
Stochastic Dominance and Decision Weights: Theory and Experiments

Manel Baucells

IESE Business School
Barcelona, Spain; and

The Fuqua School of Business, Duke University
Durham, NC

Franz H. Heukamp

IESE Business School, University of Navarra
Barcelona, Spain

Abstract

Based on recent theoretical and empirical results about the significance of Cumulative Prospect Theory (CPT), we define RW_c -SD, an extended notion of stochastic dominance that accounts for both the reflection effect (R) and the probability weighting (W_c). A second definition of stochastic dominance (R^*W^d -SD) for preferences with reverse reflection effect (R^*) as in Markowitz (1952) is presented. Using these definitions, we empirically discriminate between two competing explanations of behavior under risk, namely, CPT and Markowitz. Our experiments reject the reverse reflection effect recently advocated by Levy and Levy (2002a) and offer insight into the relevance of the weighting function in empirical research on choice under risk.

1 INTRODUCTION

Prospect Theory and its development into Cumulative Prospect Theory (CPT) have become widely accepted theories of choice under risk ever since their introduction through the landmark papers by Kahneman and Tversky (1979) and Tversky and Kahneman (1992), respectively. CPT is based on two main pillars: (1) A value function $v(x)$ where x is the change in wealth (gains or losses) with respect to some reference point. The value function exhibits risk seeking behavior for losses and risk averse behavior for gains ($v'(x) > 0$ for all x , $v''(x) > 0$ for $x < 0$ and $v''(x) < 0$ for $x > 0$). (2) A probability weighting function (pwf) $\omega(p)$ that transforms the given probabilities in decision weights.

Many empirical studies have been performed in order to test the robustness of CPT. Edwards (1996) presented in a survey article a significant number of studies available in the open literature. In the majority of cases, CPT correctly explains experimentally observed results. In a recent series of papers, Levy and Levy (2002a and 2002b), henceforth LL02a and LL02b, or LL02 for both, presented a new study challenging the explanatory power of CPT. Their experimental results lead them to conclude that CPT might be of value only in the case of all-gains or all-losses lotteries; for mixed lotteries LL02a argue that reversed S-shape value functions such as proposed by Markowitz (1952) represent more consistently the observed behavior of many individuals. The analysis of LL02a relies heavily on the assumption that probability weighting functions have no influence in lotteries with probabilities ≥ 0.25 .

This paper shows that by including a typical pwf in the analysis, the behavior observed by LL02 in mixed lotteries can be explained with CPT¹. In addition, based on the insight gained in this step, more consistent forms of stochastic dominance, called RW_c -SD and R^*W^d -SD, are introduced. Guided by this concept a new set of lotteries is designed that discriminate between individuals who exhibit a CPT value function and individuals with Markowitz value functions.

¹Wakker (2003) shows with a numerical example that the results of LL02 are compatible with a typical specification of CPT. Wakker's manuscript became available to the authors towards the end of this study.

2 CRITICAL REVIEW OF THE LL02 EXPERIMENTS

2.1 LOTTERIES AND STOCHASTIC DOMINANCE

LL02 presented an empirical study on choices under risk challenging the validity of CPT in mixed lotteries. To evaluate the response of an individual who follows CPT, LL02 use the notion of Prospect Stochastic Dominance (PSD): Let F and G be two distinct prospects with cumulative distributions F and G . F dominates G for all CPT value functions if and only if

$$\int_y^0 [G(t) - F(t)] dt \geq 0 \text{ for all } y \leq 0 \text{ and}$$

$$\int_0^x [G(t) - F(t)] dt \geq 0 \text{ for all } x \geq 0 \quad (1)$$

In the sequel we will call this type of stochastic dominance R -SD, referring to the reflection effect associated with the S-shape of the value function that is characteristic for CPT (see Figure 1, left). Formally,

$$v \in V_R \text{ iff } v''(x) \leq 0, x > 0 \text{ and } v''(y) \geq 0, y < 0. \quad (R)$$

