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Behavior in the loss domain: An experiment using the probability trade-off consistency condition

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ABSTRACT

In gambles with two or more outcomes, the two versions of prospect theory, i.e., original prospect theory and cumulative prospect theory, make use of different composition rules and therefore yield different valuations of gambles. We test these composition rules in the loss domain using the probability trade-off consistency condition. The probability trade-off consistency condition offers a convenient and efficient way to compare gambles under risk and decision makers' behavior. Experimental findings suggest that the rank dependent version of prospect theory, or cumulative prospect theory, cannot be rejected in the loss domain while original prospect theory is clearly rejected when a certainty effect is taken into account.

1. Introduction

In their seminal paper in Econometrica, Kahneman and Tversky (1979) introduced prospect theory as a convincing decision theory to study and describe choices under risk. Kahneman and Tversky (1979) presented prospect theory as an alternative to expected utility theory based on three characteristics. First, carriers of value are gains and losses relative to a reference point rather than to final wealth. Moreover, the marginal impact of a gain or a loss decreases with the distance from the reference point. This psychological phenomena, known as diminishing sensitivity, contrasts with the usual assumption of diminishing marginal utility, which supposes an increasing impact of a loss with distance from the reference point. Second, losses loom larger than equivalent gains, a phenomenon known as loss aversion. Third, probabilities are weighted nonlinearly: typically, small probabilities are overweighted and large probabilities are underweighted. The so-called original prospect theory was originally applied to three-outcome gambles involving a zero outcome. Camerer and Ho (1994) and Fennema and Wakker (1997) formulated a more complete version of original prospect theory for n-outcome mixed prospects. The lack of generality of *Original Prospect Theory* (OPT hereafter) and its failure to avoid stochastic dominance violations gave rise to a modified version of OPT, the *Cumulative Prospect Theory* (CPT hereafter). Compared to OPT, CPT offers three new key features. First, CPT extends to gambles involving any number of possible outcomes. Second, CPT is able to deal both with risk and uncertainty. Third, CPT includes the rank dependent framework introduced by Quiggin (1982) and Schmeidler (1989), which allows prospect theory to avoid stochastic dominance violations. Both versions of Prospect Theory involve a utility

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function and a probability weighting function but differ on the way those functions are related, which is often defined as composition rules.

Even if CPT has become the most preeminent form of prospect theory, interest for OPT remains. Gonzalez and Wu (2003) showed that both OPT and CPT are able to explain some standard empirical patterns. As a result, both theories may be considered as equally valid from a descriptive point of view. Several studies investigated the descriptive power of both OPT and CPT in the gain domain. According to Camerer and Ho (1994) and Wu and Gonzalez (1996), OPT fits the experimental data better than CPT. In contrast, Fennema and Wakker (1997) reanalyzed the Lopes (1993) experimental results and found that CPT performed better than OPT. Such a result is in line with Schneider and Lopes (1986) evidence that people think of risk in terms of the probability of not achieving a target (i.e., in terms of decumulative probabilities). More recently, Wu, Zhang, and Abdellaoui (2005) showed that the design of gambles plays an important role in the composition rule used by the subjects. While gambles involving a certainty effect appear to be compatible with both CPT and OPT, more complex gambles are compatible with OPT only.

