A Classroom Experiment Demonstrating the Generation of a Market Demand Function and the Determination of Equilibrium Price

Dennis J. Weidenaar

Introduction

This article describes an easily administered classroom exercise which has been successful in motivating student interest in the college principles of economics course. Its objective is to enable the student to analyze the abstract concepts of the demand function and equilibrium price and quantity, and to be able to apply them under various circumstances. In practice, instructors in principles courses frequently introduce the concept of demand by stating: "Let us assume that an individual or a group of individuals behave as follows when confronted with a series of prices for a particular good or service." The instructor then dutifully draws on the board a neat linear presentation of the demand function. Perhaps he pauses to ask the students whether the shape of the curve he has drawn is not a reasonable representation of reality: that is, at lower prices would people not be willing and able to buy larger quantities than at higher prices? This important characteristic of demand functions is then identified as the "Law of Demand."

This technique for introducing the concept of demand has two important shortcomings: It presents the concept in a completely artificial framework, and it fails to allow the student to internalize the concept. The rationale for the following experiment stems from the conviction that a thorough understanding of the concept of demand is of critical importance in economics and that real understanding does not occur until the student can relate the concept to his own experience. The experiment allows students to generate the demand function themselves, and from it the instructor, with the appropriate caveats, can generalize much more effectively than from an abstract demand function

Dennis J. Weidenaar is Assistant Professor of Economics, Purdue University.

I am indebted to Professor James Shepherd of the economics department of Whitman College for first suggesting to me this classroom exercise.

lifted from a textbook or formulated in such a way as to present a neat geometric figure.[1]

Description of the Experiment

Prior to any discussion of the demand function, the instructor pulls from his pocket a large, polished, red apple. To generate immediate class involvement and establish some "feel" for the reasonable upper limit of a price that a person in class would be willing to pay for an apple, the instructor auctions off the apple. Generally, a little salesmanship and "ham" on the part of the instructor is useful. After the apple has been purchased, the instructor asks if anyone else would like an apple. The students then usually respond by asking "what price?" or by shouting out a ridiculously low price. At this point the instructor hands out "purchase agreement forms" on which the students indicate the number of apples they are willing to buy at prices ranging from 1¢ to 50¢. He cautions the students, however, that once the market price is determined, they will be obligated to buy the number of apples that they indicated they would buy at that price on the purchase agreement. The instructor also reminds the students that, if the market price settles at a level above the highest price at which they indicated that they would buy, they will, of course, not be able to buy any apples. In effect, they will have been rationed out of the market. By the same token, if they were willing to purchase apples at a price higher than the market price, they will have to pay only the market price, thus receiving some "consumer's surplus." The instructor also tells the students he does not know what the actual price of apples will be.

The purchase agreement sheet is passed out and the instructor assists the students in filling out the sheet by starting with the highest price, 50¢, in our experiment and asking: "At a price of 50¢, how may apples will you be willing to buy at our next class session? If you do not wish to purchase any at that price, enter a zero." The instructor then continues, each time quoting a lower price until he finishes at 1¢. It is important that the instructor start from a high price and proceed to lower prices. The reason is that the student will readily understand, for example, that if he is willing to buy one apple at 23¢, then clearly he would also buy at least one apple at *all* lower prices. This may appear to be a small point, but it is an important part of understanding the concept of the demand function.

After the student has filled out the purchase agreement, the instructor should ask the student to check it over for inconsistencies—for example, offering to buy five apples at 10¢ and only three at 5¢. (The instructor may at this point query whether the students know of any goods which people would buy less of at lower prices.) Then the forms should be collected and the aggregate (or market) demand schedule calculated from the individual demand schedules.

How large a supply of apples should the instructor bring to class? Since the instructor is the only supplier, he is by definition a monopolist. Hence, to illustrate the economic principles involved most realistically, the instructor should bring that quantity of apples which maximizes his profit. This quantity can readily be determined by calculating the total revenue, cost, and profit schedules and identifying the quantity and price which yields the largest profit. Often the students will ask the instructor how many apples he will bring. If the instructor plans to behave as a profit-maximizing monopolist he of course will not know the quantity he will bring until the market demand schedule has

[1]William J. Baumol discusses the importance of the demand function and the difficulty one faces in attempting to explain it. He notes that: "Demand functions, as they are defined in economic analysis, are rather queer creatures, somewhat abstract, containing generous elements of the hypothetical and, in general, marked by an aura of unreality." He adds: "Yet no matter how ingenious the circumlocutions which have been employed, they [economists] have been unable to find an acceptable substitute for the concept. For the demand function must ultimately play a critical role in any probing of the marketing decision process, and there is really no way to get away from it."

been determined and the related calculations have been completed. The instructor should use this question, however, to show that the demand function does not depend on the supply function.

After the profit-maximizing price and quantity have been determined, the instructor can make this the equilibrium price by bringing that particular quantity of apples to class. The supply schedule will normally be perfectly inelastic since the instructor will come to class with a fixed supply of apples.

