Experimental Economics:
Putting Markets under the Microscope

Herb Taylor*

There is a famous joke about a physicist, an engineer, and an economist shipwrecked on a desert island with only a can of beans to eat. "I can help open it," volunteers the physicist. "I'll start a small fire, put the can in it, and compute how long it will take for the can to explode." "Great!" says the engineer, "I can calculate the trajectory that the beans will take and where we should stand to catch them." "Wait a minute!" the economist interrupts. "You fellows are approaching this whole thing the wrong way... First, assume we have a can opener..."

*Herb Taylor is a Research Officer and Economist in the Research Department of the Federal Bank of Philadelphia. The author thanks Vernon L. Smith for his informative discussion and very useful comments on an earlier draft.

Economists are notorious for making assumptions—assumptions that are at once crucial to their analysis and completely unrealistic. An economist discussing the bond market assumes that all market participants are "perfectly rational"; an economist analyzing the oil industry assumes that energy markets are "in equilibrium." Even
ECONOMISTS ENVISION HOW MARKETS WORK IN PRINCIPLE...

Think of any good or service—Ford Escorts or visits to the dentist. Over any little period, we can observe some quantity of this product being bought at some average price. For instance, we may find that in February, 2,127 Escorts were sold at an average price of $11,339. In the mind of an economist, both the price and the quantity that we see result from the workings of "the market" for Escorts in February. But what is this "market" and how does it work to determine the price and quantity sold?

The market for a product is comprised of those considering buying the product (the demanders), those willing to provide it (the suppliers), and the social arrangements and institutions that bring them together (the market mechanism). Typically, economists' analysis of the market includes a discussion of the factors affecting the overall demand for the product, the overall supply of it, and how the two are reconciled.

Generally the public's demand for a product is held to depend on its price, prices of related products, the income level of potential customers, and their tastes and preferences. The demand curve (Figure 1) illustrates a basic idea about market demand—the higher the price of a product, the smaller the quantity consumers will want to buy.

Suppliers' willingness to make a product available is usually held to depend on the price they can get for the product, the cost of the labor, raw materials, and other factors needed to produce it, and the available technology. The supply curve (Figure 1) illustrates a basic notion about market supply—the higher the price of a product, the larger the quantity producers will be willing to make available.

Having laid out demand and supply conditions in the market, economists add the assumption that the market settles at a price which clears it of any unsold demand or unwanted supplies. This assumption gives economists a theory about the price and quantity of the pro-
duct that we observe. The price we observe is the market-clearing price; the quantity we observe is the quantity that people want to buy and sell at that price ($P^*$ and $Q^*$ in Figure 2).

Behind the assumption that the market for a product always clears is the economists' vision of a market as a place swarming with potential buyers and sellers, each well-informed, each operating independently, and each bidding against all others in an effort to make trades. In such a competitive environment, a product's price is persistently pushed toward its market-clearing level. A price above the market-clearing level (say at $P^*$ in Figure 3) induces suppliers to produce more of the product than consumers want to buy, and the competition for customers forces suppliers to cut their prices. A price below the market-clearing level (say at $P_0$ in Figure 3) makes consumers want to buy more of the product than producers are willing to make available, and competition for the relatively scarce product induces some potential customers to offer a higher price for it. Only at the market-clearing price, where consumers want to buy exactly as much of the product as suppliers want to produce, do the incentives for buyers and sellers to adjust prices disappear.

**...BUT IT'S HARD TO SEE HOW MARKETS WORK IN REALITY**

If market competition were really keen enough to bring markets quickly into equilibrium at the competitive price, then assuming that markets were always at their competitive equilibrium would be no problem. But real world markets are not the all-out bidding wars among teeming numbers of competitors that economic theory posits. A few products are indeed offered by large numbers of small producers, but many—like autos and breakfast cereals—are supplied by a handful of large producers, and some—like computers and fast-food hamburgers—are provided by a few small producers and one giant. Trading practices and procedures often differ from the theoretical ideal, too. In the stock market traders bombard each other with bids and...
offers; but in the retail car market a salesman and a customer negotiate a price one-on-one; and in the grocery market the store clerk simply posts the price, leaving shoppers to choose between buying at that price and not buying at all. Competition may ultimately push most markets toward a competitive equilibrium. But undoubtedly some features of real-world markets slow the adjustment process, and some may even block it entirely. If so, then economists could improve their analysis by developing more realistic theories about how markets work.