The R -SD notion of stochastic dominance is contrasted by LL02a with the notion of Markowitz Stochastic Dominance (MSD). MSD assumes a value function $V_{R^*}(x)$ that has a reverse S-shape:

$$v \in V_{R^*} \text{ iff } v''(x) \geq 0, x > 0 \text{ and } v''(y) \leq 0, y < 0, \quad (R^*)$$

and was originally proposed by Markowitz (1952). Correspondingly, we will call this type of stochastic dominance R^* -SD, pointing towards the reverse S-shape value function (see Figure 1, right). For the prospects F and G as defined before, F dominates G by R^* -SD for all value functions of the form $V_{R^*}(x)$ if and only if

$$\int_{-\infty}^y [G(t) - F(t)] dt \geq 0 \text{ for all } y \leq 0 \text{ and}$$

$$\int_x^{\infty} [G(t) - F(t)] dt \geq 0 \text{ for all } x \geq 0 \quad (2)$$

LL02a and LL02b tested three lotteries, specifically Tasks I to III in Table 1, having the property that F

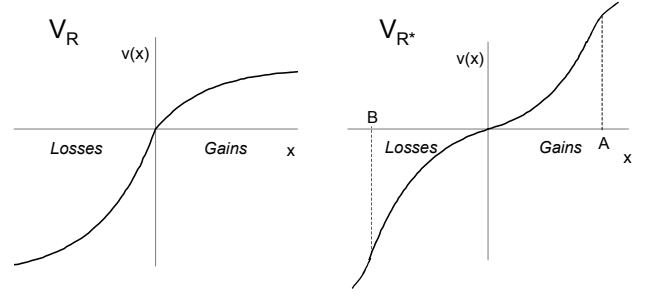


Figure 1: Left: Typical CPT Value function featuring risk aversion for gains and risk seeking for losses (reflection). Right: Markowitz Value function exhibiting convexity for gains until point A and concavity for losses until Point B (reverse reflection).

R^* -SD G , but G R -SD F . As most individuals prefer F in this head-to-head competition, LL02a reject CPT for mixed lotteries and conclude that most subjects exhibit Markowitz value functions.

2.2 RE-EVALUATION WITH PWF

In their evaluation of the experimental results, LL02 assume that for the probabilities used in the experiments ($p \geq 0.25$) no significant probability distortions are to be expected; hence the probability weighting function (pwf) is excluded from their analysis. This is convenient because the definitions of R -SD and R^* -SD do not include the distortion of probability. Considering the typical shape of a pwf, the asserted insignificance of the pwf can be questioned: Depending on where in the probability range an increment of for example 0.25 is considered, the distortion can be important. While we agree that $\omega(p) \approx p$ for $p = 0.25$, LL02 miss the fact that the decision weights in CPT are based on cumulative probabilities, so that $\omega(0.5) - \omega(0.25)$ can be significantly smaller than $\omega(0.25) - \omega(0)$. To test this proposition, we evaluate the LL02 lotteries using a standard form for the value function. We take the following specification:

$$v(x) = \begin{cases} x^\alpha & \text{for } x \geq 0 \\ -\lambda(-x)^\alpha & \text{for } x < 0 \end{cases} \quad (3)$$

$$\omega(p) = e^{-(-\ln(p))^\beta} \quad (4)$$

TASK I**	F		G	
	g/ℓ	Prob.	g/ℓ	Prob.
	-6000	1/4	-3000	1/2
	3000	3/4	4500	1/2
TASK II	F		G	
	g/ℓ	Prob.	g/ℓ	Prob.
	-1600	1/4	-1000	1/4
	-200	1/4	-800	1/4
	1200	1/4	800	1/4
	1600	1/4	2000	1/4
TASK III**	F		G	
	g/ℓ	Prob.	g/ℓ	Prob.
	-3000	1/4	-1500	1/2
	3000	3/4	4500	1/2

Table 1: Set of three experiments that repeat experiments from LL02. Double asteriks indicate that the lotteries were presented in reversed order to the subjects.

