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Consistent Choice and Falsifiability of the Maximization Hypothesis [•]

by

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Abstract:

We examine the status of the maximization hypothesis in the positive economic theory of rational choice. We argue that, contrary to a common belief, the maximization hypothesis does not play any role in large areas of positive rational choice theory. In contexts where it does, it is not logically possible for an observer to translate the restrictions implied by this hypothesis into restrictions on observed choice behavior. The maximization hypothesis is thus open to neither falsification nor verification. However, this is for reasons quite different from those usually advanced; some influential arguments in favor of this view are flawed.

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I. Introduction

In this paper, we examine the status, in positive economic theory, of the maximization hypothesis, namely, the hypothesis that the observed choice behaviour of an agent can be viewed as behaviour induced by a preference ordering over the objects from which such choices are made. We first argue that, contrary to a common belief, the maximization hypothesis, as it is usually understood, does not play any role in large and important areas of positive rational choice theory in economics. Further, we argue that, even in contexts where the maximization hypothesis does play an important role, it is not possible for an outside observer to translate the restrictions implied by the hypothesis into restrictions on *observed* choice behavior. Hence, the behavioral implications of the maximization hypothesis cannot, by themselves, be logically falsified by observation. It follows that the maximization hypothesis itself is not open to empirical falsification, nor, for that matter, to empirical verification. However, this is due to reasons quite different from those usually advanced; some influential arguments in favor of this view are in fact not tenable.

It is a common understanding that the maximization hypothesis, which is usually considered to be the very starting point of positive rational choice theory, involves the assumption that agents' choices can be viewed as if they are the consequence of maximization on the basis of a preference ordering (i.e. a complete ranking) over the objects from which such choices are made. This understanding leads to the view that the very foundation of positive rational choice theory rests on the claim that agents' choices satisfy certain formal properties of internal consistency, such as the revealed preference axioms, that can be derived as logical consequences of maximization on the basis of a preference ordering defined over objects of choice. It follows that violations of such consistency properties, if observed, would provide empirical refutation of the maximization hypothesis. However, it is often asserted that, by virtue of its logical structure itself, the maximization hypothesis is not falsifiable; nor is it, for that matter, verifiable. While common, few systematic justifications for this assertion seem to have been developed. The two best known of such justifications are those advanced by Boland (1981) and Caldwell (1983). Boland claimed that the maximization postulate does not imply any restriction on choice behavior, and therefore is not falsifiable, because it involves an existential statement about an infinite class. Caldwell, on the other hand, argued that the postulate does not imply any restriction on choice behavior because it does not specify the substantive content of the object of maximization. He also argued that observed violations of the consistency restrictions identified by revealed preference theory can not falsify the maximization postulate itself, since they can be made compatible with the postulate by assuming changes in agents' preferences and/or information sets. He thus seemed to suggest that it is possible, in principle, to empirically falsify the claim that an agent's choices satisfy the revealed preference axioms; however, such falsification can not be construed as a falsification of the maximization postulate itself.

In Section II of this paper, we briefly outline the structure of positive rational choice theory and argue that the assumption of consistent choice does not figure in (at least) one large area of this theory, namely, non-cooperative game theory. Section III analyzes the rational choice model in its classical version of parametric decision-making under certainty, where the neoclassical maximization postulate does imply consistent choice behavior. We investigate the question as to whether empirically falsifiable restrictions on observed choice behavior can be derived from consistency axioms (and, by implication, the maximization postulate) in this setting. We claim that the arguments advanced by Boland and Caldwell against such a possibility are both flawed. Contrary to Boland's claim, an existential statement about an infinite class may nevertheless be falsifiable. Unlike Caldwell's understanding, the substantive content of the object of maximization has no bearing on the logical status of the maximization postulate. We show that the maximization postulate in the context of parametric decision-making under certainty may be formulated in such a way as to make any observed violation of consistency restrictions, for any reason whatsoever, incompatible with it. Thus, Caldwell's second argument against the possibility of falsifying the maximization postulate becomes invalid as well. We proceed to show that the maximization postulate is nevertheless neither verifiable nor falsifiable, since (contrary to what Caldwell seems to suggest) an external observer can not possibly have valid grounds for ever concluding, on the basis of an agent's observed choice behavior, that the agent is either actually satisfying or violating the consistency restrictions imposed by the maximization hypothesis. We conclude in Section IV.

