PREDATION, ASYMMETRIC INFORMATION, AND STRATEGIC BEHAVIOR IN THE CLASSROOM: AN EXPERIMENTAL APPROACH TO THE TEACHING OF INDUSTRIAL ORGANIZATION

C. Monica Capra, Jacob K. Goeree, Rosario Gomez, and Charles A. Holt*

Abstract

Classroom market experiments can complement the theoretical orientation of standard industrial organization courses. This paper describes various experiments designed for such courses, and presents details of a multi-market game with entry and exit. In this experiment incumbents have a cost advantage in their "home" markets, and mobile firms decide which market to enter. After entry decisions are made, firms choose prices and quantities to offer for sale. Predatory pricing is possible with this setup, and the experiment can be used to motivate discussions of monopoly, competition, entry, and efficiency. Other classroom experiments with an industrial organization focus are surveyed.

1. INTRODUCTION

In industrial organization classes, it is often difficult to bridge the gap between the tight predictions of abstract theoretical models of industry equilibrium and the broad patterns that emerge from econometric studies of industry and firm-level data. Moreover, discussions of policy issues are often clouded by disputes over purely empirical issues, e.g. whether an alleged predator priced below marginal cost or whether a pattern of uniform behavior across firms was the result of illegal conspiracy. Laboratory experiments, in contrast, can provide a source of data that is closely related to both theoretical and policy issues. They also provide a clear way to test the predictions of game theory which is at the core of most theoretical analysis in industrial organization today. Although these experiments are typically run with financially motivated subjects in a laboratory environment, many of them can be adapted for class use. As such, they can complement the standard teaching methods in this field.

---

* C. M. Capra is at the Williams School, Washington and Lee University, J. K. Goeree and C. A. Holt are at the University of Virginia, and R. Gomez is at the University of Malaga. This research was funded in part by the National Science Foundation (SBR-9617784 and SBR-9818683). We wish to thank Kenneth Elzinga and two anonymous referees for helpful comments.

Classroom experiments can be harder to carry out successfully than would appear at first; sometimes seemingly minor design errors cause major problems with the data, as with an error in a computer program. The experimental economics literature, and the classroom experiments literature in particular, can be useful in avoiding common errors. Therefore, we begin this paper with a detailed description of a price-choice experiment that has a particularly interesting multi-market structure. The setup can generate seemingly predatory behavior. In particular, the traders who have been assigned the role of an incumbent firm have strong incentives to price aggressively. Although the resulting prices do not always violate standard cost-based antitrust rules, the outcomes are often consistent with predatory intent: entrants shy away from aggressive incumbents, who price below entrants' average costs and then raise prices to monopoly levels when rivals are driven out. The exercise provides a useful way to illustrate the possibility of predatory pricing, and the results illustrate the trade-off between foregoing current profit for future gains, the possibility of reputation building, and the strategic importance of asymmetric information. The class discussions that follow can focus on the potential effects of predatory behavior on consumer welfare, in the short and long run. The *ex post* analysis can highlight the difficulties of identifying predatory intent and the appeal of simple, cost-based antitrust rules.

The paper is organized as follows. The next section describes the multi-market price-choice experiment, both in terms of procedures to follow and how to structure the class discussion. The third section describes how to set up other types of industrial organization experiments, e.g. quantity competition (Cournot), quality competition and asymmetric information, location games, etc. The final section concludes.

2. A MULTI-MARKET EXPERIMENT WITH ENTRY AND EXIT

Market experiments, like the theoretical models that motivate them, can roughly be categorized by whether terms of trade are proposed by one side of the market (e.g. sellers) or by both sides (buyers and sellers) and by whether such terms involve prices or quantities. The most common type of market experiment is a "double auction" in which sellers can call out or enter price offers, and buyers can enter bids. There is typically a bid-ask improvement rule, i.e. a new bid must exceed the highest outstanding bid and a new ask must be lower than the lowest outstanding ask. Thus asks decrease and bids increase in a double auction, until there is a

meeting of terms, after which new bids and asks can be entered. This type of two-sided trading institution captures some features of financial markets.

Price terms are posted by sellers in many types of retail markets, and this situation is implemented by a "posted price" experiment. In each period, sellers submit prices that are posted on a take-it-or-leave-it basis, and buyers are then given the opportunity to make purchases at these prices, usually in some random order. When firms have upward sloping marginal costs, it is natural to let firms specify a maximum quantity that they are willing to sell at the price posted. This posted-price institution is essentially a simultaneous price-choice (Bertrand) game in which firms also specify maximum quantities. Actual sales quantities may, of course, be lower than the quantities offered, depending on other sellers' prices and the nature of demand. Demand is often, but not always, simulated in posted-price experiments, reflecting the fact that many markets of interest to industrial organization economists have few sellers and many buyers.[1, 2] The standard posted-price institution can be made more interesting if firms are able to choose which of several markets to enter. Entry and exit in markets where one firm has a cost advantage raises the possibility of predatory pricing, which is the topic of the next section.

2.1. Background on Predatory Pricing

Predatory pricing is broadly defined as price cutting in the short run with the intent to drive out competitors in an effort to gain monopoly profits in the long run. Despite the discovery of predatory intent in several widely cited antitrust cases, many industrial organization economists have argued that predatory pricing is irrational and rarely observed. For example, one of our colleagues, Kenneth Elzinga, in an address to the American Bar Association posed the question of whether predatory pricing is rare like an old stamp or "rare like a unicorn." The argument is

---

[1] It seems unrealistic to simulate demand when buyers' strategies may interact with those of sellers, e.g. when buyers may at some cost search for a low price (Davis and Holt, 1996), when buyers may request secret discounts from specific sellers (Davis and Holt, 1998), or when buyers must try to infer sellers' quality decisions from past experience (Holt and Sherman, 1990).

[2] In contrast, a Cournot experiment can be set up by letting sellers choose production quantities simultaneously, with the price being determined by the aggregate of sellers' quantities. Many variations of these basic designs are possible, e.g. giving firms the option of choosing which market to enter, where to locate, what contracts to use, and what quality to produce.

that pricing below cost in order to drive competitors out of the market will be irrational for two reasons: 1) there are more profitable ways (e.g., acquisitions) to eliminate competitors (Saloner, 1987), and 2) future price increases will result in new entry (e.g. McGee, 1958).