The power value function is commonly used in the literature. Tversky and Kahneman (1992) estimated median values of $\alpha = 0.88$ and $\lambda = 2.25$. Several functional forms have been proposed for the pwf $\omega(p)$ (Tversky and Kahneman 1992 and Gonzalez and Wu 1999, Prelec 1998). The qualitative features that any of these forms exhibit are

- concavity $\omega(p)$ for small p , close to 0, and
- convexity of $\omega(p)$ for large p , close to 1.

Here we use the formulation by Prelec (1998). A value of β around 0.6 is consistent with experimental values reported by these and other authors. For a more detailed overview refer to Baucells and Heukamp (2003).

We numerically evaluate the LL02 lotteries (Table 1) with our specification of CPT. We report our results for Task I. Table 2 presents a sensitivity analysis of $CE_G - CE_F$, the difference in certainty equivalents, for the parameters α and β in (3) and (4). λ has a minor influence and is kept at 2.25. The observed preference for lottery G (72%) over F (27%) reported in LL02a (Exp. 1.I) and LL02b (Exp. 2), is linked by LL02 to a reverse S-shaped value function ($\alpha > 1$). Indeed, $G R^*$ -SD F implies $CE_G - CE_F > 0$ for $\alpha > 1$. That $F R$ -SD G suggest that if $v \in V_R$, then F is preferred,

$\beta \setminus \alpha$	1.3	1.2	1.1	1.0	0.9	0.8	0.7
1.00	533	339	159	0	-127	-210	-240
0.90	668	472	287	119	-23	-127	-182
0.80	804	607	418	241	87	-36	-115
0.70	941	744	551	368	202	62	-40
0.60	1079	882	687	499	323	167	44
0.50	1217	1022	826	634	449	280	137

Table 2: Monetary gain (loss) according to CPT associated with choosing G over F in Task I.

which is consistent with $CE_G - CE_F < 0$ for $\alpha < 1$. However, this analysis relies on the irrelevance of the pwf, i.e., staying in the first row where $\beta = 1$. Table 2 reveals that in the empirically plausible range $\alpha \in [0.8, 0.9]$ and $\beta \in [0.5, 0.7]$, $CE_G - CE_F$ has positive values too, showing that CPT is perfectly compatible with $G \succ F$ (see Wakker 2003). Thus, we have two competing explanations for $G \succ F$.

Task II (LL02a, Exp. 2 and LL02b, Exp. 3) and Task III (LL02a, Exp. 3.IV and LL02b, Exp. 1.III) can be shown to be compatible with CPT in an analogous way.

3 CUMULATIVE PROSPECT STOCHASTIC DOMINANCE NOTIONS

In the re-evaluation of LL02's experiments, the potentially crucial role of the pwf has been demonstrated. This naturally suggests the incorporation of the pwf in meaningful notions of stochastic dominance. Besides the well-known First Order Stochastic Dominance (FSD) and Second Order Stochastic Dominance (SSD), more specialized definitions exist. Among them are Prospect Stochastic Dominance (R -SD) and Markowitz Stochastic Dominance (R^* -SD), introduced by Levy and Wiener (1998) and LL02 and presented above. Figure 2 illustrates the R -SD and R^* -SD stochastic dominance rule on the now familiar Task I in Table 1. The four distinct areas are equally sized. Eq. (1) integrates from the origin to the positive and negative extremes. Because in these two directions the positive circles precede the negative circles, we conclude that $F R$ -SD G . Conversely, Eq. (2) integrates

