TREATMENT UNDER AMBIGUITY

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Abstract

Economists have long associated decision making with optimization. The decision maker chooses an action from a known choice set C. The chosen action maximizes a known real-valued objective function $f(\cdot): C \rightarrow R$. Optimization assumes enough knowledge of C and $f(\cdot)$ to determine an optimal action. Suppose the decision maker knows C but not $f(\cdot)$. He knows only that $f(\cdot) \in F$, where F is a specified set of functions mapping C into R. Then the decision maker may not have enough information to determine an optimal action. This is a problem of decision under *ambiguity*.

After introducing basic themes about decision under ambiguity, I examine the problem of treatment choice. A social planner must choose a *treatment rule* assigning a treatment to each member of a population. Each person has some observed covariates and a *response function* mapping treatments into real-valued outcomes. The planner wants to choose treatments that maximize the population mean value of the outcome.

It has been conventional to assume that the planner knows (or at least can estimate) the population distribution of response functions conditional on covariates. With this knowledge, the planner faces a problem of decision under uncertainty and can choose an optimal treatment rule. There are, however, fundamental and practical limits to the knowledge of response functions that planners commonly possess. Thus planners choosing treatment rules ordinarily face problems of decision under ambiguity. This paper gives the key theoretical findings and considers the implications for treatment choice.

1. Introduction

Economists have long associated decision making with optimization. There is a universe A of actions. A decision maker chooses an action from a known choice set $C \subset A$. The chosen action maximizes on C a known real-valued objective function $f(\cdot): A \rightarrow R$.

Optimization assumes knowledge of C and $f(\cdot)$, or at least enough knowledge to determine an optimal action. Suppose that the decision maker knows the choice set but does not know the objective function. He knows only that $f(\cdot) \in F$, where F is a specified set of functions mapping A into R. Then the decision maker may not have enough information to determine an optimal action. This is a problem of decision under *ambiguity*.[1]

Economists have long recognized that decision makers may face ambiguity. See, for example, Knight (1921), Arrow and Hurwicz (1972), Maskin (1979), and Manski (1981). Nevertheless, study of the subject has remained a peripheral concern of the profession. The prevailing view seems to be that ambiguity is unusual or, perhaps, inconsequential.

In this paper I use a simple class of decision problems of considerable practical importance to show that ambiguity is both common and consequential. This is the problem of treatment choice studied by economists evaluating social programs, public health researchers comparing alternative medical treatments, and policy analysts more generally. The standard formalization of the problem

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[1] The term *ambiguity* appears to originate with Ellsberg (1961), who used it to describe decision problems in which the objective function depends on an unknown probability distribution. The term has since been adopted by Einhorn and Hogarth (1986), Camerer and Weber (1992), and others. Much earlier, Knight (1921) used the term *uncertainty* to describe these problems, but uncertainty has since come to be used to describe optimization problems in which the objective function depends on a known probability distribution. Other authors have used *vagueness* and *ignorance* as synonyms for ambiguity.

supposes that a planner must choose a *treatment rule* assigning a treatment to each member of a population. Each person has some observed covariates and an unobserved *response function* mapping treatments into real-valued outcomes. The planner wants to choose treatments that maximize the population mean value of the outcome.

It has been conventional to assume that the planner somehow knows (or at least can estimate) the population distribution of response functions conditional on covariates. With this knowledge, the planner faces a problem of decision under uncertainty and can choose an optimal treatment rule. My recent program of research on the identification of treatment effects shows that there are limits, fundamental and practical, to the knowledge of response functions that planners commonly possess (Manski, 1990, 1994, 1995, 1996a, 1996b, 1996c). Thus planners choosing treatment rules ordinarily face problems of decision under ambiguity.

Section 2 develops basic themes about decision under ambiguity. Section 3 reviews the standard formulation of the planner's problem as treatment under uncertainty and then examines the problem of treatment under ambiguity. Section 4 shows that planners commonly face ambiguity of specific forms. Section 5 considers the desirability of the planner foregoing centralized selection of treatments and instead allowing the members of the population to select their own treatments. Section 6 gives conclusions.

Before proceeding, it is perhaps necessary to say that I use the term "knowledge" in the sense of the standard deductive logic of scientific inference. The decision maker draws logical conclusions by combining empirical evidence with maintained assumptions. These conclusions constitute knowledge.

2. The Basics of Ambiguity

Knowing that $f(\cdot) \in F$, how should the decision maker choose among the elements of the choice set C? Clearly he should not choose a *dominated* action. Action $d \in C$ is said to be dominated (also *inadmissible*) if there exists another feasible action, say c, such that $g(d) \leq g(c)$ for all $g(\cdot) \in F$ and $g(d) < g(c)$ for some $g(\cdot) \in F$.

Let D denote the undominated subset of C. How should the decision maker choose among the elements of D? Let c and d be two undominated actions. Then either $[g(c) = g(d)$, all $g(\cdot) \in F]$ or there exist $g'(\cdot) \in F$ and $g''(\cdot) \in F$ such that $[g'(c) > g'(d), g''(c) < g''(d)]$. In the former case, c and d are equally good choices and the decision maker is indifferent between them. In the latter case, the decision maker cannot order the two actions. Action c may yield a better or worse outcome than action d; the decision maker cannot say which. Thus the normative question "How should the decision maker choose?" has no unambiguously correct answer.

2.1. Rules Transforming Decisions under Ambiguity into Optimization Problems

Although there is no optimal decision under ambiguity, decision theorists have not wanted to abandon the idea of optimization. So they have proposed various ways of transforming the unknown objective function $f(\cdot)$ into a known function, say $h(\cdot): A \to R$, that can be maximized. Three leading proposals -- the maximin rule, Bayes rules, and imputation rules -- are discussed below. Although these proposals differ in their details, they share a key common feature. In each case, the solvable optimization problem $\max_{i \in D} h(\cdot)$ differs from the