Unfortunately, as a practical matter, economists have not made a great deal of progress in assessing how a market's characteristics affect its performance. It is not that they haven't thought long and hard about such issues. The theory of how a monopoly producer would restrict the supply of a product to keep its price above competitive levels dates back to the 1830s. Over the years, economists have also considered how markets supplied by just a few producers (oligopolists) might behave, and they have developed many alternative theories along the way. And recently economists have gone on to develop whole new theories of how different auction formats and negotiating strategies might affect market outcomes as well. But it has proven difficult for economists to assess the accuracy of these theories or to choose among the competing ones. And they have been able to offer few answers to questions like how other trading rules affect market performance, or how long it takes for a market to come to an equilibrium, or what path prices take on the way.

The problem is that economists have been trying to improve and refine their ideas about how markets work solely on the basis of what they observe in real world markets. These markets are usually so large and complicated that it is difficult—and sometimes impossible—for economists to collect the information or

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1For a more complete discussion of auctions and other trading arrangements, see Lorine Mester's "Going, Going, Gone: Setting Prices in Auction Markets" in This Issue.

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2The induced value theory upon which the design of experimental markets is based is presented by Vernon L. Smith in "Experimental Economics: Induced Value Theory," American Economic Review (May 1976) pp. 274-279; Smith's "Microeconomic Systems as an Experimental Science," American Economic Review (December 1980) pp. 923-955; and a presentation of the experimental market methodology and results which is considered the standard.
In a typical experiment, the researcher divides the market participants into demanders and suppliers. Before the market opens, she tells the demanders that any units of the commodity they buy during the trading period can be turned in for cash after the market closes. She then gives each demander a schedule indicating the redemption values of each unit he purchases in the market. Demander A’s redemption schedule, for example, may indicate that the first unit of the commodity that he buys in the market can be redeemed for $6.00, the second can be redeemed for $5.50, the third for $4.50, and so on. Likewise, the researcher informs the suppliers that after the market closes she will charge them for any units of the commodity that they sell during the trading period. She then gives each supplier a schedule indicating how much each unit he sells in the market will cost him afterwards. Supplier Z’s cost schedule, for instance, may tell him that he will be charged $8.00 for the first unit he sells, $8.40 for the second unit, $8.60 for the third, and so on. In markets for real-world commodities, each market participant knows the value that he himself puts on the commodity, but not the value others put on it. To mimic this feature in experimental markets, each demander knows only his own redemption schedule and each supplier only his own cost schedule. Setting the redemption and cost schedules in this way establishes precisely the supply and demand conditions in the market. (See CONTROLLING THE MARKET WITH THE “INDUCED VALUE” APPROACH, pp. 20–21.)

Before the trading period begins the researcher also announces the trading rules. Prices may be established in one of three basic ways: auction, negotiation, or posting. Auctions allow the most interaction between buyers and sellers, negotiation somewhat less, and posted prices the least. The auction format most often used in experimental markets is the “double” auction, where both buyers and sellers are free to announce bids and offers to the market at any time. In the negotiated price format, buyers and sellers bargain with each other one-on-one. A seller may deal with a number of potential customers during the marketing period, but he must deal with them one at a time. Usually in a posted-price market, each seller decides on the price he will charge before the market opens and he cannot change it during the market period. In some posted-price experiments, the buyers of the commodity are required to decide what price they will pay in advance and they cannot change during the market period.

Once the trading rules are settled, trading begins. A trading period can last anywhere from five to twenty minutes. Usually there are eight to ten participants in the market, sometimes more. Often, they are college students, though working businesspeople have participated. Sometimes trading takes place in a single room; many times participants are scattered around at different locations and communicate over computer terminals. Negotiated-price markets have been conducted both using private booths to allow face-to-face contact and using telephones.

During a trading period, no money or commodities actually change hands. When a demander and supplier come to an agreement, the researcher records the price and quantity at which the transaction is completed. When the market closes, the researcher computes each participants’ gains for the session. For instance, if Demander A and Supplier Z above happened to make their first transaction of the market period with each other, with Z selling A one unit at $4.50, then at the end of the period A would be credited with $1.50 (= $6.00 – $4.50) on the deal and Z would be credited with $2.50 (= $4.50 – $2.00). If Z agreed to sell A a second unit at that price, A would be credited with an additional $0.50 (= $3.50 – $4.50) and Z would gain with an additional $0.50 (= $4.50 – $4.00) as well.

Once the gains from the first trading session have been computed, the researcher usually runs several more trading periods under the same market conditions to see how market behavior evolves. The researcher then may alter some aspect of the market’s structure in order to observe the impact of that change on the market
Controlling the Market with the ‘Induced Value’ Approach

Creating Demand and Supply Schedules

Participants in experimental markets are trading an abstract commodity of no intrinsic value. The researcher creates market demand for the commodity by giving each designated demander a redemption schedule and creates market supply by giving each designated supplier a cost schedule.

