Classroom

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A Simple Game Theory Experiment for Teaching Oligopoly

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For a number of years, I have been using a simple and brief classroom experiment to illustrate the power of game theory in explaining the behavior of oligopolists. The whole presentation takes about fifteen minutes of class time, and it has worked well in the Principles of Microeconomics course.

I begin with the simplest case in game theory, a 2x2 payoff matrix with 2 players (see Figure 1). This Prisoners' Dilemma is used to show how a payoff matrix is read, and also introduces the students to the minimax strategy (without ever using that term). After putting Figure 1 on the board, I provide some motivation for each of the payoff boxes: if both remain silent, they can only be convicted on a minor charge (upper left); if one "squeals" on the other, the squealer gets off with a suspended sentence, and they throw the book at the other one (upper right, lower left). If both confess, they each get a tenner (lower right). While it is clearly best overall for both to remain silent, I first take the viewpoint of player A, and point out that player A should consider whether to confess or not if player B confesses. It is clear to all that if player B confesses, player A is better off confessing,

saving 10 years of prison time. The first revelation comes when I examine what player A should do if B *doesn't* confess: it still pays to confess, as A saves 6 months of prison time! (You may want to point out here that A might not want to be around when B gets out.) Since this is a symmetric matrix, it is easy to show that player B can also determine that confessing is the best strategy.

Figure 1

		Player A	
		Don't Confess	Confess
Player B	Don't Confess	6 mos 6 mos	0 20 yrs
	Confess	20 yrs 0	10 yrs 10 yrs

At this point I move directly to the pricing strategy of two oligopolists. I prepare in advance two paper copies of a 3x3 profit matrix (see Figure 2). I pick three students in the front corner of the class to be Team A, and give them 3 minutes to pick a price from the three possible prices in the matrix. I also pick three students in a back corner of the class to be Team B, and give them the same charge. At this point I write the 3x3 matrix on the board, and encourage the rest of the class to "play along at home" and try to guess what prices will be chosen by Teams A and B. I also prepare in advance a piece of paper with "$8,$8" written on it. For maximum effect, I put this Nash solution in a sealed envelope and give it to another student to hold during the three minutes. At the end of the three minutes, I ask each team to write down their price, and then ask Team A to announce their price, and then Team B likewise. In nine of the last ten years, both have announced $8, at which point I call for the envelope and tear it open to reveal the correctly predicted $8 prices. In the one exceptional year, Team A picked $9, but as soon as Team B announced $8, Team A asked to change to $8, which I graciously allowed them to do before calling for the envelope.

At this point, I review the profit matrix and each team's optimal strategy, and show that there was nothing magical in my prediction. Figure 2 is of course just a 3x3 version of the Prisoners' Dilemma. I then point out that the combined profits of the $8-$8 equilibrium is the lowest of all nine elements of the matrix, while the $10-$10 combined profits are the highest. So if the

Figure 2

		Team A		
		$10	$9	$8
Team B	$10	16 16	19 13	22 9
	$9	13 18	15 15	18 12
	$8	10 20	12 16	14 13

two firms could just "agree" to charge $10, they would both make bigger profits. This leads naturally to a discussion of price-fixing. I still like to tell the "phases of the moon" story here, since the executives involved used to cheat on the price-fixing agreement, which is easily illustrated with Figure 2. This is also a good time to remind your future business leaders that a number of these convicted executives did time "in the joint."

My experience has convinced me that this classroom experiment is a quick and effective way to illustrate the basic principle of oligopolistic interdependence, the urge to collude, and efforts (often failed) to avoid "price wars." In addition, the very best students may want to pursue "game theory" further. (I recommend starting with Axelrod's paperback *The Evolution of Cooperation.*) My interpretation of examination results over the years also suggests that students on average perform better on oligopoly questions, although I have not done any controlled experiments to support this armchair empiricism.

