A FREE ENTRY AND EXIT EXPERIMENT*

Rod Garratt
Department of Economics
University of California
Santa Barbara, CA 93106

November 9, 1998

* I thank Ken Ardon, Ted Bergstrom, Ken Danger, David Mullin, Mark Walker, and two anonymous referees for helpful comments.

This paper describes an experiment that demonstrates the dynamic process that leads to long-run equilibrium in a multi-market setting. In the experiment, each student is a farmer who has to decide each period whether to supply one unit of corn, wheat, rice, or soybeans. It costs different amounts to produce each of the crops, and the prices of the crops depend on the amount supplied and consumer demand. There are no consumers in the experiment. Demand is determined from pre-specified inverse demand curves that are unknown to the participants.[1] Students are instructed to act as profit maximizers. The goal is to see how free entry and exit leads to equal profits across markets in the long run, and how opportunity costs determine what those profits are. In addition, some subtle aspects of the process that leads to long-run equilibrium are revealed.

There are two stages to the experiment. In the first stage, students decide each round which one of the four markets to enter. The opportunity cost of farming is zero, and long-run equilibrium has zero accounting profits in each market. In the second stage, the government introduces a fallow program whereby it guarantees any farmer a profit of one dollar if she does not plant a crop. The fallow program increases the opportunity cost of farming to one dollar and makes that the equilibrium level of accounting profits.

Market experiments such as the double oral auction experiment introduced by Smith (1962) are now commonly run in economics classes.[2] Such experiments focus on how competitive markets clear and on the efficiency of competitive equilibrium. The proposed experiment is a natural follow-up to the double oral auction. It should be

[1] The use of inverse demand curves to determine payoffs in experiments goes back to Fouraker and Siegel (1960, 1961) who used them to calculate bargaining payoffs. Inverse demand curves are used in the manner described here in the decentralized market experiments of Meyer et al. (1992).

[2] See Wells (1991) and DeYoung (1993) for discussions on running double oral auction experiments in the classroom.

conducted after economic profits have been defined and the short and long-run profitability of firms in competitive markets has been discussed.

I have run the experiment with class sizes between eighteen and forty-three, but it can be run with groups that are larger. It takes forty to forty-five minutes to complete the experiment. The Appendix provides individual profit charts, homework exercises, and a template the students can use to record the class data at the end of the experiment.

GETTING SET UP

The four corners of the classroom are the four markets. Before the students arrive, identify each market with a large, highly-visible sign. The sign should give the name of the market (e.g., CORN) and the unit production cost of the market. The unit production costs for the four markets are given in the table below.

Unit Production Costs

Corn	Wheat	Rice	Soybeans
8	9	10	11

Establish four market charts to keep track of the number of farmers, the price, and the profit in each market, in each round. These charts should be situated where they will be visible to everyone throughout the experiment. At the end of the experiment, students will need to copy the information on these charts so that they will have a record of the experiment for doing the homework exercises.

Once all the students have arrived, but before the experiment begins, it is necessary to count them in order to define the inverse demand functions. Each inverse demand function is assumed to be linear with slope equal to negative one. The intercepts are chosen so that each one is greater than or equal to the unit production cost in each market, and the sum of the differences between the intercepts and their respective unit production costs equals the number of participants.[3] This ensures that in long-run equilibrium there are zero (accounting) profits in each market.

The following table is useful for calculating intercepts that work for class sizes between twenty-five and forty-four.[4]

Market Demands

Farmers	Corn	Wheat	Rice	Soybeans
$25 \le N \le 29$	$P_C = 15 - Q_C$	$P_W = 18 - Q_W$	$P_R = 15 - Q_R$	$P_S = (N-10) - Q_R$
$30 \le N \le 34$	$P_C = 16 - Q_C$	$P_W = 20 - Q_W$	$P_R = 16 - Q_R$	$P_S = (N-14) - Q_S$
$35 \le N \le 39$	$P_C = 17 - Q_C$	$P_W = 22 - Q_W$	$P_R = 17 - Q_R$	$P_S = (N-18) - Q_S$
$40 \le N \le 44$	$P_C = 18 - Q_C$	$P_W = 24 - Q_W$	$P_R = 18 - Q_R$	$P_S = (N-22) - Q_S$.

The inverse demand functions should not be revealed to the participants. Once they are determined, no new students can join the experiment.