To create the typical-looking experimental market demand schedule, the researcher could give three demanders the following redemption schedule:

**Redemption Schedule**

<table>
<thead>
<tr>
<th>For the:</th>
<th>The researcher will pay you:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st unit you buy</td>
<td>$0.60</td>
</tr>
<tr>
<td>2nd unit you buy</td>
<td>$0.50</td>
</tr>
<tr>
<td>3rd unit you buy</td>
<td>$0.40</td>
</tr>
<tr>
<td>4th unit you buy</td>
<td>$0.30</td>
</tr>
</tbody>
</table>

The researcher now knows that if the commodity is available at a price between $0.50 and $0.60, each demander will make a profit on the first unit he buys, but he will lose money on the second. So, pricing that demanders prefer more money to less, each will demand exactly one unit of the commodity at a market price in that range. Market demand, then, will be exactly three units in the $0.50 to $0.60 price range. Similarly, reasoning produces the rest of the market demand schedule.

To create the typical-looking experimental market supply schedule, the researcher could give three suppliers the following cost schedule:

**Cost Schedule**

<table>
<thead>
<tr>
<th>For the:</th>
<th>The researcher will charge you:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st unit you sell</td>
<td>$0.20</td>
</tr>
<tr>
<td>2nd unit you sell</td>
<td>$0.40</td>
</tr>
<tr>
<td>3rd unit you sell</td>
<td>$0.60</td>
</tr>
<tr>
<td>4th unit you sell</td>
<td>$0.80</td>
</tr>
</tbody>
</table>

The researcher now knows that if the market price of the commodity is between $0.20 and $0.40, each supplier makes a profit on the first unit he sells, but he loses money on the second. So, as long as the suppliers prefer more money to less, each will offer exactly one unit of the commodity for sale at a market price in that range. Market supply is therefore three units in the $0.20 to $0.40 price range. Similar reasoning produces the rest of the market supply schedule.

The demand and supply schedules created by the researcher for this hypothetical experimental market establish a competitive equilibrium price range of $0.40 to $0.50, indicated by the intersection of the two schedules in that range.
The Results of a Typical Market Experiment

In this particular experiment, the researcher, Vernon Smith, used the induced value approach to create the supply and demand conditions shown in the far left panel below. Under these conditions, the competitive market theory predicts that eight units of the commodity will be exchanged at a price of $2.10. The next two panels report what actually happened when the market was put into operation in two separate experiments of five trading periods each. In these experiments market participants bought and sold one unit of the commodity per "transaction." The number of units exchanged, as measured along the horizontal axis by the number of transactions, turned out to be somewhere between zero and nine in every period. The prices at which buyers and sellers transacted, as measured along the vertical axis, varied widely during the early trading periods of each experiment but by the last period of each experiment, all transactions were at or near the $2.10 equilibrium price.

NOTE: These results were originally reported in Vernon Smith "Bidding and Auctioning Institutions: Experimental Results," Bidding and Auctioning for Procurement and Allocation, ed. Yakov Amihud, New York University Press (1976), pp. 33-63. The figure appears with the permission of New York University Press.


outcome, everything else constant. When all of
the market experiments have been run, the mar-
ket participants are paid their total gains from
the session in cash.

Some Results of Market Experiments. Perhaps
the most comforting result to come from experi-
mental market studies is the strong tendency for
auction markets to achieve the market-clearing
price and quantity predicted by the competitive
market model. A double auction market with a
few buyers and sellers usually provides enough
competition to drive the commodity price to its
theoretical equilibrium price within a couple of
trading periods. It seems that only a monopoly
supplier can prevent the price of a product from
decreasing to the competitive level in an auction
market.1

On the other hand, results from experimental
markets operating under different trading rules
are less supportive of the competitive market
paradigm. Negotiated price markets seem to
converge less quickly and less directly to the
competitive equilibrium than auction markets.
Posted-price markets are even slower to adjust
and may not converge to the competitive out-
come at all. Generally when suppliers post the
prices at which they will sell, the average price
tends to stabilize above the competitive equilib-
rium level. When demanders post the prices
they will pay, prices tend to stay below their
competitive equilibrium level.

There is little in the way of formal theory to
explain why a market’s performance varies with
its trading rules, but experimental economists
have ventured the hypothesis that information
flows play a key role. As we move from a posted-
price to a negotiated-price to an auction-price
format, market participants have a greater and
greater opportunity to observe the terms on
which others are trading and offering to trade.
Access to this type of information seems to speed
the market’s convergence to the competitive
outcome. Nonetheless, the impact of informa-
tion on market performance is subtle. In one
experiment, for instance, market participants’
knowledge of each other’s cost and redemption
schedules impeded the convergence to a com-
petitive price. In another experimental market,
the researcher’s release of data on suppliers’
profits seemed to help them keep prices above
the competitive level.

