

# Normative notions in descriptive dialogues

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**Abstract** Developments in the theory of individual decision-making have been partly shaped by two criteria: a desire for models consistent with experimental evidence; and a pre-commitment to models built on normatively appealing axioms. This paper explores the compatibility of these two selection criteria. The paper reconstructs and scrutinises an argument due to Friedman and Savage asserting that the normative appeal of axioms provides a source of ‘indirect’ evidence. I judge their argument questionable and, at best, incomplete. As such it does not provide a convincing rationale for normative appeal to be used as a criterion for selection among descriptive theories.

**Keywords:** normative appeal, theory selection, choice under risk

## 1 INTRODUCTION

One important strand of theoretical and experimental research in economics has centred on the development of non-expected utility models of individual decision-making. In a flurry of theoretical activity concentrated in the 1970s and 1980s, numerous new theories were proposed as alternatives to the received economic theory of rational choice, Expected Utility Theory (EUT). These theories were prompted by the discovery of apparently systematic violations of EUT observed and replicated in simple experimental tests including the path breaking work of Allais (1953). More recent research effort in this field has shifted towards discriminating between alternative theories and experimental evidence continues to play a significant role in shaping these developments. This field of research is interesting, from a methodological point of view, partly because it provides an example of an arguably successful and progressive research programme: theory has evolved in the face of empirical challenges; new empirical phenomena have been identified; and some distinctive predictions of new theories have found support in experimental data (see Starmer 2000 for a review).

While experimental evidence has clearly been an important factor influencing the evolution of theory in this field, in my view, the development

and selection of theory has also been guided by another significant factor: specifically, an implicit pre-commitment to models incorporating normatively appealing principles of behaviour. This pre-commitment is, I maintain, revealed both in the types of revisions which have been proposed to EUT (which have typically retained normatively attractive principles such as monotonicity and transitivity in spite of contrary evidence) and in the lack of attention devoted to evidence of experimentally observed deviations from EUT which appear normatively indefensible.

Some argue that the pursuit of normatively appealing theories is, at least to some extent, incompatible with the pursuit of descriptively valid ones (see for example Kahneman and Tversky 1979). If true, a pre-commitment to normatively justifiable theories would be a constraint, and perhaps a severe one, on the development of empirically sound theories. However, in a classic paper, two influential theorists Friedman and Savage (1952) argue that the normative appeal of EUT axioms can be read as a source of 'indirect' evidence for that theory. Their argument is interesting partly because it articulates a position that I suspect many economists may hold to informally. More significantly, if normative appeal can be read as a source of empirical evidence, the selection of theories on the basis of normative criteria may be broadly compatible with the pursuit of empirically grounded theory. In this paper I attempt to reconstruct and scrutinise the Friedman/Savage argument. En route to this, I discuss the axiomatic foundations of EUT, some empirical evidence relating to the axioms and economists' reactions to that evidence.

## 2 EUT AS A NORMATIVE THEORY

EUT has been the standard model of risk preference ever since von Neumann and Morgenstern (1947) demonstrated that the expected utility hypothesis could be derived from a set of 'appealing' preference axioms. It will be useful for what follows to provide a thumbnail sketch of key ingredients in a typical axiomatisation. A common approach has been to model risky alternatives as 'prospects' or lotteries. I will use bold case letters to represent prospects and any prospect  $\mathbf{p}=(p_1, x_1; \dots ; p_n, x_n)$  is a probability distribution over a fixed set of consequences where  $p_1$  represents the probability of consequence  $x_1$  and so on. The expected utility hypothesis can then be derived from three axioms on preferences over prospects: ordering, continuity and independence. Ordering requires there to be a complete and transitive pairwise ranking of prospects;<sup>1</sup> the addition of a continuity principle<sup>2</sup> is then sufficient to guarantee that preferences can be represented by *some* function  $V(\cdot)$  which attaches a real value to every prospect. The independence axiom of EUT adds a restriction of the following form. Consider two compound prospects  $\mathbf{q}'=(\mathbf{q}, p; s, 1-p)$  and  $\mathbf{r}'=(\mathbf{r}, p; s, 1-p)$ . The prospect  $\mathbf{q}'$  is itself a probability mixture of two

prospects; it results in  $q$  with probability  $p$  otherwise  $s$ . Similarly,  $r'$  is a mix of  $r$  and  $s$  and notice that the probability of  $s$  is the same (i.e.  $1-p$ ) for both compound prospects. Independence implies that the common component of the two compound prospects (in this case the  $1-p$  chance of  $s$ ) is irrelevant to their relative ranking which should depend purely on the ordering of the simple prospects  $q$  and  $r$ .<sup>3</sup> Given this additional assumption, preferences can be represented by the familiar expected utility function  $V(p) = \sum_i p_i u(x_i)$  where  $p$  is any prospect, and  $u(\cdot)$  is a 'utility' function defined over consequences.

Where lies the alleged appeal of this set of axioms or, equivalently, the appeal of EUT so axiomatised? One, I think enlightening, way to reconstruct it is as follows. The standard method of modern economics has been to understand behaviour through the lens of optimisation, that is, to assume that agents are rational actors moved along by coherent and stable preferences. Hence, to assume the existence of some preference function over prospects  $V(p)$ , is essentially to apply the standard method of economics to decisions over risks. But what justifies, from a normative point of view, the added restriction of independence?

A classic answer is provided by Samuelson (1952) who argues firmly that the type of independence condition entailed by EUT is itself a compelling normative principle of rationality. The nub of the argument is essentially this. Suppose you have to choose between  $q'$  and  $r'$  as defined above and suppose, for the sake of illustration, that  $p=0.5$  with the compound lotteries resolved by a coin flip which determines the outcome to be  $s$  if 'tails' comes up. Samuelson argues that, if tails does come up, you will not care which option you chose (because you get  $s$  either way) so you can safely ignore this common element of the prospects when choosing between  $q'$  and  $r'$ , just as independence requires. Once it is conceded that the outcomes associated with tails can be ignored, it then seems plain that an agent should choose between the compound prospects on the basis of their ordering over the simple prospects  $q$  and  $r$ .

The argument for ignoring the tails outcome, and for (EUT) independence more generally, turns on the proposition that there can be no (rationally justifiable) complementarity between the outcomes within a prospect because they are mutually exclusive. If this is conceded, and independence is accepted as an implication of rationality, then EUT has much more significance than simply being just one amongst many possible models of risk preference; EUT then has a claim to be interpreted as the logical extension of rational economic analysis to the realm of risk. Whether or not individual axioms of EUT can be defended as requirements of rationality has, of course, been a matter of much debate.<sup>4</sup> Fortunately, we need not enter these tricky debates because my primary concern will be to examine what follows granting, for the purpose of the argument, that the axioms of EUT *can* be taken as appealing principles of rationality.

To the extent that its axioms can be justified as sound principles of rational choice to which any reasonable person would subscribe, the axioms provide grounds for interpreting EUT normatively; that is as a model of how people ought to choose. Some writings have placed emphasis on this normative interpretation of EUT. For example, Savage (1954) presents what has become one of the most celebrated derivations of EUT explicitly as an attempt to extend logical reasoning to situations of uncertainty. His primary aim is not to provide an empirical theory for predicting human behaviour but, instead, to develop logical tools for deciding between alternative courses of action:

Decisions made in the face of uncertainty pervade the life of every individual and organisation. Even animals might be said continually to make such decisions, and the psychological mechanisms by which men decide may have much in common with those by which animals do so. But formal reasoning presumably plays no role in the decisions of animals, little in those of children, and less than might be wished in those of men. It may be said to be the purpose of this book, and indeed of statistics generally, to discuss the implications of reasoning for the making of decisions (Savage 1954: 6).