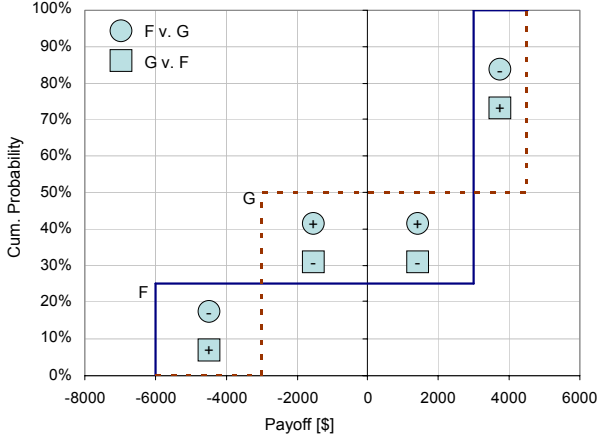


Figure 2: Illustration of R -SD and R^* -SD on Task I. The circles refer to R -SD and the squares to R^* -SD.

from the extremes towards the origin. Because positive squares precede negative squares in these two directions, we conclude that G R^* -SD F . The reflection effect of CPT attaches less importance to extreme outcomes, than to outcomes near the origin. Referring to Figure 2 this can be associated with a “stretching” of the horizontal axis in areas near the origin, leading to a preference of F over G . An individual with a reversed S-shaped value function does the inverse.

Besides the value function, the shape of the pwf influences the preference of an individual. The importance of the pwf can also be intuitively understood from Figure 2: The probability overweighting associated with the extreme events in this case “stretches” the two ends of the y-axis. Accordingly, prospects with positive stochastic dominance evaluation near 0 or 1 become more desirable. This might be the driving force in Task I. Rather than the risk aversion (stretching of the horizontal axis for large negative outcomes) attributed to V_{R^*} , the desirability of F may stem from the vertical stretching due to $\omega(p)$. To eliminate this interference of ω from these competing explanations, we look for a Stochastic Dominance notion that encompasses a certain class of pwf’s. This class has to be narrow enough to yield a useful definition, but broad enough to capture the qualitative features of $\omega(p)$ advocated by Tversky and Kahneman (1992).

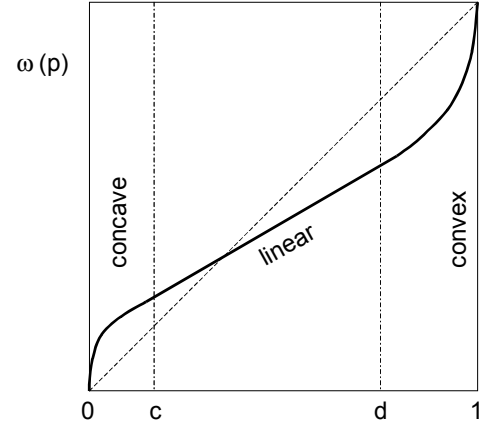


Figure 3: Schematic depiction of a W_c^d -pwf.

We define a general set of pwf called W_c -pwf. $\omega(p)$ belongs to W_c if, besides being continuous and increasing with $\omega(0) = 0$ and $\omega(1) = 1$, it is convex for $c \leq p \leq 1$. The Prelec function (Eq. 4) with $\beta < 1$ belongs to W_c , $c \geq 1/e$. A companion set of pwf’s called W^d -pwf are those continuous and increasing with $\omega(0) = 0$ and $\omega(1) = 1$, and convex in the range $0 \leq p \leq d$. An important class of weighting function is their intersection $W_c^d = W_c \cap W^d$, of pwf’s that are necessarily linear between c and d . Figure 3 shows a schematic illustration of a W_c^d -pwf.

To capture both the reflection effect (R) and the weighting function (W_c), we will use R -SD plus require (first order) stochastic dominance in the intervals $C^- = \{y < 0 : F(y) < c \text{ or } G(y) < c\}$ and $C^+ = \{x > 0 : F(x) \geq 1 - c \text{ or } G(x) \geq 1 - c\}$ corresponding to the lower-negative and upper-positive tails, respectively. In these zones, the horizontal stretching of $v(x)$ and the vertical stretching of $\omega(p)$ run in opposite directions.