A number of papers have addressed the issue whether predation can arise as equilibrium behavior by rational players. In Selten's (1978) well-known "chain-store paradox" a single monopolist faces possible entry in successive periods. In each period in which entry occurs the monopolist has to decide whether to "fight" the entrant (i.e. cut its price and forego some profit) or to "accommodate." By fighting in early periods, the monopolist can try to built a reputation in an attempt to deter later entry. However, as Selten has pointed out, such behavior is not credible. In the last period, the monopolist will surely not fight because there are no future entrants to scare away. Therefore, entry will occur in the final period, irrespective of the monopolist's behavior in the next-to-last period. But this means that in the next-to-last period there are no possible future gains from fighting, and the monopolist is better off accommodating. The next-to-last entrant realizes this and enters, regardless of the monopolist's choice in the period before. Repeating the same logic yields the inevitable conclusion that entry and accommodation will occur in each stage. Kreps and Wilson (1982) and Milgrom and Roberts (1982) have argued that Selten's result does not necessarily hold when the entrant has imperfect knowledge about the incumbent's cost function. In this case, it can be rational for the incumbent to respond aggressively in an effort to deter future entrants.[3] These reputation effects support the intuition behind Selten's chain-store paradox.

To date, there are only a few papers that discuss whether predatory pricing can be observed in a laboratory environment. Isaac and Smith (1985) conducted a series of posted offer market experiments which, based on the existing literature, seemed favorable to the emergence of price predation. A single market was served by a "large" seller that had a cost and capacity advantage over a "small" seller. In addition, the large seller was endowed with a "deep pocket"

[3] Jung, Kagel and Levin (1994) report an experiment in which one player (who can be thought of as a monopolist) faces a sequence of other players, who essentially play the roles of potential competitors. The entrants do not know whether the monopolist's cost is high or low, which is the type of information asymmetry needed to test the Kreps and Wilson predictions. Their results indicate a high level of predatory behavior, although some deviations from theoretical predictions were found. Although this is a fairly abstract game, it can be given a market interpretation.

to cover for possible initial losses. In Isaac and Smith's initial setup, sellers did not know each other's cost functions nor did they know market demand. In each period, sellers chose prices and maximum quantities offered at those prices. After the prices (but not the quantities) were made public, demand was simulated and sellers were privately informed about their earnings for that period. Isaac and Smith conducted three sessions with this design, followed by three sessions in which sellers were required to purchase entry permits before they could post prices in a market. No predatory pricing was observed in any of these treatments. Four additional sessions were run in which sellers had full information about each other's costs, but also this modification did not produce any predatory behavior.[4] One possibly confounding element in Isaac and Smith's design is that small sellers had an incentive to stay in the market no matter how fierce the competition, since exiting the market automatically resulted in zero earnings.

Harrison (1988) cleverly adapted Isaac and Smith's design by providing an "active escape opportunity" for the prey. In his setup, there were five markets, four of which were served by a large firm (or natural incumbent) which had a cost and capacity advantage over any other firm that entered that market. The fifth market had no incumbent and served as a refuge. In addition to the four incumbent sellers, there were seven small, or mobile, sellers who could move freely from market to market. The mobile firms could earn positive profits in the refuge market provided it did not become too crowded. At the start of each market period, firms chose a market to enter, a price, and a corresponding maximum quantity. After all decisions were made and collected, prices (but not the quantities) were written on a blackboard, enabling sellers to observe all prices so that reputations could develop. Harrison reports numerous cases of predatory pricing. However, he only provides data for a single session, using very experienced students from his own class. Goeree and Gomez (1998) have tried to replicate these results using Harrison's procedures for the five-market design, using subjects with similar experience.[5] They ran three sessions and their findings are quite different from those reported by Harrison. Of the

[4] This may explain their provocative title "In Search of Predatory Pricing."

[5] They also provided sellers with experience in monopoly and duopoly markets prior to running the five market design.

144 price decisions made by the large sellers, only three could possibly be classified as predatory.[6] To summarize, predatory pricing is rarely observed with this particular design and the evidence for predatory behavior is at best mixed (Gomez, Goeree, and Holt, 1999).

In the next section we describe the procedures for a multi-market classroom experiment with a design that is analogous to the one used by Harrison (1988). In particular, there are three markets, two with an incumbent seller and one "escape" market. Two possibly significant differences are that the incumbent sellers in our setup have complete information about demand and others' costs, whereas the smaller mobile sellers only know their own costs. This asymmetry can provide the incumbent with the ability to establish a credible reputation for aggressive pricing. Second, the smaller mobile sellers choose their markets first for the period, and these decisions are recorded on the blackboard before all sellers make their price and quantity choices. This information gives the large seller the ability to cut price when entry occurs and then to raise price to the monopoly level following exit. (Recall that the incumbent sellers in Harrison's design did not know whether entry had occurred when price decisions were made, so monopoly prices were especially risky.) Furthermore, the demand and cost functions are chosen such that the incumbent firms have a strong incentive to drive their rivals out of the market, i.e. monopoly profits are large compared to the equilibrium profits.

2.2. Design of the Experiment

There are two types of sellers: two "fixed" sellers that play the role of incumbent firms in market I and II respectively, and four "mobile" sellers that can enter any of the three markets. The instructions are the same for fixed and mobile sellers; only the specific information sheet that is attached to the instructions is different for the two types. The setup of the experiment is the same in all periods. First, mobile sellers choose the market they wish to enter for that period. After their entry choices have been recorded on the blackboard, sellers select a price and a corresponding quantity to be offered at that price. These prices are then written on the blackboard, and buyer behavior is simulated in each market. Once purchases have been made,

[6] The three cases were predatory in the sense that price was below marginal cost but not so low as to preclude positive profits for the entrant. This is what Harrison termed "type II" predation, which would not have been classified as predatory by Isaac and Smith (1985).

sellers are told the number of units they sold, after which they can determine their earnings for that period.

Table I Sellers' Costs and Buyers' Valuations

Units	Buyer Values	Fixed Seller's Marginal Costs	Mobile Seller's Marginal Costs
1	3.55	2.60	2.80
2	3.55	2.60	2.80
3	3.55	2.60	2.80
4	3.55	2.60	3.30
5	3.55	2.60	
6	3.55	2.60	
7	2.85	2.60	
8	2.85	3.00	
9	2.85	3.00	
10	2.85	3.00	
11	2.60		
12	2.60		

Before describing the procedural details of the experiment, let us explain the cost and demand structure in Table I. It is apparent from the third and fourth columns of this table that fixed sellers have at most ten units to trade and mobile sellers have only four. When sellers are competitive price takers, the fixed seller offers no units below $2.60, seven units at prices between $2.60 and $3.00, and ten units at prices above $3.00. A mobile seller offers no units below $2.80, three units at prices between $2.80 and $3.30, and 4 units at prices above $3.30. Figure 1 shows the resulting supply function for the case of one fixed and one mobile seller. Similarly, the demand function is determined by the buyers' values in Table I. Notice that, in the presence of one mobile firm, the efficient, competitive outcome involves a market price between $2.80 and $2.85, with seven units being offered by the fixed seller and three by the mobile seller. For prices in this range, the profits for the fixed seller lie between $1.40 and

