

An Experimental Education Market with Positive Externalities

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In this experiment, students see how competitive markets underproduce in the presence of a positive externality. Students also learn how private negotiations might internalize a positive externality. The externality comes in the form of spill-over benefits from education. I use this experiment in my principles of economics course to introduce the idea of market failure. A standard market (double oral auction) experiment earlier in the semester convinces students that the invisible hand efficiently allocates resources. This version of the market experiment lets students test the limits of that earlier result. Moreover, this experiment introduces the economic role behind the government provision of services that generate positive externalities, such as education.

DESCRIPTION OF THE EXPERIMENT

Participants take one of three roles: buyers of education, sellers of education, and interested bystanders. The experiment consists of a series of market periods, each completely separate from the preceding period. (See Appendix A for the instructions.) In each period, buyers may purchase as many as three years of education, and sellers may provide as many years of education as they choose. Each buyer has a private marginal benefit for each year of education. Each seller has a constant marginal cost of producing a year of education and no fixed costs. All sellers have the same marginal cost, but buyers have marginal benefits that decrease with each year of education, and different buyers have different marginal benefits. Each interested bystander receives benefits for every year of education consumed by each buyer. These benefits represent the spill-over advantages accruing to society at large when an individual becomes better educated. The benefits to the interested bystanders are constant and the same across all bystanders. The benefits and costs for all participants are private information.

Buyers and sellers trade each period using a double oral auction, that is, by mingling and calling out offers to buy or offers to sell a specified quantity at a specified price. I suggest forbidding trades at fractional prices to decrease haggling time. To speed convergence to equilibrium, the instructor could record each trade on the blackboard. A buyer may purchase multiple years of education (up

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to three in a period) from the same seller or from different sellers. After the buyers and sellers have conducted all the trades they desire, that period ends and a new period starts. Nothing in the previous period carries over to this new period. Buyers can again purchase up to three years of education, and they again begin with the same marginal benefit schedule for each of the three years as before. In the first few periods, while the market approaches equilibrium, the interested bystanders record the benefits they receive from buyers purchasing education. They do nothing else in these early periods.

For every buyer, the marginal benefit of each of the first two years of education exceeds the constant marginal cost of producing a year of education. However, the marginal benefit for every buyer's third year is less than the marginal cost. In a competitive equilibrium, because price equals marginal cost, each buyer will purchase two years of education. Although the private benefit of the third year of education is less than the cost of producing this year, the benefit to society as a whole is greater than the cost. That is, the marginal benefit to the individual buyer, plus the sum of the marginal benefits to all interested bystanders, is greater than the marginal cost. Thus, the competitive equilibrium does not maximize net social benefits.

After the market has reached the competitive equilibrium, which may take three to five periods, the instructor encourages the interested bystanders to become involved in the market. The instructor asks the interested bystanders whether they would like to see buyers purchase more education and suggests that the interested bystanders may be able to take some action to make that happen. If possible, the instructor should avoid suggesting what form the involvement take, leaving the interested bystanders to come up with their own solutions. If the interested bystanders cannot come up with any solutions, then the instructor could suggest subsidies to buyers or sellers. After the interested bystanders have had a few periods to implement their solutions, the instructor may wish to announce that the interested bystanders now control the government, and their wishes have the force of government edict. These government interventions can promote a follow-up discussion of the role of government in the market for education, including state laws requiring schooling up to a particular age or grade level.

RESULTS

I ran this experiment in two different sections of my principles of economics course at Whitman College. I included it in the section on market failure that concludes the microeconomics half of the semester. In both classes, students had conducted four market experiments earlier in the semester, including a double oral auction. The experiments took place in class, with mandatory participation.

Each of the classes had 22 students, and both times we used the entire 50 minutes for the experiment. We had eight buyers, seven sellers, and seven interested bystanders in each class. Sellers had a constant \$36 marginal cost of production. The marginal benefit schedule of the buyers is shown in Table 1. All of the buyers had marginal benefits for the first and second year of more than \$36 and mar-

TABLE 1
Marginal Benefit Schedule for Buyers (in dollars)

Buyer's ID	MB of first year	MB of second year	MB of third year
1	50	40	30
2	55	45	35
3	50	40	30
4	55	45	35
5	45	40	35
6	58	45	32
7	59	42	33
8	57	44	31

Note: MB is marginal benefit.

ginal benefits for the third year of between \$30 and \$35. Thus, in a competitive equilibrium, buyers would each purchase two years of education. The interested bystanders each received \$2 of benefit for every year of education consumed by each of the buyers. Because the spill-over benefits of one extra year of education equal \$14 (\$2 for each of the seven interested bystanders), maximum net social benefits occur when all buyers consume a third year of education. For instance, the buyer with the lowest marginal private benefit for a third year would receive only \$30 for that third year, but society as a whole would receive $\$30 + \$14 = \$44$, which exceeds the \$36 marginal cost of producing the year of education.