Research in the gain domain has developed considerably, but only few results are available in the loss domain. Notably, experimental evidence is scarce concerning the descriptive power of CPT in the loss domain. However, such data would be useful in the field of insurance where CPT, or Rank Dependent Utility (the sign-independent version of CPT), has emerged as a viable alternative to Expected Utility (Doherty & Eeckhoudt, 1995; Schmidt & Zank, 2007; Wang, 1995). Experimental findings recognized the specificity of losses since both utility and probability weighting could be sign-dependent. Measurements of the shape of utility for gains and losses have generally confirmed prospect theory's assumption of concave utility for gains and convex utility for losses. Concerning the shape of the probability weighting function, recent studies showed a more pronounced overweighting of small probabilities in the loss domain than in the gain domain (under risk: Abdellaoui (2000), Lattimore, Baker, and Witte (1992), Wu, Zhang, & Gonzales (2003) on the basis of the 1992 Tversky and Kahneman data; under uncertainty: Abdellaoui, Vossman, and Weber (2005)). Etchart-Vincent (2004) found probability weighting to be insensitive to the magnitude of the consequences, a result compatible with prospect theory. As a result, the two elements of prospect theory's composition rules (either for CPT or OPT), namely utility and probability weighting, are sign-dependent. None of these studies has directly addressed the question of the specific composition rule used by the subjects in the loss domain. The aim of this paper is to fill this gap.

In order to study the composition rules used by individuals in the loss domain, we present an experiment using the *probability trade-off consistency* condition. Probability trade-off consistency offers a convenient and efficient way to compare gambles that involve risk. The probability trade-off consistency condition used in the axiomatic work of Abdellaoui (2002) requires the restrictions on probability transformations on one set of gambles to be consistent with restrictions on probability transformations on another set of gambles. In other words, this condition implies a consistent ordering of probability transformations, independently of the underlying outcomes. This approach is the dual of the trade-off consistency condition for outcomes developed by Wakker (1994), Chateauneuf and Wakker (1999), Köbberling and Wakker (2003), and Schmidt and Zank (2001). By focusing on the probability trade-off consistency, Wu et al. (2005) offer a simple way to test the composition rule used by individuals in the gain domain, the sets of related gambles implied by the condition being different in each specification. Based on the method introduced by Wu et al. (2005), our empirical investigation suggests that CPT cannot be rejected for any gambles, while OPT is clearly rejected when a certainty effect is at stake.

The remainder of the paper is organized as follows: Section 1 describes the two versions of prospect theory and the corresponding probabilistic trade-off consistency conditions. Section 2 describes the design of the experiment. Section 3 reports the results and compares the composition rules. Section 4 concludes.

2. Probability trade-off consistency conditions under original and cumulative prospect theory

Let $(p_1, x_1; p_2, x_2; p_3, 0)$ denote a *three-outcome prospect* that yields outcome x_1 with probability p_1, outcome x_2 with probability p_2 and outcome 0 with probability $p_3 = 1 - p_1 - p_2$. Throughout the paper we will use only two non-zero negative outcomes prospects with $x_1 < x_2 < 0$. In order to show the main differences between OPT and CPT as well as their implications, we assume that utility and probability weighting functions are independent from the composition rule used by the decision maker. The decision maker evaluates prospects through a prospect theory functional and chooses the prospect that offers the highest overall utility. The overall utility of a prospect is expressed in terms of two functions: a probability weighting function w for losses, and a utility function u. The latter is similar to a standard utility function reflecting the subjective value of the outcomes except for the fact that it exhibits sign-dependence. $u(\cdot)$ is supposed to be continuous and increasing in its argument x. By convention $u(0)$ is set equal to 0. The probability weighting function is strictly increasing from [0, 1] to [0, 1] with $w(0) = 0$ and $w(1) = 1$.

In OPT, individuals tend to distort objective probabilities by transforming the initial probabilities directly. Following Fennema and Wakker (1997), under OPT a prospect $(p_1, x_1; p_2, x_2; p_3, 0)$ is evaluated according to:

$$V_{OPT}(p_1, x_1; p_2, x_2; p_3, 0) = w(p_1)u(x_1) + w(p_2)u(x_2) \tag{1}$$

According to OPT, the weighted probability of an outcome enters the preference functional directly as the decision weight attached to this particular outcome.

Under CPT, the general assumption is that utility is a ratio scale and the probability weights used in the evaluation of lotteries are no longer a direct transformation of probabilities but differences in cumulative probabilities. Under CPT a prospect $(p_1, x_1; p_2, x_2; p_3, 0)$ is evaluated according to: