The Economics of Risky decision making (2)

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An outline of the lectures

- Lecture 1: An introduction to economic risky decision making. Expected Value and Expected Utility.
- Lecture 2: Beyond Expected Utility: Prospect theory, non-linear probability weighting, loss aversion, WTA/WTP gap.
- Lecture 3: The economics of time discounting. A brief history of time preferences and the models used to describe time preferences.
- Lecture 4: Applications of time discounting in fields of economics, with a particular focus on environmental economics.

Up until now in discussing about risky decision making

- In the previous lecture we introduced the fundamental model of decision theory under risk, the Expected Utility Theory model. We also discussed about Expected Value.

- Applications from financial markets (CAPM), gambling and health economics were discussed along with concepts like utility curvature, risk aversion, the Arrow-Pratt coefficients and market risk premium.

Today's lecture

- In this lecture we will go beyond Expected Utility theory and Expected Value and we will examine the most comprehensive decision theory model, Prospect Theory (PT).

- Concepts like non-linear probability weighting, reference dependence and loss aversion will be introduced.

- We will see applications about low probability events and insurance purchase, the determinants of loss aversion, the endowment effect and the asymmetry between Willingness to Pay (WTP) and Willingness to Accept (WTA).

Problems with Expected Utility Theory

- Despite the dominance of Expected Utility Theory in economics, quite a few paradoxes and problems have been observed with this theory.

- We briefly discuss the most important of them and importantly, we will see how these problems paved the way for alternative theoretical models in decision making like Prospect Theory.

Objective probability?

- From Kahneman and Tversky (1979) (p. 266):

You are asked to choose among the following two lotteries:
A= (4000, 0.8; 0, 0.2) or B= (3000, 1; 0, 0)
20% choose A while the remaining 80% choose B.

You are asked to choose among the following two lotteries:
C= (4000, 0.2; 0, 0.8) or D= (3000, 0.25; 0, 0.75)
65% of the subjects choose C while 35% choose D.

What would be your choice for either problem?

Maurice Allais (1911-2010)
Nobel laureate (1988)

Allais paradox

- The two problems differ only in that the probabilities (of the first outcome of A and B) are up-scaled by a factor of four compared to C and D. This is called the “common ratio effect”.

- If A is preferred to B, then C should be preferred to D. However, most decision makers prefer B to A and C to D. This implies that the EUT cannot describe risk attitudes accurately in these two simple problems.

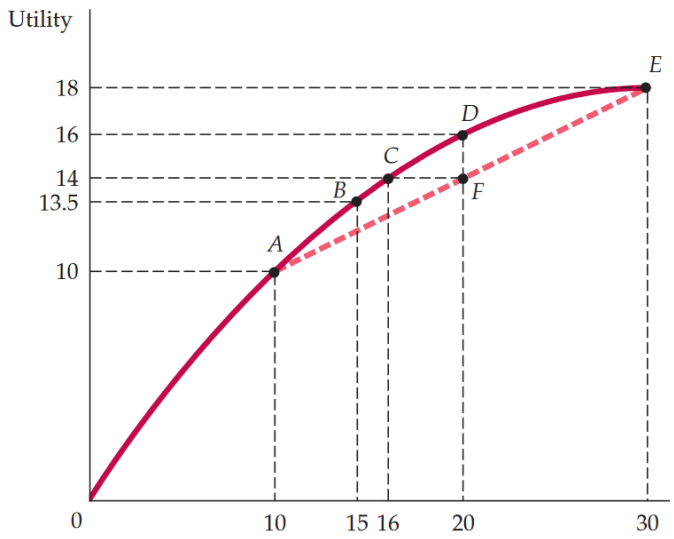
- Allais’ paradox illustrated clearly that many people do not have a linear perception of probability.

Just utility curvature?

- Another criticism has to do with the insufficiency of utility curvature alone to describe risk preferences.

- Rabin (2000) has shown that risk aversion over small gambles leads to very high (nonsensical) risk aversion for large gambles.

- "… a person always turns down a 50-50 lose £100/gain £110 gamble, she will always turn down a 50-50 lose £800/gain £2,090 gamble" (Rabin, 2000, p. 1283).



Rabin's claim implies that Expected Utility (and subsequently utility curvature) could be inadequate to accurately describe risk attitudes.

- In a seminal paper, Holt and Laury (2002) show that higher stakes could lead to a sharp rise in risk aversion, so the magnitude of the rewards could matter here. This implies that the argument of Rabin might be valid.

- A solution that Rabin proposes is the use of reference-dependence and loss aversion which if ignored could lead to mis-modelling of risk attitudes.

