# THE `COMPUTABLE' IN EXPERIMENTAL ECONOMICS

## Herbert Simon Lectures, 2

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*Experimental economics has come of age. Vernon Smith's recent JEBO article[3] describes the challenges experimental economics has faced, and has yet to overcome. In this lecture I'll show that computable economics is the natural theoretical underpinning for modern experimental economics: this lecture delves into the history of experimental economics from the view of the present, and suggests points of tangency and fruitful convergences between computable economics and experimental economics. A road map for computable and experimental economics---linked fundamentally to computational intelligence---is given.*

"The test of all knowledge is experiment. Experiment is the sole judge of scientific "truth"."

R. Feynman, Feynman Lectures on Physics, 1964.

### INTRODUCTION

IN the previous lecture, we looked at the foundations of experimental economics, and took a glimpse at the computable nature of the experiment in economics. First, let me paraphrase Giambattista Vico: "we can know nothing that we have not made". I'll argue in this lecture that we need to be aware of what we are making when we do economic experiments, and that what we make may very well be in advance of any current economic theory.

First, I'll describe the search for 'task invariant behaviours', then I'll link that search to Simon's behavioural economics. I'll then describe the properties of these 'task invariant behaviours', and show some experimental results which may be forerunners in the search for these behaviours, and lay out a road map for computable and experimental economics.

"All life is problem solving"

K. Popper.

Herbert Simon, as we have seen, based his search for the sources of human decision making on three pillars:

1. *Human Problem Solving.* Human agents are best described as information-processing systems.

2. *Programs.* Well described behaviours can be represented via programs with different structures and contents.

3. *Task environment*. The task environment (plus the intelligence of the problem solver) determine to a large extent the behaviour of the problem solver, independently of the detailed internal structure of his information processing system.

"In what other way, if not simulation by a Turing machine, can we understand the process of making free choices? By making them, perhaps."

R.Nozick, Philosophical Explanations

Given these three pillars, it possible to describe experimental economics as t*he systematic search for task-invariant behaviours*, that is, average responses or solutions to problems posed by the experimenter which are repeated across many different types or specifications of experiment, and which give symmetric and predictable average responses. The search process takes place as I described in lecture 1: by the systematic elimination or ‘breaking’ of model assertions. It is this systematic breaking of the model that leads both experimenter and theorist towards what Smith[1] calls the *edge of validity*:

> “In any confrontation between theory and observation the theory may work or fail to work. When the theory works it becomes believable in proportion to its predictive "miracle," instead of only respectable in proportion to its internal elegance or its association with authority. But when it works, you lean mightily upon the theory with more challenging "boundary" experiments designed to uncover the edges of validity of the theory where certainty gives way to uncertainty and thereby lays the basis for extensions in the theory that increase its empirical content.”

“But not paying attention to experiments like that is a characteristic of cargo cult science.”

R. Feynman, Cargo Cult Science, 1974.

“[I]f you're doing an experiment, you should report everything that you think might make it invalid — not only what you think is right about it; other causes that could possibly explain your results; and things you thought of that you've eliminated by some other experiment, and how they worked — to make sure the other fellow can tell they have been eliminated.”

R. Feynman, Cargo Cult Science, 1974.

## THE SEARCH FOR LOCAL TASK-INVARIANT BEHAVIOURS

Two analogies to physics are appropriate in this lecture. First, the current corpus of knowledge amassed by experimenters has been compared[3] to the state of late 19th Century physics:

> In summary I think there is a sense in which the state of experimental economics is comparable to the description of knowledge in physics a century ago: “The mass of insufficiently connected experimental data was overwhelming . . .”

Second, the search for invariance principles is a feature of modern physics, as explained by Eugene Wigner, quoted in McCauley. What is an invariance? In physics, local invariances form the theoretical basis for repeatable identical experiments. So, we get observations whose results can be reproduced by different observers independently of where and at what time the observations are made, and independently of the state of relative motion of the observational machinery. This local invariance search is the goal of experimental economics. The promise of induced value theory is that preferences are induced monetarily for abstract commodities that exist only for the purpose of the experiment, and, once the five precepts of the theory (non-satiation, saliency, dominance, privacy, parallelism) are met, the results from the experiment are generalisable to other experiments, times, and places, where the same conditions exist.

