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## The Problems of Testing Preference Axioms with Revealed Preference Theory\*

*Abstract:* In economics, it has often been claimed that testing choice data for violation of certain axioms—particularly if the choice data is observed under laboratory conditions—allows conclusions about the validity of certain preference axioms and the neoclassical maximization hypothesis. In this paper I argue that these conclusions are unfounded. In particular, it is unclear what exactly is tested, and the interpretation of the test results are ambiguous. Further, there are plausible reasons why the postulated choice axioms should not hold. Last, these tests make implicit assumptions about beliefs that further blur the interpretations of the results. The tests therefore say little if anything about the validity of certain preference axioms or the maximization hypothesis.

### 0. Introduction

Economists explain and predict human behaviour in terms of agents' preferences. Some people buy insurance because they prefer a certain amount of security over the goods that they could have bought for the premium; others enrol at university because they prefer the degree to the salaries they could have earned in that time; yet others take out a loan because they prefer a steady stream of consumption to a tight budget now and wealth at retirement.

When economists explain a person's action, they attribute to her preferences that *rationalize* her action—i.e. that make it rational for her to have chosen this action. When economists predict a person's action, they determine the choice the person would rationally take, given her preferences and environmental conditions.

The problem with explanations and predictions of this sort is that the preferences employed in them raise empirical scruples. Preferences are subjective mental states that are not directly observable; hence the question arises whether they are compatible with good scientific practice. The principle most often endorsed by economists today to overcome these scruples is that of *methodological behaviourism*: preferences must be inferred exclusively from observed behaviour, and introspection is generally not admissible.<sup>1</sup>

The most prominent methodology that economists use to attribute prefer-

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<sup>1</sup> Note, however, that verbal expressions are admissible as evidence for preferences according

ences according to this principle is the *revealed preference* concept.<sup>2</sup> It claims that the satisfaction of certain axioms over an agent's choices is equivalent to the existence of a preference ordering that rationalizes these choices. From this purported equivalence, economists derive some important results. The claims are as follows: that one can infer, first, the preference ordering from the observed choices if the choice axioms are satisfied, and second, the irrationality of the preference ordering if the choice axioms are violated. If both of these claims were true, revealed preference theory would indeed be a very powerful tool. In this paper, I will argue that such optimism is unfounded. On closer inspection, revealed preference theory does not hold what it seems to promise, and turns out to be a tool of rather limited use.

I will start by sketching the theoretical framework of revealed preference theory in section 1. However, the questions cannot be answered by investigating the formal apparatus alone; nor should one expect to base one's criticism on its potential flaws. Rather, the centre of attention must be the interpretations which this framework has enjoyed: how economists have understood the revealed preference theory, and—even more importantly—to which uses they have put it in their scientific practices. Thus, in section 2, I will discuss three different interpretations: first the understanding of revealed preference theory as an elimination of the language of preference and other motivational states altogether; second the attempt to estimate the form of a preference ordering from an agent's observed choices; and third, the attempt to test the validity of the preference axioms by testing for the violation of the choice axioms.

In section 3, I will focus on this testability claim. First, I contest the relation between particular preference axioms and the neoclassical model of consumer behaviour, which is the chief target of the tests. I then show that the test results which show the violation of the choice axioms are ambiguous in their implications for preferences, despite all efforts to control the experimental conditions in the laboratory. Third, I will argue for reasonable properties of preference orderings which require the choice axioms to be false. Finally, I show that revealed preference theory makes implicit assumptions about beliefs which ambiguate the interpretation of choice axiom violations even further. On the basis of these four arguments, I conclude that one cannot test for the satisfaction of preference axioms on the basis of revealed preference theory.

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to methodological behaviourism as long as they are interpreted as verbal *behaviour*, in contrast to introspective knowledge.

<sup>2</sup> An informal survey of microeconomic textbooks shows that the revealed preference concept is indeed still part of the economic canon. Compare for example Mas-Colell et al. 1995 or Varian 1992 where the notion takes centre stage in the chapters on consumer choice and demand functions. Further, a search for 'revealed preference\*' in *EconLit* shows that 50 refereed journal articles were published on this subject between 1990–94, 61 between 1995–99 and 79 between 2000–04.

## 1. The Framework

Revealed preference theory specifies axiomatic constraints over choice data as well as axiomatic constraints over preferences. It then shows the equivalence between some of these axiomatic constellations.