Once the equilibrium price is determined, the instructor must sort out all the purchase agreements that indicate which students are willing to buy one or more apples at the price now determined. The sum of the apples demanded at the market price should, of course, equal the supply if the calculations are accurate. It is useful to prepare a graph of the demand and supply schedules and distribute copies to the class or display it on an overhead projector.

The fact that the instructor exploits his monopolistic position by limiting the apples he supplies to the profit-maximizing quantity will stimulate students to consider the effect on price and quantity of "allowing" other suppliers, students for example, free entry into the "apple market." The competitive equilibrium price will be reached only when supply has increased sufficiently to drive the price down to the point where monopolistic profits have been eliminated.

Suggested Questions to Draw Out Discussion

Below are some suggested comments to draw out discussion and enhance understanding.

1. What would have happened if the instructor had brought more or less apples? (shifts in the supply schedule.)
2. How would the demand schedule of an 8:30 a.m. class compare to an 11:30 a.m. class? Why would they differ?
3. Why were some people willing to pay a higher price (or lower) than others?
4. Why is the demand curve almost vertical at high prices and almost horizontal at low prices?
5. Since the instructor is a monopolist, what would have happened if several students had also brought apples to sell?
6. How low could the price fall if other suppliers, students for example, were allowed to bring apples.
7. What does movement down or up the demand curve reflect?
8. What would happen to the demand schedule if someone were giving peaches away free just outside the classroom?
9. If you knew how many apples the instructor was going to take to class, would your behavior have been different? If so, how? Why?
10. Since the instructor has made a profit, what should he do with it? What is the goal of nonprofit institutions.
11. What goals other than profit-maximization might the instructor have chosen? How should his behavior change to achieve these goals?
12. This experiment has used class time. What is the opportunity cost of this experiment?

Evaluation

The evaluation undertaken did not attempt to measure the effectiveness of the "Apple Experiment" in raising economic knowledge per se, but rather, the reaction of students in terms of its effectiveness as a pedagogical device.

The evaluation consisted of two parts, with 150 students participating. The first

part—two multiple-choice questions—yielded the following results:

1. What is your evaluation of the Apple Game as a medium of instruction compared to the regular classroom presentation (lecture)?
   - 86 a. Much better
   - 55 b. Better
   - 8 c. About the same
   - 0 d. Worse
   - 1 e. Much worse
2. As a means of learning, how effective do you feel this approach has been in enabling you to "internalize" the concept of demand?
   - 65 a. Very effective
   - 75 b. Effective
   - 9 c. Average
   - 1 d. Less than average
   - 0 e. Much less effective

The second part of the evaluation allowed the students to express in their own words their reaction to the experiment. As was to be expected from the answers to the multiple-choice questions, the results were overwhelmingly favorable.[2]

Characteristics and Benefits of the Exercise

1. The exercise has the following characteristics:
   a. The actual experiment can be run in one or two class periods.
   b. The experiment has carry-over benefits in that the data generated by the experiment can be used to teach numerous concepts.
   c. The experiment uses a convenient commodity.
   d. The experiment can be run with little assistance.
2. The benefits derived from the experiment are:
   a. The game used encourages learning at the behavioral levels of application, analysis and synthesis as well as the more commonly achieved knowledge level. The concepts of the demand function and equilibrium price are built upon an experience rather than a chart lifted from a textbook.
   b. The data generated by the experiment can be used as the basis for generating additional economic concepts in microeconomics.
   c. The experiment has wide applicability. It can be used in the college principles course, in an advanced microeconomics course or in a high school economics course.
   d. The experiment is easy to administer, it does not consume hours and hours of class time, and it does not require extensive preparation.
   e. It is fun! Perhaps the most important facet of this experiment is that the student enjoys what is going on in class. This interest-generating effect provides that scarcest of all resource inputs, motivation.

Algebraic Determination of Equilibrium

One of the useful aspects of this relatively simple game is the opportunity it presents to make sophisticated applications of the concepts involved. For example, students with

[2]A sample of specific comments together with: examples of the demand, total revenue, total cost, and total profit schedules generated in the experiment; graphs of these schedules; and a sample purchase agreement form will be sent to those who send a self-addressed envelope to me at Department of Economics, Krannert School of Industrial Administration, Purdue University, Lafayette, Indiana 47907.

good backgrounds in mathematics and statistics are eager to apply their skills by fitting a demand curve to the demand schedule generated in class. Once this has been done, the equilibrium price and quantity can readily be determined by the simultaneous solution of the supply and demand functions. Even more challenging problems are created when students seek to identify the equations of the total revenue and total profit functions generated in the apple game.

