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Economics as Lab Science: Nobel Prizes Give Boost to Growing Field

By James Case

A participant in some of the earliest market experiments on record, Vernon Smith shared the 2002 Nobel Prize in economics "for having established laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms."

Daniel Kahneman and Vernon Smith, who shared the 2002 Nobel Memorial Prize for Economic Science, were both cited for results obtained via laboratory experiment. Until quite recently, experimentation was deemed revolutionary in economics, and viewed with some distrust. Today, it is increasingly well regarded—thanks in large part to Kahneman, the Eugene Higgins Professor of Psychology and a professor of public affairs at Princeton's Woodrow Wilson School of Public and International Affairs, and Smith, a professor of economics and of law at George Mason University. Web pages devoted to experimental economics currently abound, the ten-year-old Economic Science Association publishes a journal titled *Experimental Economics*, and many of the older journals have begun to publish experimental results.

Kahneman wrote his landmark paper [5] on decision-making under conditions of uncertainty in the late 1970s with Amos Tversky, who would surely have shared Kahneman's honor had he not died in 1996. During a press conference held at Princeton to announce his Nobel, Kahneman expressed doubt that he would ever have won the prize "if exactly the same paper had been published in a psychological journal." Had it not appeared in a leading journal of economics, the paper would almost surely have failed to arouse the interest of economists in an alternative approach to the study of decision-making under uncertainty—one that focused on the shortcuts people take, and the biases they yield to, when making decisions in the absence of any obvious and systematic way to proceed.

"When people can't do what they want," Kahneman said at the press conference, "they do what they can." Apparently, this was "news to psychologists and economists." By confirming it experimentally, Kahneman fathered a subdiscipline known as behavioral economics, the purpose of which is to introduce psychologically more realistic models of economic agents into economic theory. Such models are particularly important, according to Princeton economics chair Gene Grossman, for understanding equity markets in which investor psychology plays an obvious role. Traditional market models, in which all participants are rational, self-interested, and calculating agents endowed with perfect information and the means to exploit it, simply don't explain the observed fluctuations of financial markets.

Early Market Experiments

Vernon Smith's involvement in experimental economics began in 1948, when he participated as a student in some of the earliest market experiments on record. Conducted at Harvard by E.H. Chamberlin, they were meant to test the validity of perhaps the simplest and most influential of all economic models—the one in which a rising supply curve meets a falling demand curve at a single point. In theory, the coordinates of that point predict the volume of trade that will occur, as well as the average transaction price. Chamberlin resolved to test that long accepted theory in the laboratory.

To create the requisite supply curve, he contracted to sell stated numbers of easily recognized tokens (so much for the first token, so much less for the second, and so on) to certain of his subjects at stated prices. These individuals would become the sellers in his token market. If offered a low redemption price, they could be expected to claim only a small (and highly predictable) number of Chamberlin's tokens. At a higher redemption price, they would demand more. Next, he created a demand curve by reversing the process. From the rest of his subjects—destined to become the buyers in his experimental market—he contracted to repurchase his tokens at specified prices. Finally, he turned both groups of students loose to negotiate among themselves.

As might be expected, the subjects broke up into small clusters, in which different average prices emerged. Moreover, the observed volume of trade exceeded that predicted by theory, while the average transaction price was lower. Whereas Chamberlin's experiments were largely ignored by contemporaries, Smith continued to dwell on them, suspecting that the divergence between predicted and observed results was due to the clustering of participants.

On receiving a PhD from Harvard in 1955, Smith joined the faculty at Purdue, where he designed and conducted a modified series of experiments meant to eliminate the effects of clustering. This he did by forcing each transaction to pass through a central "clearing house," as is done in most of the world's stock exchanges. The market-clearing mechanism he eventually settled on, now known as the "double-auction" mechanism, requires that both the highest outstanding bid and the lowest current asking price be on public display at all times. A transaction occurs whenever a prospective buyer agrees to pay the lowest current asking price, or a prospective seller agrees to accept the current high bid. In either event, the gap between "bid" and "asked" closes temporarily, and transactions continue until it reopens.

Years of experiment by any number of investigators suggest that double-auction markets cause bid and asked prices to converge to a common limit at least as rapidly as any rival mechanism. Moreover, the common limit agrees closely with the theoretically predicted transaction price, and the number of tokens traded approximates the predicted transaction volume.