The axiomatic constraints over choice data are expressed as constraints over specific *revealed preference relations*. This name is somewhat misleading, as a revealed preference relation is only an arbitrarily constructed relation between alternatives chosen under different conditions. It is not necessarily identical to the preference relation employed in the explanation and prediction of behaviour. Rather, it is the *interpretation* of some economists that the relation constructed thus is—under specific conditions—identical to the relevant preference ordering. This interpretative claim has to be clearly separated from the formally sound constructions and proven identities. It will be discussed in section 2 and criticized in section 3, while the formal apparatus is presented here.

The relations and the constraints are constructed as follows. An observation of an agent's behaviour at time  $i$  yields a pair  $p_i, x_i$  such that  $p_i$  and  $x_i$  are vectors of  $\mathbb{R}_+^n$  of the same dimensionality.  $x_i$  records the specific bundle of goods the agent chose at time  $i$  (say: 1 cup of coffee, 2 pieces of cake, 1 cigarette and 1000 money units), while  $p_i$  records the unit prices for the respective goods at that time (where money units trivially have the price 1). Let's now assume that the only constraint on the availability of goods is a budgetary one: if the agent has sufficient income to pay  $p_i \cdot x_j$ , then  $x_j$  is available to her at time  $i$ . Therefore, for all  $x_j$  with  $i \neq j$ , if  $p_i \cdot x_i \geq p_i \cdot x_j$ ,  $x_j$  was available to the agent at  $i$  but she did not choose it. Under these conditions it is said that  $x_i$  is revealed preferred to  $x_j$ , and the *revealed preference relation*  $W$  is defined as:

$$x_i W x_j \Leftrightarrow p_i \cdot x_i \geq p_i \cdot x_j$$

Given that a cup of coffee costs \$2, a piece of cake \$4 and a cigarette \$0.25, the above agent could, for example, have had the consumption bundle  $x_j$ : 2 cups of coffee, no cake, a pack of cigarettes and \$1000 left for other consumption. Because she chose  $x_i$  over  $x_j$ , even though she could afford  $x_j$ , one says that she revealed prefers  $x_i$  to  $x_j$ .

Similarly, it is said that  $x_i$  is strictly revealed preferred to  $x_j$  when she not only could have afforded  $x_j$ , but  $x_j$  under those prices was strictly less expensive. The *strictly revealed preference relation*  $S$  is defined as:

$$x_i S x_j \Leftrightarrow p_i \cdot x_i > p_i \cdot x_j$$

Further, it is said that  $x_i$  is indirectly revealed preferred to  $x_k$  if the two bundles are connected by  $W$  through a number of intermediary bundles – for example when  $x_i$  is revealed preferred to  $x_j$  and  $x_j$  is revealed preferred to  $x_k$ . The *indirectly revealed preference relation*  $N$  is then defined as:

$$x_i N x_j \Leftrightarrow x_i W x_1^* W \dots W x_n^* W x_j$$

The intuition behind these definitions can be illustrated with the example of a two-goods economy, as depicted in figure 1.

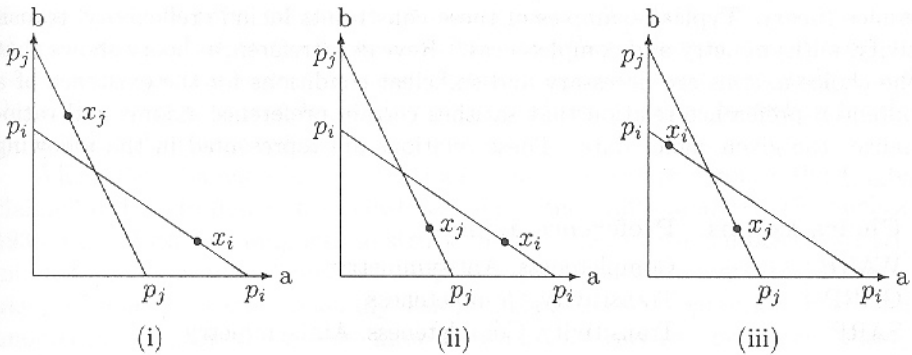


Figure 1: Revealed Preferences in a Two-Goods Economy

In a two-goods economy, a consumption bundle  $x_i$  consist of goods  $a$  and  $b$  only:  $x_i = \langle a, b \rangle$ . The respective price vector has the form  $p_i = \langle p_a, p_b \rangle$ . An agent is restricted in her choices by her budget constraint: she cannot choose a consumption bundle  $\langle a^*, b^* \rangle$  which is greater than her income  $m$ :  $p_a a + p_b b \leq m$ . This budget frontier is depicted in figure 1 by the lines indexed  $p_i$  and  $p_j$ , respectively. On the line itself, the agent can replace one unit of  $a$  in her consumption bundle by  $\frac{p_b}{p_a}$  units of  $b$ . Every point  $x_k$  to the lower left of the budget frontier is thus affordable to the agent under the given prices:  $p_i \cdot x_i \geq p_i \cdot x_k$ . Thus,  $x_i$  is  $S$ -revealed preferred to all these points (and  $W$ -revealed preferred to all these points to the lower left of and on the budget frontier).

