Classroom

EXPERNOMICS

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EQUITY AND EFFICIENCY IN A GAME

Ken Peterson*

The classroom exercise described below is a fun way to illustrate equity-efficiency tradeoffs, the frustration associated with relative inequality, and the interdependence of decisions among members and institutions in society. It was designed for a principles of microeconomics course of about twenty to thirty students.

The game itself is extremely simple. Students are told to write down either "1/2" or "3" on a piece of paper. They will receive extra credit points equal to the number they wrote down--unless more than three members of the class have written down 3s in which case the entire class receives zero extra credit points. The outcome in the first several rounds is predictable: more than three people write down 3s and each student receives zero points. (Note: If the class size falls below twenty students, you may wish to assign a payment of zero when TWO or more people write down 3s--I have had a few close calls in smaller classes.) I make the students pause at the end of each round to note how wonderful it feels to have a perfectly equal distribution of extra credit points and ask them whether the outcome was Pareto efficient.

After some time, if the class has not already

figured it out, I encourage them to talk to each other about ways to improve their situation. Someone usually suggests that *everyone* write down 1/2. This is when the game really gets interesting. The students usually realize that this, too, is Pareto inefficient, but they often differ from one another (sometimes vehemently) in their assessment of how important it is to maintain perfect equality and how important it is to attain Pareto efficiency. Several classes have arrived at a compromise by agreeing to give each member of the class an equal *probability* of receiving the higher payoff by drawing numbers out of a hat. I like to draw analogies to "equality in the distribution of goods and services," which may lead to Pareto inefficiency in the real world, vs. "equality in access to training or other human capital acquisition opportunities," which may be less likely to produce inefficiencies but more likely to result in an unequal distribution of goods and services.

In one class, three students persisted in writing down 3s, even in the face of intense social pressure to alter their choice from students who had a strong preference for equality. Several students who would have been happy with 1/2 point suddenly became militant and sabotaged the rest of the class by changing their selection from a 1/2 to a 3, thus causing everyone to get 0's, even though they had nothing to gain from it (other than the satisfaction of observing perfect equality). This class got into a fairly heated argument and tried to "gang up" on the three people who were intending to write down 3s, even though the others were willing to accept 1/2 point as long as the distribution of points was perfectly equal. With emotions running high, I pointed out how insignificant their problem was compared to the gross inequalities in the distribution of housing, health care, food, and education. After this exercise, my students saw more clearly how inequalities in the distribution of income could contribute to riots in Los Angeles

and revolution in Mexico. (Running time: 35 to 50 minutes).

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AN EPA-STYLE AUCTION OF POLLUTION PERMITS

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Introduction

This exercise simulates a Chicago Board of Trade auction of allowances to emit sulfur dioxide, one of the pollutants which causes acid rain. The CBOT began running these auctions in March of 1993 on behalf of the Environmental Protection Agency. The EPA uses the auctions as part of a market-based program to cut power company emissions of sulfur dioxide in half between the years 1990 and 2000. This simulation demonstrates the cost savings from using the market-based approach versus requiring an across-the-board cut in emissions.

As part of its market-based program, the EPA in 1993 issued utilities a limited number of pollution permits, some of which the EPA set aside for the initial auction. Utilities wishing to sell their permits can do so via the auctions, and can specify a minimum bid they are willing to accept. A utility which chooses to reduce pollution, either by cleaning up its production process or by reducing its power output, can then sell its extra permits to utilities which cannot reduce pollution as cheaply. So under this market-based approach, utilities have the incentive to find the least costly way to distribute pollution reduction among themselves. Since environmental conservation groups can buy and retire pollution permits, the market also allows for the possibility of even greater reduction in total pollution emissions.

The Auction

I ran this experiment in a one-semester principles of economics class, at the end of the section on microeconomics. We had 80 minutes, divided roughly equally between my explanation of the experiment, time for them to plan strategy, the auction itself, and a discussion at the end. Eight pairs of students represented electrical utilities, and one pair represented an environmental conservation group. I told the conservation group privately how much money they could spend, and gave each pair of utility representatives a sheet of information on their firm's marginal product, marginal cost of production, and marginal cost of pollution abatement equipment, as well as the industry price of electricity. (See the instructions for copies of these sheets.)