II. Maximization and Consistent Choice

The maximization hypothesis, as it is usually stated or understood, is the hypothesis that an agent's choices can be `rationalized' in terms of a preference ordering defined over the objects from which the agent makes his/her choices. What role does it play in the different areas of economics dealing with rational choice? To see this, it is useful to note first certain basic differences between the conceptual frameworks in which the problem of choice is posed in different areas of economics. All theories of rational choice in economics start with an agent (a person or a collectivity such as a firm or a government) having to choose an *action*, from a given set of mutually exclusive feasible actions. The set of feasible actions, can, of course, change, but the agent has to make a choice from each such feasible set. In the classical theory of choice under certainty, each action is associated with a unique outcome, and the agent knows exactly which outcome follows from which action. The maximization postulate is introduced in the form of the assumption that the agent's choices can be visualized as being motivated by the goal of obtaining the best possible outcome according to some preference ordering over the set of all possible outcomes. Given the one-to-one correspondence between actions and outcomes and the agent's awareness of this relationship, the theory of choice under certainty usually discards the notion of an action altogether and formulates the problem as one of choosing directly from alternative sets of feasible outcomes. This allows the maximization hypothesis (the rational-choice content of the theory) to be captured in terms of the requirement that the agent's choices be rationalizable in terms of an ordering defined over the objects of choice, which in turn implies that the choices of the agents must satisfy various consistency requirements, such as the different revealed preference axioms. [1]

The picture becomes a little more complex in the classical theory of choice under (probabilistic) uncertainty. An action no longer leads to a unique basic outcome here. Each action leads instead to a unique lottery over basic outcomes, the probabilities in the lotteries being given by the beliefs of the agent. However, so long as these beliefs remain unchanged, the problem of choice from alternative feasible sets of actions can be visualized as a problem of choosing from alternative sets of feasible lotteries. The theory then assumes that these choices are rationalizable in terms of a preference ordering over the set of all possible lotteries. This, of course, implies consistency restrictions for the agent's choices from different sets of lotteries. Thus, in both the standard theory of choice under certainty and that under probabilistic uncertainty (with invariant beliefs), the maximization hypothesis requires 'consistency' in the choices made by the agent.

The picture becomes fundamentally different in the theory of choice in strategic environments of the type that non-cooperative game theory typically analyzes. Here the outcome for each agent is determined jointly by the actions of all agents. Consequently, the link between the actions of a given agent and its outcome is completely broken. It is still assumed that the agent's choices can be visualized as being motivated by the goal of obtaining the best possible outcome according to some preference ordering over the set of all possible outcomes. In this sense, the theory still remains a theory of rational choice. However, the rational-choice content of the theory can no longer be captured in terms of the requirement that the agent's choices of actions or strategies be rationalizable in terms of an ordering defined over the objects of choice (i.e., strategies). Consequently, game theory virtually never imposes the requirement of rationalizability in terms of an ordering, nor any consistency property implied by it, on the choice of the only entities (strategies) that are ever actually chosen by the agents in the model. Indeed, it is quite often the case that a player's choices of strategies in standard non-cooperative games violate basic consistency conditions and cannot therefore be rationalized in terms of any ordering defined over all strategies. Two examples will clarify the point.

First, consider the notion of dominance solvability of a (normal form) game.[2] Suppose, to start with, we have a game with two players, 1 and 2, where 1's strategy set is {a, b, c} and 2's

[1] The major achievement of the theory of revealed preference is precisely the identification of conditions such as the Weak Axiom of Revealed Preference, the Strong Axiom of Revealed Preference, the Weak Congruence Axiom and the Strong Congruence Axiom, all of which are necessary and some of which are sufficient for the agent's choices be rationalizable in terms of an ordering defined over the objects of choice. See, among others, Samuelson (1948), Houthakker (1950), Arrow (1959) and Richter (1966).