The three graphs in figure 1 represent three different pairs of observed choices. In graph (i),  $x_i$  is not affordable under prices  $p_j$  and neither is  $x_j$  affordable under prices  $p_i$ . Hence there is no revealed preference relation between these two bundles. In graph (ii),  $x_i$  is not affordable under prices  $p_j$  but  $x_j$  is affordable under prices  $p_i$ . Hence  $x_i$  is  $W$  and  $S$ -revealed preferred to  $x_j$ . Further, there is an area that is to the lower left of the  $p_j$  line but not to the  $p_i$  line. Hence  $x_j$  is  $S$  and  $W$ -revealed to all points in this area, but  $x_i$  is not. However, because  $x_i$  is  $S$  and  $W$ -revealed to  $x_j$ ,  $x_i$  is  $N$ -revealed preferred to these points. In graph (iii),  $x_i$  is affordable under prices  $p_j$  and also  $x_j$  is affordable under prices  $p_i$ . Hence  $x_i$  is  $W$  and  $S$ -revealed preferred to  $x_j$ , and  $x_j$  is  $W$  and  $S$ -revealed preferred to  $x_i$ . This last case violates the axiomatic restrictions imposed on choices, which will be presented now.

The three relevant axioms of revealed preference theory are the WARP axiom ('weak axiom of revealed preferences') which requires the relation  $W$  to be antisymmetric:  $x_i W x_j \Rightarrow \neg(x_j W x_i)$ , for all non-identical bundles  $x_i, x_j$ ; the GARP axiom ('generalized axiom of revealed preferences'), which requires that  $N$  is not contradicted by  $S$ :  $x_i N x_j \Rightarrow \neg(x_j S x_i)$ , and the SARP axiom ('strong axiom of revealed preferences'), which requires the antisymmetry of  $N$ :  $x_i N x_j \Rightarrow \neg(x_j N x_i)$ . Obviously, SARP implies GARP and WARP, while there is no general implication relationship between GARP and WARP.

The axiomatic constraints over a preference relation  $\succeq$  are known from preference theory. Typical examples of these constraints include reflexivity, transitivity, antisymmetry and completeness.<sup>3</sup> Revealed preference theory shows that the choice axioms are necessary and sufficient conditions for the existence of a potential preference relation that satisfies certain preference axioms and rationalizes the given choice data. These relations are represented in the following table.<sup>4</sup>

Choice axioms	Preference axioms
WARP	Completeness, Antisymmetry
GARP	Transitivity, Completeness
SARP	Transitivity, Completeness, Antisymmetry

Table 1: The relation between choice and preference axioms

More specifically, the satisfaction of a choice axiom on the one hand implies the existence of a preference relation which satisfies the specified axioms and rationalizes the given choice data (relative to some notion of optimization). On the other hand, if the agent's preference ordering satisfied the specified axioms, the choices it rationalizes (given a notion of optimization) would satisfy the respective choice axiom.

What revealed preference theory does not show—despite all talk about the ‘equivalence’ of choice axioms and preference axioms—is that the specific preference relation implied by the respective choice axiom is indeed the preference ordering on which an agent bases her deliberation. In the next section, I will show that economists often claim this to be the case—without, however, providing any argument for it. Instead, this claim is either entertained as a hidden assumption; or revealed preference theory is held—wrongly—to justify it. This will become clearer by looking at economists' practices.

## 2. Interpretations

The formal results of revealed preference theory are rigorously proven; to criticize the theory does not mean to find fault with its formal results. As Hausman points out,

“to see how one can consistently deny that choices reveal preferences without challenging the revelation theorem[s], one must distinguish carefully between the theorem and its interpretation.” (Hausman 2000, 100–101)

Thus the criticism presented here is about the way economists have understood the formal results, and how they have used them in their scientific practices.

<sup>3</sup>  $\succeq$  is reflexive iff for all  $x : x \succeq x$ . It is transitive iff for all  $x, y, z : x \succeq y$  and  $y \succeq z \Leftrightarrow x \succeq z$ . It is antisymmetric iff for all  $x, y, x \neq y : x \succeq y \Leftrightarrow \neg(y \succeq x)$ . It is complete iff for all  $x, y : x \succeq y$  or  $y \succeq x$ .