The first time this experiment ran, we had the following results. In each of the five periods before the interested bystanders became involved, buyers purchased the competitive equilibrium quantity of two years of education each. Prices fell on average during these periods, reaching \$36.3 by period 5. Every price in period 5 was either \$36 or \$37. I allowed no fractional prices. As one student noted in the laboratory report I assigned after the experiment:

The theoretical equilibrium price of a year of education would be between \$36 and \$40. However, theory would predict that the price would eventually drop to \$36. This is the marginal cost for producers, and they would undercut each other until the price dropped down to this level. As a matter of fact, since each producer could produce as many units as they wished, all that it would take is one producer selling at \$36 to make that the market price.

In fact, we had one producer in period 5 sell half of the total years purchased, at a price of \$36. Four other sellers supplied the other half of the market.

After I encouraged them to become involved, the interested bystanders decided to act as a group. In period 6, they offered a \$1 subsidy to buyers of a third year of education, which induced the three buyers with a \$35 marginal benefit to purchase a third year at a price of \$36. Note that the interested bystanders made this offer as a group, so that each interested bystander only spent one-seventh of a dollar for each one-year subsidy. The interested bystanders always split the costs of their subsidies evenly, and none of them attempted to free ride. In period 7, the interested bystanders raised the subsidy to \$2 for buyers of a third year. However, because the seven sellers colluded and managed to raise prices to \$37

or \$38, with an average price of \$37.2, there were still only three buyers who purchased a third year.

I wondered what solutions the interested bystanders would devise if allowed to legislate an outcome. I therefore announced that because education is so critical to society's well-being, interested bystanders have the support of society as a whole when they propose legislation concerning education. Thus, the interested bystanders as a group could effectively enact legislation to enforce their will on society. The interested bystanders considered but then rejected as unfair the idea of simply forcing buyers to consume a third year of education. Instead, the interested bystanders instituted a price ceiling at \$36, and again offered the \$1 subsidy to buyers of a third year. The price ceiling allowed sellers to just cover their marginal cost. However, because sellers had no profit opportunity in trading and because they took offense at the price ceiling, they all refused to trade that period. Thus, no trades occurred in period 8.

In period 9, the interested bystanders imposed a \$37 price ceiling on education and offered a \$1 subsidy to sellers for each time a seller supplied a buyer with that buyer's third year of education. Prices in this period dropped to \$35 or \$36, with an average price of \$35.8. This solution induced only two buyers to purchase a third year, so the interested bystanders started developing a need-based scholarship program. That is, they decided to ask buyers to reveal their private marginal benefits and to provide each buyer with just enough subsidy to allow him to break even on his purchase of a third year of education. Thus, the interested bystanders devised a market-based strategy that would provide them with the greatest net benefits possible without forcing anyone else to incur a loss. Unfortunately, the class ended before the interested bystanders could implement their plan.

One year later, I ran the experiment again with a different section of principles students. We again had eight buyers, seven sellers, and seven interested bystanders, all with the same values as before. We ran four periods before the interested bystanders became involved. In these first four periods, each buyer purchased two years of education each period. The average price dropped slightly through each of the four periods, reaching \$39.6 in period four. Five of the trades in period 4 occurred at prices above the equilibrium range of \$36–\$40. A few more trading periods would likely have eliminated the out-of-equilibrium prices, but I moved on to leave enough time for the rest of the experiment. After period 4, I encouraged the interested bystanders to become involved. While they considered what actions to take, the buyers asked them for scholarships, and the sellers asked them for subsidies. The interested bystanders then stepped outside of the classroom to confer as a group and soon invited the buyers outside to join them. As one interested bystander reported in his laboratory report:

We knew that if we could get the buyers to each buy a third year of education, the benefit to each interested bystander would be an extra \$16. We realized that we could give up to \$15 each in scholarships to the buyers for them to purchase the third year of education. We talked with the buyers and asked them how much they would each need (minimum) to purchase the third year of education at the going price towards the end of each period (\$36–\$37). After they told us (between \$2–\$7), we decided as

a group to give no more than \$7 in scholarships each during a period. Thus, we could get all the buyers to purchase the third year, while still maximizing our benefits.