[2] See Kreps (1990) for a formal definition.

strategy set is {a’, b’, c’}. The payoffs are given below, the first number in each pair referring to player 1’s payoff.

	a'	b'	c'
a	(0, 0)	(0, 0)	(2, 0)
b	(1, 0)	(1, 0)	(1, 1)
c	(0, 0)	(1, 10)	(0, 0)

Under the notion of dominance solvability, 1 will choose strategy a, rejecting strategies b and c; while 2 will choose c’, rejecting a’ and b’. Now suppose, other things remaining the same, the strategy b becomes non-feasible for player 1. It can be easily checked that, in the new game, 1 will choose strategy c, rejecting strategy a, while 2 will choose strategy b'. Consider 1’s choices in the two situations. His choice of a from {a, b, c} and of c from {a, c} violates the Axiom of Rejection, which is an elementary consistency requirement weaker than even the Weak Axiom of Revealed Preference (WARP).[3]

It may be argued, against the example above, that if we use instead the more common notion of a Nash equilibrium as the proper solution concept, a player's choice of strategies cannot violate the Axiom of Rejection. While this is true, it is still possible for a player's strategy choices to violate WARP. To see this, consider a game with two players, X and Y. Suppose Y's strategy set is {a', b', c'}, while X's strategy set changes from {a, b, c} to {a, b, d}. The payoffs are given below, the first number in each pair referring to player X's payoff.

	a'	b'	c'
a	(10, 12)	(11, 12)	(9, 10)
b	(9, 4)	(12, 5)	(7, 1)
c	(6, 6)	(15, 2)	(4, 3)
d	(16, 7)	(12, 3)	(8, 10)

Clearly, when X's strategy set is {a, b, c}, the unique Nash equilibrium is (a, a'), whereas, when his strategy set changes to {a, b, d}, the altered game yields the unique Nash equilibrium (b, b'). Thus, X's choice of actions (strategies) violate WARP.

The conclusion that emerges from the preceding discussion is this. In a large area of rational choice theory, namely that deriving its basic structure from the theory of non-cooperative games, the choices made by an agent do not necessarily satisfy the familiar consistency properties necessary for

[3] This condition requires that, if, from a set {x, y}, the agent chooses x and rejects y, then, when the feasible set is expanded by adding other options, the agent should not choose y from the expanded set while rejecting all other options in the expanded set. Clearly, violation of this condition implies the violation of WARP as well, though the converse is not true.

the rationalizability of such choices in terms of an ordering. This, however, does not cause any intuitive concern since, here, the things that the agent actually chooses from (namely, the strategies), are not directly linked to 'outcomes', i.e., the things that the agent would like to choose from, if he could (knowingly) do so.[4]

III. The Problem of Falsification

As discussed earlier, the principal context where the maximization hypothesis does, in fact, play a crucial role is that of the classical model of (parametric) choice under certainty. The issue therefore is whether it is in fact logically possible to empirically falsify the maximization postulate in such a context. In a well-known paper, Boland (1981) argued that the general maximization postulate is a *metaphysical* statement in the sense that it is neither verifiable nor falsifiable.[5] Subsequent commentators such as Hollis (1994) have taken positions similar to Boland's.[6]

A. The Structure of Boland's Reasoning:

According to Boland, the (neoclassical) maximization hypothesis is that "all decision-makers maximize something". This statement may be put slightly more formally as follows.

For every decision-maker i, there exists a such that a is maximized by i. (1)

Boland's argument that (1) is a metaphysical statement then proceeds in four steps, the first being a broad restatement of the classic position of Popper (1959).

Step 1: A universal statement (e.g. "all swans are white") about an infinite class is non-verifiable, and an existential statement (e.g. "there exists a black swan") about an infinite class is non-falsifiable.

Step 2: Since the class of all decision-makers is an infinite class, by Step 1, the presence of the universal quantifier, "for every", in (1) makes (1) non-verifiable.

Step 3: Since the class of all a that a decision-maker may maximize is an infinite class, by Step 1, the presence of the existential quantifier, "there exists", in (1) makes (1) non-falsifiable.

Step 4: From steps (2) and (3), it follows that (1) is neither verifiable nor falsifiable, and hence, it is a metaphysical statement.

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[4] This is in fact prior to the problem of misrevelation of preferences, or as Sen (1973) puts it in a more formal fashion, the 'problem of establishing correspondence between rankings of the outcome space and those of the strategy space'.