Theorem 1 F RW_c -SD G for all $v \in V_R$ and for all $\omega \in W_c$ if and only if

$$\int_y^0 [G(t) - F(t)]dt \geq 0 \text{ for all } y \leq 0 \quad (5)$$

$$\int_0^x [G(t) - F(t)]dt \geq 0 \text{ for all } x \geq 0 \quad (6)$$

$$G(t) \geq F(t) \text{ for all } t \in C^- \cup C^+ \quad (7)$$

To generalize R^* -SD into R^*W^d -SD we ensure stochastic dominance in the intervals $D^- = \{y < 0 : F(y) \geq d \text{ or } G(y) \geq d\}$ and $D^+ = \{x > 0 : F(x) < 1 - d \text{ or } G(x) < 1 - d\}$ corresponding to the lower-positive and upper-negative tails, respectively.

Theorem 2 $F R^*W_c$ -SD G for all $v \in V_{R^*}$ and for all $\omega \in W^d$ if and only if

$$\int_{-\infty}^y [G(t) - F(t)]dt \geq 0 \text{ for all } y \leq 0 \quad (8)$$

$$\int_x^{+\infty} [G(t) - F(t)]dt \geq 0 \text{ for all } x \geq 0 \quad (9)$$

$$G(t) \geq F(t) \text{ for all } t \in D^- \cup D^+ \quad (10)$$

The proofs can be found in Baucells and Heukamp (2003).

Remarks:

- As c decreases, the pwf class becomes smaller, but it enlarges the set of pairs F and G that satisfy RW_c -SD. The same is true of R^*W^d -SD as d increases. If $c = 0$ ($\omega(p)$ convex), then (7) is void and RW_0 -SD is the same as R -SD. This particular case, in which R -SD holds for this class of pwf, was shown by Levy and Wiener (1998). They also proof that R^* -SD encompasses concave weighting functions, which is clear because if $d = 1$, then (10) is void. While this allows the authors to preserve the definition of R -SD and R^* -SD, it does not capture the qualitative features of typical pwfs.
- $RW_c - SD$ simply uses the fact that W_c is convex in the upper part. It seems natural to exploit the fact that $\omega(p)$ is concave below c to propose a broader definition of stochastic dominance. Unfortunately, this is impossible because in C^- or in C^+ the convexity of v counteracts the concavity ω . Formally, any condition different from (7) may have $G(y) < F(y)$ for some $y \in [y_1, y_2] \subset C^-$. If $v'(y) = 0$ for $y \leq y_1$, and

$$\omega(p) = \begin{cases} p/F(y_2) & \text{if } p \leq F(y_2) \\ 1 & \text{if } p > F(y_2) \end{cases}$$

yields $V(G) > V(F)$. A similar construction can be created for C^+ , which shows that (7) cannot be weakened.

- Loss aversion, the parameter λ in (3) reported to be greater than one, plays no explicit role in our definitions. Baucells and Heukamp (2003) explore stochastic dominance definitions that incorporate this feature of CPT.
- Let $\omega \in W_c^d$. If the expected values of F and G are identical, and conditions (7) and (10) hold with equality, then

$$F RW_c^d - SD G \Leftrightarrow G R^*W_c^d - SD F$$

4 CPT v. MARKOWITZ EXPERIMENTS

4.1 DESIGN

We emphasize that the qualitative features of the pwf of CPT are captured by the class W_c^d with values of c and d around 10% and 80%, respectively. If we are willing to assume that our individuals' pwf belongs to $W_{0.1}^{0.8}$, then remark 3 is instrumental to concoct lottery pairs F and G such that $F RW_c^d$ -SD G , and $G RW_c^d$ -SD F . This sets a head-to-head competition between R (CPT) and R^* (Markowitz), net of the confounding effect of the pwf. The series of experiments consists of 10 pairs of lotteries (Tasks I to X) which were presented to 205 individuals. The group of individuals consisted of 83 college students, 24 MBA students, and 98 executives. Individuals were presented the prospects with the question: "Suppose that you decide to invest \$10,000 either in stock F or in stock G. Which stock would you choose, F, or G, when it is given that the dollar gain or loss one month from now will be as follows?" The goals we aim to achieve are:

1. Show that the sample follows well documented rules of behavior and in particular is not significantly different from the LL02 sample.
2. Test the importance of the stakes in relation to the change of curvature at points A and B in Figure 1 and advocated by Markowitz (1952) and LL02a.