Each utility initially emits 500 tons of sulfur dioxide per year, but must now hold a permit for each 100 tons it continues to emit. Utilities may reduce pollution by installing abatement equipment or by reducing their output of electricity. The total number of pollution permits available will allow for total industry emissions that are only 60% of current industry emissions. Each utility receives two permits, with the remaining permits (one per utility) to be auctioned individually by the EPA. As EPA auctioneer, I announced that after auctioning these permits, I would accept for auction any permits that utility representatives wanted to sell. Sellers wrote on the back of the permit the minimum bid they were willing to accept.

I kept track on a blackboard of the successful bids and the name of the bidding firm. Our permits sold for between six and ten million dollars each. While firm data on costs and revenues were private information, it became obvious early in the auction process that firms were not identical. Our discussion of the results brought out the observation that the

firms who abated and sold their permits were the utilities with low abatement costs. (See, for example, EMF Utilities in the instructions.) Those who sold their permits and went out of business were the low-productivity, high-cost utilities. (See, for example, Coal Power in the instructions.) The newer and higher productivity firms bought permits because their state-of-the-art abatement equipment made additional abatement expensive. (See, for example, Big Modern in the instructions.) We compared the total industry cost of using this market-based method of reducing pollution, with the industry cost from requiring each firm to reduce by 40%. The class concluded that not only was it cheaper to reduce pollution with the market-based method, but that it was also much more palatable to the firms.

Discussion Questions

1. Which firms bought permits and why did

2. Which firms sold permits and why did they

3. Did any firm go out of business, and if so,

4. How much did it cost altogether to get the ket-based approach?
5. How much would it have cost if, instead of EPA had required every firm to cut back 40% on pollution

6. How much did society save by using the s-the-board reduction in pollution emissions?

Instructions

As students show up, put them in pairs. Tell one pair privately that they represent a conservation group with $10 million of membership contributions. Hand each other pair one of the sheets of information on electrical utilities from the appendix. To the group as a whole, read the following:

You are representatives of electrical power companies. Your firms are each currently producing 500 tons of sulfur dioxide per year. Because sulfur dioxide causes acid rain, the federal government has decided that you must reduce by 40% the total amount of sulfur dioxide your industry produces. One way to make you reduce this pollution would be to require each of your firms to cut sulfur dioxide emissions to 300 tons/year. However, economists have suggested that there are cheaper ways to get the same total amount of reduction. You are about to implement one of these suggestions, an auction of pollution permits. From now on, you must own one pollution permit for each 100 tons of sulfur dioxide you emit. As the Environmental Protection Agency representative, I am giving each firm 2 permits. I have additional permits which I will auction, one at a time, to the highest bidder. There are ____ of these permits, just enough so that total industry emissions will be 40% less than their current level.

On your sheet, you see information about your firm's marginal cost and marginal product. Because you each have two permits, you all currently have the right to emit 200 tons of sulfur dioxide. If you were to buy another permit, you could emit 300 tons total, thereby increasing your output of electricity. On your sheet, you see what happens if you do go from 200 to 300 tons of sulfur dioxide (i.e. from 2 to 3 in the column marked "pollution level before abatement"). Your additional output of electricity in megawatts you can read from the marginal product column. Electricity sells for one million dollars per megawatt. Your additional costs (in millions of dollars) from producing that electricity you can read from the marginal cost column.

Every time you buy another permit, you may emit another 100 tons of sulfur dioxide. You may also choose to install pollution abatement equipment. If you install abatement

equipment, you can produce electricity without emitting sulfur dioxide. So, for instance, if you would like to continue producing the amount of electricity you were producing up to today, then one way to do that is to use your two permits to emit 200 tons of sulfur dioxide and also install enough pollution abatement equipment to reduce 300 tons of sulfur dioxide. Your marginal cost of installing abatement equipment is given at the bottom of your sheet. The first number is the cost of reducing the first 100 tons, the second number the cost of reducing the second 100 tons, etc. You may reduce up to 400 tons of sulfur dioxide through abatement.

