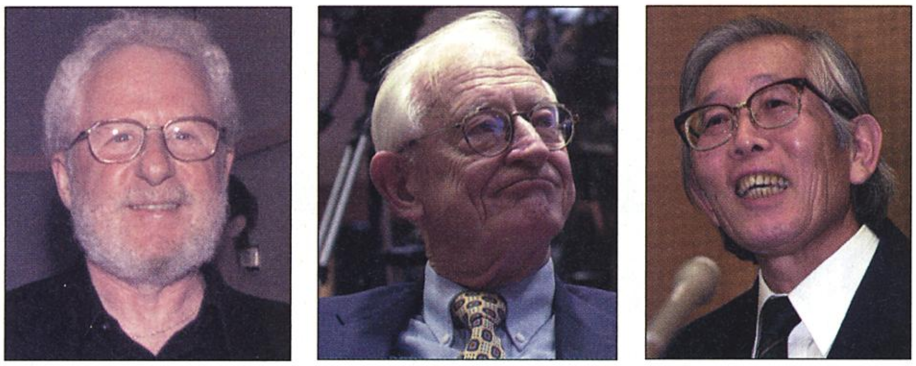


Plastic electronics. Alan Heeger, Alan MacDiarmid, and Hideki Shirakawa (*left to right*).

relative ease. That discovery created a field that has been hopping ever since.

Despite widespread agreement among chemists that the trio selected by the Nobel committee are worthy recipients, the selection is "rather controversial," says Stephen Forrest, a materials scientist at Princeton University. Many applications of plastic electronics, it turns out, are based on more recently discovered relatives of the metallic polymers that Heeger, MacDiarmid, and Shirakawa originally experimented with. These behave like silicon and other semiconductors. The Nobel committee chose not to honor the discoverers of these materials. Forrest and most others call that understandable. "Now the research has more emphasis on semiconducting polymers," says Zhenan Bao, a chemist at Lucent Technologies' Bell Laboratories in Murray Hill, New Jersey. "But it's all based on [Heeger, MacDiarmid, and Shirakawa's] early concepts."

Such concerns haven't clouded the moment for the Nobel recipients. "It's been a wonderful week," says Heeger, who adds that the prize came as a "complete surprise." MacDiarmid says that when he was told the news by a friend who saw it on the World Wide Web, he didn't believe it. "I thought it must be a hoax. But then I immediately got calls from reporters in France and Germany and thought maybe this is real."

The reaction has been particularly enthusiastic in Japan, where Shirakawa's selection is the first chemistry Nobel Prize awarded to a Japanese researcher in 19 years. It was front-page news the following morning, and throughout the week newspapers ran large photos, such as shots of Shirakawa receiving bouquets of flowers from students at Tsukuba University. And it prompted the editors at the *Mainichi Shimbun*, one of Japan's largest daily newspapers, to say they hoped the award would serve as a catalyst to "update the nation's dilapidated and cramped research facilities."

–ROBERT F. SERVICE

With reporting by Dennis Normile in Tokyo.

CREDITS: (CLOCKWISE FROM TOP LEFT) P. KLEIN/AP; D. LOH/AP; K. SASAHARA/AP; P. SAKUMA/AP; D. ENGLE/AP

ECONOMICS NOBEL

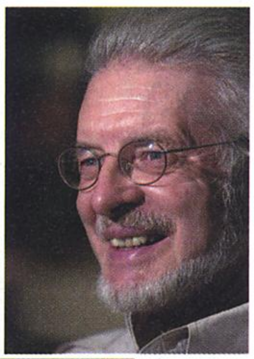
Dealing With Biases And Discrete Choices

To a biologist, "micro" means bacterium-sized. To an economist, it means people-sized. And this year's Bank of Sweden Prize in Economic Sciences, given in honor of Alfred Nobel, goes to two researchers who gave the field of microeconomics—the study of individuals' economic behavior—new tools to help draw conclusions from imperfect data.

As any scientist knows, statistical investigations are prone to error; inadvertent biases in choosing the sample or systematic errors can doom a project. The situation is even dicier for economists who take statistical samples of complex, semirational objects like human beings.

James Heckman of the University of Chicago wins half of this year's prize for coming up with ways to deal with selection biases. He developed two methods that formalize the handling of such biases, and then he used them to analyze things such as how wages affect the behavior of married women in the labor market.

Burton Singer, a demographer at Princeton University, says he believes Heckman's best achievements were not in the mathematical methods, but in what he was able to do with them. For instance, Heckman analyzed whether African Americans in Southern states like South Carolina were being helped more by education improvements or by the civil rights movement. "Government legislation had a more profound impact than schools per se," as did activism in the African-American community, says Singer, who notes that this surprising conclusion "had almost been ignored by the economic community."



Individual choices. James Heckman and Daniel McFadden (*inset*).

Heckman also thinks his most valuable work is applied rather than theoretical. "Economics is a field where you're solving real problems," said Heckman by telephone from Brazil, where he and his students are studying education and economics. "Being able to tackle real problems has always been an attraction for me."

Daniel McFadden of the University of California, Berkeley, tackled a different conundrum: how to quantify discrete choices rather than continuous ones. "Before McFadden did his work, economists were concerned with buying amounts—how many oranges a consumer buys, et cetera," says Charles Manski, an economist at Northwestern University in Evanston, Illinois. "But many important choices are discrete: Do you go to college or not? Do you buy an auto or not?"

McFadden had two insights that allowed him to tackle discrete problems. First, he came up with a way of comparing apples and oranges—or buses and cars, as the case may be. "For instance, if you choose to commute to work, you can go by bus, by rapid transit, or by auto," says Manski. "If you think of an auto as a bundle of characteristics—values for travel time, cost, and comfort—and a bus as a different bundle, you can compare them." Now that all these different choices were directly comparable, he could model how consumers behave when given those choices.

This is where McFadden's second insight comes in: He turned the discrete choices into more continuous, tractable functions by looking at them in terms of probabilities. For instance, a consumer might have, say, a 20% chance of taking a car to work, a 40% chance of taking a bus, and a 40% chance of taking rapid transit. This method, inspired by similar approaches used by psychologists, turned discrete problems into continuous ones—and it led to his helping design the Bay Area Rapid Transit system.

Marketers, sociologists, political scientists, and others are indebted to McFadden's methods, says Steve Lerman of the Massachusetts Institute of Technology: "The number of applications, in both marketing and economic analysis, must be in the thousands—maybe even higher."

–CHARLES SEIFE