The history of physics shows that mathematical law cannot be discovered from empirical data unless something is repeated systematically.

Joseph McCauley, Dynamics of Markets: The New Financial Economics, 2nd ed, 2009.

So far, so uncontentious. Now I'm going to get a little confrontational, and claim the *only* way to discover these invariances is by careful, controlled, experiment.

Why? Think of the double auction market. The theory behind the double auction when Smith studied it in the 1960s was a static theory, requiring full information on the part of the participants, as well as assuming unlimited computational power. Yet, the very first experiment Smith constructed was a dynamic, algorithmic, low-information environment. In 1962, the experiment was far in advance of the theory, because it was built and 'made' in the real world, as Vico would have wanted. To see this a little more clearly, let's think about the following experiment. I'll pass a handout to two volunteers in the class.

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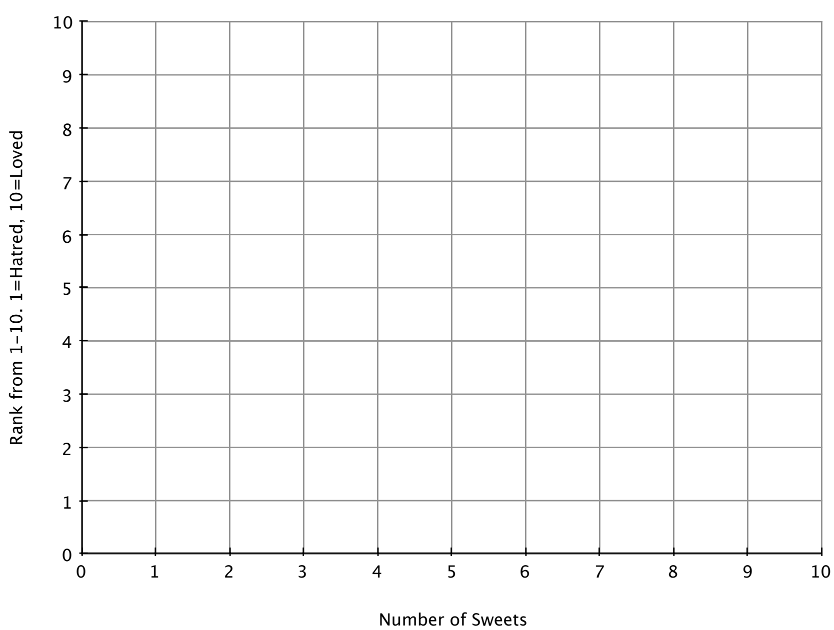
**Instructions.** You have ten sweets in front of you. Please eat as many of them as you can. As you eat, consider how eating the sweet makes you feel, that is, how much pleasure do you get from eating the sweet. Rank your pleasure from 1 to 10, with 1 being hatred of the sweet, and 10 being love of the sweet. Please report your results by filling in the chart below. The first one to finish the experiment will be paid 100 TND.

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Now, in class, let's think about what's going on in this little experiment, and what treatments we can think of, and what lessons we can learn from this 'straw man'.

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## TURING MACHINES AND EXPERIMENTAL ECONOMICS

Turing machines are simple models of computing. A Turing machine[2, 4] consists of a head that switches between states while reading from and writing on a tape, as in the cake-cutting example we saw yesterday. The symbols read or written are called colors. Generalisations of Turing machines can have multiple heads or tapes, as we see from the *Mathematica* Demonstration I'll show in class.

The plot I'll show in lectures shows evolutions of 3-state, 2-color Turing machines, like the one shown to the right. Each row of squares gives one step in the evolution of the tape. The squares correspond to bits on the tape: white squares represent 0-digits, yellow squares stand for 1-digits. The small 'tears' represent states.

One of the 2985984 rules for a 3-state, 2-color Turing machine can be selected with the slider or by setting the base 12 rule digits for each of the six possible inputs. Combined icons for state and color on the left of these six setter bars give the inputs which trigger their selected settings. Similar combined icons over those six setter bars give the twelve possible right-hand sides of the rules. Another row of icons shows the resulting directions of movements for all possible results.