$1.75, whereas the mobile firm makes at most 15 cents. The fixed seller profits are far less than the profit of $5.70 which the fixed seller could earn as a monopolist with a price of $3.55, i.e. $5.70 = 6($3.55 - $2.60).[7]

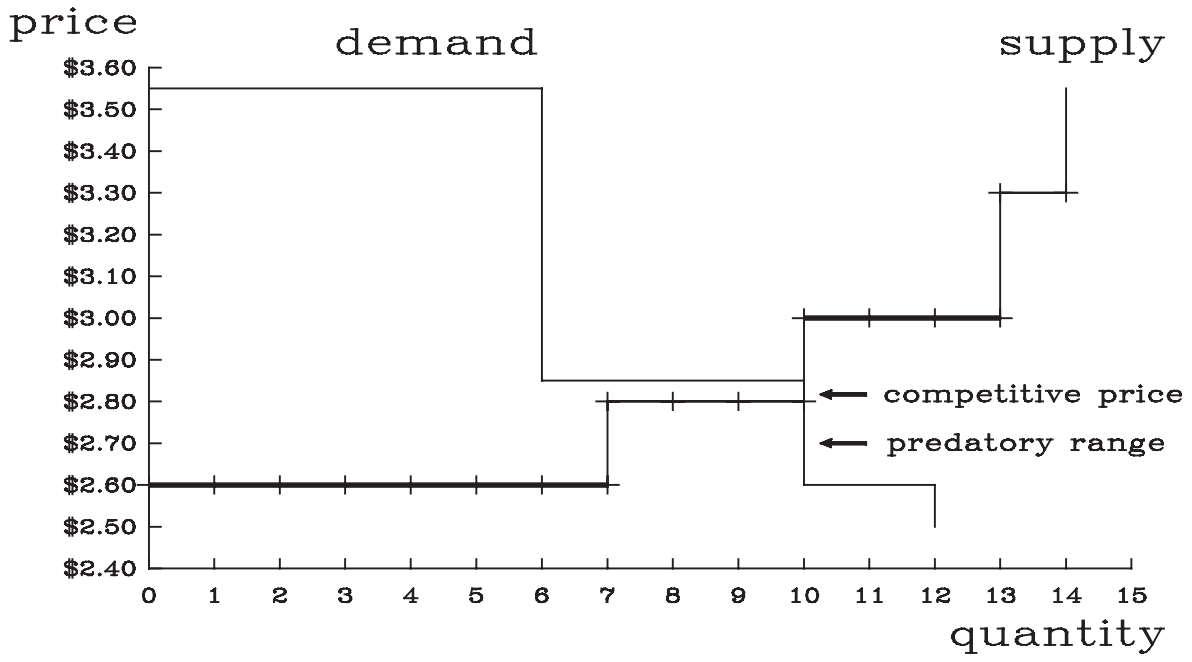

Figure 1 Demand and Supply
Key: Bold segment of supply represents fixed seller's units.
Thin segment of supply represents mobile seller's units.

Given the large difference between competitive and monopoly profits, it is clear that the fixed seller has a strong incentive to drive all rivals out of the market. Loosely speaking, a fixed seller's behavior is *predatory* when it is intended to block any profitable sales from the competition. In our setup this occurs when a fixed seller chooses a price below $2.80 and offers 10 units for sale. In legal cases, predatory pricing is often defined as pricing below one's own marginal cost. Notice that for our setup this legal definition is more stringent: when a fixed

[7] When there is more than one mobile seller in market I or II, the competitive price is $2.80, resulting in zero profits for the mobile sellers. In market III, mobile sellers can make a monopoly profit of $2.25 when there is no other mobile firm, and competitive profits are between $0.15 and $1.50 when there are two of them. With three or four mobile sellers the competitive price is $2.85 and $2.80 respectively, leading to profits of 15 and 0 cents.

seller offers 8, 9, or 10 units at a price between $2.80 and $3.00, behavior is predatory in the legal sense even though a mobile seller could still make a profit in this market.

To see how strong the incentives for the incumbent are to set predatory prices, consider the following three-period analysis. When the fixed firm behaves competitively for three periods in a row, it sells seven units in each period at a price of at most $2.85, leading to a profit of $1.75 per period. Now suppose the fixed seller sets a predatory price of $2.75 in the first two periods accompanied by an quantity offer of ten units. The fixed seller's profit will then be reduced to $0.30 for each of the first two periods, i.e. $0.30 = 7($2.75 - $2.60) + 3($2.75 - $3.00). However, if these low prices are successful in driving out rivals, the fixed firm receives a monopoly profit of $5.70 in the third period, which more than compensates the foregone profits of the first two periods. Thus the particular parameterization of the cost and demand functions used in this exercise makes it very worthwhile for the fixed sellers to price aggressively.

2.3. Procedures

The exercise requires a blackboard and copies of the instructions contained in the Appendix. Students will be sellers in one of three markets (labeled I, II, and III) for a sequence of ten trading periods. Prior to beginning the experiment, choose two fixed and four mobile sellers and number them 1 to 6. In a large class, one can group students together in a team and let them play the role of a single seller. For instance, with a class size of twenty-four, six groups of four students could be formed, with two groups playing the role of fixed sellers and the other four groups being mobile sellers. Since there are two kinds of sellers, each with their own private costs, try to seat sellers as far apart as possible. Before you form the groups of sellers, you may want to select one or two students to help collect decision sheets, write prices on the blackboard, determine sales quantities, etc.

Prepare for the exercise by setting up a record table on the blackboard. You can use three columns (one for each market) and several rows (one for each period). Begin by reading the instructions aloud, omitting the private information written on the specific information sheets. At the start of period one, the four mobile sellers choose the market they wish to enter for that period (recall that the two fixed sellers are always in markets I and II respectively). To decide which mobile seller gets to choose first, you can roll a die to select one of them, and then deal

with the other mobile sellers in ascending order. The sellers should write their choices on their decision sheets, and you should copy these on the blackboard. Make sure that you leave enough space for the prices.

Next, all sellers choose a price and a corresponding quantity to be offered at that price. Once they have recorded their decisions, collect the decision sheets and write the prices on the blackboard, using sellers' identification numbers to label them. Then demand is simulated: in each market there are twelve (fictitious) buyers who are ordered by their valuations, as shown in the second column of Table I. The high-value buyers purchase first. Each buyer purchases at most one unit, at the lowest available price, as long as that price is less than or equal to the buyer's valuation. In case a price tie occurs, you can throw a die to determine which seller goes first. Treat each buyer in order as you move down column 2 of Table I until there is no more demand or until all offered units have been sold. After all purchases have been made, you should write the number of units sold on each seller's decision sheet and return the sheets. Sellers can easily determine the earnings for the period by subtracting the costs of all the units sold from the total revenue (price times quantity sold). Each seller should use the specific information sheet attached to the instructions to determine costs. The process may be repeated a total number of 6-10 periods.

