This 'fix' for economic theory changes everything from gambles to Ponzi schemes

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Whether we decide to take out that insurance policy, buy Bitcoin, or switch jobs, many economic decisions boil down to a fundamental gamble about how to maximize our wealth over time. How we understand these decisions is the subject of a new perspective piece in *Nature Physics* that aims to correct a foundational mistake in economic theory.

According to author Ole Peters (London Mathematical Laboratory, Santa Fe Institute), people's real-world behavior often "deviates starkly" from what standard economic theory would recommend. Take the example of a simple coin toss: Most people would not gamble on a repeated coin toss where a heads would increase their net worth by 50%, but a tails would decrease it by 40%.

"Would you accept the gamble and risk losing at the toss of a coin 40% of your house, car and life savings?" Peters asks, echoing a similar objection raised by Nicholas Bernoulli in 1713.

But early economists would have taken that gamble, at least in theory. In classical economics, the way to approach a decision is to consider all possible outcomes, then average across them. So the coin toss game seems worth playing because equal probability of a 50% gain and a 40% loss are no different from a 5% gain.

Why people don't choose to play the game, seemingly ignoring the opportunity to gain a steady 5%, has been explained psychologically—people, in the parlance of the field, are "risk averse". But according to Peters, these explanations don't really get to the root of the problem, which is that the classical "solution" lacks a fundamental understanding of the individual's unique trajectory over time.

Instead of averaging wealth across parallel possibilities, Peters advocates an approach that models how an individual's wealth evolves along a single path through time. In a disarmingly simple example, he randomly multiplies the player's total wealth by either 150% or 60% depending on the coin toss. That player lives with the gain or loss of each round, carrying it with them to the next turn. As the play time increases, Peters' model reveals an array of individual trajectories. They all follow unique paths. And in contrast to the classical conception, all paths eventually plummet downward. In other words, the approach reveals a fray of exponential losses where the classical conception would show a single exponential gain.

Encouragingly, people seem to intuitively grasp the difference between these two dynamics in empirical tests. The perspective piece describes an experiment conducted by a group of neuroscientists led by Oliver Hulme, at the Danish Research Center for Magnetic Resonance. Participants played a gambling game with real money. On one day, the game was set up to maximize their wealth under classical, additive dynamics. On a separate day, the game was set up under multiplicative dynamics.

"The crucial measure was whether participants would change their willingness to take risks between the two days," explains the study's lead author David Meder. "Such a change would be incompatible with classical theories, while Peters' approach predicts exactly that."

The results were striking: When the game's dynamics changed, all of the subjects changed their willingness to take risks, and in doing so were able to approximate the optimal strategy for growing their individual wealth over time.

"The big news here is that we are much more adaptable than we thought we were," Peters says. "Theseaspects of our behavior we thought were neurologically imprinted are actually quite flexible."

"This theory is exciting because it offers an explanation for why particular risk-taking behaviors emerge, and how these behaviors should adapt to different circumstances. Based on this, we can derive novel predictions for what types of reward signals the brain should compute to optimize wealth over time" says Hulme.

Peters' distinction between averaging possibilities and tracing individual trajectories can also inform a long list of economic puzzles— from the equity premium puzzle to measuring inequality to detecting Bernie Madoff's Ponzi scheme.

"It may sound obvious to say that what matters to one's wealth is how it evolves over time, not how it averages over many parallel states of the same individual," writes Andrea Taroni in a companion Editorial in *Nature Physics*. "Yet that is the conceptual mistake we continue to make in our economic models."

More information: The ergodicity problem in economics, *Nature Physics*, DOI: 10.1038/s41567-019-0732-0 , nature.com/articles/s41567-019-0732-0

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