<sup>4</sup> For reference see Richter 1966; Shafer 1975 and Varian 1982.

In this section I will discuss three different types of understanding. First, the interpretation of revealed preference theory as an elimination of the language of preference and other motivational states altogether.<sup>5</sup> Second, the attempt to estimate the form of a preference ordering from an agent's observed choices; and third, the attempt to test the validity of the preference axioms by testing for the violation of the choice axioms.

When Paul Samuelson in 1938 pioneered revealed preference theory, he claimed to be "dropping off the last vestiges of the utility analysis" (Samuelson 1938, 62). With this proposal he struck the right note with the positivistically minded, to whom the reference to subjective (and hence unobservable) states—like preferences—seemed generally disreputable to scientific practice. From this understanding grew the radical interpretation that revealed preference theory might desist from reference to mental properties altogether. In this vein, Hicks claimed that demand theory study human behaviour without claiming to be able "to see inside their heads"; while Little spoke of a theory of human behaviour solely based on the notion of consistent *behaviour*. Such a framework, he suggested, would be scientifically more respectable, because it reduced the number of concepts and axioms and avoided reference to non-observables altogether:

"If an individual's behaviour is consistent, then it must be possible to explain that behaviour without reference to anything other than behaviour." (Little 1949, 97)

This attempt to introduce radical behaviourism into economics by denying any scientific role for mental properties never succeeded. The problem is particularly clear in Little, who tried to specify what 'consistent behaviour' was supposed to mean:

"Consistent behaviour, by definition, can be taken to mean: (a) if an individual once chooses *A* rather than *B*, then he will always do so, (b) choice is a transitive relation, and (c) the individual never chooses a smaller collection when a larger is available." (Little 1949, 91)

In contrast to the confidence of this claim, it is simply not clear how the concept of consistency fits to the concept of behaviour. Little himself seemed to have had no clear intuition why choosing *A* over *B* at one time and *B* over *A* at another is inconsistent and thus claimed consistency 'by definition'. Similarly, it is not clear why choice is supposed to be a relation, and a transitive one at that. Such a notion of consistency *by fiat* is unsatisfactory: it tries to overcome the empirically difficult concept of preference by forcing its indispensable properties onto the empirically more savoury concept of choice. But all the intuition behind consistency is derived from deliberation based on mental states; to deny this background while insisting on its intuition is to want the song without the bird. Instead of arguing for such an absurd standpoint, one should admit that the

<sup>5</sup> This project set out to revolutionize economics but has lost most of its significance today. I discuss it here to avoid misunderstandings that often arise when readers first encounter the revealed preference framework.



alleged relationality, transitivity and antisymmetry of choice are properties of specific kinds of preference relations, and they only make sense when applied to them.

“What makes [behaviour] look inconsistent is precisely the peep into the head of the consumer, the avoidance of which is alleged to be the aim of the revealed preference approach.” (Sen, 1973, 56)

For these reasons, the revealed preference approach as the elimination of non-observable concepts was never a success, and does not play a relevant role in today's economics anymore.

Samuelson himself soon clarified his interpretation of the framework. His goal was not the elimination of the preference concept, but the development of a method that allowed the testing of preference axioms as well as the inference of the form of the preference relation. In his interpretation, the methodology allows testing, because the relation between preference and choice axioms specify observable criteria for the satisfaction of particular preference axiom constellations.

“Modern utility theory [which requires certain preference axioms to hold] ... is a hypothesis which places definite restrictions upon demand functions and price-quantity data, these could be refuted or verified under ideal observational conditions.” (Samuelson 1947, 92)

If the preference axioms hold, the methodology further allows the derivation of preferences from choice data:

“The individual guinea-pig, by his market behaviour, reveals his preference pattern – if there is such a pattern.” (Samuelson 1938, 243)

Both of these functions of revealed preference theory find wide application in today's economic practices, as non-parametric and parametric tests. I will discuss these two methodologies in turn.

*Parametric tests* estimate a preference ordering from available price, environmental and behavioural data. Estimates range from preferences over classical consumer goods through investment decisions to urban living locations. A typical example of this approach can be found in Kahn (1995), who estimates the quality of life rankings of US cities in terms of people's choices of where to live. In a first step, Kahn estimates agents' hypothetical wages and rents for all cities. These estimates then function as the 'price vector' for each city. In a second step, he interprets people's decision to stay in a city even though they could afford to live in another city as their preference for living in that city: “If a person can raise his wages and lower his rentals by moving from city *a* to city *b*, then city *a* must be nicer than city *b*.” (Kahn 1995, 222) His method yields a ranking for LA, San Francisco and NYC over Houston and Chicago.