### **3 EUT AS AN EMPIRICAL HYPOTHESIS**

Notwithstanding this normative interpretation, many economists interpret and use EUT as an empirical theory intended to predict and/or explain actual behaviour. Indeed, Savage (1954) suggests that EUT may have some potential as a simple, if 'crude', empirical theory for predicting human behaviour, albeit in 'suitably limited domain'. More specifically, Friedman and Savage (1948) argue that, given a suitable specification of the utility function over wealth, the theory can explain a set of stylised facts about how people respond to risk, particularly in the context of gambling and insurance. They present a set of five stylised facts to be explained and they propose a functional form for the utility of wealth that is shown to be consistent with the presented facts. A crucial feature of their proposal is that the utility function contains both concave and convex segments. As such it allows the same individual to express both risk averse (insurance) and risk-seeking (gambling) behaviour – one of the key stylised facts they set out to explain.

Since these early defences of EUT as an empirical theory it has been subjected to extensive direct testing which has revealed some limitations of it as a descriptive model. One of the most famous challenges to EUT came in the form of the 'Allais paradox' which can be illustrated as follows. Consider the act/state payoff matrix described in Figure 1 where each row represents one of four risky acts (g1 to g4), and columns represent possible

states of the world (with probabilities given at the top of each column). The numbers in the matrix are to be read as the state contingent payoffs to each act (in, say, 000s \$). Consider a choice between g1 and g2. The independence axiom implies that since these two acts give the same consequence in the third state of the world, that third state must be irrelevant to that choice. The same argument applies to the choice between g3 and g4. But, notice that if the third column is blanked out, the choice between g1 and g2 is identical to the choice between g3 and g4 (i.e., 0.11 chance of 500 vs. 0.1 chance of 2500). Hence, independence implies that if g1 is (not) preferred to g2, g3 is (not) preferred to g4. There is considerable evidence that many people faced with pairs of choices with this general structure choose g1 over g2 and g4 over g3 in violation of independence.

Since the late 1970s, numerous alternatives to EUT have been proposed largely motivated by empirical counter examples such as the Allais' examples.<sup>5</sup> In these developments, although economists have been prepared to relax the independence axiom in pursuit of better descriptive models, there has been an apparent reluctance to give up other normatively appealing principles such as transitivity or monotonicity. Loosely stated, monotonicity means that objective improvements to a prospect (e.g., increasing at least some of its payoffs holding others constant) should not reduce its attractiveness. However, there is considerable experimental evidence documenting violations of it. One example due to Tversky and Kahneman (1986) is presented in Table 1. The Table describes a choice between two options were one (Option D) is objectively better than the other (Option C) in the sense of first order stochastic dominance. But this is not that easy to see without careful inspection of the options. In fact, Kahneman and Tversky found that a majority of subjects (58 per cent) chose the dominated option C violating monotonicity.

While various violations of monotonicity are now well documented, economists have not been busy trying to explain them. In fact, the situation is quite the reverse because theories that allow violations of monotonicity have been subject to some strong criticism. One example is the model that extends EUT by attaching simple decision weights to probabilities such that agents are assumed to maximise a function of the form:  $V(p)=\sum w(p_i)u(x_i)$ .

Table 1 A violation of monotonicity

*Consider the following pair of lotteries, described by the percentage of marbles of different colors in each box and the amount of money you win or lose depending on the color of a randomly drawn marble. Which lottery do you prefer?*

Option C	90% white \$0	6% red win \$45	1% green win \$30	3% yellow lose \$15
Option D	90% white \$0	7% red win \$45	1% green lose \$10	2% yellow lose \$15"

		0.1	0.01	0.89
Choice 1	g1:	500	500	500
	g2:	2500	0	500
Choice 2	g3:	500	500	0
	g4:	2500	0	0

*Figure 1* The Allais paradox

This is essentially the type of value function assumed in prospect theory of Kahneman and Tversky (1979) and they show that the Allais paradoxes can be explained by non-linearities in  $w(p_i)$ . But this strategy for explaining the Allais examples has the side-effect that predicted choices among at least some prospects will violate monotonicity. This has generally been regarded as a fatal flaw sufficient to damn theories of this type. Arguments to this effect have been made by Fishburn (1978), Machina (1982) and Quiggin (1982), each of them heavyweights in the arena of choice theory.