- In practice, incorporating reference dependence in decision making is not an easy task given the absence of a solid theory to support the inclusion of reference points.

Reference point

- A potential problem with Expected Utility is that it defines an estimation process that depends on final positions, that is, the final values/outcomes an individual will enjoy.

- However, the evaluation of outcomes could be affected by a reference point beyond which changes in wealth are perceived as gains or losses by an individual. This is an important point to understand. This contradicts the idea of asset integration: the rewards of the lotteries/gambles and of one's assets are integrated to determine the selection (or not) of the lottery.

- This idea has not been incorporated into Expected Utility but it plays a central role in Prospect Theory.

Change in wealth – Reference point

- In the examples in the next page, the final wealth (expected value) is the same. You can check this. However peoples' choice is not the same.

- What does this mean? These examples imply that "… the carriers of value or utility are changes of wealth, rather than final asset positions" (Kahneman and Tversky, 1979, p. 273).

- The important novelty of Prospect Theory is that it does not relate utility/values with final wealth as Expected Utility Theory does.

- It is this idea that paves the way for introducing reference dependence in Prospect Theory.

PROBLEM 11: In addition to whatever you own, you have been given 1,000. You are now asked to choose between

A: (1,000, .50), and B: (500).

$N = 70$ [16] [84]*

PROBLEM 12: In addition to whatever you own, you have been given 2,000. You are now asked to choose between

C: (−1,000, .50), and D: (−500).

$N = 68$ [69*] [31]

Source: Kahneman and Tversky (1979)

In problem 11, 84% of the respondents choose B while in problem 12, 69% choose C. It seems that people neglect the bonus in each problem which would have led to the same final wealth.

Reference point

- Since changes in wealth matter as we have just seen, the obvious question is how we can define the reference point.

- Usually, zero serves as reference point in most applications (so that easily to differentiate between gains and losses). In addition, factors like a person's current assets or a status quo level of wealth, the average wealth or even their expectations (Kőszegi and Rabin, 2006) about their future income. In turn, context and different considerations could have an impact on how one evaluates prospects. No theory to clearly define reference points.

- Note that theoretically reference point might not remain constant and it could be shifted due to asset integration (people do not view the rewards as gains and losses any more).

Framing effects

- Another important point not considered in Expected Utility is how a question is posed. Different approaches and types of questions could lead to different preferences.

- You can see the different choices between the two pairs of questions in the examples in the next page. Notice however that programs A and C are identical apart from how they are framed (people saved, people died). The same holds for programs B and D. So, a different way (frame) in which a problem is presented could lead to different answers by the respondents.

- Also, this could well imply different perceptions for gains and losses for the people who make the choices.

Problem 1 [N = 152]: Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs are as follows:

If Program A is adopted, 200 people will be saved. [72 percent]

If Program B is adopted, there is 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved. [28 percent]

Which of the two programs would you favor?

Problem 2 [N = 155]:

If Program C is adopted 400 people will die. [22 percent]

If Program D is adopted there is 1/3 probability that nobody will die, and 2/3 probability that 600 people will die. [78 percent]

Which of the two programs would you favor?

Source: Tversky and Kahneman (1981)

Framing effects

- The previous example is the prototypical example of framing effects in risky choices and is about posting positive and negative frames. Note that the context of the question could vary a lot by referring to different subject fields: finance for example or effort and performance by medical staff (Lagarde and Blaauw, 2021).

- A reason why framing is important is because it can cause preference reversals which violate the invariance principle of experiments (this principle states that different representations of the same problem should return the same results). Preference reversals can be a headache for social scientists and policymakers.

Prospect Theory

- Up until late 1970s Expected Utility was the dominant decision theory model and the assumption of human rationality was prevalent.

- Two Israeli psychologist, Amos Tversky and Daniel Kahneman introduced an alternative theory, Prospect Theory (PT), which later expanded to Cumulative Prospect Theory (CPT), that accounted for the Expected Utility problems and for other inconsistencies in choice.

Daniel Kahneman and Amos Tversky

A note

Kahneman and Tversky were not economists. They were both psychologists.

Prospect Theory utilized both theoretical soundness and insight from empirical and experimental results. In that way a really comprehensive model was built.

Economists tended to shun experimental work at the time; this has changed in the last years and has led to significant changes in the field which have been widely recognized.

“The economic world is extremely complicated. There are millions of people and firms, thousands of prices and industries. One possible way of figuring out economic laws in such a setting is by controlled experiments. A controlled experiment takes place when everything else but the item under investigation is held constant. Thus a scientist trying to determine whether saccharine causes cancer in rats will hold “other things equal” and only vary the amount of saccharine. Same air, same light, same type of rat.

Economists have no such luxury when testing economic laws. They cannot perform the controlled experiments of chemists or biologists because they cannot easily control other important factors. Like astronomers or meteorologists, they generally must be content largely to observe.” Samuelson and Nordhaus (1985).

As you can see, experiments in economics have gone a long way in the last decades.

The two phases

- According to Prospect Theory there are two phases during decision making: first editing and then evaluation.
- In the editing phase there is a first analysis of the prospects (e.g. coding, the gain-loss consideration). In the second phase, prospects are evaluated and the choice is made.
- Economic analysis has been centred on the second phase (evaluation) and this is where we will focus on during this lecture.
- However, let's have a brief look on a few interesting aspects of the editing phase.

- Coding: people normally perceive outcomes as gains or losses relative to a reference point (and not as finals states of wealth).

- Combination: simplify gambles by combining the probabilities of the same outcomes e.g., (1000, 0.3; 1000, 0.2) can be simplified to (1000, 0.5).

- Segregation: riskless parts (components) of a gamble are segregated from the risky parts e.g., (100,0.7; 150,0.3) can be segregated into a riskless part of 100 and a risky part of (50,0.3).

- Simplification: when we round probabilities or outcomes e.g., (100, 0.99) could be rounded to a sure gain of 100. Note that outcomes that are very unlikely, they can be ignored completely (zero probability).

Cancellation: When reducing the common parts of a gamble (probabilities and outcomes), e.g., choosing between

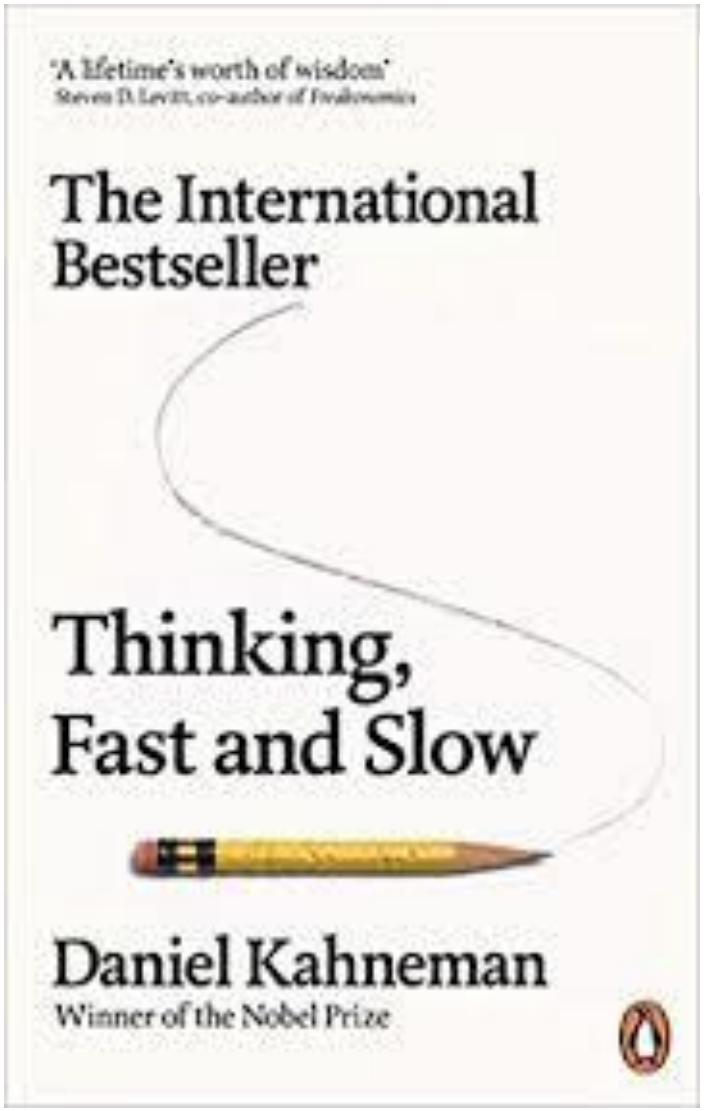
(200, 0.20; 100, 0.50; -50, 0.30) and

(200, 0.20; 150, 0.50; -100, 0.30)

is the same as a choice between

(100, 0.50; -50, 0.30) and

(150, 0.50; -100, 0.30) (the common parts of(200, 0.20) are cancelled).



These ideas were further developed and popularized by Daniel Kahneman in his book "Thinking, Fast and Slow".

System 1: A fast automatic system (emotional, unconscious).