After I have auctioned my permits, I will accept for auction any permits you would like to sell. I will give you all the proceeds of the auction of your permit. You may write on the back of the permit the minimum bid you are willing to accept. One reason that you may choose to sell your permits is that you choose to use pollution abatement equipment instead. Another reason is that you may earn more from selling your permit than you would from producing electricity. In that case, you may even leave the electricity producing business altogether, thereby producing no pollution.

Your bosses have instructed you to bid at this auction so as to maximize your firm's profits. Your bids must be in one million dollar increments. There are also representatives of a conservation group here whose members have instructed them to buy pollution permits which they will then set aside unused.

Sample Firm Information Sheets
(Note: Electricity sells for $1,000,000 per megawatt.)

Company: EMF Utilities

Pollution level before abatement (100 tons of SO2)	Marginal Cost ($1,000,000)	Marginal Product (Megawatts)
1	55	35
2	10	30
3	10	25
4	10	20
5	15	20

Marginal cost of pollution abatement equipment per 100 ton reduction in SO_2 emissions:

First $4,000,000
Second $5,000,000
Third $6,000,000
Fourth $8,000,000

Company Coal Power

Pollution level before abatement (100 tons of SO_2)	Marginal Cost ($1,000,000)	Marginal Product (MegaWatts)
1	50	20
2	10	20
3	10	20
4	10	20
5	10	20

Marginal cost of pollution abatement equipment per 100 ton reduction in SO_2 emissions:

First $15,000,000
Second $15,000,000
Third $15,000,000
Fourth $15,000,000

Company: Big Modern

Pollution level before abatement (100 tons of SO_2)	Marginal Cost ($1,000,000)	Marginal Product (Megawatts)
1	120	60
2	35	60
3	35	60
4	35	60
5	35	60

Marginal cost of pollution abatement equipment per 100 ton reduction in SO_2 emissions:

First $30,000,000
Second $35,000,000
Third $40,000,000
Fourth $45,000,000

References

Suntoli, Michael. "Cantor Fitzgerald Aspires to Become Hub of Environmental Brokerage Market." *The Wall St. Journal*. September 12, 1994.

Taylor, Jeffrey. "Auction of Rights to Pollute Fetches About $21 Million." *The Wall St. Journal*. March 31, 1993.

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I would be happy to send all ten firm information sheets to those who request them. If you do use this exercise, please let me know your results and suggestions for improvements.

EXPERIMENTAL ECONOMICS MAKING INROADS AT THE PRINCIPLES LEVEL

"Because of the complexity of human and social behavior, we cannot hope to attain the precision of the physical sciences. We cannot perform the controlled experiments of the chemist of biologist. Like the astronomer, we must be content largely to 'observe.'"

-- Paul Samuelson (1976)

Although experimental economics has been around for over 30 years in one form or another, economics textbook writers are just beginning to acknowledge and integrate experimental methods into their textbooks and/or supplements. The above quote from Samuelson was typical of the profession's view of the nature and scope of economic method at the time, at least as represented to the general undergraduate population. But, to quote Bob Dylan, "the times, they are a-changin'."

Several new textbooks have recently appeared on the market trumpeting the relevance of experimental economics. Among these new textbooks are *Economics* (Houghton Mifflin) by John Taylor and *Microeconomics: A Modern Approach* (Harper Collins) by Andrew Schotter. Even Paul Samuelson, in the 14th edition of *Economics* (McGraw-Hill), acknowledges the growing use of laboratory experiments in understanding economic behavior.

Schotter, it seems, weaves the results of research experiments into the body of his intermediate microeconomics text at every opportunity. Among the experiments discussed are double auctions, tournaments, the prisoner's dilemma, coordination games, public goods experiments, and bargaining experiments.

While other principles textbooks usually make reference to the double oral auction in passing during the discussion of market behavior, Taylor's new principles book presents the double oral auction experiment as an integral part of his discussion of market interaction (Chapter 7). Also included in the text are references to posted price auctions and prisoner dilemmas. To accompany Taylor's textbook, Delemeester and Neral have created a manual containing eighteen experiments for classroom use, many of which originally appeared in this newsletter.

Andreas Ortmann and David Colander have also prepared a booklet to accompany Colander's *Economics* (2e, Irwin) which contains eight experiments/demonstrations for classroom use. These experiments include the double auction, a rational expectations exercise, a moral hazard experiment, a common resource experiment, and a collusion experiment.

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