GETTING STARTED: STAGE 1

To start the experiment, give everyone a copy of the Farmer Profit Chart shown in Appendix A, and then provide the following instructions:

> In this experiment you are a farmer, and each year you must decide what to plant. You have four choices of crops: corn, wheat, rice, or soybeans. Each crop has a different unit production cost. These are eight dollars for Corn, nine dollars for wheat, ten dollars for rice and eleven dollars for soybeans. You make your choice by physically going to the market of the crop you wish to plant. The amount of the crop you supply is always one unit. Once everyone has selected a market, I will announce prices and profits for each market, and record these numbers on the market charts. Your profit in each round is equal to the price minus the unit production cost in the market you selected. At the end of each round,

[3] Formally, let the intercepts and unit production costs be denoted by a_k and c_k, respectively, k = C,W,R,S, and the number of participants be N. Then the intercepts must satisfy $a_k > c_k$, k = C,W,R,S, and $\sum^4_{k=1}(a_k - c_k) = N$.

[4] These inverse demand curves are suggestions that have worked well in the past. They are specified so that there will be a non-uniform distribution of farmers across the markets in equilibrium. Students might suspect that there should be an equal number of students in each market in equilibrium. This helps prevent equilibrium from being reached too quickly.

> record your individual outcome on your Farmer Profit Chart. The process will be repeated up to eight times.

After giving the instructions, proceed by asking the students to select a market. In the first period there may be some confusion as students have no grounds on which to base their initial crop selection. If need be, instruct students to pick a market at random. Once students have divided into the different markets, record the number of farmers supplying crops in each of the markets on the market charts. Then, post prices and profits for each market, using the inverse demand functions you specified at the beginning of the session.

After students have recorded their individual profits from Round 1, repeat the process by asking students to select a crop to produce in Round 2. It is important to give students enough time to count the farmers in the different markets and analyze the market charts so that they can make informed market selections. Continue until all markets yield equal (zero) profits.

STAGE 2

To start stage two, place a sign that reads "Government Fallow Program." in the center of the room, and read the following instructions:

> The government has initiated a fallow program whereby you receive a guaranteed profit of one dollar if you plant nothing. You select this option in any round by going to the center of the room. Put GFP in the market column in any round where you choose not to plant.

The experiment proceeds as before the introduction of the fallow program. Ask students to select a market, or enter the fallow program. Continue for up to four more rounds, or until profits are equalized once again.

RESULTS AND EVALUATION

In stage one, the students typically converge to long-run equilibrium with zero profits in each market in five or six rounds. It can take longer if there are more than forty students. In the second stage, profits gravitate to one or two dollars in each market within two or three rounds. Note that because farmers supply either zero or one unit of each crop, it is unreasonable to expect equal profits across markets in stage two. Many students are able to identify the one-to-one negative relationship between the number of farmers in a market and price. A student in the fallow program who is earning one dollar by not producing anything has no incentive to enter a market where the price is two dollars above cost since she will drive the price down one dollar.[5] This outcome is not as aesthetically pleasing as the stage-one outcome, and should be explained to the students if it occurs.

When initiating the discussion on the theory of the firm we (or alternatively, textbooks) usually state profit maximization as the objective of the firm, and at least implicitly assume that the managers of the firm are sophisticated enough to carry out this objective. The experiment illustrates that the equal-profit property of long-run equilibrium does not depend on these assumptions. First, "profit-seeking" behavior is enough to steer the markets into long-run equilibrium. Such behavior need not involve optimizing, and can simply be adaptive. Second, profit seeking is only required by a few 'marginal' firms. It is often the case that some students will sit in the same market for the

[5] Viewed as a game, where the strategies of the agents are their choices of markets, the problem is that there are multiple Nash equilibria.

entire experiment. Such a student may be disinterested or confused. The point is that such behavior does not effect the outcome of the experiment so long as it is not pervasive. Students observe that it only takes a few profit seekers to equalize profits across markets. This is an interesting point that the experiment allows students to discover on their own. It is also nice that the experiment is somewhat immune to deviant behavior.

The different outcomes in the two stages illustrate the distinction between accounting profit and economic profit. Students see that when the opportunity cost of planting a crop is zero (as it was in stage one) economic profit and accounting profit are the same. Both are zero in every market in the long run. However, when the opportunity cost of planting a crop is not zero (as in stage two), they see that accounting profits are not zero in long-run equilibrium. It becomes clear that zero economic profits means having positive accounting profits equal to the opportunity cost of the farmer's decision to plant.

CONCLUDING REMARKS

The experiment is about the consequences of free entry and exit, but it motivates students to think about the desirability of free entry and exit to market incumbents and potential entrants. Students often say that they would like to be able to block further students from entering a market in which they are making positive profits. Such comments may be used to lead into discussion on different types of barriers to entry that exists in real markets, actions firms sometimes take to create them, and government laws and regulations prohibiting such actions.