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PREDATION IN THE CLASSROOM

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Predation is one of the oldest concepts in the industrial organization literature. Yet until relatively recently, there was no firm theoretical basis for predation. Consider a finite game of full information where an incumbent (the potential predator) faces a sequential series of potential entrants. In such games, it is usually more profitable for the incumbent to "accommodate" entry rather than "preying" on it, at least in the last period of the game. Knowing this, the last potential entrant will choose to enter, realizing that its entry will be accommodated. Given this, and the process of "backward induction," one is able to generate the "Chain Store Paradox" and conclude that accommodated entry will occur in every period, much to the incumbent's regret.

Now change the game into one of asymmetric information. Assume that a small percentage of incumbent firms are "hard" competitors, and that entrants cannot tell which incumbents are hard, at least without observing their actions. These hard competitors actually prefer predating and losing money to accommodating entry and making money. Given the existence of hard competitors, "soft" profit-maximizing competitors will desire to mimic hard competitors and prey on any entry that occurs early in the game. For an incumbent to do otherwise would be to advertise to all potential entrants that it is soft. This would in turn invite entry, and deny the incumbent the opportunity to make monopoly profits. Thus, even soft firms will predate (at least early in the relevant game) so as not to generate a reputation for being soft. (See, for example, Milgrom and Roberts (1982).)

Now look at the situation from the point of view of an entrant early in the game. It knows that while the probability of it actually entering against a hard competitor is small, and by itself not enough reason to deter entry, no matter who it enters against it will suffer the pain of predation. Given this, no entry will occur until late in the game when soft incumbents have little or no reason to protect their reputations.

This combination of strategic conclusions: 1) that entry makes sense in the one period game; 2) that in a multi-period game even soft incumbents will predate early in the game; and 3) that, given 2), potential entrants will not enter early in the game, is a significant

challenge for most undergraduates. To help the students in my senior level industrial organization class understand this, I run the experiment printed below, which is a modification of Jung, Kagel, and Levin (1994). The experiment takes about 75 minutes to perform.

In their article Jung, Kagel, and Levin (at 74) indicate that it is important that all concepts be expressed in neutral terms. To achieve this, I take the following steps. First, I run the experiment before I teach the concept of predation in class. Second, the experiment title has no connection to the purpose of the experiment. Third, instead of entrants and incumbents, players are called "starters" and "finishers". Fourth, instead of "soft" and "hard" finishers (incumbents), finishers are either "blue" or "green". Fifth, starters move either "up" or "down", instead of staying out of or entering the market. Finally, instead of accommodating or preying, finishers move either left or right.

In addition, it is important to prevent student play from being affected by the reputation of particular students. To achieve this, experiment pairings are kept anonymous and randomized through use of an "indicator" system.[1] Students report to me that this system leaves them unable to determine whom they are playing against.

In my experience, in the first round almost all entrants choose to enter in the first period. Soft incumbents almost always accommodate, while hard incumbents predate. The ensuing three periods then generate entry against accommodating soft incumbents (who by accommodating in the first period have already identified themselves) and no entry against hard incumbents. By the second round, about half of the students realize that to accommodate entry is to identify yourself to the world as soft and to invite entry. They therefore predate in the early periods of that round, discouraging later entry. By the third round, most players have figured through the three relevant steps.

To make sure almost all students understand the concepts, it would probably be necessary to run a fourth round of the experiment. Unfortunately, the limits on class time preclude this. Nevertheless, I find this experiment serves as an important tool to encourage students to think through the strategic implications of predation theory.

[1] The careful observer may notice that I borrowed the indicator approach from the method in baseball by which catchers tell pitchers what pitches to throw without their signs being "stolen" by opposing players on second base.

References

Jung, Yun Joo, John H. Kagel, and Dan Levin, "On the Existence of Predatory Pricing: An Experimental Study of Reputation and Entry Deterrence in the Chain-Store Game," RAND Journal of Economics 25(1): 72-93 (1994).