To summarize: 1) Prepare separate fixed and mobile seller instructions, with the appropriate specific information and decision sheets. 2) Decide on the number of students to serve on each seller team. Photocopy enough seller instructions and specific information sheets for participants and observers. 3) Prepare the record table on the blackboard. 4) Distribute seller instructions, specific information and decision sheets to sellers, keeping the two kinds of sellers separate. Read the common instructions aloud, omitting the texts on specific information, and answer questions. 5) Begin the first period by asking mobile sellers which market they would like to enter for the period and write the identification numbers on the blackboard. 6) Ask sellers to make decisions about prices and quantity offers for period 1, collect all decision sheets, and write prices on the blackboard. 7) Order the sheets by market and price and determine the units sold by each seller in each market. Then return the decision sheets to sellers. 8) Ask sellers to calculate their earnings for the period. The exercise takes about an hour, including discussion.

2.4. Discussion of Results

This exercise can be used to focus class discussion on competition, monopoly, anti-competitive behavior like predatory and limit pricing, and related antitrust issues. Students will be eager to explain what prices they chose, but only after finding out which fixed and mobile sellers earned the most. Try to organize the discussion by guiding them through the sequence of prices written on the blackboard.

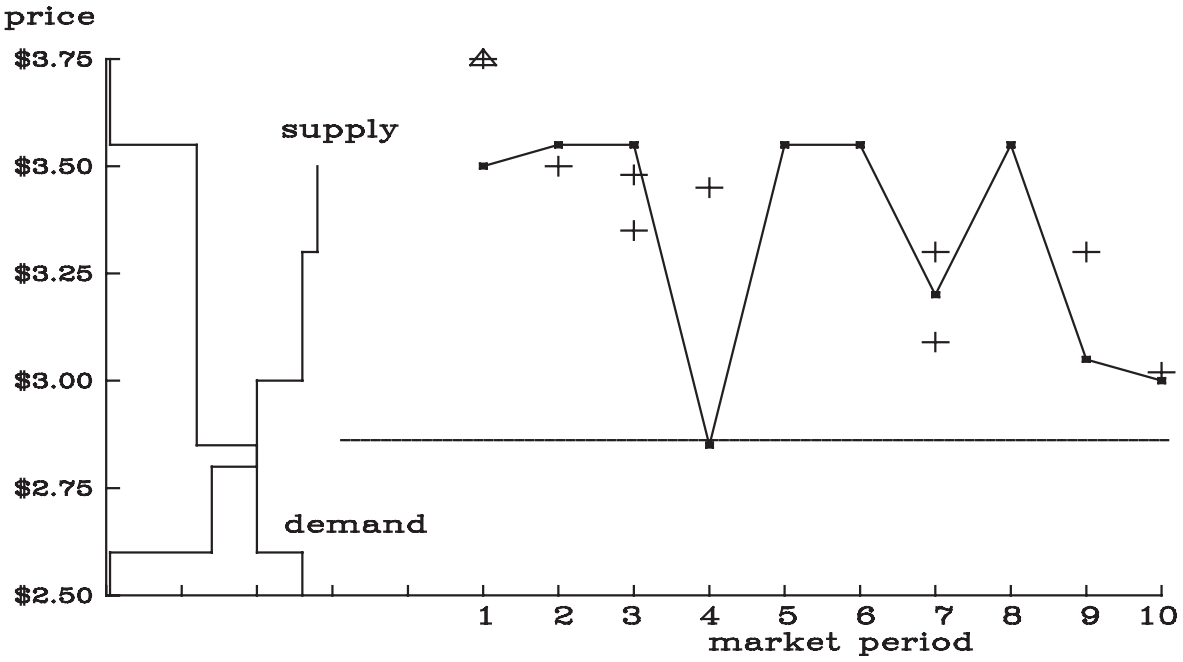

Figure 2. Prices for Fixed Seller (line) and Mobile Sellers (+) in Market II (Virginia)
Key: Supply Function is for One Fixed and One Mobile Seller

You can start by asking the fixed sellers about their initial price choices and subsequent price changes. For instance, the fixed seller in market II at Virginia initially chose prices close to the monopoly level of $3.55, as shown by the solid line in Figure 2. However, these high prices attracted other sellers whose prices are indicated by "+" marks, and as a result the fixed seller had no sales in period 3.[8] Then in period 4 the fixed seller lowered the price to $2.85 and

[8] The triangle over the plus sign in the first period indicates prices that were off the price scale in Figure 2.

offered *ten* units for sale.[9] Three of the units offered in period 4 by the large seller were at a price below the marginal cost of $3.00, and this action is therefore predatory in a legal sense, under a cost-based rule. Although a price of $2.85 does not necessarily imply zero profits for a mobile seller, the offered quantity of ten units seems to show predatory intent. In fact, when we asked this fixed seller about his price and quantity choice, he admitted that he thought no mobile seller would go below a price of $2.85, which would thus be sufficient to keep any mobile seller from making a profit. Not only did this guess turn out to be correct, this strategy also paid off in the next two rounds in which the fixed seller had a monopoly position. In our setup, sellers know all the prices but not the quantities offered or sold by the other sellers. In this sense, a low price cannot have a predatory effect (i.e. induce the exit of rivals) if it is not accompanied by a sufficiently large quantity. A low price will have the effect of deterring the entry of potential rivals, who see on the blackboard a very low price and can conjecture that the small seller did not make any sales for the period (as occurred in period 4). In this manner, the incumbent's low price can deter future entry.

Try to engage the students in a discussion about the effects of very low prices. Let them explain that low prices are in the interest of consumers, but that low prices may also have anti-competitive effects if the number of competitors in a market is diminished. The data for the experiment conducted in Malaga show this most clearly (see Table II). In market II for instance, the fixed seller (S2) chose aggressive prices between $2.60 and $2.79 if a rival was in the market, which occurred in 8 of the 10 periods. For these eight periods, consumers enjoyed a total surplus of $45.78, which exceeds the surplus consumers would have enjoyed in a competitive equilibrium for these eight periods (between $33.60 and $35.20). In this market, consumers did not have any surplus in periods 4 and 9, but the other periods more than compensated them for the losses in these two periods. In contrast, fixed seller (S1), after choosing aggressive prices for periods 1 and 2, obtained a monopoly position in five of the remaining periods. In these periods, there was no surplus for the consumers, and the surplus the

[9] There is no chance for "hit-and-run" behavior in our setup, since sellers know the number of competitors in the market before they select a price to offer. So an incumbent can give a quick response to entry by charging a low price for the period, and increase the price later when it is the only seller in the market.