Controlled market experiments are not only
helping economists isolate the conditions under
which markets achieve a competitive equilib-
rium, they are also helping economists sort out
what is happening when they do not. For instance,
monopolists in experimental posted-price markets
seem to achieve the higher price and
restricted quantity that traditional theory sug-
gests a profit-maximizer should, though conver-
gen to this situation may take quite a few
trading periods. Other experiments with small
numbers of suppliers in non-auction markets
suggest that oligopolists sometimes find some
arrangement for collusion so that they can boost
joint profits. For instance, when researchers ran
experiments designed to mimic the major fea-
tures of a barge transportation market and the
market for a gasoline additive in order to address
some regulatory issues, they found that ad-
herence to certain rules for posting prices in
these industries enabled suppliers to maintain
higher than competitive prices.

Researchers have also used market experi-
ments to strike out in new directions as they try
to refine economists’ understanding of the way
markets operate. In a very practical example,
study physically separated suppliers and
demanders of the commodity and then intro-
duced a group of “middlemen” who spent one
period in the suppliers’ room buying and the
next period in the demanders’ room selling.
They found that a market with a number of
“middlemen” was relatively quick to achieve a

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1This summary of experimental results is based heavily on
a classic review of the literature in this area by Charles R.
Cline, "Industrial Organization Theory and Experimental
Economics," Journal of Economic Literature (December 1983)
p. 1489-1527. Another, somewhat more technical, sum-
mary is by Vernon L. Smith, "Experimental Methods in the
167-173.
competitive equilibrium. Broader in their implications are the data from experimental markets which suggest that different supply and demand conditions produce different patterns of adjustment to equilibrium: when the market demand curve has a steep slope, for instance, prices tend to start out above the equilibrium price and then decline. Economists have just begun testing some rudimentary theories that attempt to explain these kinds of patterns.4

...AND HELP CLARIFY HOW ASSETS ARE PRICED IN FINANCIAL MARKETS

When economists turn their attention from product markets to financial markets, considerations like buyers' tastes and sellers' operating costs move into the background and expectations play the major role. In financial markets buyers and sellers are leading IOUs—promises of future money payments—and presumably the prices at which they are willing to trade are dictated by their expectations about the value of those future payments.

According to the efficient markets theory, competition among well-informed market participants always drives a financial asset's current market price to a level which reflects the best possible forecast of its future payment stream. So the current price of a share of IBM stock, for instance, presumably would represent the best available evaluation of the dividend stream that IBM will pay in the future. Likewise, if financial markets are efficient, then the current price of an AT&T bond represents the best possible evaluation of AT&T's promise to make the interest payments and pay the face value.

At least until recently, many economists maintained that financial markets were efficient, but the October stock market crash has created some doubts. It is hard to imagine that informed market participants' best estimate of all future stock dividends could plummet by 20 percent in one day. The crash helped resuscitate a competing theory that financial markets are subject to speculative bubbles that burst. An asset's price can be bid up above its intrinsic value—the value of its expected future payout—today because some market participants believe that others will be willing to pay still more for it tomorrow. For a while this belief is self-sustaining and the market booms, but eventually participants lose faith that prices can rise further and the market crashes.

Are financial markets efficient? Do real world asset prices simply reflect a well-informed market's expectation about assets' future payout stream? Or are financial markets subject to booms and busts unrelated to changes in assets' intrinsic values? Ironically, studies of real-world financial markets cannot offer much in the way of direct answers to these important real-world questions. Measuring market expectations is at the core of the problem. There are too many market participants, the possible future contingencies they must evaluate are too complex, and the constant inflow of new information changes their outlook too quickly for all of their expectations to be measured. But experimental market methods can be used to get at some answers. In an experimental asset market, the researcher can specify the payout stream of the financial asset, control the flow of relevant information to market participants, and then observe both individual and market responses. Such experiments have been run and have produced some interesting results.

**Constructing an Experimental Asset Market.** Experimental asset market designs are essentially multiperiod versions of experimental commodity price designs. In a typical experiment, the researcher issues each market participant some certificates which entitle the holder to dividends to be paid out at the end of each “week” of the market “year.” The market “week”

is actually a trading session lasting several minutes; a market "year" may consist of two, three, or more market "weeks." Each participant is told what the dividend payout will be on any certificate that she holds at the end of a period, or at least told the probability distribution of the dividends—for instance, trader C may be told that for any certificate she holds at the end of "week" two she has a 50-percent chance of receiving a $1.00 dividend and a 50-percent chance of receiving no dividend. Participants are not told what payouts the other traders can expect.