System 2: A logical system, more slow, more calculating.

"The interaction of the two systems is a recurrent theme of the book, and a brief synopsis of the plot is in order. In the story I will tell, Systems 1 and 2 are both active whenever we are awake. System 1 runs automatically and System 2 is normally in a comfortable low-effort mode, in which only a fraction of its capacity is engaged. System 1 continuously generates suggestions for System 2: impressions, intuitions, intentions, and feelings. If endorsed by System 2, impressions and intuitions turn into beliefs, and impulses turn into voluntary actions. When all goes smoothly, which is most of the time, System 2 adopts the suggestions of System 1 with little or no modification."

Loss aversion

- The reference point is closely related with the concept of loss aversion.
- Loss aversion means that people tend to weight heavier losses than equivalent gains e.g., one would prefer not to lose an outcome than to gain the same outcome ("losses loom larger than gains").
- Note that graphically loss aversion is depicted as a "kink" in the value function in the loss domain which becomes steeper than the one in the gain domain, i.e., $-u(-x) > u(x), x > 0$.

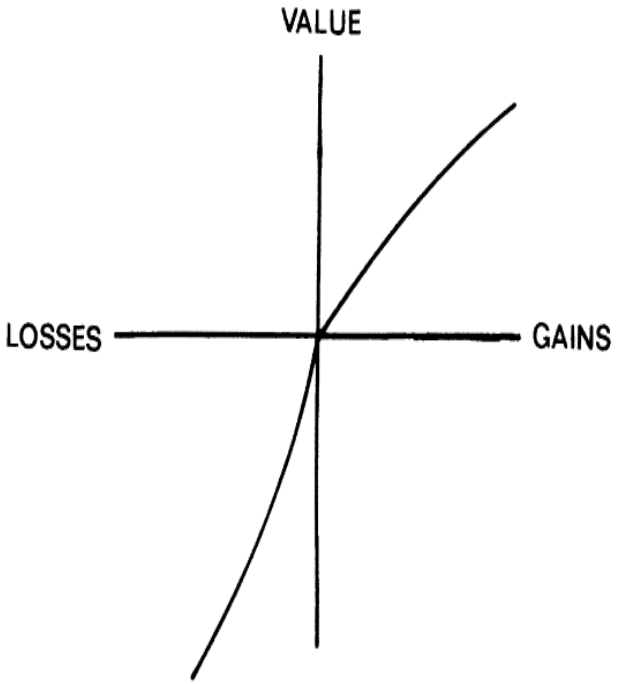


FIGURE 3.—A hypothetical value function.

Source: Kahneman and Tversky, 1979)

- A common value for loss aversion in the literature is a number around 2.
- Loss aversion is a concept for which there are different types of definitions (local, global definitions) and for which disagreements about the imposition of constraints could affect the identification.
- This makes more difficult any attempt to quantify it accurately.
- Some also believe that loss aversion "...is an adapted response to the project of genuine, damaging, survival-threatening loss" (Camerer, 2005).

Riskless choices

- Note that the concept of loss aversion is also applicable to riskless choices. This has been called the endowment effect (see Kahneman et al. (1981)).

- Utilizing coffee mugs and pens, they show that participants, who were initially given a mug, demanded more money to give the mug they own (Willingness to Accept, WTA) than what individuals who are not endowed with the mug are willing to pay for it (Willingness To Pay, WTP).

- The rationale here is that people put a greater value on things they own.

WTP-WTA gap

Recall the example with the coffee mugs: there was an asymmetry between willingness to pay (WTP) for the mug and willingness to accept (WTA) money for the mug; the buying and selling prices for a good are different.

Generally, WTA is substantially higher than WTP. This asymmetry has been observed in a number of studies with a different range of products (nuclear waste, hunting rights, movie tickets (see Horowitz and McConnell (2002) for a survey).

Hammack and Brown (1974) found that hunters were willing to spend $247 to continue hunting, but they demanded $1044 on average to sell their hunting rights.

- But why this gap matters? It contradicts traditional economic theory which states that endowments should not affect preferences and valuations.

- Despite the prevalence of the WTA-WTP gap, economist are not really sure what is the underlying cause.

- The gap can be interpreted as a kind of asymmetry with respect to a reference point (the reference point could be the endowment with the mug), something that is in accord with Prospect Theory. This has been called the endowment effect.

- Note that a typical ratio of WTA/WTP is around 2, the same approximately value as loss aversion for risky choice typically has. However, this ratio could vary substantially and can reach values above 4, the mean is around 2.6 (Gächter et al., 2007).