[5] Thus, according to Boland, empirical criticisms such as Simon's (1979) or Leibenstein's (1979) that claim that the maximization hypothesis is actually false are similarly impossible to verify or falsify. It would follow that these theories, in terms of their predictive content, would be consistent with the general maximization hypothesis. On the basis of what appears to be a similar understanding, De Alessi, in a debate with Leibenstein, argued that X-efficiency should be encompassed by a generalized version of neoclassical theory that explicitly incorporates transactions costs and property rights considerations. See De Alessi (1983a, 1983b) and Leibenstein (1983).

[6] While the spirit of his argument is very similar to that of Boland's, Hollis (1994, p. 57) actually claims that the maximization postulate is a *tautology*, which, as Boland notes, is formally different from a 'metaphysical' statement. For an argument as to why the maximization postulate is *not* a tautology, see below.

To see that Boland's reasoning is not tight, consider the following claim.

For every person i brought up in a non-clinical environment, there exists an air pollutant, t, belonging to the class of all air pollutants to which i is exposed in the first year of his life, such that t causes people exposed to it in the first year of their lives to turn completely bald by the age of twentyfive. (2)

Statement (2) involves a universal quantifier with reference to an infinite class (the class of all persons brought up in a non-clinical environment). It also involves an existential quantifier with reference to an infinite class (the class of all air pollutants to which a person i brought up in a non-clinical environment is exposed in the first year of his/her life). Yet, (2) is clearly falsifiable, and, is, in fact, false since we can find persons, brought up in non-clinical environments, who are above twentyfive yet not completely bald. Thus, the presence of an existential quantifier with respect to an infinite class does not, by itself, render a statement non-falsifiable. If one claims that the maximization hypothesis is non-falsifiable because of the presence of an existential statement about an infinite class, then that claim needs to be based on some additional characteristic of that specific existential statement, not on the general structure of existential statements.

B. The Maximization Postulate in the Classical Model of Choice:

Before proceeding further, it is necessary to interpret the maximization postulate more precisely in the context of parametric choice under certainty, where the problem of choice can be formulated directly in terms of choosing among outcomes. In particular, the notion of a decision-maker, and that of maximization, which figure in (1), need to be defined in this context. Following standard economic theory, a decision-maker may be defined as follows.

Definition 1. A *decision-maker,* i, is characterized by a triple $\langle X_i, Y_i, C_i \rangle$ such that:

(i) X_i is a non-empty set, interpreted as the universal set of options,

(ii) Y_i is a non-empty class of non-empty subsets of X_i, the elements of Y_i being interpreted as the different feasible sets of options with which i may be confronted; and

(iii) C_i is a function (to be called i 's choice function) which, for every element A of Y_i, specifies exactly one singleton subset $C_i(A)$ of A, the unique element of $C_i(A)$ being interpreted as the option which would be chosen[7] by i, when confronted with the feasible set A.

Intuitively, an agent is a decision-maker if and only if, confronted with different subsets of some class of alternative options (actions), she always (a) chooses one option and rejects others and (b) chooses the same option from identical subsets of alternative options. For example, in standard indifference

[7] A more general definition would allow $C_i(A)$ to contain more than one element. However, when $C_i(A)$ has more than one element, there is some intuitive difficulty in interpreting these alternatives as the options

curve analysis, the decision-maker (a consumer) is characterized by: (i) a universal set comprising the entire non-negative quadrant of n-dimensional real space, (ii) the set of all possible budget sets, and (iii) a function specifying, for each budget set, a singleton subset of the budget set, containing the uniquely chosen commodity bundle. In the standard theory of competitive producers' behavior, the decision-maker's (i.e. a price-taking producer's) universal set is the Cartesian product of the set of all input-output combinations technologically feasible for him and the set of all possible price vectors. The feasible set under any given price vector is the subset of this universal set corresponding to that particular price vector. The producer's choice function specifies, for each such feasible set, a singleton subset, which in turn provides the input-output vector chosen uniquely under the corresponding price vector.

Next, consider the notion of maximization in (1). Standard economic theory is usually phrased in terms of decision-makers maximizing something specific, such as utility, profits, etc. However, the basic abstract notion of maximization does not require a reference to any specific object of maximization. A maximizer can be defined, without any specification of the object of maximization, in our context as follows.