Without discussing any details here, the problem of all these parametric tests is that they test for two things at the same time. First, they test that there is a preference relation which satisfies particular axioms and serves as a basis for maximizing deliberation; and second, that this preference relation has

a particular form. Because both aspects cannot be tested at the same time, the parametric approach in effect postulates the satisfaction of the preference axioms and estimates the form of the preference relation on the basis of this postulation.

In contrast to this, *non-parametric tests* purport to test the validity of the preference axioms by examining whether individual demand data satisfies the axioms of choice. From these test results—with the help of the equalities between choice and preference axioms—revealed preference theory claims to derive empirically founded judgments about the satisfaction of preference axioms.

A non-parametric test algorithm was developed by Varian (1982) on the basis of GARP. Remember that GARP requires the bilateral asymmetry of  $N$  and  $S$ :  $x_i N x_j \Rightarrow \neg(x_j S x_i)$ . The test proceeds by constructing the relations  $W$ ,  $S$  and  $N$ : for each price vector  $p_i$ , order all consumption vectors  $x_1, \dots, x_n$  according to the magnitude of their product  $p_k \cdot x_k$ ,  $k = 1, \dots, n$ . All consumption vectors ordered below  $x_i$  are then  $x_i W x_j$ , and all those consumption vectors ordered below  $x_i$  with a sum smaller than  $p_i \cdot x_i$  are  $x_i S x_j$ . The relation  $N$  is then constructed from the relation  $W$  as defined in section 1. Comparing the  $N$ -relations with the  $S$ -relations defined over the set of consumption vectors, every occurrence of  $x_i N x_j$  and  $x_j S x_i$  counts as a violation of GARP.<sup>6</sup> For Varian, this test has far reaching significance:

“We have a straightforward and efficient way to check a finite amount of data for consistency with the neoclassical model of consumer behaviour.” (Varian 1982, 949)

In the microeconomic literature in general, negative test results for any of the choice axioms have been interpreted even more strongly. For example, in one of the standard microeconomic textbooks, the violation of SARP is interpreted as a violation of preference transitivity:

“The strong axiom is essentially equivalent to the rational preference hypothesis ... Violations of the SA[RP] mean cycling choices ... This suggests preferences that may violate the transitivity axiom.” (Mas-Colell et al. 1995, 92)

Both interpretations suffer from the problem of preference instability. If preferences have changed over the observation period, it is possible that choices based on an inconsistent preference ordering do not violate the respective choice axiom; and it is possible that choices based on a consistent preference ordering do violate the respective choice axiom.<sup>7</sup> This is a common problem encountered

<sup>6</sup> Varian develops a slightly different test algorithm than presented here, because he is interested in its computational efficiency. This does not have any effect on the conceptual framework, hence I have chosen a different presentation for reasons of clarity.

<sup>7</sup> Therefore, to observe no SARP violations in the aggregate consumption data from the UK in the period from 1900 to 1955 does *not* mean that no taste change occurred—contrary to a claim by Landsburg 1981:

“We observe what quantity of each good was observed in 1900 ... and we calculate what the price of this market basket would have been had it been purchased



with tests based on panel data, where the observed choices stretch out over a time period that might easily accommodate one or more preference changes.

In a number of recent articles, economists have pointed out the use of laboratory experiments to avoid this particular kind of ambiguity. Because they allow limiting the time period in which the observed choices are made, and because external shocks (like changes of income, influx of information, observation of other consumers' behaviour) can be controlled for the period of the experiment, the possibility of preference instabilities is very much reduced and can—so the authors claim—be excluded as an interpretation of choice axiom violation.

The design of the different experiments is similar to a large degree.<sup>8</sup> Experimental subjects are asked to make hypothetical choices between a number of consumption goods. Menus with different prices (sometimes income is adjusted in order to compensate for price changes) are offered under different budget constraints. Experimental subjects are told that they will receive one of the chosen bundles—selected at random—after the experiment ends. Subjects have to perform the hypothetical choices in a short time, usually less than one hour. The results of all experiments show high violation rates. Varying with the experiment, one quarter to two thirds of the test persons violated GARP. In the experiments that tested for SARP violations (Sippel 1997), the violation rate lay between 73% and 90%.

Given that the problems related to preference instability were circumvented by the laboratory conditions, the experimenters felt entitled to draw strong conclusions:

“We find a considerable number of violations of the revealed preference axioms, which contradicts the neoclassical theory of the consumer maximizing utility subject to a given budget constraint.” (Sippel 1997, 1443)

“The behaviour of a significant number of individual consumers is inconsistent with the neoclassical model.” (Mattei 2000, 495)

From investigating the conventional understanding and usage of revealed preference theory in contemporary economics, I conclude that it is believed to be a tool for testing the validity of preference axioms as well as the general maximization hypothesis. In the next section, I will show that this belief is unfounded.