Table II. A Classroom Experiment with Three Markets (Malaga)

Key: Offer quantities are shown in parentheses. Predatory price/quantity combinations are indicated in bold.

	Market I	Market II	Market III
period 1	S1: \$2.65 (7) S4: \$5.78 (3)	**S2: \$2.60 (10)** S5: \$3.30 (3)	S3: \$3.25 (3) S6: \$5.00 (3)
period 2	S1: \$2.85 (7) S5: \$3.10 (3)	**S2: \$2.60 (10)** S3: \$3.75 (4)	S4: \$3.35 (4) S6: \$3.85 (3)
period 3	S1: \$3.55 (6)	**S2: \$2.60 (10)** S3: \$2.90 (3)	S4: \$3.00 (4) S5: \$3.25 (4) S6: \$3.00 (4)
period 4	S1: \$2.75 (7) S3: \$3.50 (4)	S2; \$3.55 (6)	S4: \$3.00 (2) S5: \$2.90 (3) S6: \$2.90 (2)
period 5	S1: \$3.55 (5)	S2: \$2.70 (7) S4: \$2.85 (3)	S3: \$2.89 (3) S5: \$2.90 (3) S6: \$2.85 (3)
period 6	S1: \$3.55 (6)	S2: \$2.60 (7) S4: \$3.00 (3)	S3: \$3.00 (3) S5: \$2.83 (3) S6: \$2.95 (4)
period 7	S1: \$3.55 (6)	S2: \$2.75 (7) S4: \$2.85 (3)	S3: \$2.85 (4) S5: \$2.85 (3) S6: \$2.85 (3)
period 8	S1: 3.55 (6)	S2: \$2.75 (7) S4: \$2.83 (4)	S3: \$2.83 (3) S5: \$2.84 (3) S6: \$3.00 (4)
period 9	S1: \$2.70 (7) S3: \$2.85 (3) S4: \$3.00 (3)	S2: \$3.55 (6)	S5: \$2.85 (3) S6: \$2.86 (3)
period 10	S1: \$2.65 (7) S3: \$2.90 (3)	S2: \$2.79 (7) S4: 2.85 (3)	S5: \$2.84 (3) S6: \$2.95 (4)

consumers obtained in the low price periods did not nearly compensate them for these losses. Consumer surplus amounted to \$25.55 over all ten periods in this market, which is close to half the value it would have been in a competitive equilibrium (between \$42.00 and \$44.00).

Next turn to the actions of the mobile sellers, by asking those who moved frequently to explain their choices. It is quite likely that mobile sellers will be experimenting in the first few

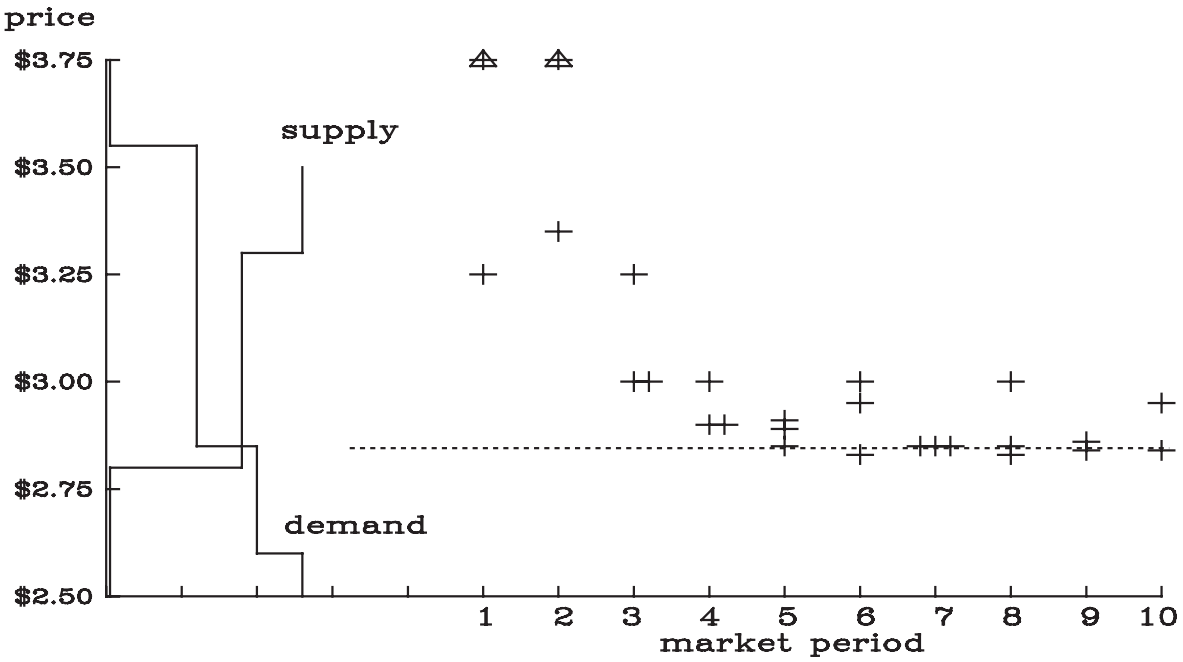

Figure 3 Price Data for Market III (Malaga)
Key: Supply Function is for Three Mobile Sellers
Dashed Line is the Competitive Price

periods, since they do not have any information about demand or fixed sellers' costs. One of the students in Virginia who played the role of a mobile seller remarked that he did not "trust" the markets with the fixed sellers, because their behavior was so unpredictable with prices jumping down from the monopoly level to close to $2.85. Of course, he did not realize that the fixed seller had full information about costs and demand. In later periods the mobile sellers are generally driven towards the "escape" market, and prefer to share market III with two other sellers rather than to be in a market with one fixed seller. This behavior is illustrated in Figure 3 which gives the price data for market III from the Malaga class. Notice that prices start high, but that market pressures are strong enough to drive prices down to the competitive level of $2.85. You can also discuss the effects of seller uncertainty about the number of market periods, which may explain why very low prices were sometimes observed even in the last periods (e.g. periods 9 and 10 in Table II). If such low prices are observed in the final periods, you can ask

the sellers if prior knowledge of the number of periods would have motivated them to choose a higher price. This discussion can be tied to the backward induction arguments used in Selten's "chain store paradox."