Definition 2. Let i be a decision-maker characterized by some triple $\langle X_i, Y_i, C_i \rangle$. Then i is said to be a maximizer if and only if there exists an *ordering* R_i, defined over X_i, such that R_i rationalizes the choice function C_i (i.e., for all A in Y_i, $C_i(A)$ is the set of all R_i - greatest elements in A).[8]

Intuitively, under Definition 2, a decision-maker is a maximizer if and only if, for every feasible set of options, the decision-maker chooses the 'best' alternative in that feasible set, defined according to some ordering over the universal set of options. In other words, a decision-maker is a maximizer if and only if his choices are consistent with some *complete ranking* of all alternative options contained in the universal set. Thus, maximizing behavior is essentially behavior that satisfies a particular notion of consistency, defined independently of any substantive interpretation, or justification, or content that may be attached to such consistency.[9] In the standard theory of consumers' behavior, the ordering which is assumed to exist, additionally happens to be interpreted as that reflecting the exogenously given preference ranking over the universal set of consumption

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chosen by i from A. We use the stronger definition to bypass this intuitive difficulty. Clearly, if this strong version of the maximization postulate is not falsifiable, then the weaker version will not be falsifiable either.

[8] Given a binary relation R_i defined over a set X_i, and a subset A of X_i, an element, a, of A is an R_i - greatest element of A if and only if, for all $b \in A$, aR_ib. R_i is an ordering over X_i if and only if R_i satisfies (i) reflexivity: for all $x \in X_i, xR_ix$; (ii) connectedness: for all distinct $x, y \in X_i$, xR_iy or yR_ix; and (iii) transitivity: for all $x, y, z \in R_i, [xR_iy$ and $yR_iz]$ implies xR_iz. What we call (following Sen (1970)) an ordering is also often called a 'pre-order', a 'weak order' or a 'weak ordering'.

[9] The substantive interpretation may however be important in providing an a priori motivation for the theorist's interest in this particular notion of consistency.

bundles. In the standard theory of competitive producers' behavior, the given price vector determines the producers' ranking of alternative production plans, since the producer's ordering is defined over the universal set of alternative combinations of price vectors and technologically feasible production plans. Additionally, it is assumed that the producer's ordering over this universal set can be represented by a real-valued function that ascribes to each option in this set its corresponding profit level.

Using the notion of a decision-maker specified in Definition 1 and that of maximization specified in Definition 2, we can now state the maximization postulate more precisely as follows.

For every agent i, there exists a triple $\langle X_i, Y_i, C_i \rangle$ such that: (a) i is a decision-maker characterized by $\langle X_i, Y_i, C_i \rangle$; and (b) there exists an ordering R_i, defined over X_i, which rationalizes the choice function C_i characteristic of i. (3)

Restatement of the maximization hypothesis in the form given by (3), rather than (1), helps to clarify the weakness of the argument advanced by Caldwell (1983) in response to Boland's thesis. Caldwell accepts Boland's conclusion, but attributes the 'metaphysical' nature of (1) to the fact that it does not specify what a is, i.e. it does not specify what the agent maximizes. Caldwell argues that the same problem would arise if one assumed that the agent maximizes 'glitch', when no one knew what glitch was. However, the statement of the maximization hypothesis in (3) does not specify the substantive content of the ordering R_i that figures in it. In fact, one could even postulate that the ordering is a 'glitch' based one, and that the agent is maximizing 'glitch'. Formulation (3), as distinct from formulation (1), is free from any reference to an $'a'$ that the agent maximizes. Therefore, the specific interpretation of such an a is irrelevant for the falsifiability or otherwise of (3). Since the specification of the substantive content of the agent's preference ordering is not essential to the economic theory of choice, its absence cannot have any bearing on its logical status.

Statement (3) is the conjunction of two claims. First, every agent is a *decision-maker* according to some characterization. Second, for every agent, the class of all orderings defined over the universal set characteristic of the agent *qua* decision-maker contains at least one member that has the property of being able to rationalize the choice function characteristic of that agent. Note that, while the class of orderings defined over any non-empty universal set must necessarily be non-empty, there is no a priori reason why choice functions must necessarily be rationalizable in terms of orderings, or, for that matter, why they must necessarily exist. Nor is there any a priori reason why choice functions will never (a) exist, or (b) be rationalizable in terms of orderings. Hence, neither (3), nor its negation, can be considered tautologically valid: the maximization hypothesis cannot be shown to be true or false merely as a matter of internal consistency. Empirical evidence is necessary to settle the issue.

