Time to move beyond average thinking

Taking the expectation value of an observable is not the same as averaging over time.

In 2012, Tom Murphy, an astrophysicist at the University of California, San Diego, wrote about a recent conversation with an eminent economist over dinner. His blog post ‘Exponential economist meets finite physicist’ (<https://go.nature.com/2XqS3aE>), which is still read and shared widely nearly eight years after it was written, captures a sentiment that resonates with many physicists: if resources are finite, how can economic growth be indefinite?

Natural scientists tend to put stock in the laws of thermodynamics, and therefore struggle to get to grips with the credo of never-ending economic growth. For all the ingenious innovation and services out there, surely economic activity cannot be untethered from basic material and energy resources? After all, there can be no free lunch. And since we know these resources are finite (we assume we can keep this conversation serious, by confining it to planet Earth), we must therefore expect to run into problems sooner or later.

When confronted with this argument, many economists tend to get defensive. They will readily acknowledge the limitations of excessively narrow definitions for measures of economic performance, while also pointing out that much of the criticism they receive is itself based on caricaturing the work that they do.

It is true that the reality of economics is both messier and richer than it gets credit for. Moreover, economists rightly point out that it is very easy to take the actual benefits of economic growth for granted: the experience of countries that have gone through a prolonged economic contraction should be a cautionary tale for anybody that wants to play fast and loose with people’s livelihoods.

Still, as the issue of climate change becomes ever more urgent, it is notable that natural scientists’ argument that economists ignore the limits of growth is, essentially, the basis upon which the case for action put forward by environmental activists such as Greta Thunberg rests. Given their significant institutional weight, such economists therefore have a special responsibility to engage in this debate: failure to do so will not do much to quell the politics of polarization that has taken hold in so many countries of late.

Image courtesy of Pasquale Cirillo.

The cultural clash that exists between branches of physics and economics is largely a product of their different histories, and therefore the distinct conceptual foundations upon which each is built. Much of economic theory — certainly the branch of the discipline that is usually referred to as expected utility theory — is rooted in ideas of risk and randomness developed in the seventeenth century, as part of the formulation of probability and statistics. For example, we now instinctively calculate expectation values with the implicit belief that they reflect what happens over time.

Two hundred years later, in the 1850s, the development of statistical mechanics by James Clerk Maxwell and Ludwig Boltzmann led to this question being explored more carefully: under what circumstances is the expectation value of a quantity informative of what happens over time? Famously, in the cases of the thermodynamic behaviour of gases, this ergodic hypothesis, as it has since become known, holds. But proving ergodicity mathematically is generally very hard: in fact, for any system that finds itself out of equilibrium it is safe to assume it is non-ergodic.

In a [Perspective](#) in this issue, Ole Peters recounts this history before revisiting the question of ergodicity in the simplest of possible economic models: gamble evaluations. Along with colleagues at the London Mathematical Laboratory, he

has worked on developing a theoretical framework that naturally accounts for much of the ‘irrational’ economic behaviour that is normally patched up with psychological arguments about human behaviour.

‘Ergodicity economics’ makes a number of empirically testable predictions, and as Peters describes, one of these has already been the subject of an intriguing experimental investigation. Perhaps more encouragingly, it also offers an opportunity to re-interpret a number of other puzzles that beset the current economic formalism, and as Peters points out, it does so in a way that is more closely aligned with our moral intuitions.

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. Yet that is the conceptual mistake we continue to make in our economic models. By correcting for this error when studying aggregate systems, it also becomes possible to make a statement that is pertinent to the issue Murphy was concerned with in 2012: a measure such as gross domestic product, an ensemble average, does not reflect individual wellbeing, a time average. There is therefore no need to optimize it blindly.

Another mindset is possible: it requires moving beyond average thinking. □

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