The following equation represents one attempt to identify a demand function which approximates the demand curve generated in a recent class:

$$P = 121.0\ Q_d^{-.3548}$$

where P equals price and Q_d equals the quantity demanded.[3] This equation was estimated over the range of prices from 15¢ through 30¢ using the demand schedule shown in Table 1. When plotted on a graph using log scales for both the price and the quantity axes, the estimated demand function is linear.

Table 1
Demand Schedule for Apples

Price	Quantity	Price	Quantity	Price	Quantity
.50	5	.33	34	.16	238
.49	5	.32	37	.15	326
.48	5	.31	37	.14	342
.47	5	.30	50	.13	366
.46	5	.29	52	.12	419
.45	9	.28	53	.11	456
.44	9	.27	68	.10	656
.43	10	.26	72	.09	691
.42	10	.25	101	.08	814
.41	10	.24	113	.07	966
.40	10	.23	117	.06	1106
.39	12	.22	133	.05	1561
.38	14	.21	137	.04	1825
.37	14	.20	186	.03	2289
.36	28	.19	206	.02	3192
.35	33	.18	216	.01	5384
.34	34	.17	228		

The equilibrium values of price and quantity can readily be determined for any supply of apples the instructor might bring. In the experiment which generated the demand schedule shown in Table 1, the cost per apple was 10 cents and the profit-maximizing quantity supplied was computed to be 186 apples. Therefore, the supply equation is: $Q_s = 186$. This supply equation and the estimated demand equation can be solved simultaneously to yield the equilibrium price and quantity:

Demand function: $P = 121.0\ Q_d^{-.3548}$
Supply function: $Q_s = 186$
Equilibrium condition: $Q_d = Q_s$
Solution:

$$P = 121.0 \times 186^{-.3548}$$
$$\log P = \log 121.0 - .3548 \log 186$$
$$\log P = 2.123 - .3548\ (2.2695)$$
$$\log P = 1.2792$$
$$P = 19 \text{ cents}$$

[3]Two textbooks which instructors will find useful in estimating equations are *Applied General Statistics*, by Croxton and Cowden, and *Methods of Correlation Analysis*, by Ezekiel.

This estimate differs from the actual equilibrium price associated with a quantity of 186 apples by 1 cent. The actual and fitted demand curves and the supply curve appropriate for profit-maximization are shown in Figure 1.

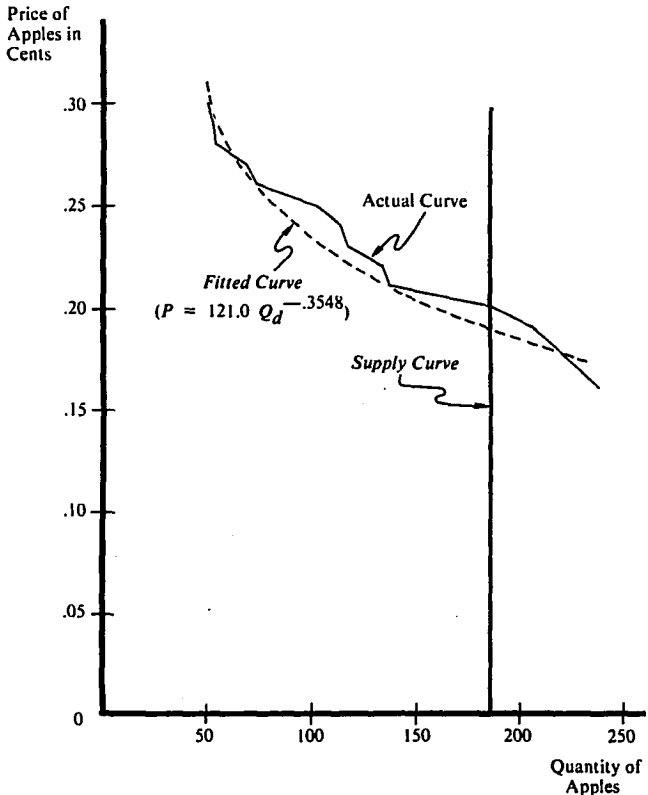

Figure 1

Relevant segments of actual and fitted demand curve and the supply curve.

Related Concepts

This experiment can be used to illustrate and explain many microeconomic concepts. Some of these concepts are:

1. Price and income elasticity
2. Total, marginal and average revenue
3. Total, marginal and average cost
4. Profit maximization
5. Opportunity cost
6. Consumer's and producer's surplus

7. Market organization
   a. Monopoly (including behavior of a perfectly discriminating monopolist)
   b. Perfect competition
   c. Monopsony (collusion among class members)

REFERENCES

1. William J. Baumol, *Economic Theory and Operations Analysis*, 2nd edition. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1965, pp. 210-211.
2. Frederick E. Croxton and Dudley J. Cowden, *Applied General Statistics*, 2nd edition. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1958, Chapter 20.
3. Mordecai Ezekiel, *Methods of Correlation Analysis*, 2nd edition. New York: John Wiley & Sons, Inc., 1956, Chapter 6.