No doubt conscious of these potential criticisms, Kahneman and Tversky (1979) propose an editing heuristic that eliminates dominated options, so long as they are detected. This strategy for inducing monotonicity, however, has attracted further criticism from some economists. Quiggin (1982), for example, has criticised the approach on two counts. First, he argues that by appropriate specification of the preference function the editing heuristic can be rendered redundant. Second, he criticises the Kahneman and Tversky strategy for imposing monotonicity using editing because it has the further spin-off effect that the theory then admits violations of transitivity in pairwise choice. Quiggin (1982: 327) describes this an ‘undesirable result’.

What is the basis of this latter claim? It is not, I contend, based on sound empirical evidence. First of all there is well-established evidence – Tversky (1969) produced some of the earliest – that cyclical choice is a robust and reasonably general phenomena. It is true that the form of cyclical choice predicted by prospect theory is of an unusual kind and distinct from other forms of intransitivity. That, however, presents a useful opportunity for testing a novel prediction of prospect theory. Starmer (1999) reports an experiment which tests for the specific form of intransitivity implied by prospect theory and finds clear evidence of it.

Notwithstanding this evidence,<sup>6</sup> the economics literature continues to be dominated by models built on transitivity and monotonicity. In light of this, I am inclined to the view that economists’ reactions to evidence, in the theory of choice under risk, have been mediated by certain theoretical pre-commitments. In particular, a pre-commitment to preference theories which satisfy normatively appealing criteria such as transitivity and monotonicity. This pre-commitment has, in my view, delimited certain problems as interesting (i.e. those that appeared at least potentially soluble in terms of

the pre-committed assumptions) and others as uninteresting or outside the realm of economic enquiry.

#### 4 NORMATIVE APPEAL AS INDIRECT EVIDENCE

With this backdrop in mind, I now turn to an argument set out in Friedman and Savage (1952) (for brevity I refer to this henceforth as FS52). This paper suggests an intriguing possibility: that a pre-commitment to normatively appealing assumptions might in fact be consistent with the pursuit of a descriptively accurate individual decision theory.

FS52 present EUT as an empirical hypothesis to be evaluated relative to the 'evidence' and they distinguish between *direct* and *indirect* forms of evidence. Direct evidence comes from comparing the implications of a theory with observations generated within its intended domain of application, while indirect evidence relates to phenomena that are not in the 'primary' domain of interest. To the extent that EUT is intended to explain market phenomena such as gambling and insurance decisions, Friedman and Savage (1948) is in good part an evaluation of EUT on the basis of direct evidence. In contrast, the main purpose of FS52 is to articulate indirect support for EUT.

An interesting feature of the argument is that it seeks to licence reading the normative appeal of EU axioms as a source of empirical support. I will refer to this manoeuvre as the 'FS-twist'. The argument goes like this. There is, FS52 argue, 'indirect evidence rendering it plausible that the hypothesis will continue to fail to be contradicted, in at least some important domains' (FS52: 466). The primary source of this evidence<sup>7</sup> is 'the plausibility of a set of postulates that are sufficient for derivation of the hypothesis' (466). The postulates are a set of axioms essentially equivalent to those discussed above. The question I wish to pursue here is how 'the plausibility of postulates' translates into (indirect) empirical support for EUT? At first blush this seems slightly mysterious, but some insight is provided by the following passage from FS52:

In saying that these postulates are more plausible than the hypothesis to which they are logically equivalent, we mean that the postulates immediately call to mind a host of implications (or predictions from the hypothesis) susceptible to casual observation. With respect to the class of phenomena to which these implications relate, the hypothesis has had many opportunities for contradiction and has repeatedly failed to be contradicted. The evidence is indirect because this is not the class of phenomenon we are primarily interested in using the hypothesis to predict (466).

