The Science of Economics

by Kimm Fesenmaier

John Ledyard is an economist, but when he talks about the work that he and his colleagues who study socioeconomic systems at Caltech have completed over the last decade with the support of the Gordon and Betty Moore Foundation, he looks to astronomy for an appropriate metaphor. He's trying to find a way to explain the importance and utility of a suite of software they have developed.

"It's kind of like building a new, powerful telescope," Ledyard says. "It's not that all of the astronomers using that telescope are working on the same thing, but because of the larger telescope, they can all do a lot more, different work. What the Moore Foundation grant enabled us to do was to build a bigger measurement device."

The new software, along with funding, has enabled researchers to create and run experiments in the lab to test all sorts of market systems involving social interactions—everything from the effect of inequality on tax rates to the best way for the United Nations to auction off pallets of natural rubber in Vietnam.

"We bring big problems down to something you can actually study," says Charlie Plott, a pioneer in the field of experimental economics—the practice of testing economic theories by studying the way that people *actually* behave in situations that involve, for example, markets, voting, or group decision making, by creating those scenarios under controlled lab conditions using real-life incentives, such as money. "Creating experiments forces you to get into the detail; observing those experiments gets you even more into the detail. And the devil in these sorts of problems is always in the detail."

That has proven to be the case, for example, in the work Plott has done designing and improving what are known as combinatorial auctions, where bidders in different locations can make offers on individual or multiple units up for sale. The goal is to maximize efficiency, enabling the greatest profits while limiting bidder frustration. In the case of the auction for Vietnamese rubber, the United Nations wanted to run an auction where bidders located around the world could log into the system, see leading bids on pallets from a number of different plantations, and enter bids for those they were interested in buying.

Plott designed the auction system to continuously solve what computer scientists know as the knapsack problem: given a knapsack of a certain size, which objects of various weights and values do you pack to maximize the collection's value while limiting its weight? Looking at the rubber auction, some bidders wanted individual pallets while others were interested in specific combinations. The system had to be able to solve a complex combinatorial optimization problem almost instantaneously, sifting through all of the different permutations and combinations to quickly determine the best fill for the collective knapsack.

Once programmers in Plott's group made the auction system a reality, Plott tested it in the lab to see how it fared. Participants in his test auctions were motivated by monetary rewards to try to purchase certain units for the best prices. As a result of these experiments, Plott discovered several aspects of the system that needed tweaking. For one, he found that the auction should allow not only bids that would become leading bids but lower offers as well. The latter bids remained as potential partners for succeeding bids that needed partners in order to become leading. Plott also found that to keep bids coming at a reasonable pace he needed to implement a timing system that involved two clocks—one counted down five minutes from the last bid submitted while the other counted down 15 minutes from the last change in leading bids. When either clock timed out, the auction would be over. The first clock encouraged bidders to make offers in a timely manner, and the second ensured that bidders weren't just making small concessions, waiting for others to give more—that they would actually get a deal done.

Plott remembers logging in to watch the actual auction play out in real time. "I was sweating bullets for the first few minutes," he says. "Here was this auction that I had created, that the UN had put its faith in, and only one bidder was entering bids."

Eventually new bids started rolling in, and the system worked beautifully, he says, attributing much of the auction's success to the sophistication of the software that ran the market and the experiments he conducted to work out the bugs.

"You can philosophize all you want, but you can't imagine exactly what has to be done until you actually see it," says Plott, who has also designed auctions to sell water rights, fleets of cars, the procurement of transportation services for getting disadvantaged students to school, and the rights to fish in certain areas off the coast of Australia, to name a few. "When you treat economics like a science—when you put in the time—you get long-term benefits."

Multistage Steps Up

As experimental economics has grown and developed as a field, so too has the level of complexity of the experiments its practitioners conduct. Many Caltech economists are now interested in complex systems that involve not only markets and economic decision making but also other behaviors and considerations such as voting, bargaining, committee deliberations, and abstract games.

In order to run lab experiments on such complex systems, researchers found about a decade ago that they needed a new modular software platform that could be customized to include any number of those considerations. As director of Caltech's Social Science Experimental Laboratory at the time, Tom Palfrey oversaw the development of this platform, known as Multistage.

"Multistage integrates all of these things that had been previously done as separate components," says Palfrey. "People would study voting alone, or people would study bargaining, or auctions, or markets. Our idea with this software was to pull these things together under a wrapper where you

could look at all of these things all at once along with their interactions."

In one study, Palfrey used the software to analyze what happens when people are allowed to buy and sell votes as they would commodities. Political scientists and economists have suggested such open trading of votes as a possible way to deal with the theoretical situation where a minority of voters cares intensely about an issue but is defeated by a majority of indifferent voters. But the notion of trading votes has remained controversial in the field, as some have suggested such a practice could lead to corruption.

In the lab, Palfrey gave participants a set amount of time to trade votes on an abstract issue. They could buy and sell votes freely, and each participant was assigned different monetary payouts for various vote outcomes, setting up a situation in which people sometimes had opposing preferences.

In the end, Palfrey and his collaborators found that prices for votes converged to equilibrium prices—those at which everyone in the market would cease trading, happy to stop buying and selling—and that those prices were determined by a single voter who valued the issue most. That meant that in an effort to accumulate a controlling share, one voter was always willing to pay a price that was higher than anyone else was willing to pay.