Milgrom, Paul, and John Roberts, "Predation, Reputation, and Entry Deterrence," Journal of Economic Theory, 27: 280-312 (1982).

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THE JELLY BEAN EXPERIMENT

PLEASE DO NOT ASK ANY QUESTIONS ABOUT STRATEGY. Only ask questions about the rules of the game.

There are two types of players: starters and finishers. Starters have two types of moves, UP and DOWN. Finishers have two types of moves, LEFT and RIGHT. There are two types of finishers, BLUE and GREEN. Only two of the finishers are green, the rest are blue. Play is sequential, starters move first and are followed by finishers.

If a starter chooses UP, she always receives a payoff of 0 points. If she chooses DOWN and the relevant finisher chooses LEFT, she receives 10 points. If she chooses DOWN and the finisher chooses RIGHT, she receives -5 points.

For BLUE finishers, if a starter chooses UP, the relevant finisher always receives 25 points. If the starter chooses DOWN, and the finisher chooses LEFT, the finisher receives 10 points. If the starter chooses DOWN, and the finisher chooses right, the finisher receives -2.5 points.

For GREEN finishers, if a starter chooses UP, the relevant finisher always receives 25 points. If the starter chooses DOWN, and the finisher chooses LEFT, the finisher receives -2.5 points. If the starter chooses DOWN, and the finisher chooses right, the finisher receives 10 points. Payoff tables are as follows:

Payoff Table Blue Finisher			
		Blue Finisher	
		Left	Right
Starter	Up	0, 25	0, 25
	Down	10, 10	-5, -2.5

Payoff Table Green Finisher			
		Green Finisher	
		Left	Right
Starter	Up	0, 25	0, 25
	Down	10, -2.5	-5, 10

The experiment is conducted as follows. At the beginning of each round students are divided into starters and finishers. Round one has four periods, while rounds two and three have six periods each. Two numbers are randomly selected to be assigned to green finishers. Both starters and finishers are randomly assigned numbers. Please do not tell anyone which number or type you are.

At the beginning of each period, each starter is assigned her matching finisher randomly by use of an "indicator number" written on the board. Indicator numbers work as follows. Let A be the number of the starter, B be the indicator number, and C be the number of matched pairs in the game. Given A, B, and C, player A plays against finisher

$$\begin{array}{ll} A + B & \text{if } A + B \leq C; \\ A + B - C & \text{if } A + B > C. \end{array}$$

Thus, if there are 8 matched pairs in the game and the indicator number is 3, starter 4 is matched against finisher 3 + 4 = 7. If the indicator number is 6, starter 3 plays against finisher 3 + 6 - 8 = 1. Starters should write down their matched finisher as soon as the indicator number is put on the board.

The starter then writes on her own index card her number, the number of the finisher, *circled*, and the chosen strategy, either "up" or "down." The starter should then write her chosen strategy down on her scorecard. The index cards are collected, and the chosen strategies are written on the board next to the number of the relevant finisher. (Please note that starter strategies are *not* revealed by number.)

All finishers are then asked to write their number on an index card. (Finishers are asked to determine their strategies before their matches' strategies are written on the board.) Those finishers whose relevant starters have chosen "down" should then write their relevant response strategies, "left" or "right". Finisher responses are then posted on the board, ending the period. At the end of each period players are asked to write down on their scoresheets their strategies, the strategies chosen by their "matched" players (the starters or finishers they are paired against), the relevant payoff, and the cumulative payoff for the round.

At the end of each round, please add up your total points for the round. To start a new round, starters become finishers and finishers become starters. The sequence described above is then repeated.

It is important that players not reveal their strategies to one another, or reveal what number they are playing. Please try not to discuss what happens in the experiment, except to clarify issues about the rules.

Starter Scoresheet
Round 1

Name _____
Starter #: _____
Round #: _____

Your payoffs are as follows: if you choose UP, you always receive a payoff of 0 points; if you choose DOWN and the relevant finisher chooses LEFT, you receive 10 points; if you choose DOWN and the finisher chooses RIGHT, you receive (minus) -5 points.