The suggestion that the 'postulates immediately bring to mind a host of implications' seems very reasonable at least partly because the axioms make

explicit particular formal properties of EUT which may be less than transparently obvious from a statement of the hypothesis. For instance, once I see and comprehend a statement of the independence principle, it then becomes clear that it is implicit in EUT that common components of prospects under consideration should be irrelevant to my choice among those prospects. The argument, however, involves two further claims that strike me as less obviously justified. One is the assertion that implications which the postulates bring to mind are ‘susceptible to casual observation’, the second is the assertion that such casual observation has broadly supported the hypothesis.

A difficulty arises in relation to both of these latter assertions because it is not obvious what to understand by ‘casual observation’ in this context. Perhaps the most natural interpretation would be to think that casual observations refer to instances of behaviour thrown up by choices that people happen to make in the world. But if we put aside, for the moment, observations from specifically designed experimental tests of axioms, it is doubtful that the world throws up much data bearing on the validity of EUT axioms. An important reason for this is that the axioms are (for the most part) propositions about consistency between choices and as such they do not typically tell us how individuals will choose in specific decision problems. Because of this, it is far from obvious that casual observations of decisions in the world generate rich opportunities for testing EUT axioms. For example, if we know that an agent prefers some prospect *a* over *b*, and *b* over *c*, we can test transitivity if we can also observe their preference between *a* and *c*. But it seems to me that casual opportunities for collecting such sets of observations are rather infrequent.

Another possibility is that ‘casual observation’ is to be understood as arising from introspective thought experiments, that is from personal reflections of roughly the form: would I violate the transitivity principle in this setting; or would I violate the independence principle in that setting; etc, etc? Such introspections, however, could hardly be regarded as providing objective tests of what the agent’s *behaviour* would be. If an agent is, or tends to become convinced of the proposition that ‘I would not deliberately violate choice principle *x*’, it seems that further introspections of the form ‘would I violate *x* in this specific case’ can no longer be considered independent observations. To the extent that the agent is concerned to reason coherently, it seems the cognition that ‘I would not deliberately violate choice principle *x*’ will move them to conclusions consistent with this, in thought experiments. Such thought experiments would, therefore, seem inevitably biased towards ‘confirming’ any principle so ‘tested’.

However, there is another potential argument articulated in FS52 to motivate the FS-twist. This works in two steps. The first is to argue that the axioms are ‘introspectively very appealing’ (468) and seeks to persuade the reader that each principle ‘is not one he would deliberately violate’<sup>8</sup> (FS52:



4690). It seems reasonable to suppose that many people would so endorse the principles. The second step is to assert that the introspective appeal of the axioms is some reason for supposing that people do actually tend to avoid flagrant violation of the principle<sup>9</sup> (FS52: 469). This second step appears to involve a questionable leap from propositions about the intuitive appeal of choice principles to propositions about choice *behaviour*. In order to make this leap explicit, consider propositions P1 and P2:

(P1) the agent accepts axiom  $x$  as a principle they would not deliberately violate

(P2) the agent probably behaves in accordance with axiom  $x$

As I read it, this part of the FS52 paper essentially asserts that because P1 holds, P2 is likely. But while P1 and P2, are not inconsistent, in the absence of further premises, P2 is not implied by P1. P1 is a proposition about normative judgements while P2 is a proposition about behaviour. In order to generate the implication suggested by FS52 it is necessary to introduce some premise linking normative beliefs with behaviour. For example:

(P3) agents rarely behave in contradiction with principles they believe they would not deliberately violate

Notice, however, that it is not enough just to assume P3: for it to do the job of converting normative appeal to evidence, it has to be empirically valid or at least plausible. How would one assess whether this is an empirically plausible claim? I can think of at least two possibilities. One would be to refer to a theory of the choosing mind. If one could point to some model of human mental processes which implied that normative beliefs govern choice behaviour, and show that there is satisfactory empirical support for it, that would be one way to motivate a principle like P3. This strategy, however, would involve a major departure from the 'as if' methodology famously set out in Friedman (1953).