"The idea behind a market for votes is to allow the outcome to reflect intensity of preference," says Palfrey, "and it does that, but we found that it reflects only the intensity of preference of one person. So instead of being more like a democratic outcome, it turns out to be an outcome where one person basically becomes a dictator by buying the majority of votes."

Making a Good Match

Leeat Yariv (above) also used the Multistage software to look at an entirely different set of questions—those related to matching problems. These are situations in which people need to be paired with other people, positions, or institutions. The goal is to make so-called stable matchings—those where no one would prefer to be alone rather than paired, and no pair's members would prefer to be with one another over their respective matches. A well-known centralized matching system is the one that, following a fairly simple algorithm, pairs medical students with residency programs.

But there are also decentralized matching markets, where people act freely and try to make their own pairings. Think of the dating scene, for example, where any number of possible pairings is possible, and in which it is extremely difficult to say whether an optimal match has been made. For researchers, it is also hard to collect data that capture the whole decision-making process from beginning to end.

Yariv has studied this type of problem using two approaches. First, she identified a decentralized matching system that actually *does* track the kind of information she needs: the adoption process in the United States, specifically when aided by an online facilitator. An adoption facilitator serves as a channel through which potential adoptive parents can see information related to children up for adoption and apply to be their parents, giving birth mothers a pool from which to select.

Since 2004, Yariv and her collaborators have been working with data from one such facilitator to try to understand how decentralized markets operate. "Using the data, we could both estimate the model of matching and get at very basic things like the preferences people have for children's characteristics," she says.

What they found was a strong preference for Caucasians, girls, and babies who are closer to birth. "The findings make us think about how to design these processes better, so that more children are adopted. Now that we know the preferences, we can start thinking about how to redesign things," she says.

The data also showed that approximately 17 percent of accepted applications were from same-sex couples.

"These kinds of results offer some insight about the potential effect of policy," says Yariv. For example, in some states, same-sex couples are not allowed to adopt children. Had the facilitator that Yariv and her collaborators studied banned same-sex couples from its pool of applicants, the number of successful adoptions it made during the study would have dropped by 9 percent.

In tandem with the adoption study, Yariv and her colleagues, including Caltech professor of economics Federico Echenique, re-created centralized and decentralized markets in the lab, aided by the Multistage software. First they assigned each participant to be either a food (e.g., apple, banana, cherry) or a color (e.g., red, green, blue) and gave everyone a matrix of payoffs for potential pairings (e.g., apple–red = $5, banana–red = $3, banana–blue = $10). In the decentralized setup, participants were then allowed to make nonbinding offers to anyone in the market by entering offers online. For example, a red participant might get a note on his computer screen asking if he would like to match with banana, and would have to decide whether to accept that offer.

In the centralized setup, half of the participants—either foods or colors—were asked to input their offers sequentially. They were prevented from making offers to anyone who had already rejected one of their offers. The other half of the participants simply accepted or rejected the offers. With these restrictions in place, the system emulated what happens using an algorithm like the one governing the National Resident Matching Program.

In the end, the researchers found that participants managed to establish a stable matching nearly twice as often in decentralized markets relative to their centralized counterparts. This was wholly unpredicted by theory. Indeed, centralized clearinghouses are often put in place with the very goal of implementing stable outcomes.

It's Complicated

Ledyard points out that before Caltech's new software suite was developed, it would have been extremely difficult or impossible to test such intricate systems. "In order to run these complex markets in the laboratory we actually need more complicated software than what the NASDAQ needs to run its markets," he says. "We need to keep track of more things and we need to do it faster."

In his own group, Ledyard has developed additional software to study the problem of overfishing in fisheries—an issue that requires him to look not only at quantities of fish but also at environmental considerations and the effect of buyback auctions, where fishermen are invited to name a price that they would take to stop fishing, and some number of those fishermen are paid to take their boats out of the water.

Based on the results of his experiments, he has recently made concrete recommendations for how to improve buyback auctions, such as making them uniform-price auctions where fisheries let fishermen know that they will pay all of those leaving the water the same price—the highest bid that removes the desired number of boats, rather than their individual bids. This has been shown to produce more honest bidding and results in the removal of more boats than a traditional auction system. Ledyard hopes in the future to use the same software he has used for the fishing problem to study global-warming treaties—the bargaining processes involved, whether it makes sense to use cap-and-trade programs, and how to arrive at good policies.

"The work in all of our groups is ongoing," says Ledyard. "But it would have been extremely difficult, if not impossible, to get started without the Moore Foundation's help." e&s

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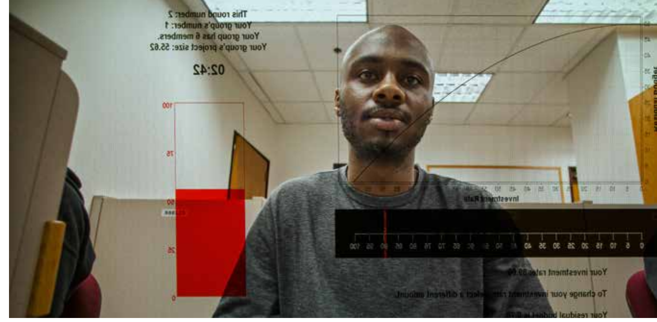

Subjects at Caltech's Social Science Experimental Laboratory (SSEL) participate in economic studies using the Multistage software developed at the Institute.