Smith's early experiments have by now been replicated many times over. The observed level of agreement between theory and experiment is at least as good as that achieved in a typical undergraduate physics lab, provided that subjects are allowed to keep their substantial cash earnings. These conclusions remain valid even if the buyers and sellers are (relatively) few in number, meaning that one of the traditional hypotheses—the one stipulating that the market of interest contain large numbers of each—is superfluous. Moreover, the outcome is "efficient" in the not unrelated senses that (i) the buyers and sellers between them take home about as much of the experimenter's money as possible without violating the constraint that no buyer buys, or seller sells, at a loss, and (ii) the volume of transactions is about as large as it could be without violating the same constraint. A very small number of either buyers or sellers can, on the other hand, often exploit a plethora of potential trading partners about as effectively as could a secure monopolist or monopsonist*.

What emerges most clearly from the early experiments is that market outcomes are exceedingly sensitive to the rules governing individual transactions. Whereas the outcome of a double auction is accurately predicted by traditional theory, a small change in the prevailing rules, such as a reversion from Smith's rules back to Chamberlin's, or a severe shortage of either buyers or sellers, can seriously degrade market efficiency. Years of experimentation have identified a host of inefficient designs. The mere fact that a given market harbors both a supply curve and a demand curve is no guarantee of efficiency.

Market Bubbles

In recent years, Smith has turned his attention to financial markets, seeking to identify the causes of market bubbles, such as the one that afflicted the Nikkei index during the late 1980s or the NASDAQ index until March 2000. In a series of experiments dating back to the mid-1980s, he has developed a format that seems to work rather well.

Each of several subjects is seated at a computer terminal, and endowed with a sum of money, as well as a portfolio of "shares" in a fictitious commercial enterprise. Subjects are encouraged to communicate by computer, but forbidden to do so in any other way. Each share pays an identical dividend at the end of each 5-minute trading period, and (for ease of comparison) each experiment lasts for 15 trading periods. In some experiments, the dividends are chosen at random from the list $L = \{0¢, 8¢, 28¢, 60¢\}$, making them IID random variables with mean $\mu = 24¢$ and standard deviation $\sigma = 23.152¢$. In other experiments, the dividend is a guaranteed 24¢ per period. The subjects are encouraged, during each trading period, to trade shares for cash and cash for shares in hopes of increasing their total earnings.

In experiments with deterministic dividends, the initial \$3.60 "buy-and-hold" value of each share diminishes by 24¢ at the end of each trading period. When the dividends are chosen at random from L, the buy-and-hold value becomes a random variable whose expected value after n trading periods is still $\mu_n = (15 - n)\mu$, but whose standard deviation is now $\sigma_n = \sigma(15 - n)^{1/2} > 0$. During every trading period, the amount of cash in circulation equals the sum of the subjects' initial cash endowments, sometimes augmented by dividends distributed.

If there were a rule prohibiting the sale and purchase of shares, subjects could earn nothing at all on their cash reserves, and neither more nor less than the buy-and-hold return on their shares. In the absence of such a rule, subjects are free to speculate (wager) that shares will return more than the expected value of their buy-and-hold returns—by assuming the risk that they will return less—simply by paying more to obtain additional shares. This is exactly what is observed in most experiments, where transaction prices regularly exceed their (expected) buy-and-hold values by significant amounts.

Smith and his many colleagues have identified several factors that seem to encourage bubble formation in financial markets. In [4], for instance, Caginalp, Porter, and Smith found significant differences, depending on (i) whether dividends were distributed at the end of each trading period or deferred until the end of the final period, (ii) whether market participants had complete and up-to-date information concerning current supply and demand conditions, and (iii) how much cash was in circulation relative to the quantity of income-bearing assets. Some of their results are depicted in Figure 1.

In the three experiments (marked by circles) in which prices soar far above the straight line, there was an abundance of cash in the market from the beginning, augmented by dividends distributed at the end of each trading period; traders had incomplete information about evolving conditions of supply and demand. In the remaining three experiments (marked by diamonds) the opposite conditions prevailed, and no bubbles formed. By far the most influential factor was the quantity of cash in circulation as compared with the buy-and-hold value of the outstanding shares. At least a few speculators seem to be compelled to convert whatever cash they can put their hands on into income-bearing assets, whether or not those assets can reasonably be expected to justify the acquisition price.