It is clear that Friedman and Savage do favour an 'as if' interpretation of EUT. For instance, Friedman and Savage (1948: 298) provide this methodological aside with respect to evaluation of EUT:

An objection to the hypothesis just presented that is likely to be raised by many, if not most, readers is that it conflicts with the way human beings actually behave and choose. Is it not patently unrealistic to suppose that individuals consult a wiggly utility curve before gambling or buying insurance, that they know the odds involved in the gambles or insurance plans open to them, that they can compute the expected utility of a gamble or insurance plan, and that they base their decision on the size of the expected utility?

While entirely natural and understandable, this objection is not strictly relevant. The hypothesis does not assert that individuals explicitly or

consciously calculate and compare expected utilities. Indeed it is not at all clear what such an assertion would mean or how it could be tested. The hypothesis asserts rather that, in making a particular class of decisions, individuals behave as if they calculated and compared expected utilities and as if they knew the odds. The validity of this assertion does not depend on whether individuals know the precise odds, much less on whether they say that they calculate and compare expected utilities or think that they do, or whether psychologists can uncover any evidence that they do, but solely on whether it yields sufficiently accurate predictions about the class of decisions with which the hypothesis deals. Stated differently, the test by results is the only possible method of determining whether the as if statement is or is not a sufficiently good approximation to reality for the purpose at hand.

This clearly has a great deal of resonance with the methodological position of Friedman (1953): we should not count it against EUT that its assumptions appear 'unrealistic'; EUT is not to be interpreted as a model of conscious human decision processes but as an 'as if' model for predicting behaviour; as such, the only relevant test of EUT is its predictive performance relative to the intended domain of application. This 'as if' strategy entails that theories not be judged in terms of whether they are defensible models of mental processes. So to invoke a model of mental process as a defence of the theory does not seem to provide an interpretation of the FS-twist which is consistent with Friedman (1953) or Friedman and Savage (1948).

Another possibility would be to interpret P3 as a purely empirical (but untheorised) principle. This would provide an interpretation more consistent with the 'as if' approach, but the evidence from behavioural research clearly runs against a general claim that peoples' behaviour satisfies principles that most would take to be normatively appealing. The Allais paradox discussed (Figure 1) above provides one of many possible illustrations that could be used to support this point.

For present purposes it is particularly noteworthy that Savage himself, in Chapter 5 of *The Foundations of Statistics*, conceded that he also violated independence when first confronted with the Allais paradox. He reports that having once recognised the inconsistency, he reflected upon the situation. But his belief in the normative appeal of independence was unshaken and instead he determined that he must have made some error in one of his choices. Re-examining them he concludes that his initial choice of  $g_4$  over  $g_3$  was a mistake which the application of normative reasoning allowed him to detect and correct. This account seems unproblematic in relation to the argument of Savage (1954). In that context, Savage is explicitly concerned with developing a normative theory which may be used to 'police decisions'. The fact that real decisions may depart from the normative is a pre-requisite

for there to be any interesting policing role for his axioms. However, the example provides a counter argument to the proposition that being normatively committed to a decision principle implies conforming behaviour and the example seems especially compelling when the person concerned is an eminent decision theorist violating a principle which is the most important in his own normative theory.