Period	Your Match's Number	Your Strategy	Your Match's Strategy	Your Payoff	Total Payoffs This Round
1					
2					
3					
4					

Starter Scoresheet
Rounds 2 and 3

Name _____
Starter #: _____
Round #: _____

Your payoffs are as follows: if you choose UP, you always receive a payoff of 0 points; if you choose DOWN and the relevant finisher chooses LEFT, you receive 10 points; if you choose DOWN and the finisher chooses RIGHT, you receive (minus) -5 points.

Period	Your Match's Number	Your Strategy	Your Match's Strategy	Your Payoff	Total Payoffs This Round
1					
2					
3					
4					
5					
6					

***BLUE* Finisher Scoresheet**
Round 1

Name _____

Finisher #: _____
Round #: _____

You are a BLUE finisher. Your payoffs are as follows: if the relevant starter chooses UP, you always receive 25 points; if the starter chooses DOWN, and you choose LEFT, you receive 10 points; if the starter chooses DOWN, and you choose RIGHT, you receive (minus)-2.5 points.

Period	Your Match's Strategy	Your Strategy	Your Payoff	Total Payoffs This Round
1				
2				
3				
4				

BLUE **Finisher Scoresheet**
Rounds 2 and 3

Name _____
Finisher #: _____
Round #: _____

You are a BLUE finisher. Your payoffs are as follows: if the relevant starter chooses UP, you always receive 25 points; if the starter chooses DOWN, and you choose LEFT, you receive 10 points; if the starter chooses DOWN, and you choose RIGHT, you receive (minus)-2.5 points.

Period	Your Match's Strategy	Your Strategy	Your Payoff	Total Payoffs This Round
1				
2				
3				
4				
5				
6				

GREEN **Finisher Scoresheet**
Round 1

Name _____
Finisher #: _____
Round #: _____

You are a GREEN finisher. Your payoffs are as follows: if the relevant starter chooses UP, you always receive 25

points; if the starter chooses DOWN, and you choose LEFT, you receive (minus) -2.5 points; if the starter chooses DOWN, and you choose RIGHT, you receive 10 points.

Period	Your Match's Strategy	Your Strategy	Your Payoff	Total Payoffs This Round
1				
2				
3				
4				

***GREEN* Finisher Scoresheet**
Rounds 2 and 3

Name _____
Finisher #: _____
Round #: _____

You are a GREEN finisher. Your payoffs are as follows: if the relevant starter chooses UP, you always receive 25 points; if the starter chooses DOWN, and you choose LEFT, you receive (minus)-2.5 points; if the starter chooses DOWN, and you choose RIGHT, you receive 10 points.

Period	Your Match's Strategy	Your Strategy	Your Payoff	Total Payoffs This Round
1				
2				
3				
4				
5				
6				

Instructor's Scoresheet

This is Round #: _____
Green finishers are: _____

	Period __		Period __	
Finisher Number	Starter Play	Finisher Play	Starter Play	Finisher Play
1				

2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

BOOK REVIEW

The Handbook of Experimental Economics. John H. Kagel and Alvin E. Roth, editors. Princeton, New Jersey: Princeton University Press, 1995, pp. xvii, 721. $55.00.

The long awaited *Handbook of Experimental Economics* has arrived. The text represents eight chapters written by an impressive group of economists known for their work in experimental economics. The contributors include: Colin Camerer, Charles Holt, John Kagel, John Ledyard, Jack Ochs, Alvin Roth, and Shyam Sunder. The work on each chapter in the text began in 1990. A final presentation of the chapters was made at the 1994 American Economic Association meetings. The first chapter provides an overview and historical account of experimental economics. Chapters two through eight survey areas of economics where there has been a concentration of experiments looking at specific topics.