The experimenter also announces the trading rules: usually experimental asset markets are organized as double auctions, just as a real-world exchange would be. Trading then begins. The experiment usually runs for several market "years" with the researcher recording all bids, offers, and transactions. The experiment can then be repeated with some alteration in experimental design in order to provide data about the impact that changing some feature of the financial environment has on the market outcome.

Experimental Evidence about Asset Market Behavior. Results from simple asset market experiments are consistent with the idea that asset markets are efficient. But efficiency seems to be a fragile attribute. Studies have shown that relatively minor modifications to a simple design can easily destroy efficiency in an experimental asset market.

In the most basic asset market designs, the experimental market is run for several "years" of two or three "weeks" each, with the same weekly distribution of dividends every year. In these cases, traders tend to pick up the pattern in market prices quickly. After a few market years, each week's asset prices settle at levels consistent with the expected value of market participants' dividend streams over the rest of the market year. But in an experiment where the dividend distributions are systematically shifted from year to year, asset prices do not converge to efficient levels and fail to follow any discernible pattern. More dramatically, a batch of experiments in which the market year was simply extended to fifteen or more weeks consistently produced a speculative "boom-bust" cycle for the first couple of years. It seems that when an asset's maturity is a long way off, market participants lose sight of the dividend payments the asset is expected to yield over its lifetime and focus instead on the potential for reselling the asset at a higher price later. Only when the asset's time of maturity draws near does its expected payout become the focus of traders' attention. So there is a pronounced tendency for asset price bubbles to arise early in the market year, and for these bubbles to burst at the end as prices plunge to the efficient market price. In some of these experiments the subjects were businesspeople, not students, suggesting that it is lack of experience with a particular market situation, not an overall lack of business experience, which contributes to the speculative market behavior.

Variations in experimental asset market design have produced some other interesting pieces of evidence about the way financial markets work. In one set of experiments, some traders were given "inside information" about what future


dividends on the certificates would be. The researchers found that such information was quickly reflected in the asset's market price. In several experiments, futures markets were added to allow traders to buy and sell certificates for delivery one or two "weeks" in the future. Here researchers found that the addition of futures markets reduces price volatility and speeds the convergence to efficient pricing in the spot market. In another interesting twist, market participants were prescreened and divided into two groups, more risk averse and less. Each group participated in an experimental asset market of identical design. From this experiment, the researchers concluded that less risk averse traders, those who might be termed speculators, make prices more volatile, but also help the market achieve an efficient asset price more quickly.7

CONCLUSION
Experimental economics—observing the behavior of subjects in controlled market environments—is giving economists the opportunity to test their assumptions and theories about market outcomes in ways that the more traditional studies of "real world" markets cannot. Much of the experimental work that has been done so far is supportive of traditional economic theory. For instance, economists' standard assumptions that product markets are competitive and that asset markets are efficient are consistent with much of the evidence from experimental markets. On the other hand, experimental work has also demonstrated that there are some important gaps and shortcomings in standard economic theory. Observing the behavior of experimental markets underscores the fact that market adjustments are not always quick, smooth, or certain. Taking a more positive perspective, experimental economics not only points out the need to develop economic theory, but also helps economists frame new theories and provides the tools for testing them. For instance, market experiments have demonstrated that market information influences individuals' expectations and decisions in complex ways. But experiments have also provided some data to help refine economists' theories about individuals' expectations formation and decision-making processes. Some of this work has taken a look at some of the traditional expectations hypotheses in economics; some has tapped into psychologists' and other social scientists' theories of learning and decisionmaking.8

Experimental economics is a relatively new tool that researchers have developed to take a closer look at the way markets operate. So far they have put some relatively simple market structures under this new "microscope," but seeing even these simple structures up close is changing their perspective on how real world markets function.9

8Washington W. Williams, "The Formation of Price Forecasts in Experimental Markets." Journal of Money, Credit and Banking (February 1987) pp. 1-18 reports on attempts to survey market participants' expectations and model them directly. The evidence of adaptive expectations formation that Williams found is consistent with the notion that repetition of a market situation facilitates achieving the efficient markets outcome. The Journal of Business 59(4) pt. 2 (October 1986), in a special issue containing the proceedings of a conference entitled "The Behavioral Foundations of Economic Theory," gives some indications of how experimental economics work ties into that of other behavioral scientists.