TASK IV	F		G	
	g/ℓ	Prob	g/ℓ	Prob
	-60000	1/4	-30000	1/2
	30000	3/4	45000	1/2

Table 3: Tasks IV is the tenfold version of Task I.

3. Resolve this head-to-head competition between R and R^* .
4. Determining the lower limit of the application range of c and d .

To accomplish the *first goal* mentioned above, we run Tasks I to III (Table 1) to match the experiments run by LL02 to advocate for R^* . Here we set F R -SD G and G $R^* - SD$ F . We expect to mimic LL02 and obtain $G \succ F$. Task IV in Table 3 accomplishes the *second goal*. It is identical to Task I except that the stakes are multiplied by ten. If the Markowitz value function holds, and it has a convexity-concavity switch (Points A and B in Figure 1), then we expect to observe a tendency to change behavior towards F .

In Table 4, observe that Tasks IX is a modification of Task II, while Tasks V and VII are modifications of Task III. All exhibit F RW_c^d -SD G and G $R^*W_c^d$ -SD F . Of course, some tasks were presented to the subjects in reverse order. This is indicated by double asterisks in the Tables. To construct task VII, for example, we take Task III and embed the probability range of F and G in the interval 0.1 to 0.9. We then add to both F and G a common lower (-6000) and upper tail (+6000). Clearly, F $RW_c - SD$ G as long as $\omega \in W_{10\%}$. Reflecting on the role of d in (10) we realize that G $R^*W_c^d$ -SD F as long as $\omega \in W^{0.7}$. The values of c and d in W_c^d are indicated in the Table. Recall that the higher the c , and the lower the d , the less stringent is the requirement on ω . Task IX embeds Task II in the interval 1/6 to 5/6 and adds common extreme consequences of -5000 and +5000. Task V embeds Task III in the interval 0.1 and 0.9 and adds common extreme consequences of -3000 and +4500, which coincide with the lowest and highest outcomes of Task III. Tasks VII, IX, and V aim at our *third goal*: if R is a more accurate description of actual choices,

TASK IX	F		G	
$\omega \in W_{1/6}^{0.5}$	g/ℓ	Prob.	g/ℓ	Prob.
	-5000	1/6	-5000	1/6
	-3000	1/6	-2000	1/6
	-500	1/6	-1500	1/6
	2000	1/6	1000	1/6
	3000	1/6	4000	1/6
	5000	1/6	5000	1/6
TASK V**	F		G	
$\omega \in W_{0.1}^{0.7}$	g/ℓ	Prob	g/ℓ	Prob
	-3000	30%	-3000	10%
			-1500	40%
	3000	60%		
	4500	10%	4500	50%
TASK VII**	F		G	
$\omega \in W_{0.1}^{0.7}$	g/ℓ	Prob.	g/ℓ	Prob.
	-6000	10%	-6000	10%
	-3000	20%	-1500	40%
	3000	60%	4500	40%
	6000	10%	6000	10%

Table 4: Tasks VII, IX, and V are modifications of Tasks I, II, and III, respectively.

then F is the expected answer; and if R^* is a more accurate description, the G is the expected answer.

Tasks X, VI, and VIII in Table 5 are all modifications of Task I. In the three choices, again F $RW_c^d - SD$ G and G $R^*W_c^d$ -SD F . Our purpose here is to change c , the probability magnitude of the common tail. Tasks X, VI, and VIII embed Task I in the ranges 1/6 to 5/6, 0.1 to 0.9, and 0.02 to 0.98, respectively. In all cases the common extreme consequences of -6000 and +4500 are the lowest and highest outcomes of Task I. Besides casting further evidence for R v. R^* , we aim at the *fourth goal*: to determine the validity of $\omega \in W_c$ as c decreases. Because VIII is very close to Task I, we expect some subjects to move from F to G in Task VIII ($c = 0.02$).