One possible defence against this example would be to suggest that Savage's mistake lay not in his choice, but in his adoption of independence as normative. An alternative interpretation of the Allais paradox is that it shows that independence is not a compelling normative principle (indeed, this is Allais' own reading). Someone who took this line would have the option of arguing that the Allais paradox does not demonstrate any inconsistency between compelling normative principles and choice behaviour. That line of argument, however, can be quickly dismissed. Recall the violation of monotonicity discussed above (and presented in Table 1). The principle of monotonicity has very wide appeal as a persuasive principle of rational choice and so, unsurprisingly, it turns out that if the problem described in Table 1 is presented in a way that makes the dominance relation clear, very few if any people chose to violate it. Yet, it remains the case that in general people do not behave consistently with monotonicity even though most would accept its normative force.

## **5 CONCLUSION**

FS52 seek to argue that because EUT can be restated in terms of normatively appealing axioms, that provides a source of indirect support for the model as an empirical theory of behaviour. This is what I have called the FS-twist. I think that is a questionable claim for at least three sets of reasons. First, the connection from norm to decision, at least in FS52, seems mysterious. Second, while it might be possible to articulate some connection, say by specifying a model of decision process with that feature, my impression is that the literature which does seek to model decision processes would typically point in the opposite direction: in general, models of decision process provide many varied reasons for thinking that behaviour will deviate from normatively appealing criteria. Third, I have pointed to experimental evidence against the presumption that normative appeal implies empirical validity.<sup>10</sup>

In my view the argument made by FS52 is of more than passing historical interest not least because developments in modern economic theory have been swayed in significant ways by a widely presumed (but I think misconceived) connection between normative principles and actual behaviour. If it is granted that such a pre-commitment has been at work, is that bad thing? I am not certain that it is. Some philosophers of science, among them Kuhn and Lakatos, provide strong arguments for thinking that some

kinds of theoretical pre-commitments may be pre-requisites for healthy, ongoing, scientific enquiry. On a Lakatosian interpretation for instance, principles of rational choice like monotonicity and transitivity, might be taken as part of the ‘hard core’ of the research programme of choice under risk. What is questionable, however, is any tendency to mistake such a pre-commitment for evidence in favour of it.

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### NOTES

- 1 More precisely, this axiom entails that: (1), for any pair of prospects  $q, r$ : either  $q \succsim r$  or  $r \succsim q$  or both where  $\succsim$  represents the relation ‘is (weakly) preferred to’; and (2) for any three prospect  $q, r, s$ , if  $q \succsim r$  and  $r \succsim s$ , then  $q \succsim s$ .
- 2 Continuity requires that for all prospects  $q, r, s$  where  $q \succsim r$  and  $r \succsim s$ , there exists some probability  $p$  such that there is indifference between the middle ranked prospect  $r$  and the prospect  $(q, p; s, 1-p)$ .
- 3 More formally, the independence axiom of EUT entails that for all prospects  $q, r, s$ : if  $q \succsim r$  then  $(q, p; s, 1-p) \succsim (r, p; s, 1-p)$ , for all  $p$ .
- 4 For the reader wishing to explore these debates a good place to start is Sugden (1991).
- 5 I review some of these developments in Starmer (2000).
- 6 For a more detailed discussion of evidence relating to monotonicity and transitivity see Starmer (2000).
- 7 They also suggest as an aside that ‘Coherence with rest of economic theory’ (466) may count as indirect evidence for EUT.
- 8 While FS52 discuss each of the EU axioms, a key part of their argument is concerned with justifying the independence axiom. This seems natural given that this was and continues to be the most controversial axiom of EUT and the assumption that gives it most of its empirical content.
- 9 Although the claim here seems a moderate one given the qualification that normative appeal is just ‘some’ reason, I take it there is meant to be a

substantive claim here given that the main argument of the paper seeks precisely to use normative appeal as a source of evidence.

- 10 It is possible that some real choice environments could feature selection mechanisms that promote conformity with normative principles. I discuss this possibility in Starmer (2004) which contains an extended version of the argument set out here.

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