

# She who understands the fruit fly would do more for economics than Adam Smith: introduction to the special issue

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*“He who understands baboon would do more towards metaphysics than Locke”*

– Charles Darwin, Notebooks

In honor of Darwin, I summarize this volume as,

She who understands the experimental evolution of fruit flies, bacteria, and slime mold would do more towards the future of economics than Adam Smith.

In a previous paper, my co-authors and I propose experimental evolution as a novel, powerful methodology to improve economics (Burnham et al. 2015). This special issue of the Journal of Bioeconomics has the same title as the original paper, “Experimental Evolution and Economics.” This issue expands on the original paper via multiple, complementary approaches including historical papers, original empirical work, economic interpretations of prior work in experimental evolution, and innovative proposals for future studies.

## 1 Economics is in crisis; experimental evolution can help

Economics is a field in quiet crisis. The cause of the crisis lies at the foundation of the field, in a controversial, and empirically-challenged, set of axioms regarding human nature.

Economics is a Cartesian field where results are derived from a small set of assumptions. As such, the unresolved issues regarding the axioms are particularly crippling

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**Table 1** The axioms of economics are controversial

| Economic axiom  | Mainstream economic view  | Behavioral economic view   |
|-----------------|---|--|
| Decision-making | People optimize by picking the best, feasible option  | People often make bad choices  |
| Goods           | People have consistent likes and dislikes   | People have inconsistent likes and dislikes  |
| Risk            | People make good, consistent decisions regarding risk   | People make bad, inconsistent decisions regarding risk   |
| Time            | People make good, consistent decisions involving multiple time periods. Often this assumption takes the form of exponential discounting | People make bad, inconsistent decisions involving multiple time periods  |
| Other people    | Individuals care about themselves and derive no pleasure or pain from the fate of others  | Individuals are sometimes altruistic in sacrificing for others, and at other times, individuals are spiteful in obtaining pleasure from other individuals' displeasure |

to the field. 'Preferences' serve as the foundation of economics. Canonical economics assumes that people have preferences (i.e., tastes) over goods, risk, time, and the happiness of others, and given those preferences, each individual makes the best decisions for herself or himself.

Cartesian systems are powerful because they allow strong, unambiguous conclusions (e.g., If two lines intersect, then they intersect in exactly one point). Economics is unique among the social sciences in deriving results from a set of axioms. However, because Cartesian systems draw strong inferences, it is essential that the axioms be incontrovertible.

Economics is justified, therefore, in making strong statements only if the axiomatic assumptions regarding human nature are correct. However, there is a substantial behavioral economic literature challenging each and every axiom of economics (see Table 1).

In addition to being disputed, the axioms of economics are taken as given from outside the field ('exogenous'). Therefore, economics faces a serious barrier to progress because preferences, the foundation of the field, are 'axiomatic, controversial, and exogenous.' (Burnham et al. 2015)

Is free trade good? The conclusions of David Ricardo, and other economists, regarding the consequences of free trade are valid only insofar as the axioms are correct. Every economic theory is similarly speculative, because all economic theorems are derived from axioms that are unproven.

The crisis in economics is caused by its foundation in controversial, and unproven, axioms regarding human nature. Experimental evolution allows the empirical study of these core assumptions, and, as such, holds tremendous potential to improve economics.

## 2 Summary of the works in this volume

### 2.1 Adam Smith's views on evolutionary impacts on human economic behavior

Adam Smith is 'the father of modern economics'. Two papers in this volume argue that Adam Smith may also deserve the title of the father of evolutionary economics. Most famous for his second book, *An Inquiry into the Nature and Causes of the Wealth of Nations*, Adam Smith's first book, and perhaps his own favorite among his works, was *The Theory of Moral Sentiments*.

Vernon Smith describes the historical context of Adam Smith's life and intellectual works. This paper then applies Adam Smith's concept of 'self-love', the fundamental axiom of human behavior in '*Sentiments*' regarding motivation, to a variety of issues including modern experimental economic work. Maria Pia Paganelli reveals Adam Smith's implicitly evolutionary mindset, particularly in the role that wealth plays in shaping the payoffs to various institutional structures.

### 2.2 Theoretical applications of evolution for finance

Allen Orr and, in a related paper, Andrew Lo, Orr, and Ruixun Zhang, apply ideas from evolutionary biology to theories of portfolio growth. The Kelly criterion plays a central role in the results of these two papers. Whereas traditional portfolio growth theory focuses on absolute wealth, an evolutionary focus on relative wealth leads to novel insights into optimal investment decisions in uncertain environments.

