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Rational inattention and revealed preference: The data-theoretic approach to economic modeling

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ABSTRACT

Beliefs have as pervasive a role as utility functions in economic models of choice, and are no more visible to the naked eye. This suggests the value of a data-theoretic approach to imperfect information along the lines of Samuelson's "revealed preference" approach to utility maximization. I introduce a recently developed approach of this nature (Caplin and Martin, 2013a; Caplin and Dean, 2013a, 2013b). I highlight the broader potential of the data-theoretic approach to answer questions of an inter-disciplinary nature and to discipline an oncoming flood of behaviorally-relevant data.

1. Introduction

In introducing the theory of revealed preference, Samuelson (1938) defined a "data-theoretic" approach to utility maximization. This approach is built around an idealized data set of potentially observable choices. Properties of the observed data drive forward the modeling agenda. Revealed preference tests identify whether or not any model of utility maximization can rationalize observed choices.[1] A positive answer leads to more detailed questions concerning the appropriate model of utility. A negative answer suggests the need for a new model that better fits observed patterns. Ideally, the nature of the gap between data and theory guides the search for new theories.

Beliefs are as pervasive as utility in their impact on choice. They are also no more visible to the eye than are utility functions and preferences. This suggests the value of an approach to imperfect information along the lines of Samuelson's revealed preference approach to utility maximization. I survey in this paper just such a data-theoretic approach (Caplin and Martin, 2013a; Caplin and Dean, 2013a, 2013b): henceforth CM, CDa, and CDb). I also highlight the broader potential of the research program to address questions that involve elements of both economics and psychology. Finally, I outline the need for the data-theoretic approach to discipline an oncoming flood of choice-related data that lies beyond the reach of traditional theories.

As its name suggests, the defining feature of the modeling approach outlined herein is the central place accorded to data. In order to render classical choice theory testable, Samuelson called for unusually rich choice data on choice from budget sets. For theories of imperfect information, the required data is yet richer. We consider data on "state dependent stochastic choice": how likely is each available option to be chosen in each state of the world. CM use this data to characterize Bayesian

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[1] Samuelson did not want to see utility theory enshrined for all time as the only model of choice, but rather to open up to possible feedback (Dixit, 2012; Green, 1991). This is now happening in standard choice theory, under the leadership of Manzini and Mariotti (2007), who characterize forms of boundedly rational behavior in choice data.

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expected utility maximization. CDa consider in addition the general theory of rational inattention. In both cases the identifying tests are simple and clean. CDb develop the behavioral signature of the standard Shannon entropy model of rational inattention due to Sims (2003). On a separate note and to aid in applications, it introduces new methods of model solution.

The data-theoretic approach is designed to enhance the relationship between theory and evidence. To highlight how vital is this interaction, I sketch experimental tests of the rational inattention model. I also present ongoing applications and allied data expansions. Caplin and Martin (2013b) are applying the data-theoretic approach to categorize attentional framing effects. Together with Joseph Briggs, Daniel Martin, and Christopher Tonetti, I am developing and estimating search models with a "due diligence" period. Development of the data-theoretic approach to strategic situations along the lines laid out by Bergemann and Morris (2013), CM, and Martin (2012) is also of great promise. There are also applications to mechanism design, with a case in point being the institution of the jury trial, a topic that Andrei Gomberg and me are currently investigating. All of these developments involve closely relating models of behavior to correspondingly rich data.

By placing data front and center, the approach outlined herein presents theorists with new challenges and opportunities. It highlights their key role in disciplining the massive flows of new behaviorally-relevant data that is coming on line, whether it be metadata from internet search, survey data, neurological data, or genetic data. Without the active involvement of theorists in the design of such data, the resulting empirical analyses will produce little by the way of durable understanding.

The data-theoretic approach can also be applied to ensure that information is generated sufficient for testing important theories. In particular, I believe that policy makers unwillingness to provide adequate data and their broader lack of transparency bedevils policy analysis. By highlighting the damaging implications of this lack of transparency, data-theoretic analysis may help change incentives. Ideally, policy makers will be pressured into lifting the veil of secrecy behind which they currently operate.

On a more positive note, I believe that the data-theoretic approach will directly advance research on the increasingly porous boundary between economics and psychology. For example, testing models of cognition, perception, and memory is based on data sets analogous to those we use to discipline theories of inference and of attention. With further development, behavioral models of such phenomena as test anxiety appear within reach. There are also more directly biological applications in the emerging areas of neuroeconomics and genoeconomics. Ideally, theory and data will co-evolve as the first evidence suggests.

In Section 2 I introduce state dependent stochastic choice data and tests of Bayesian expected utility maximization. In Section 3 I detail definitive tests of rational inattention theory. In Section 4 I outline ongoing research modeling attention in various applied contexts. Each such application requires specific additional data enrichments. In Section 5 I present opportunities and challenges associated with the broader data-theoretic research agenda. Concluding remarks are in Section 6.

2. Bayesian expected utility maximization

Jurors are listening to evidence being presented at a trial. The standard theory suggests that they have a simple goal, which is to minimize errors with some relative weight on convicting the innocent as opposed to acquitting the guilty. As the trial continues, more and more information can in principle be gleaned concerning guilt or innocence. In the standard theory this is treated as involving receipt by each juror of a certain number of signals which leads to updating of their priors in a Bayesian manner. But what is this information exactly? Is it accurate to model jurors as having perceived all information perfectly? Should we instead model them as perceiving noisy signals? If so, what form should these signals take and from what distribution should they be drawn? How many are received? Is updating really Bayesian?

The first question motivating the data-theoretic approach concerns how an outside observer can get insight into whether or not the standard model applies. Absent enriched data, the challenge posed by Samuelson (1938) for the case of utility maximization remains unanswered. In standard choice data, the model may be able to explain any and all observations and hence be untestable. Once one allows for subjective internalization of evidence, the theory of Bayesian expected utility maximization appears at first glance to have no power whatever to restrict jurors' decisions.

The key question from the data-theoretic viewpoint is how to render standard theory testable. We need to introduce an idealized data set in which the basic behavioral hypothesis places some restrictions on jurors' behavior. This challenge applies equally to any and all models that involve subjective processing of potentially informative signals. To make progress, CM specify rich data that we now detail for the general case.

2.1. *Decision problem and data*

A decision maker (henceforth DM) has available a known set of actions A of cardinality $|A|=J$ with generic element $a \in A$. Separate from the actions, there is a set of possible prizes X of cardinality $|X|=N$. The DM knows the set of possible prizes, but may be unsure about the exact prize that will result from choosing each action.

We define the underlying state of the world as specifying precisely the connection between actions and prizes. Given the finiteness of X and A, there are finitely many such states, $\Omega=\{1,\ldots m,\ldots M\}$, with state m corresponding to function ω_m: $A \rightarrow X$.