The initial position of the head is given in relation to the specified initial condition of the tape, which can be cyclic, padded by an infinite number of 0- or 1-digits, or padded by repetitions of the selected 8-bit initial tape specification.

There is clear algorithmic content within experiments, as we can see from the two experimental feedback mechanisms shown to the right.

This leads me to re-iterate a quote Smith's Nobel lecture:

"Markets are rule-governed institutions providing *algorithms* that select, process and order the exploratory messages of agents who are better informed as to their personal circumstances than that of others."

Where are the algorithms that Smith describes? They are not within the theory, but within the experiment, and within the real world. The experiment is inherently algorithmic, dynamic, and non-axiomatic, and thus far ahead of the theory at the moment, as Smith describes.

A Roadmap for Computable and Experimental Economics

Where next for computable experimental economics?

1. Search for task-invariant properties, guide the search using simulations from the perspective of computational intelligence.

2. Use the systematic breaking of models as a guide for

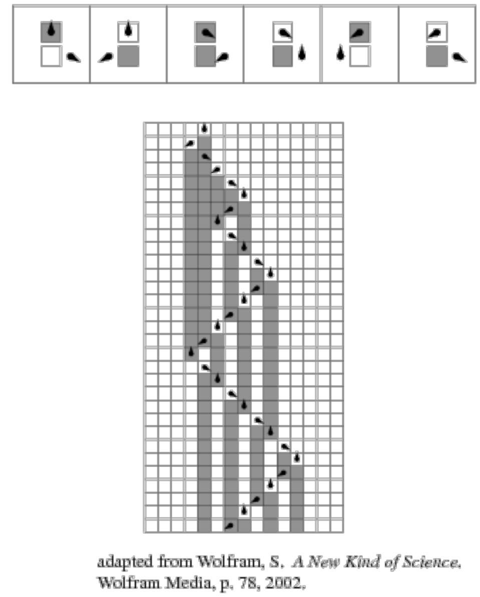


Figure. Turing Machine.

S. Wolfram, A New Kind of Science, Wolfram Research, 2002.

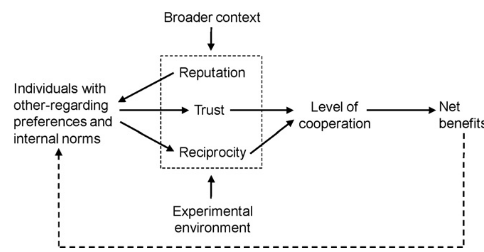


Figure. Trust feedbacks, reputation flows.

Source: Poteete, A., Janssen, M., Ostrom, E., 2010. *Working Together: Collective Action, the Commons, and Multiple Methods in Practice.* Princeton University Press, Princeton, NJ.

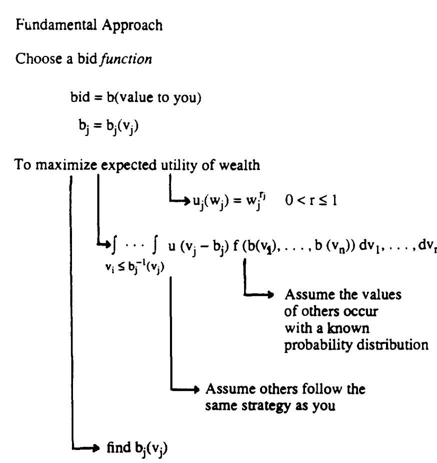


Figure. Fundamental flow chart for Individual Choice experiments. Source: Charles Plott, Will Economics become an experimental science? Southern Economic Journal, 57(4), 901-919, 1991

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where to go next in this search.

3. Conceive of the subjects as information processors, that is, capable in some sense of computing the answer to a set of inputs.

## Conclusion

Where is the computable in experimental economics? Everywhere. Because one executes the experiment in finite time using limited resources that come to a conclusion, you are, in fact, doing computable economics. The experimental results are far in advance of the theory, and should be used to guide theory more effectively in the search for task-invariant behaviours.

## References


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