4.2 RESULTS AND DISCUSSION

The results of the experiments are presented in Table 6. Entries represent percentages. If answers for F and G do not add up to 100, the difference corresponds to undecided individuals. Regarding our goals:

TASK X**		F		G	
$\omega \in W_{1/6}^{2/3}$	g/ℓ	Prob.	g/ℓ	Prob.	
	-6000	1/3	-6000	1/6	
			-3000	1/3	
	3000	1/2			
	4500	1/6	4500	1/2	
TASK VI		F		G	
$\omega \in W_{0.1}^{0.7}$	g/ℓ	Prob.	g/ℓ	Prob.	
	-6000	30%	-6000	10%	
			-3000	40%	
	3000	60%			
	4500	10%	4500	50%	
TASK VIII**		F		G	
$\omega \in W_{0.02}^{0.74}$	g/ℓ	Prob.	g/ℓ	Prob.	
	-6000	26%	-6000	2%	
			-3000	48%	
	3000	72%			
	4500	2%	4500	50%	

Table 5: Tasks X, VI, and VIII are modifications of Task I with tail probabilities equal to 1/6, 1/10, and 1/50, respectively.

1. The results of Tasks I, II, and III are in line with the findings of LL02, both in the prospects that are preferentially chosen as well as to the numerical results. We therefore assume that our sample is comparable to the one LL02 used.
2. The preference of the individuals for prospect F in Task IV is slightly increased as the stakes increase. This means that the change from risk seeking behavior to risk aversion for gains (point B), and vice versa for losses (point A), which the Markowitz value function asserts for high stakes cannot be replicated.
3. With the possible exception of Task VIII, Tasks V to X exhibit $F RW_c^d - SD G$ and $G R^* W_c^d - SD F$, for $c = 0.1$ or lower and $d = 0.74$ or higher. Assuming $\omega \in W_{0.1}^{0.8}$, if $v \in V_R$, then subjects would choose F; and if $v \in V_{R^*}$, then they would choose G. In ALL cases, subjects choose F. Thus, we conclude that $v \notin V_{R^*}$. This answers the unresolved question in Section ?? and Wakker (2003) about the two competing explanations for LL02 results. Further, if $v \notin V_{R^*}$ and $v \in V_R$, then in Task I to III it must be the case that $\omega \notin W_0$, i.e.,

Tasks	c	F	G	Comments
I	0	36	63	27- 71 in LL02
II	0	45	54	38- 62 in LL02
III	0	33	67	23- 76 in LL02
IV	0	29	71	$\searrow R^*$
IX	0.17	66	34	\nearrow CPT, $\searrow R^*$. Editing?
V	0.10	82	17	\nearrow CPT, $\searrow R^*$
VII	0.10	63	37	\nearrow CPT, $\searrow R^*$. Editing?
X	0.17	78	22	\nearrow CPT, $\searrow R^*$
VI	0.10	83	17	\nearrow CPT, $\searrow R^*$
VIII	0.02	81	19	\nearrow CPT, $\searrow R^*$. $c = 2\%$!

Table 6: Results in percent of our lottery experiments, Tasks I to X.

$\omega(p)$ is not convex or linear near the origin.

4. In Task VIII, the percentage preference for F does not decrease, as compared to Tasks X and VI. We learn that $\omega \in W_{0.02}$ is a plausible pwf class. Of course, this produces the behaviorally surprising result that a minor change of 4% probability attached to *common* outcomes is sufficient to reverse the preference. The good news is that to move from R -SD to RW_c -SD requires minor modifications of the lotteries. This emphasizes the significance of the certainty effect and the usefulness of our stochastic dominance notion that account for ω , even if $\omega \in W_{0.02}$.