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in 1910. If the price is lower than the price of the basket which was actually consumed in 1910, then we conclude that (in 1910) the 1910 basket was considered preferable to the 1900 basket. We repeat this procedure for every possible pair of years over some time period. Then we search for intransitivities ... . In other words, we search for violations of the Strong Axiom of revealed Preferences [SARP]. Such an intransitivity is taken as evidence of a change in tastes.” (Landsburg 1981, 92–93)

I will discuss this ambiguity further in section 3.

<sup>8</sup> Detailed accounts can be found in Sippel 1997; Mattei 2000; Février and Visser 2004.

(1973) suggests the alternative concept of liberal maximization. It says that an alternative is optimal (and hence chosen) iff it is not dominated by any other alternative. Such a notion of optimization requires the underlying preferences only to be transitive, but not complete. Schwartz (1972) further suggests a notion of optimization that satisfies intuitive criteria of rationality but does not require the underlying preference relation to be transitive. Last, Hansson (2004) constructs a preference-based choice function that may be both incomplete and intransitive.

It is important to maintain that these notions of optimization are not fundamental deviations from the model of preference axiomatization. Rather, they are expansions of the narrow maximization model, and as such they are in principle compatible with expected utility analysis. In fact, economists have begun incorporating these notions into their work, and a representation result exists at least for preferences that serve as the basis of liberal maximization (compare Dubra et al. 2004). Given that any specific preference axiom is a rationality requirement only relative to a specific notion of optimization, and given that there exist different notions of optimization that qualify as the neoclassical maximization model, the claim that a violation of a choice axiom shows that something is wrong with the neoclassical model in general is unjustified.

But even if the 'neoclassical model' only meant a model of conventional (narrow or liberal) maximization, the non-parametric tests would, in principle, not be sufficient for its rejection. The satisfaction of GARP, for example, is a necessary condition for the existence of a transitive and complete preference relation that rationalizes the observed choice data. Conversely, the violation of GARP implies the violation of at least *one* of the following four options. The agent's preferences might have been (i) unstable, (ii) intransitive, (iii) incomplete, or (iv) the agent might not have followed the maximization rule, despite her preferences being stable, transitive and complete.<sup>9</sup> As discussed in section 2, laboratory conditions can exclude (i) as a viable option. Further, strict maximization implies transitivity *and* completeness, hence the violation of either will imply the violation of strict maximization. Nevertheless, ambiguities remain. For one, it is impossible to deduce from the violation of GARP (or SARP) that the underlying preference ordering is intransitive, as it is claimed in Mas-Colell et al. (1995, 92, quoted above): the violation could just as well have been caused by an incompleteness or the violation of strict maximization. Further, if liberal maximization is part of the neoclassical model, it is impossible to deduce from the violation of GARP (or SARP) that the agent does not observe the maximization rule, because the violation could have been caused by an incompleteness.

These ambiguities in testing the structure of deliberation in human agents is not in itself a new discovery. Donald Davidson for example, who worked in experimental psychology before turning to philosophy, found himself in a very similar dilemma when deciding how to interpret negative evidence.

"My conclusion from these experiments, and a hundred more of which

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<sup>9</sup> The violation of SARP implies at least one of the options (i) to (iv) or an indifference between two alternatives, the violation of WARP implies at least one of the options (i), (iii), (iv) or an indifference between alternatives.

I have read, is that they can be taken, if we want, as testing whether decision theory is true. But it is at least as plausible to take them as testing how good one or another criterion of preference is, on the assumption that decision theory is true." (Davidson 1974b, 272)

Davidson concluded that this ambiguity is ultimately irresolvable with empirical methods alone. Instead, he suggested that psychology had to deal with theoretical concepts that arranged observed choices in a consistent pattern. This is an interesting suggestion that merits further attention; at this point, however, it is sufficient to conclude that revealed preference theory is too ambiguous to derive the conclusions that one purportedly can from choice axiom violations. Neither the violation of SARP, GARP nor WARP give us unambiguous evidence that the agents preferences are intransitive, or that the agent does not observe the maximization rule.<sup>10</sup>

In addition to the ambiguity that remains when one diagnoses a violation of any one of the choice axioms, I now want to look at the plausibility of the preference relations whose existence is implied by the respective choice axioms. If the implied preference relations are found implausible, then one might conclude that the respective choice axioms *should* not be satisfied at all.