When the buyers returned to the classroom, they announced that after each buyer purchased a second year of education, he or she would go see the interested bystanders for a scholarship for the third year.

In periods 5 and 6, the interested bystanders provided need-based scholarships for the third year, and every buyer purchased a third year. All of the third years traded at a price of \$36 or \$37, with the prices of all trades averaging \$38.6 in period 5 and \$37.9 in period 6. One buyer explained this drop in prices in his laboratory report:

I asked the interested bystanders to offer me the difference between my value and the price of education, and they encouraged me to hunt the lowest price. The interested bystanders were willing to help, but they too had limited resources and could not just toss money in our direction. So we had to bargain with the sellers for a lower price.

One of the sellers explained in her laboratory report her reaction to the scholarship system:

I was happy when the interested bystanders worked with the buyers in a way that allowed them to purchase a third year of education. At the beginning I made greater profits by being able to sell that third year. Quickly the prices the buyers would agree to dropped and I realized that my profit was lower with such a system.

In response to the lower profits, the sellers got together before period 7 to collude. Another seller explained what happened:

I was frustrated at the fact that I was making only \$1 from trade. It was obvious that the buyers had much higher values for their first, and even their second year of education, than they were paying for them. We decided, therefore, to ask for \$41 for the first school-year sold. After that, the buyers could get the lowest price they could find. We found this to be perfectly fair because everyone was making a surplus from our products except us.

Meanwhile, the buyers and interested bystanders got together again to collude. As one buyer reported:

The buyers and interested bystanders felt that if the sellers could sell at a price between \$36 and \$42, the prices at which education was being sold in periods 5 and 6, that the buyers should insist on a particular price, which ended up being \$37 for all three years of education. Their rationale was that the sellers could afford to do this (since the price of \$37 was above what their cost must have been, since some were selling at \$36) but low enough so that the interested bystanders could afford the resources to ensure that all eight buyers were able to buy three years of education.

Each side stuck to its guns and no trade occurred in period 7. One of the buyers reported:

I was afraid to go against the price ceiling imposed by the agreement between the buyers and bystanders. I thought that if I bought at a price higher than \$37, the bystanders would refuse to fund my third year of education. I knew that if the buyers were forced to buy their third years at \$41, there'd be no way that the bystanders would have enough scholarship money to go around. The threat of finding myself on the scholarship blacklist kept me from breaking my agreement, as it probably also

did for the rest of the buyers. I'd imagine that the sellers' obstinacy was fueled by ours; they probably didn't negotiate because we wouldn't.

I had to end the experiment after period 7 because of time constraints. However, students felt that given more time, trade would have resumed in subsequent periods. One student commented:

I believe that the impasse wouldn't have continued if we had been able to continue in our experimenting, for some sort of negotiation would have gone on between the three groups. That is to say, we interested bystanders wouldn't have allowed such a halt in our absorption of free benefits to continue!

DISCUSSION

In the class meeting before the experiment, I defined positive and negative externalities and asked the students to come up with examples of each. In the class after the experiment, I presented the theory of externalities and gave my students a writing assignment in which they used economic theory to explain their experimental results. I provided the data from the experiment, including the values for all buyers and interested bystanders, the sellers' costs, and information on all the trades. They then wrote laboratory reports in which they addressed the questions in Appendix B. As part of their assignment, students made a graph or constructed a chart of the marginal benefit and marginal cost data from the experiment to find the socially optimal quantity of education. Using the values from the experiment made this rather tricky exercise more concrete and easier to understand. After they had finished their lab reports, we discussed the experiment. As part of our discussion, students considered whether the solutions the interested bystanders tried in the laboratory would work with a larger, more heterogeneous society subject to the free-rider problem. For a good background reference on the economics of education as a positive externality, see Rosen (1995, 80–85, 112–16, 523–24, 540–43). See also Levin (1987) on public versus private provision of education.

SOME SUGGESTIONS

I believe this experiment would work well with groups as small as 10 students, composed of four buyers, four sellers, and two interested bystanders. The combination of four buyers and four sellers generally produces competitive results, according to Davis and Holt (1993, 150–52). I recommend a minimum of two interested bystanders, so that they have the opportunity to confer with each other. With a large group, I suggest not having more than eight interested bystanders, to keep the discussion and potential consensus among these people manageable. I believe the experiment would work with classes as large as 50. Note that because sellers may produce as many years of education as they choose, the experiment does not require any particular ratio of buyers to sellers. For an instructor who does not know in advance exactly how many students will show up for the experiment, I suggest leaving the number of sellers flexible.

