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# Economists' views on the ergodicity problem

**Jason N. Doctor[1], Peter P. Wakker[2]✉ and Tong V. Wang[2]**

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Peters'[1] Perspective on the possible role of ergodicity in the formalism of economics provides a fresh take on an established problem, yet his remedies are unjustified and give an inaccurate impression of the economics field as a whole (Supplementary Information).

Expected utility (EU) concerns choices between probability distributions over outcomes. Utility $U$ assigns a subjective value to each possible outcome. Then the probability distribution with the highest EU value (probability-weighted average $U$) is chosen. This procedure involves imagining consequences that may not happen. We do such scenario planning every day, and—contrary to Peters' claims[1]—we need not invoke 'parallel universes' to do so.

Peters shows that his ergodic model, when assuming ergodicity, has some mathematical properties similar to EU. Peters criticizes EU, and then all of economics, for supposedly assuming ergodicity implicitly (Supplementary Information). Yet this dynamic assumption is outside the scope of EU as a static theory. Furthermore, mathematical isomorphisms between intertemporal and other choices have been demonstrated previously[2].

Peters approvingly cites an experimental work by Meder et al.[3], but we must note that static EU is inappropriately applied to a dynamic context there (Supplementary Information). Specifically, Meder et al.[3] report inconsistencies in EU-utility measurements that, in turn, are interpreted as a falsification of EU. Such falsifications of EU are not new[4], however, and numerous other falsifications of EU have been reported in the past[5]. Many economists have therefore used improved theories, including prospect theory[6], which have found widespread use[7]. Peters' citation of a falsification of EU to criticize all of economics is therefore unwarranted. Also, although some ergodic predictions seem to be faithful to preference, others do not. Would a person ever prefer a process that, after three rounds, diminishes wealth from US$10,000 to 0.5 cents over one that yields a 99.9% chance of US$10,000,000 and otherwise US$0? Ergodic theory predicts that this is so because the former has a higher average growth rate (Supplementary Information).

Peters suggests that intertemporal growth is the primary factor that explains economic phenomena. He suggests that the dependence of utility and other attitudinal characteristics on persons is not important, as with objects studied in physics. But kicking a person is not like kicking a rock—different people react differently. We cannot predict human choices directly from stimuli. Thousands of economic studies find interpersonal variations[8], and they work well to explain behaviours such as undersaving and smoking, to make only two examples.

Although it is true that our consumption of economic goods develops over time, time is not the most central aspect of all our decisions. For many of our decisions, other equally ubiquitous aspects such as risks, strategy and the balancing of pros and cons are more central. Just because something is ubiquitous, it should not be confused with being explanatory; for example, we can argue that everything consists of molecules, but it is not a reason to think that all questions in economics, geography and throughout life should be answered by molecular dynamics. We therefore caution that there is no single paradigm that is superior for answering all (economic) questions.

Economists use static EU for static decisions, when dynamics are not central. Otherwise, a dynamic model is used. Additive or multiplicative growth are specified whenever appropriate, and usually without the need to assume ergodicity. Such examples are common throughout finance and economics, including life-cycle consumption theory or Grossman's model of health[9]. In such cases, it is the consumption paths that are optimized, and not just the entire final wealth state, as in Peters' models.

We conclude with an appeal to physicists to think carefully about human behaviour to help improve economics.

## Online content

Any methods, additional references, Nature Research reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41567-020-01106-x.

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[1]Sol Price School of Public Policy, University of Southern California, Los Angeles, CA, USA. [2]Erasmus School of Economics, Erasmus University Rotterdam, Rotterdam, the Netherlands. ✉e-mail: wakker@ese.eur.nl