Is it then possible, in principle, to empirically establish that (3) is false? For this, one has to proceed in four stages.

Stage 1: One has to pick an agent, k, and assume that k is a decision-maker.

Stage 2: One has to identify the alternative feasible sets k would choose from; i.e. identify the sets X_k and Y_k which characterize k as a decision-maker.

Stage 3: One has to observe k's choices from at least some of the sets belonging to Y_k (if Y_k is an infinite class, then it will not be possible to observe k's choice from every set belonging to Y_k).

Stage 4: Finally, on the basis of observations in Stage 3, one has to demonstrate that the decision-maker's choice function is not rationalizable in terms of an ordering.

Boland's reasoning would suggest that Stage 4 would constitute the main hurdle. Whenever X_k happens to be an infinite set, the class of all orderings over X_k is infinite as well. Hence, the claim that agent k's choices can be rationalized in terms of some ordering involves an existential statement about an infinite class, which, according to Boland's reasoning, is logically closed to falsification.

However, we know that, if a decision-maker's choices can be rationalized in terms of an ordering, then his choices must necessarily satisfy WARP. Given an agent, k, and the corresponding pair $\langle X_k, Y_k \rangle$ which characterizes k as a decision-maker, one can observe the choices made by k from at least some of the feasible sets, and check whether some pair of choices involve a violation of WARP. It is possible in principle that one will find a violation. Thus, given an agent, k, if we can correctly identify the universal set and the class of feasible sets $\langle X_k, Y_k \rangle$ which characterize k as a decision-maker, then, by observing k's actual choices from alternative feasible sets, it is possible in principle to show that the maximization postulate is false.

C. The Problem of Characterization:

The real problem lies in Step 2, i.e., in how the observer identifies the feasible sets (and, consequently, the observed choices) which characterize an agent k as a decision-maker. Typically, decision theorists rely on observations of an agent's behavior in an environment, such as the market, which is not controlled by the former. If the observer relies on observations in an uncontrolled environment, then she can never be certain that the pair $\langle X_k, Y_k \rangle$ and the corresponding set of observed decisions, that she identifies as characterizing the agent under consideration as a decision-maker, truly define the decision-making characteristics of that agent. This argument may be illustrated with the help of two examples.

Our first example is taken from the literature on stochastic choices (see, for example, Bandyopadhyay, Dasgupta and Pattanaik (1999)). Consider a consumer who eats hot meat dishes when it is cold and light salads when it is hot. On cold days, given the choice between beef stew and rice salad, he chooses beef stew, while, on hot days, given the same choice, he chooses rice salad. An observer, who does not have any information about the weather prevailing at the time of the consumer's choice or about the link between the weather and the consumer's choice of food, may visualize the alternatives as beef stew and salad. In that case, the observer would see the consumer as sometimes choosing beef stew from {beef stew, rice salad} and, at other times, choosing rice salad from {beef stew and rice salad}. Clearly, when the alternatives and the feasible set are conceived in this way, there is not even a choice function for the consumer. Hence, the consumer can't be even considered a decision-maker, and, obviously, there cannot possibly be any single ordering over the set {beef stew, rice salad} in terms of which one can rationalize the consumer's choices. However, one can also visualize the alternatives as: beef stew in cold weather, beef stew in hot weather; rice salad in cold weather, and rice salad in hot weather. In that case, the consumer can be seen to be choosing "beef stew in cold weather" from the feasible set {beef stew in cold weather, rice salad in cold weather} and "rice salad in hot weather" from the feasible set {beef stew in hot weather, rice salad in hot weather}. It is now possible to find an ordering over the set {beef stew in cold weather, rice salad in cold weather, beef stew in hot weather, rice salad in hot weather} which can rationalize the consumer's choices from the feasible sets {beef stew in cold weather, rice salad in cold weather} and {beef stew in hot weather, rice salad in hot weather}.

Our second example has its conceptual origin in Sen (1993, 1997). Suppose, we observe that, in parties, whenever the tray of fruits contains several apples, several oranges and several pears, guest k always picks up an apple, while the same guest always picks up an orange when the tray contains one apple and several oranges. How does the decision theorist identify the feasible sets of options here and the corresponding choices? One possibility is to identify the two feasible sets as B = {x, y, z} and D = {x, y}, where x = take an apple from the tray; y = take an orange from the tray; and z = take a pear from the tray. In this case, one can specify k's choice function to be C_k such that $C_k(B)$ = {x} and $C_k(D)$ = {y}. However, one may also interpret the feasible sets as $B' = \{x', y', z'\}$ and $D' = \{x'', y'\}$, where x' = take one of several apples in the tray; y' = take one of several oranges in the tray; z' = take one of several pears in the tray; and x'' = take the sole apple in the tray, and, as a result, be considered rude. One may then specify k's choice function to be C'_k where $C'_k(B')$ = {x'} and $C'_k(D')$= {y'}. While the choice function C_k violates WARP and cannot be rationalized by any ordering defined over $\{x, y, z\}$, we can find an ordering over $\{x', y', z', x''\}$ which rationalizes the choice function C'_k.

Both examples illustrate the following. What constitutes an option or an alternative for an agent is not directly revealed to an observer who perceives aspects of the agent's behavior in an environment that the observer does not control. Any option chosen or rejected by an agent would be associated with an infinite number of features that may be considered irrelevant by the agent himself for purposes of decision-making. Changes in these features would not be perceived by the agent to have changed the set of alternatives open to him. However, exactly what features are relevant for the agent, in his capacity as a decision-maker, is not revealed to the observer. As a consequence, when the observer tries to characterize an agent k as a decision-maker by identifying a triple $\langle X_k, Y_k, C_k \rangle$, she would be faced with infinitely many alternative ways of specifying the triple. As she cannot know which features of the environment are relevant for the agent in his decision-making capacity, she cannot know what the "true" specification, (i.e., the specification that the agent himself would find appropriate) is. Furthermore, she cannot have any external logical ground for considering one characterization more valid than any other.

The problem of correctly identifying an agent's decision-making characteristics has far reaching consequences for the possibility of falsifying the maximization postulate on the basis of an outside observer's perceptions in an environment not controlled by the latter. Suppose, on the basis of such observations, the observer characterizes agent k as a decision-maker by identifying a pair $\langle X_k, Y_k \rangle$, interprets k's observed choices accordingly, and then finds that WARP is violated for this characterization. In that case, there must necessarily be at least one option that the observer considers as being available to the decision-maker under two different feasible sets. However, since choice behavior is observed in an uncontrolled environment, the observer cannot possibly know whether some feature relevant to the decision-maker is considered by the decision-maker to have changed across two choice situations, thereby making the two feasible sets completely distinct. Thus, if k is a decision-maker, all that one can conclude from the observation is that exactly one of the following three possibilities holds: (1) the observer's characterization of k is the true characterization, but k is violating WARP so that the maximization postulate is false; (2) the observer's characterization of k is not the true characterization of k, and, if one considered the triple that truly characterizes k, k would be found to be satisfying WARP, so that the maximization postulate is not necessarily false; and (3) the observer's characterization of k is not the true characterization, and, even if one considered the triple that truly characterizes k, k would be found to be violating WARP, so that the maximization postulate is false. However, there is no way of saying which of these three possibilities holds (or, indeed, whether k is really a decision-maker at all). This is because what one is really testing is the conjunction of two hypotheses, namely, (a) that the agent is characterized as a decision-maker by the options and choices that the observer has specified for him, and (b) that the decision-maker thus characterized satisfies WARP.

If only a finite number of alternative characterizations were possible, then one could conclude that the maximization hypothesis is false, if one found a violation of WARP for every single characterization. However, since an infinite number of alternative characterizations are possible, it is impossible to falsify the claim that there exists some re-characterization that will eliminate any given violation of WARP. Consequently, it is logically impossible to test this consistency restriction (and, therefore, the maximization hypothesis), by itself, on the basis of data gathered in an uncontrolled environment. The same difficulty would arise, in exactly the same form, if what one was testing was some consistency restriction other than WARP.