During the course of the experiment students are instructed to record their individual profits. This is proposed as a means to get students to focus on profit seeking. As an incentive, I provide a UCSB mug to the student who makes the most profit over the course of the experiment. The students appreciate this, moreover, since the prize is awarded on the basis of relative profits, it provides an incentive for students in the fallow program to enter markets with profits equal to two dollars in the second stage. Recall that this is necessary to get the preferred equilibrium outcome in stage two.

The objective of the free entry and exit experiment is for students to allocate themselves into four separate markets so that profits are equal in all markets. As such, the experiment seems to present a coordination problem of the type studied by Ochs (1990) and Meyer et al. (1992). In fact, the design has features in common with the decentralized market experiments described in these papers. In Ochs' experiment, nine prizes are placed in different locations and nine participants select locations in hopes of obtaining one of the prizes. Likewise, in the Meyer et al. experiment, six participants individually select one of two pots with the understanding that their payoffs depend on the number of people who select each pot. In both of these experiments, the payoff as a function of the number of people in a location is known to the participants, and participants make their selections simultaneously. The process by which the participants' simultaneous selections produce equilibrium outcomes is the coordination problem which these researches address.[6]

[6] For instance, Meyer et al. are primarily interested in how agents make use of history to coordinate on an equilibrium outcome.

The feature that separates this experiment from decentralized market experiments designed for research purposes is that in the proposed treatment, participants observe each other select locations. This eliminates the coordination issues that are of interest to researchers. Furthermore, because students can observe each others' choices and make adjustments within rounds, cobweb cycles that often occur when entry is simultaneous are avoided.

REFERENCES

DeYoung, Robert. 1993. Market experiments: The laboratory versus the classroom. *Journal of Economic Education* 24 (Fall): 335-351.

Fouraker, Lawrence E. and Siegel, Sidney, *Bargaining Behavior,* McGraw-Hill Book Company, Inc., San Francisco, 1963.

Meyer, D., J. Van Huyck, R. Battalio, and T. Saving. 1992. History's role in coordinating decentralized allocation decisions. *Journal of Political Economy* 100 (April): 292-316.

Ochs, Jack. 1990. The coordination problem in decentralized markets: An experiment. *Quarterly Journal of Economics* 105 (May): 545-59.

Siegel, Sidney, and Fouraker, Lawrence E., *Bargaining and Group Decision Making*, McGraw-Hill Book Company, Inc., New York, 1960.

Smith, Vernon. 1962. An experimental study of competitive market behavior. *Journal of Political Economy* 2 (April): 111-37.

Wells, Donald. 1991. Laboratory experiments for undergraduate instruction in economics. *Journal of Economic Education* 22 (Summer): 293-300.

Appendix A.

<u>Free Entry and Exit Experiment</u>

Farmer: ________________________________. Section: _____________________.

FARMER PROFIT CHART

Round	Market	Price	Profit
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
F1	_____	_____	_____
F2	_____	_____	_____
F3	_____	_____	_____
F4	_____	_____	_____

Total profit equals the sum of the Profit column: ____________.

Appendix B.

Free Entry and Exit Experiment

Farmer: ___________________________________. Section: ______________________.

Market for Corn

Round	Number of Farmers (Q_C)	Price (P_C)	Profit $= P_C - 8$
1			
2			
3			
4			
5			
6			
7			
8			
F1			
F2			
F3			
F4			

Market for Wheat

Round	Number of Farmers (Q_W)	Price (P_W)	Profit = Pw-9
1			
2			
3			
4			
5			
6			
7			
8			
F1			
F2			
F3			
F4			

Market for Rice

Round	Number of Farmers (Q_R)	Price (P_R)	Profit $= P_R-10$
1			
2			
3			
4			
5			
6			
7			
8			
F1			
F2			
F3			
F4			

Market for Soybeans

Round	Number of Farmers (Q_S)	Price (P_S)	Profit $= P_S - 11$
1			
2			
3			
4			
5			
6			
7			
8			
F1			
F2			
F3			
F4			

Exercises

1. Using the data from the classroom experiment, calculate linear demand curves for each market. For example, in the Corn market, assume $Q_C=a+bP_C$ and use two price-quantity observations to solve for a and b (Note: b will be a negative number).

2. Calculate the quantity demanded in each market if the price in each market equals the unit production cost.

3. The quantities from Question 2 give the distribution of farmers that results in zero profit in every market. Did we observe this distribution in the classroom experiment? If so, in what round(s)?

4. After the introduction of the government fallow program, each farmer could earn one dollar by not growing anything. Calculate the quantity demanded in each market if the price in each market equals the unit production cost plus one dollar. These quantities give the distribution of farmers that results in profits of one dollar in every market. Did we observe this distribution in the classroom experiment? If not, can you explain why?

5. The profits reported on the market charts are accounting profits. Are these the same as economic profits? What were the economic profits in each market in the last round of the experiment.