Some previous experience with a double oral auction would help, especially if the class time permits only 45 or 50 minutes for the experiment. The interested

TABLE 2
Interested Bystander Record-Keeping Sheet

Period	Total number of years of education buyers purchase	Your total benefits
1		
2		
3		
⋮		
⋮		

bystanders can come up with a strategy faster if they have experience with the market institution. I also recommend having the interested bystanders record their benefits so that they are absolutely clear on how much they would achieve if they convinced the buyers to purchase a third year each. I think that the interested bystanders were so tentative with their scholarship offers the first time I ran the experiment because they were not entirely sure of their own benefits. The second time I ran the experiment I had the interested bystanders fill in Table 2, and they were all quite clear about their potential benefits.

CONCLUSIONS

This experiment provides a flexible format that not only demonstrates the problem of underproduction in the presence of a positive externality but also allows participants to come up with solutions. The experimental data give students practice working with marginal social benefit and cost graphs (or charts). The graphs and the theory become clearer because of students' roles as market participants. The results provide fodder for a discussion of the various ways society might improve the allocative efficiency of education.

APPENDIX A Instructions

This experiment will last several periods. Some of you are buyers of a service, some of you are sellers of that service, and the rest of you are interested bystanders. The service is education. A buyer may buy as many as three years of education each period. If you are a buyer, your private slip tells you the benefits to you of each additional year of education. If you are a seller, your private slip tells you the cost of providing each additional year of education. Sellers have no fixed costs of operation. Sellers may sell as many years of education as they choose. The market institution is the double oral auction. Buyers and sellers will mingle and call out offers to buy or sell a year of education at a specified price. Each time an agreement is reached, buyer and seller will come to the front of the room and report the price for that year of education, and their identifying number or letter, so that the instructor can record this information on the board. Buyers and sellers may then return to the trading floor and attempt to reach another agreement in the same period with the same partner, or with another. Recall that buyers may buy no more than three years of education, but sellers may sell as many years as they choose.

Interested bystanders gain from the amount of education consumed by buyers. If you are an interested bystander, you have a slip that tells you what you gain from each year of

education consumed by each buyer. On your record-keeping sheet, please keep track of the total number of years buyers purchase each period and the total benefits you receive each period. You calculate your total benefits by multiplying your gain by the total number of years buyers purchase.

APPENDIX B Questions for Written Report

1. Consider the real world. In what ways do interested bystanders in society gain from someone else getting an education?

2. Draw the supply curve for sellers and the demand curve for buyers of education, or construct a chart of the demand and supply schedules. (Hint: demand and supply depend on the buyers' values and sellers' costs, not on the actual outcome of the experiment.) What is the theoretical competitive equilibrium price and quantity of education for our experiment? How many years of education would each consumer buy in equilibrium? In the periods before the interested bystanders became involved, how close did our results come to the theoretical prediction?

3. Suppose your goal was to achieve the greatest possible net benefits (i.e., benefits minus costs) for society as a whole. In other words, you want to insure that buyers consume every year of education that provides more in benefits to the buyers and interested bystanders than it costs to produce. How many years of education should buyers consume to achieve this goal? (To answer this question, use a schedule or graph that compares the marginal benefit to society of producing another year of education with the marginal cost of producing another year.) Is the number of years that maximizes net social benefits the same number that you predicted would be purchased in a competitive market?

4. Consider the actions of the group of interested bystanders. Did the interested bystanders' actions maximize net social benefits? Did the interested bystanders' actions maximize their own profits? If not, what more could you suggest that they do?

5. In our experiment, interested bystanders each received \$2 for every year of education buyers consumed. Suppose that some of the interested bystanders had instead received more than \$2 and some had received less. How do you think our results would have been different if the interested bystanders had not all received the same amount of benefits?

NOTES

1. All benefits and costs were denoted in dollars but were, in fact, hypothetical payments. No dollars changed hands, nor did course grades depend on performance. However, a component of the course grade did depend on a student's active participation in course experiments.
2. Certainly, the interested bystanders were familiar with this solution, in the form of compulsory elementary and secondary education. However, the interested bystanders were students themselves, so perhaps they were especially concerned with fairness in the market for this service. They also had considerable experience with market experiments in the classroom, none of which had ever before permitted one group to enforce its will on another. This fact might explain why they sought a market-based solution.

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