Once students realize why the fixed sellers chose low prices, and are aware of the anticompetitive effects of predatory behavior, you could bring up policy issues. For instance, most U.S. courts have embraced the Areeda-Turner test, i.e. that a price below the short-run marginal cost should be considered predatory and unlawful.[10] You can point out some of the common objections to such cost-based rules. For instance, since the short run marginal cost is difficult to observe, it is typically approximated by the average variable cost, but this approximation can be quite crude unless the incumbent has constant marginal costs. In the context of our setup, assume that an incumbent offers 10 units at $2.79. This action would be clearly predatory since no rival could make a profitable sale, but this price would not be predatory in the Areeda-Turner sense because average variable cost on 10 units is $2.72, which is below the posted price of $2.79. Finally, you can point out that, in practice, it is almost impossible to prove predatory intent, since any alleged predator will claim that the low prices correctly reflect a more efficient way of production.

After students have discussed their strategies and explained the price patterns generated in the classroom experiment, you can reveal the costs of the fixed sellers and the demand to the mobile sellers. You can ask students to identify the profit maximizing price level for the monopolist (MR = MC) and compare it to the competitive price level. This can lead to a discussion of efficiency and consumer surplus. Ask students to identify the efficient configuration of production and sales in each market, and let them point out that efficiency requires entry by a small firm. Then ask them to identify the range of predatory prices range and the corresponding offer quantity needed to block any profitable trade by mobile sellers. Finally,

[10] For a discussion of U.S. antitrust policies on predatory pricing, see Areeda (1982), Areeda and Turner (1978), and Sullivan (1977). Analogous policies in the European Community are discussed in Fox (1984, 1986), Hawk (1986), and Utton (1994).

let them compare these theoretical results to the data from the experiment.[11]

3. OTHER TYPES OF EXPERIMENTS

In this section we present a brief survey of other possible classroom experiments with an industrial organization focus.[12] In each case we give an outline of the instructions and procedures, and indicate how the discussion after the experiment can be structured.

The Cournot quantity-choice paradigm is probably the most commonly used model in industrial organization courses. Laboratory experiments with quantity choices have a long history (e.g. Fouraker and Siegel, 1963). The setup can be quite simple; you simply give subjects information about costs and demand and ask them to write their quantity choices on sheets of paper. The market price is then determined by the sum of all sellers' quantities. It is probably best to avoid duopoly markets, which can yield variable results due to tacit collusion (Holt, 1985). Even with larger numbers of sellers, the price patterns in Cournot markets can be highly variable from period to period, due to cobweb-like adjustment patterns.[13]

Classroom experiments can also be used to illustrate market failures that may result from asymmetric information about product quality.[14] Holt and Sherman (1999) describe an

---

[11] One question that may come up is whether the competitive equilibrium is a Nash equilibrium for a market with one fixed seller and one mobile seller (under full information). The large firm sells 7 units and earns \$1.75 = 7(\$2.85 - \$2.60) at the competitive price. If the small seller is offering 3 units at that price, the large seller can unilaterally deviate to a price of \$3.55 and still sell 3 units, since only 3 of the 6 high-value units will be taken by the small seller. This deviation will increase the large seller's earnings to \$2.85 = 3(\$3.55 - \$2.6). Thus the competitive equilibrium is not a Nash equilibrium when there is only one mobile seller, and in this sense, the large seller possesses market power when there is only one other competitor. The monopoly price of \$3.55 is not a Nash equilibrium either, nor is any other common price, since each seller has an incentive to "undercut" the other's price. The Nash equilibrium in such cases will involve randomization (the step-function nature of the supply and demand structure used in experiments can complicate the calculation of the mixed-equilibrium price distributions). There have been research experiments to investigate treatments that create market power in price-choice experiments, e.g. moving units of capacity from small to large sellers in a manner that creates market power, i.e. that provides the large seller(s) with a unilateral incentive to raise price above the competitive level. Davis and Holt (1994) report one such experiment, where the creation of market power raised prices significantly above competitive levels (although the stage-game mixed-strategy equilibrium does not provide a very good description of the price distributions).

[12] There is some web-based software that can be used to run two-person matrix games with various options, e.g. fixed or random matchings, deterministic or random stopping rules, etc. (Grobelnik, Holt, and Prasnikar, 1999).

[13] Results from Cournot experiments are surveyed in Plott (1989) and Holt (1995).

[14] This literature is surveyed in Davis and Holt (1993, chapter 7), and in Plott (1989).

experiment in which sellers choose price and "grade." Buyers' earnings depend on the grade of the product and on the price that they pay. High grades are more costly for sellers to produce, and the increasing marginal cost of raising quality results in an interior optimal grade. In the first several periods, both price and grade are posted for buyers to see, and grades in these "full-information" periods converge rapidly to the optimal level. Then an asymmetry is introduced by only posting sellers' prices, not their grades. Sellers reduce their grades quickly, but prices are often not reduced before some buyers are fooled into paying high prices for "lemons." As a result, quality grades fall to the minimum levels. Even though prices fall and some trade takes place, the low grades result in low levels of efficiency.[15]

Other relevant topics in industrial organization such as spatial competition can also be implemented in a classroom environment. For example, one can illustrate minimum product differentiation in a Hotelling-type model as follows: two students or "firms" choose locations on a road of unit length, with consumers uniformly located along the road, and sell an identical good at a fixed price. In each period, consumers buy one unit of the good at the fixed price. In addition, the consumers pay a travel cost that increases linearly with the distance. In this model, consumers will choose the seller closest to them. The Nash equilibrium for the single-period game is for each firm to locate at the midpoint of the road, which results in minimum product differentiation (in terms of locations). Brown-Kruse, Cronshaw, and Schenk (1993) conducted a series of duopoly experiments with this structure, and find a strong tendency for subjects to locate at the center.

There are many other types of market experiments that can be used in industrial organization classes. Bergstrom and Miller (1997), for example, contains some interesting auction experiments and some exercises involving collusion. Collusion is generally more successful if sellers can select prices on a take-it-or-leave-it basis, as with the posted-price institution discussed in section 2. Collusion often breaks down when sellers can offer secret discounts from posted "list" prices, perhaps at the request of buyers. Sellers may even end up

[15] It has been argued that this lemons outcome may be avoided if there are restrictions on price advertising. The intuition is that there is less incentive to cut quality in order to match another's price cut if that price cut is not as visible to buyers. There is no experimental evidence to support this point of view. See Holt and Sherman (1990) for the results of a series of experiments motivated by Federal Trade Commission actions against trade association restrictions on price advertising.

fixing a uniform price that is not much above the competitive level. And discounts may occur even when the price that is fixed is essentially competitive (Davis and Holt, 1998).[16] Collusion is interesting to implement in classroom experiments since discussion will raise the key issues that face any cartel: agreeing on price, agreeing on quantity allocations, detecting cheating, etc.

4. CONCLUSION

Many theoretical and policy issues that arise in industrial organization classes are difficult to evaluate with data from actual markets. Despite the general agreement on using non-cooperative game theory, the predications of this theory depend on the structure of the model, and it is often difficult to say whether one model is better than another in terms of explaining data patterns from a particular industry. Moreover, many policy debates about issues like predation and the effects of collusion are difficult to evaluate without precise information about cost and demand conditions. Similarly, the effects of prohibiting a particular type of sales contract or requiring a particular kind of price announcement may be unclear if the alternative to current practice has not been observed. In each of these cases, laboratory experiments can be useful, since precise information about costs and demand is available, and alternative structures can be evaluated in a parallel manner. Laboratory methods are increasingly being used by industrial organization for these reasons.

Teaching in industrial organization can be enhanced by the use of classroom exercises that have evolved from research experiments. It is often a little more difficult to set up and run a market experiment than is the case for a simple game, since most markets are typically more interactive than simple games. Asymmetries in costs or buyer/seller roles may add other complexities. By using standard instructions, however, it is possible to set up useful market situations. Moreover, the students are often much more interested in participating and discussing market experiments that have the look and feel of real markets. This willingness to participate in a well-designed classroom market makes it unnecessary to pay students for their participation, as might be the case in a repetitive and simple game like a prisoner's dilemma. Our impression

[16] In these experiments sellers were allowed to meet and discuss price before returning to their desks to choose prices independently.

is that such participation enhances learning at a different level, i.e. at a level of doing more than memorizing the results, but rather of believing in the relevance of what is being learned. These experiments can provide students with a strong conviction about the benefits of competition, the dangers of monopolization, and an appreciation of the subtle effects of interactive strategic behavior.

References

Areeda, P. E. (1982) *Antitrust Law: An Analysis of Antitrust Principles and their Application (Supplement)*, Boston: Little, Brown and Company.

Areeda, P. and D. F. Turner (1975) "Predatory Pricing and Related Practices under Section 2 of the Sherman Act," *Harvard Law Review, 88*, 697-733.

Areeda, P.E. and Turner, D.F. (1978) *Antitrust Law*, Boston: Little, Broun and Company.

Bergstrom, Theodore C. and John H. Miller (1997) *Experiments with Economic Principles*, New York: McGraw Hill.

Brown-Kruse, Jamie L., Mark B. Croshaw, and David J. Schenk (1993) "Theory and Experiments in Spatial Competition," *Economic Inquiry, 31*, 139-57.

Davis, Douglas D. and Charles A. Holt (1993) *Experimental Economics*, Princeton: Princeton University Press.

Davis, Douglas D. and Charles A. Holt (1994) "Market Power and Mergers in Laboratory Experiments with Posted Prices," *RAND Journal of Economics, 25*, 467-487.

Davis, Douglas D. and Charles A. Holt (1996) "An Experimental Examination of the Diamond Paradox," *Economic Inquiry*, *34*, 133-151.

Davis, Douglas D. and Charles A. Holt (1998) "Conspiracies and Secret Price Discounts," *Economic Journal*, *108*, May 1998, 1-21.

Fouraker, Lawrence E. and Sidney Siegel (1963) *Bargaining Behavior*, New York: McGraw Hill.

Fox, E. (1984) "Abuse of a Dominant Position Under the Treaty of Rome: A Comparison with U.S. Law," in B. Hawk, ed., *The Annual Proceedings of the 1983 Fordam Corporate Law Institute*, New York: Matthew Bender, pp. 367-421.

Fox, E. (1986) "Monopolization and Dominance in the United States and the European Community: Efficiency, Opportunity, and Fairness," *Notre Dame Law Review, 61*, 981-1020.

Goeree, Jacob K. and Rosario Gomez (1998) "Predatory Pricing in the Laboratory," University of Virginia, draft.

Gomez, Rosario, Jacob K. Goeree, and Charles A. Holt (1999) "Predatory Pricing: Rare Like a Unicorn?" prepared for the *Handbook of Experimental Economics Results*, C. Plott and V. Smith, eds., New York: Elsevier Press.

Grobelnik, Marco, Charles A. Holt, and Vesna Prasnikar (1999) "Classroom Games: Strategic Interaction on the Internet," forthcoming in the *Journal of Economic Perspectives.*

Harrison, Glenn W. (1988) "Predatory Pricing in a Multiple Market Experiment. A Note," *Journal of Economic Behavior and Organization, 9*, 405-417.

Hawk, B. (1986) *United States, Common Market, and International Antitrust*, 2nd ed., New York: Law and Business, Inc.

Holt, Charles A. (1985) "An Experimental Test of the Consistent-Conjectures Hypothesis," *American Economic Review*, *75*(3), 314-325.

Holt, Charles A. (1995) "Industrial Organization: A Survey of Laboratory Research," in J. Kagel and A. Roth, eds., *Handbook of Experimental Economics*, Princeton: Princeton University Press, 349-443.

Holt, Charles A. and Roger Sherman (1990) "Advertising and Product Quality in Posted-Offer Experiments," *Economic Inquiry* 28(3), 39-56.

Holt, Charles A. and Roger Sherman (1999) "Classroom Games: A Market for Lemons," *Journal of Economic Perspectives*, Winter 1999, 205-214.

Isaac, R. M. and V. L. Smith (1985) "In Search of Predatory Pricing," *Journal of Political Economy*, *93*, 320-345.

Jung, Y. J., J. H. Kagel, and D. Levin (1994) "On the Existence of Predatory Pricing: An Experimental Study of Reputation and Entry Deterrence in the Chain-Store Game," *RAND Journal of Economics*, *25*, 72-93.

Kreps, D.M. and R. Wilson (1982) "Reputation and Imperfect Information," *Journal of Economic Theory*, *27*, 253-279.

McGee, J.S. (1958) "Predatory Price Cutting: The Standard Oil (N.J.) Case," *Journal of Law and Economics*, *1*, 137-169.

Milgrom, P. and D. J. Roberts (1982) "Predation, Reputation, and Entry Deterrence," *Journal of Economic Theory*, *27*, 280-312.

Plott, Charles R. (1989) "An Updated Review of Industrial Organization: Applications of Laboratory Methods," in R. Schmalensee and R. Willig, eds., *Handbook of Industrial Organization*, Vol. 2, Amsterdam: North-Holland.

Saloner, G. (1987), "Predation, Mergers, and Incomplete Information", *RAND Journal of Economics*, *18*, 165-186.

Selten, R. (1978), "The Chain-Store Paradox," *Theory and Decisions*, *9*, 127-159.

Sullivan, L.A. (1977) *Handbook of the Law of Antitrust*, St. Paul, Minnesota: West Publishing.

Utton, M.A. (1995) *Market Dominance and Antitrust Policy*, Hants: Edward Elgar.

Appendix: Instructions

Earnings

In this experiment there are three independent markets, markets I, II, and III, in which the same good is exchanged. Each of you is a seller in one of the three markets for a series of periods. The sellers with identification numbers 1 and 2 will be in markets I and II respectively, in all periods. The rest of you will choose to join a market in sequence, at the beginning of each period. We will use seller identification numbers to indicate which sellers are in which markets. This information will be written on the blackboard. Each of you has a number of units to sell. If you sell a unit, you will incur a cost for that unit, as explained below. Once you have seen the number of sellers in each market, you will be asked to set an offer price and choose a corresponding quantity to be made available at that price. All units that you sell will be sold at the same price. The only restriction you face is that the quantity offered must be positive and an integer (i.e., you cannot sell zero units or half a unit). You must write the price and quantity you selected on your seller decision sheet, in the appropriate column for the current period. After all sellers have chosen prices and quantities, the decision sheets will be collected and the prices for all markets will be written on the blackboard. Sellers' identification numbers are used to label their prices. Then, we will simulate the buyers in the following manner: in each market there are 12 fictitious buyers. Each of the 12 buyers is willing to purchase at most one unit of the good and will purchase it only if the price offered is less than or equal to the "value" the buyer has for the unit. The buyers are ordered by their values so that the buyer with the highest value purchases first. Then, the buyer with the second highest value purchases, and so on. The buyers purchase their units from the seller that offers the lowest price. If two or more sellers in a market choose the same low price and there are not enough consumers willing to buy all the units offered at that price, we will randomly select one of the sellers to be the first to sell. Your earnings are determined in the following manner:

earnings = price offered * quantity sold - cost of units sold

Note: the buyers could buy less units than the number of units offered when the price is too high or when there are not enough buyers in the market. If this happens, you will only incur the cost of the units that you actually sell, not the costs of the units that you offered.

Example: suppose you have four "units" to sell and that your production costs are

Cost of producing first unit:	$3.30
Cost of producing second unit:	$3.10
Cost of producing third unit:	$2.90
Cost of producing fourth unit:	$2.70

If you select a price of $5.75 and you sell 4 "units", then your earnings are:

$5.75 * 4 - $3.30 - $3.10 - $2.90 - $2.70 = $11.00.

If you select a price of $2.85 and offer to sell 4 units but only sell 3 units, then your earnings are:

$2.85 * 3 - $3.30 - $3.10 - $2.90 = -$0.75, i.e. a loss of 75 cents.

The trading period ends when the last buyer has had the chance to buy or as soon as all of the units offered have been sold. When the period has ended we will write on your seller decision sheet the units you sold, and we will return the decision sheets to you so that you can calculate your earnings for the period.

Record of Results

Please examine the specific information sheet that is attached to the instructions. Your identification number is written on the top-right part of the page. This sheet contains specific information about your production costs and your market; this information is private, please do not reveal this information to anyone. Others may or may not have the same production costs as you have.

Next, please have a look at the decision sheet. Going from left to right, you will see columns for the "Period", "Market", "Your Price", "Your Quantity", "Quantity Sold" and "Your Earnings." At the start of period 1 you select and record the market you would like to enter in period 1 (recall that sellers 1 and 2 have been selected to be in markets I and II for all periods). We do this by choosing one seller at random, with the throw of a 10-sided die, and let that seller choose a market first. Then we let the seller with the next higher ID number choose, etc. We will write your market decisions on the blackboard. After all sellers have selected their markets, each of you must select a price and maximum quantity decision and write these decisions in the appropriate columns of your decision sheet. After you have made and recorded your decisions, we will collect the decision sheets and write the prices for all sellers on the blackboard. Next we will use the simulated demand to determine the quantity actually sold by each seller in each market. When all purchases are finished, we will write the quantity you sold on your decision sheet and return it to you so that you can calculate your earnings for the period, as described above. This process will be repeated a number of periods. At the end of the experiment we will randomly select one of you by throwing a 10 sided die to pay you in cash a percentage (___%) of your total earnings.

Please read the specific information sheet that is attached to the instructions. Do you have any questions about the instructions or procedures? If you have a question, please raise your hand and I will come to your seat to answer it. Please be careful not to reveal any information that appears on your specific information sheet.

ID_____

Specific Information. (Fixed sellers)

You have been selected to be a seller in **Market ____**. You will be in this market for all periods as a fixed seller. You will have an amount of $4.00 at the beginning of the session as written on your decision sheet. This is your initial capital.

These are **your production costs**. You can offer to sell at most ten units in each trading period. The production costs for each of these units are:

Unit	**Cost**
1	$2.60
2	$2.60
3	$2.60
4	$2.60
5	$2.60
6	$2.60
7	$2.60
8	$3.00
9	$3.00
10	$3.00

Note that you must sell the first unit (and incur its production cost) before you sell the second unit and so on. You may offer to sell no more than ten units, and if you offer to sell fewer, your sales will not exceed the quantity you offer. Remember that you do not incur costs on units that are not sold, whether or not you offered to sell these units. That is, if you offer to sell X units and you only sell Y, then you only pay the costs for your first Y units.

Any other seller who could join this market is a "mobile" seller. Below are the **production costs for a mobile seller**. Each mobile seller can sell at most four units.

Unit	**Cost**
1	$2.80
2	$2.80
3	$2.80
4	$3.30

In addition, the values of the buyers in this market are as follows: there are six buyers who are willing to pay at most $3.55 for one unit each. There are four other buyers who are willing to pay to $2.85 for a unit. Finally, the two buyers with values of $2.60 will purchase one unit each at the best available price.

ID_____

Specific Information. (Mobile Sellers)

At the beginning of each period you will select the market you want to enter. You can select any of the three markets. You are **a "mobile" seller**.

These are **your production costs**. You can sell at most four units each trading period.

Unit	**Cost**
1	$2.80
2	$2.80
3	$2.80
4	$3.30

Note that you must sell the first unit (and incur its production cost) before you sell the second unit and so on. You may offer to sell no more than four units, and if you offer to sell fewer, your sales will not exceed the quantity you offer. Remember that you do not incur costs on units that are not sold, whether or not you offered to sell these units. That is, if you offer to sell X units and you only sell Y, then you only pay the costs for your first Y units.

SELLER DECISION SHEET

Period	Market	Your Price	Your Quantity	Quantity Sold	Your Earnings
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					