In Tasks IX and VII, the preference of the individuals for the $RW_c - SD$ dominating prospect F is reduced to values of 66% and 63%, respectively. Precisely in these two tasks, F and G have the same extreme outcomes *and* the same extreme probabilities. Because the first and last rows of lotteries F and G are the same, it is plausible that the subjects mentally cancel these common rows in the “editing” phase, as proposed by Tversky and Kahneman (1979). If this mental elimination of the extreme outcomes is carried out *prior* to the CPT evaluation, then Task VII becomes Task I and Task IX becomes Task II. The weaker adherence to F suggests that some editing is taking place, but the results are still consistent with CPT. In addition, comparing Task V (82%) to Task VII (63%), we observe that both tasks modify Task I by adding an upper and a lower common tail of 0.1. In contrast with Task

VII, the probabilities of the extreme outcomes (first and last row) in Task V are different across lotteries, reducing the chance of editing.

5 CONCLUSIONS AND EXTENSIONS

To summarize, numerical evaluations and sensitivity analysis of the results by LL02 after including the pwf show that their experimental results are compatible with CPT. We propose a stochastic dominance notion that encompasses a class of pwf's that is qualitatively appropriate. With the pwf accounted for, lotteries can be designed to test CPT v. Markowitz value functions. Our experimental results indicate that increasing the stakes in lotteries does not lead to the switch in preferences as suggested by the Markowitz value function. More importantly, in head-to-head competitions between CPT and Markowitz value function, without the interference of the weighting function, most individuals follow CPT. Finally, we notice that the possibility of editing prior to evaluation may affect the results significantly.

Future experimental work is required to fine-tune the behavioral models and account for some of the variability of the results. Additional features of CPT, such as loss aversion, could be included in specialized stochastic dominance definitions and tested empirically (Baucells and Heukamp 2003).

Acknowledgements

The authors wish to thank Robin Hogarth (UPF) for helpful discussions and Javier Gómez, César Beltran de Miguel, and Jordi Utgés (All IESE Business School) for their support in conducting the experiments. We are also grateful to the *Fundación BBVA* for financial support.

References

Baucells, Manel and Franz H. Heukamp (2003). "Features of Cumulative Prospect Theory and Stochastic Dominance: Theory and Experiments," IESE Business School.

Edwards, K.D. (1996). "Prospect Theory: A literature review," *International Rev. Financial Anal.* **5**(1), 18-38.

Gonzalez, Richard and George Wu (1999). "On the Shape of the Probability Weighting Function," *Cognitive Psychology* **38** (1). 129-166.

Kahneman, Daniel, and Amos Tversky (1979). "Prospect Theory," *Econometrica* **4**. 263-291.

Levy, H. and Z. Wiener (1998). "Stochastic Dominance and Prospect Dominance with Subjective Weighting Functions." *Journal of Risk and Uncertainty* **16**, 147-163.

Levy, Moshe and Haim Levy (2002a). "Prospect Theory: Much Ado About Nothing?," *Management Science* **48** (10), 1334-1349.

Levy, Moshe and Haim Levy (2002b). "Experimental test of the prospect theory value function: A stochastic dominance approach", *Organizational Behavior and Human Decision Processes* **89**, 1058-1081.

Markowitz, Harry (1952). "The Utility of Wealth." *Journal of Political Economy* **60** (2), 151-156.

Prelec, Drazen (1988). "The Probability Weighting Function," *Econometrica* **66** (3), 497-528.

Tversky, Amos, and Craig R. Fox (1995). "Weighting Risk and Uncertainty," *Psychological Review* **102** (2). 269-283.

Tversky, Amos and D. Kahneman (1992). "Advances in Prospect Theory: Cumulative Representation of Uncertainty," *Journal of Risk and Uncertainty* **59**, 297-323.

Wakker, Peter P. (2003). "The Data of Levy and Levy (2002), 'Prospect Theory: Much Ado about Nothing?' Actually Support Prospect Theory." *Management Science*. Forthcoming.