To start with SARP and WARP, they are sufficient for the existence of preference relations that are antisymmetric and complete. But these are strange properties for a preference relation. If an agent had a preference relation of that sort, she would hold a strict (and transitive) preference between any two alternatives. Whatever pair of consumption sets the agent is confronted with, she always preferred one over the other—she always had a reason to choose one rather than another, and she would not be indifferent between any two alternatives. Assuming these properties for preferences excludes the possibility that agents are faced with genuine *picking* situations.

But picking is an important aspect in human deliberation. An agent picks between two alternatives if she is indifferent between the two—if she does not have a reason to choose one over another. Paradigmatic examples for such a picking situation are supermarket shelves.<sup>11</sup> Confronted with a shelf full of the same product—say soup cans of a particular brand—the agent will choose those cans that are not dented, not beyond their due-date and within her reach. But many cans will usually pass these criteria, and she still has to arrive at

<sup>10</sup> An attempt to improve the significance of the test has been made by Diaye et al. They suggest a method of simultaneously testing SARP, GARP and WARP, that seems to allow a somewhat less ambiguous interpretation in one case. If one and the same set of choice data violates SARP and GARP but not WARP, they conclude that the agent "maximizes a stable complete and antisymmetric preference over the period. However since the agent violates SARP, this preference relation is not transitive." (Diaye et al. 2002, 6) In all other cases, they concede that the test result remains ambiguous. This is indeed an interesting refinement of the test against the concerns I have voiced so far. However, I will argue that there are good reasons why WARP *should* be violated just as SARP and GARP, such that the particular case that Diaye et al.'s refinement rests on is an anomaly of the data. And indeed, as their own empirical investigations show (Diaye et al. 2002, 9), WARP is violated in almost all those cases where SARP and GARP is violated. The relevance of this case for empirical tests of preference axioms is therefore small.

<sup>11</sup> As discussed in Ullman-Margalit/Morgenbesser 1977, 761.

one can to put into her trolley. Running out of further reasons to choose from these, the agent will pick a can. This is not to say that there *are* no further reasons; all that is relevant here is that the agent does not *have* them. She could possibly undertake a chemical or radiological analysis of the cans and their content, which might give her good reasons to prefer one over the other. Under given food hygiene standards, however, the costs of such an analysis in comparison to the expected gain derived from it might be prohibitive. Taking cost considerations into account then creates a sphere in which it is rational for the agent to rely on the subjective discernibility of two goods instead of investigating possible objective differences relevant for her evaluations. Hence picking situations based on indifference are important for a model of deliberation and hence for a plausible preference relation.

To include the possibility of picking situations, either the completeness or the antisymmetry of the preference relation must be given up. In either case, the ensuing preference relation will violate both SARP and WARP. Because indifference relations are a plausible feature of preference orderings, SARP and WARP should be violated.

GARP, in contrast to SARP and WARP, is sufficient for the existence of a transitive and complete preference relation. Hence picking situations based on indifferences can be included in a preference relation that rationalizes choices.

However, there is another important aspect of deliberation that is excluded from such a preference ordering, namely situations of genuine non-comparability. Archetypical for this is Sartre's anecdote—related in 'Existentialism and Humanism'—about a young man who is torn between staying at home to look after his ailing mother or leaving to join the Resistance in order to help free his countrymen from oppression. According to the anecdote, the young man has reasons for staying at home to the exclusion of joining the Resistance *and* he has reason for joining the Resistance to the exclusion of staying at home. Hence, clearly, he is not indifferent between the two alternatives—rather he finds it impossible to compare the two.

As in the case of indifference, incomparability can be resolved (although Sartre seems to claim the opposite, namely that the young man must simply throw himself one way or the other). They can be resolved through inquiry:

"To be sure, one must guard against the temptation to fix on a solution arbitrarily so as to avoid the need for inquiry. And the better the agent's computational capacity and memory ... the more effective is his capacity to carry out inquiries." (Levi 1986, 13)

But inquiry is costly, and computational cost might be prohibitive in comparison to the expected gains. In those situations, instead of investigating one's evaluation further, an agent might again pick one of the alternatives.<sup>12</sup>

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<sup>12</sup> This picking is the behavioural consequence of an aspect of the preference ordering different from indifference. From observations at one point in time, pickings based on indifference and pickings based on non-comparability cannot be distinguished. From observations over a time period, however, the two kinds of pickings can be distinguished. First, one can expect pickings based on indifference to be more robust in the face of new information than pickings

It is therefore plausible to distinguish between indifference and incomparability in a preference ordering. To incorporate both concepts, both the antisymmetry and the completeness axiom must be given up. In that case, the ensuing preference relation will violate GARP. Hence, because indifference and incomparability relations are a plausible feature of preference orderings, GARP should be violated.