### 2.3 Economic implications of prior experimental evolutionary work

The Black Queen Hypothesis specifies settings where natural selection favors the loss of the ability of an organism to perform a vital function. In such cases, the organism necessarily relies upon some other organism to provide the needed function and its products. The Black Queen hypothesis thus provides a mechanism for overcoming the threats of competition and cheating in order to evolve specialization, trade, and cooperation, ideas central to economics. J. Jeffrey Morris and Eric Schniter explore the implications of the Black Queen hypothesis for the provision of public goods and other aspects of cooperation, concluding by arguing for a Black Queen informed economics.

The Long Term Evolution Experiment (LTEE) directed by Richard Lenski has studied the evolution of bacteria in a human-designed, novel environment for over 60,000 generations. As such, it is the longest running study of experimental evolution. Given that the organisms involved are bacteria, are there any lessons for economics from the LTEE? In an admittedly speculative paper, Richard Lenski and I argue that yes, there are indeed lessons for economics and for human behavior in general. While the phylogenetic distance between humans and bacteria is enormous, the process of natural selection is the same for all organisms. Furthermore, like the bacteria in the LTEE, humans live in a novel environment created—although not *designed*—by people.

## 2.4 Original experimental evolution studies relevant to economics

Natural selection favors evolution that increases biological fitness. Two original, experimental evolutionary studies in this issue illustrate that, in practice, however, the path of evolution is not obvious or predictable.

Mellissa Marcus, Dave Stephens, Aimee Dunlap and I study fruit flies that are placed in an environment where they can lay their eggs on different colored patches. While the flies are free to lay eggs on any color, founder eggs for the next generation are harvested only from the aqua-colored patches. Whereas economics takes tastes ('preferences') as fixed by some unspecified process, this experiment sought to evolve flies with a 'taste for aqua'. In this experiment, the evolved flies do indeed lay more eggs on aqua, but they also lay more eggs on other colors, demonstrating no evolution for an increased preference for aqua.

In a second study with a similar message regarding the subtleties of evolution, Mike Travisano, Michihisa Maeda, Fumie Fujii, and Toshiaki Kudo report that microbes moved to a novel environment sometimes evolve to have dramatically lower fitness. Rather than evolving to prosper in the new environment, under certain conditions, these microbes collapse in population size to near extinction.

## 2.5 Future experimental evolution studies

Finally, I have encouraged leading scholars to propose exciting evolutionary studies that could be performed in the future. Along with Jay Phelan, I contribute work on the mismatch between human genes and modern industrialized societies. Brian Hare proposes selection experiments to differentiate competing hypotheses regarding aggression. Jay Phelan outlines experimental evolution studies of aging using k-selected species (e.g., bats) to complement seminal experimental aging studies with r-selected species (e.g., fruit flies). Robert Trivers discusses experimental modes of attacking malaria via mosquitoes. Paul Zak outlines studies of the evolution of cooperation and trade with a particular focus on the role of oxytocin in these behaviors.

## 3 The future of experimental evolution and economics

Edward O. Wilson states in *On Human Nature* (1978) that economics needs to integrate with Darwinian theory to move forward, "Without it [Darwinian theory] the humanities and social sciences are the limited descriptors of surface phenomena, like astronomy without physics, biology without chemistry, and mathematics without algebra. With it, human nature can be laid open as an object of fully empirical research, biology can be put to the service of liberal education, and our self-conception can be enormously and truthfully enriched (p. 2)."

The current schism between mainstream and behavioral schools is one manifestation of the failure to incorporate Darwinian theory into economics. With experimental evolution, every axiom of economics can become, in EO Wilson's words, 'an object of fully empirical research.' Experimental evolution connects economics to myriad areas in the natural sciences. These natural science fields are undergoing rapid method-

ological and theoretical change due to the combination of genetic sequencing and increasingly cheap computing power.

The papers in this issue, as well as the previously paper (Burnham et al. 2015), lay out some of the possibilities for a research agenda using experimental evolution. The range of future experiments, however, goes far beyond these modest beginnings. There are literally thousands of productive experiments using microbes, fruit flies, and mammals that would be relevant to economics.

The goal of this special issue is to catalyze research activity into experimental evolution and economics. Changing the intellectual course of economics to invest significant effort into, for example, studying the genes of evolved populations of bacteria, has to be understood as one of the more amazing long shots in the history of science.

Economics is a field divided against itself, using antiquated social science methodologies from the eighteenth, nineteenth, and twentieth centuries. Experimental evolution holds the promise of changing economics and integrating the field with modern, natural science methodology. The hope is a more accurate and comprehensive economics, firmly grounded in biological and evolutionary thinking.

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