Note that, by the same token, it is also logically impossible to *verify* any consistency restriction (and, hence, the maximization hypothesis) on the basis of observations in an uncontrolled environment, even for *a single decision-maker*. Suppose all choices of an agent characterized as a decision-maker in a specific fashion are observed and satisfy WARP. One still cannot rule out the possibility that (a) there exists some alternative characterization of this agent that will generate a violation of WARP, and (b) it is this alternative which is the true characterization. Thus, one cannot infer that the decision-maker is not really violating the consistency restriction. It follows that Boland's justification for the non-verifiability of the maximization hypothesis in terms of its universal character is redundant. Furthermore, since, by the same argument, it is not possible to either verify or falsify the claim that the agent's choice behavior can be represented by a *choice function*, it is not even possible to either falsify or verify the assumption that the agent is indeed a decision-maker.

Caldwell also asserts that tests of the maximization hypothesis through tests of the revealed preference axioms are inconclusive. However, in his formulation, this is so because they involve the joint testing of: (a) the maximization hypothesis; and (b) the hypothesis that preferences, as well as "the states of information" confronting the decision-maker in different choice situations are stable (see Caldwell (1983, p.824)). The particular form of the problem of joint testing that we have drawn attention to is fundamentally different, and more basic. In our specification of the maximization hypothesis, once an agent has been characterized by the observer, any violation of WARP, for any underlying reason whatsoever (including changes in preferences and information) can only be interpreted as a violation of the maximization hypothesis itself, assuming that the characterization is correct. Insofar as characterization of the agent as a decision-maker is the very first conceptual step that one has to take in testing any hypothesis about the agent, the problem of joint testing of hypothesis arises at a more primitive level in our formulation. In our formulation, the problem of joint testing arises essentially due to the impossibility of identifying the true decision-making characteristics of the agent through external observation. Thus, Caldwell's argument would seem to imply that it is possible to falsify the claim that a given decision-maker satisfies WARP, but that it is not possible to infer, from such falsification, that the decision-maker is also violating the maximization hypothesis. We are making the more basic argument that it is not possible to falsify (nor verify), by itself, the claim that an agent satisfies WARP, or, indeed, any consistency restriction on choice behavior whatsoever.

It should be clear from the above discussion that consistency restrictions on choice behavior may, in principle, be falsified if the observer (a) can control every conceivable feature of the environment in which choice takes place, and (b) knows that (a) is true. It however seems extremely unlikely that empirical experiments satisfying these two conditions could be implemented, or, indeed, even conceptualized in a logically coherent manner.

The problem is actually one example of a quite general methodological difficulty with trying to empirically falsify any hypothesis whatsoever. Arguably, every empirical testing of a hypothesis, taking place as it does under external conditions that cannot be completely controlled, actually involves the joint testing of more than one hypothesis. The theorist's decision to accept or reject a particular hypothesis on the basis of such results depends, to an extent, on considerations external to the logic of that hypothesis itself. Therefore, refutations derived empirically cannot, in general, be considered logically conclusive.[10]

IV. Concluding Remarks

In this paper, we have argued that, contrary to a common belief, the maximization hypothesis, as it is usually understood, does not constitute the foundation of the theory of rational choice in many areas of economics. In fact, in strategic contexts, where strategies, as distinct from outcomes, are what the agents actually choose, consistency of actual choices of an agent is neither assumed nor implied by the theory. Furthermore, in contexts where the hypothesis does play a crucial role in the analysis, it is not logically possible to establish either a violation or a satisfaction of the hypothesis, on the basis of observations of an agent's choice behavior. While contesting some earlier arguments made in favor of this conclusion, we have advanced the following independent justification. When an observer seeks to test some consistency restriction on choice behavior, what the observer really tests is the conjunction of the consistency hypothesis and the assumption that the agent's decision-making characteristics have been correctly identified. Hence, observation cannot possibly falsify (nor verify) by itself, the claim that a decision-maker satisfies any consistency restriction on choice behavior whatsoever. It follows that the substantive significance of critiques of positive rational choice theory that are formulated in terms of the inflexibility and empirical implausibility of internal consistency restrictions on choice behavior is open to question.

[10] This argument is well-known in the literature as the Duhem-Quine thesis. For the classic general statement of the problem, see Quine (1953).

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