

White, H., "A Heteroscedasticity-consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity," *Econometrica*, 48 (1980), 817–838.

Wilson, R., "Game-theoretic Analyses of Trading Processes," in T. F. Bewley (Ed.), *Advances in Economic Theory*, Cambridge University Press, 33–70, 1987.

Zwick, R., A. Rapoport, and J. C. Howard, "Two-person Sequential Bargaining Behavior with Exogenous Breakdown," *Theory and Decision*, 32 (1992), 241–268.

Accepted by Jehoshua Eliashberg; received October 28, 1991. *This paper has been with the authors* 11 *months for* 3 *revisions.*