The book has a self-proclaimed purpose of providing an overview of experimental economics in order to lower the barriers to entry for anyone considering entering the field [xv]. The charge to each author was to provide a survey of specific areas of experimental economics for both the experimentalist and the nonexperimentalist and to suggest further research. The work is different from other recently published experimental economics texts in that it contains no methodology chapter. There is no chapter that deals exclusively with "how to do" experiments. To various degrees, the authors of each chapter discuss the methodology of conducting experiments in their own particular area.

A brief book review of this length does not do justice to the scope of coverage of topics included in the text. Chapter 1 provides an overview and history of experimental economics. Its author, Roth, bills it as a "folk history" [p. 5] of the work of numerous individuals conducting experiments. Those new to the field of experimental economics will find the bibliography of this chapter an effective introductory reading list [pp. 98-109].

Chapter 2 deals with the provision of public goods and the tendencies economic agents have to free ride. One of the most interesting sections has to do with the identification of factors that reduce free- riding. The author of this section, Ledyard, discusses 19 different factors that can affect the level of contribution of agents in a voluntary contributions environment [p. 143].

Chapter 3 deals with coordination problems in economic games involving multiple equilibria. Much of the discussion in this chapter is motivated by macroeconomic models [p. 244]. In this chapter, Ochs makes several suggestions for future research. Ochs also makes a useful point in this section by identifying that much of experimental economic work is "exploratory" [p. 205]. It is exploratory in that the experiments run in this area represent changes in numerous experimental parameters. It should be the

goal of future research to provide replications of current findings and to carefully control the variation of experimental parameters.

The subject of chapter 4 is bargaining. This chapter by Roth is divided into two sections. The first section considers the terms of agreement observed in bargaining experiments. The second section looks at disagreements in bargaining situations and the factors that lead to inefficiency in these situations [p. 253].

Both chapters 5 and 6 address exchange issues in the now familiar market experiments proposed by Chamberlin. Chapter 5 looks at industrial organization topics and chapter 6 considers asset markets. Chapter 5 is one of the most methodological chapters in the text. Holt, writing in a very effective conversational style, reviews many of the procedural issues that arise in the conduct of market experiments. He emphasizes the importance of the rules and informational conditions of laboratory market institutions [p. 349]. The material discussed by Sunder in chapter 6, dealing with asset markets, represents work of recent vintage. The first asset market experiments were not conducted until the early 1980s [p. 445]. These experiments are important because they provide insight into the efficiency of the provision of information.

Chapter 7 surveys the study of auction markets. The author of this chapter, Kagel, points out that the value of the study of auctions lies in the way they illustrate games of incomplete information. In these games, bidders' private information is the main factor affecting strategic behavior [p. 501]. In this chapter he considers various types of auctions. The auctions considered include: first-price auctions, Dutch auctions, second- price auctions, and English auctions. The chapter also discusses the notion of a "winners curse" both in economic experiments and in "real world" applications.

The final chapter, chapter 8, surveys much of the interrelated work of economists and psychologists. Though this chapter makes various comparisons to the work of psychologists, it is one of the most theoretical economic chapters. Camerer attempts, in this chapter, to analyze systematic mistakes made by experimental subjects and the procedures that seem to create these mistakes [p. 589].

As a reference tool, one of the greatest strengths of the text is the note section and the bibliography section at the end of each chapter. The work surveyed in this text is well documented. Several chapters in the text have in excess of one hundred notes. Likewise, several chapters have bibliographies over ten pages in length. If one is looking for a light overview of experimental economics, this is not the text for him or her. There are other recently published texts that provide a less rigorous

presentation of the field of experimental economics. These same texts also would be more useful for those considering the use of experimental economics as a teaching tool. If, however, one is considering entering the research field of experimental economics or if one is considering adding an experimental component to his or her existing research, this is probably a better text to consult. As Roth argues in chapter 1, "...there are few if any areas of economics which experimental methods do not have the potential to complement, at least indirectly, more traditional methods of investigation" [p. 4]. Readers of this text should be pleased by the level of rigor and depth presented in this text.

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