So far, my criticism of revealed preference theory has focussed on the relation between choices and preferences. What I have left unquestioned—as do the revealed preference theorists—was the observability of choices themselves, in particular the claim that one can observe an agent choosing one alternative over another. This claim is difficult, because it assumes the identification of the alternatives as unproblematic.

To explain an agent's purchase of a health insurance policy, economists refer to her preference for the goods-bundle 'security and fewer other consumption goods' over the goods-bundle 'no security and more consumption goods'. But when observing her making this choice, who determines the 'amount' of security and the number of goods she compares? Relevant for the agent's choice are clearly *her* assessment of the risks and *her* beliefs about the nature and prices of the other goods available to her, not the observer's understanding nor any 'objective' numbers. Revealed preference theory does not provide a method to investigate these beliefs. Instead it assumes that the nature and quantity of goods-bundles can be determined before the choices are observed. But in most cases, this is not the case: one needs both the preferences and beliefs of an agent to explain her choices, and conversely, one can infer an agent's preferences from her choices only given her beliefs.<sup>13</sup>

Revealed preference theorists reply that beliefs are assumed to be fixed across relevant periods. Only on the basis of assumptions "about the nature of price-income or choice situation that the consumer faced" (Wong 1978, 88) do choices reveal preferences. But this assumption only increases the list of possible interpretations of a choice axiom violation. Take for example the agent who chose health insurance over a new car. Under the fixed-belief assumption she supposedly reveals her preference for  $x$  amount of security over the car. Just before the insurance policy is up for renewal, however, she consults a quack who convinces her that she is immune to all sorts of diseases. Consequently, she does not renew her contract but buys a new car.

Obviously, the fixed belief assumption is violated here. A revealed preference theorist who disregards the belief change will find that the agent violates SARP, GARP and WARP. If the belief change had been more hidden, the above interpretations would have concluded that either (i) her preferences were intransitive, or (ii) she was not a maximizing consumer. In light of the belief change, both conclusions are wrong; but revealed preference theorists disregard this aspect

based on non-comparability. Second, an indifference can be dissolved by attaching a small extra bonus to one of the alternatives, while an incomparability cannot be solved this way. Third, if this can be constructed at all, we can expect an indifference relation to be transitive, while a non-comparability relation might be intransitive. I thank John Cantwell and Sven-Ove Hansson for a helpful discussion of this point.

<sup>13</sup> This point has been clearly made by Rosenberg 1992, 123, and Hausman 2000, 103–106.

of deliberation completely and thus make the method even less tenable than it already is.

#### 4. Conclusion

I have argued that one cannot test the validity of the preference axioms or the hypothesis of the maximizing consumer by testing the validity of the choice axioms.

This result in the first place should caution against embracing too enthusiastically the results of economic experiments whose interpretation crucially depends on the theoretical apparatus. However well the experiments I discussed are designed, their ultimate conclusions remain unwarranted because the claims are *theoretically* unfounded. The crucial work that is found wanting—at least in areas like the one I have discussed here—concerns the theory. This is irrespective of the recent ardour with which experiments have been propagated in economics.

Beyond this, the conclusion could be that after 66 years of work, the preference framework and the maximization hypothesis still do not have a firm empirical foundation. Hardcore empiricists might draw the consequence that economics is therefore not a science at all. But to maintain this would mean to fall back to the position from which the unsuccessful revealed-preference framework grew in the first place. Instead, economists should admit that their science operates with theoretical concepts, which never can be fully defined in terms of observable parameters. Such an admission would leave economics in good company—the concept of the gene in biology, and the concept of the inter-atomic bond in chemistry are of a similar type, and few deride these sciences for operating with them. Crucial, of course, is that this admission would be followed by research into the structure of such theoretical concepts, and the way they can and should be applied.

Last, the above discussion has used a notion of rationality that is less monolithic than economists had conceived of in the post-war period. There are many ways that an agent's behaviour can be rationalized, and it is increasingly possible to specify the formal optimization algorithm, the necessary conditions on the underlying preference ordering, and even the numerical representations for these respective notions of rationality. This new pluralism of rationalities (in however, a well-defined and comparatively narrow sense) is an exciting development: it reduces the testability of any particular claim, but it increases the importance of investigating the optimization algorithms and the preference frameworks as *theoretical concepts*. What I showed in this paper is that the revealed preference theory is not the appropriate tool for such an investigation. Instead, economists need to develop a better methodological instrumentarium that matches the new and richer conceptual landscape.



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