Gunduz Caginalp, a professor of mathematics at the University of Pittsburgh (and editor of *The Journal of Psychology and Financial Markets*, in which Smith has published many of his recent results), has collaborated in the development of a system of ordinary differential equations meant to account for the shapes of the curves in Figure 1. When the underlying assets pay deterministic dividends, the equations are deterministic. When the dividends are stochastic, the equations are too, yet the expected value of the dividends still obeys a deterministic equation. A detailed derivation of the relevant equations can be found in [3]. The solutions of the equations are shown in [1] to compare favorably with experimental results obtained previously by Smith and Porter. The deterministic equations can be generalized to stochastic ones in various ways, the most satisfactory being highly nonlinear.

*As a monopolist is a single seller, a monopsonist is a single buyer.

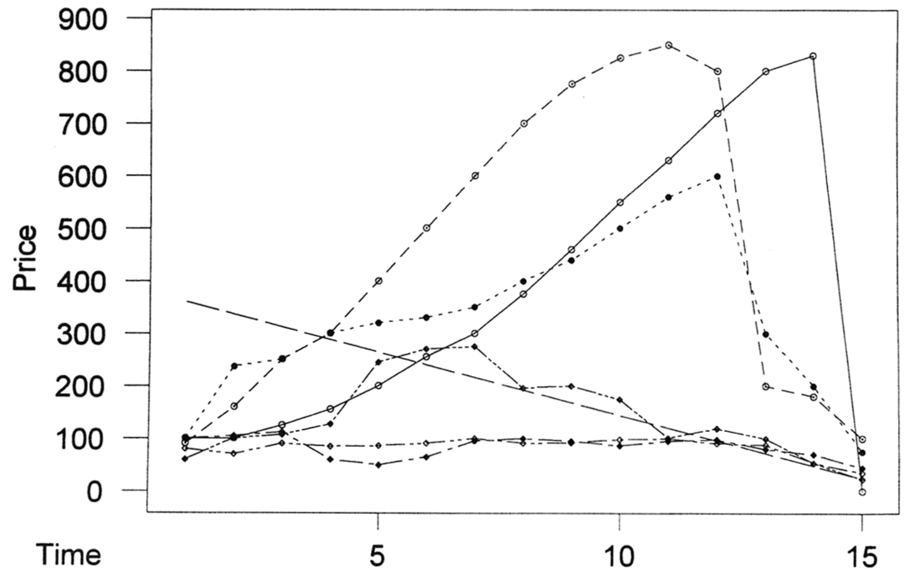

Figure 1. *Price evolution under conditions maximizing and minimizing bubbles. From [4].*

Accordingly, the existing theory of stochastic ODEs sheds little light on either the qualitative or the quantitative nature of the solutions. Simulation results are reported in [2],the main thrust of which is to confirm that excessive amounts of cash in circulation do indeed promote bubble formation in financial markets.

In a particularly interesting series of experiments [3], the most profitable traders from previous experiments were recruited to act as "market experts." These subjects derived their entire earnings from the accuracy of the asset price forecasts they were required to submit at the end of each trading period for the following two periods. Though forbidden to trade in the market themselves, they had instant access to all bids, asking prices, and contract prices. The results suggest that:

- The model equations and the market experts have similar predictive power.
- For predicting two periods ahead, the model equations are more powerful than any of the other forecasting methods tested.
- The ARIMA models performed worse than any of the other forecasting models tested.

Such experiments are of consequence because forecasting methods must function in real time in order to have practical value.

If excessive amounts of cash are indeed conducive to bubble formation, the so-called efficient markets hypothesis needs to be re-examined. First enunciated during the late 1950s, the EMH maintains that the free market cannot long or egregiously overprice negotiable assets because market prices automatically constitute the best possible estimates of asset values. Robert Schiller rather convincingly discredited the EMH in 1982, and again in his best-selling 2000 book *Irrational Exuberance* [6], where he predicted (as he had been doing at least since 1996) the demise of the dot.com and telecom bubbles—as well as the subsequent collapse of the Dow Jones and S&P 500 indices—in the process of demonstrating that market prices can persistently fail to reflect credible estimates of asset value. The fact that the evidence developed by Caginalp, Porter, and Smith tends to confirm Schiller's conclusions should make it that much more difficult for champions of the EMH to dismiss warnings of its unreliability.

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