Determinants of loss aversion

- But what are some factors (determinants) which could influence loss aversion? What the literature says about this issue?
- This is an important question: loss aversion is a fundamental concept of Prospect Theory and has proven to be very popular in economics (approximately 697,000 results in Google Scholar as of June 2022).

- Gächter et al. (2007), in a field experiment in Germany, Austria and Switzerland, report no gender effect (that there are differences between men and women).
- They report however that loss aversion increases in age (the older the more loss averse), increases with household income and wealth.
- But, loss aversion declines as the level of education increases.

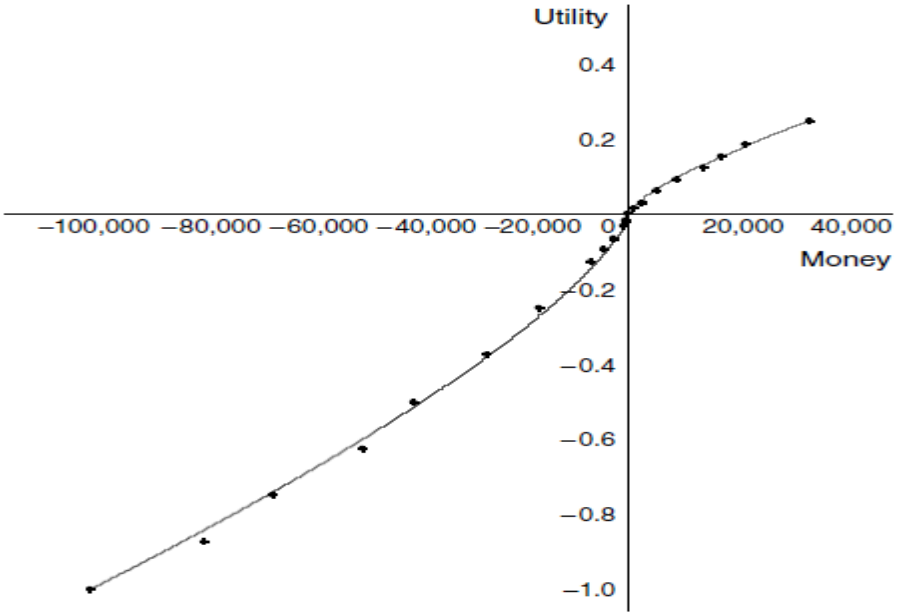
Value function

- In prospect theory, the name value function is used instead of utility (in the sense that it is the changes in the value of the wealth that matter).

- The value function accommodates both gains and losses: its shape is (generally) an S-shape which indicates risk aversion for gains (concave utility) and risk seeking for losses (convex utility).

- Note that this mirror image in risk preferences between gains and losses is called the reflection effect. This implies an equivalence of the coefficients of the value function at each domain.

Figure 2 **Parametric Fit of the Power Function Based on the Median Data**



Source: Abdellaoui et al. (2007)

How to model the value function mathematically?

$$v(x) = \begin{cases} x^{\alpha}, x \geq 0 \\ -\lambda(-x)^{\beta}, x < 0 \end{cases}$$

A piece-wise power function is usually the standard choice to model the value function, $\alpha, \beta > 0$.

Probability weighting

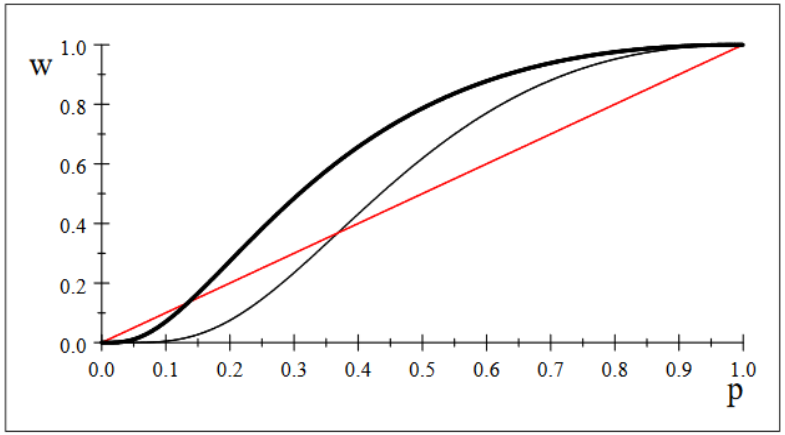
- In Prospect Theory the (subjective) value of an outcome is multiplied not by the (objective) probability but by a decision weight.
- This means that probability becomes subjective (there is no longer a linear perspective) and therefore it has to be transformed properly into a decision weight.
- This transformation takes place through a probability weighting function which could have 1 or 2 parameters.

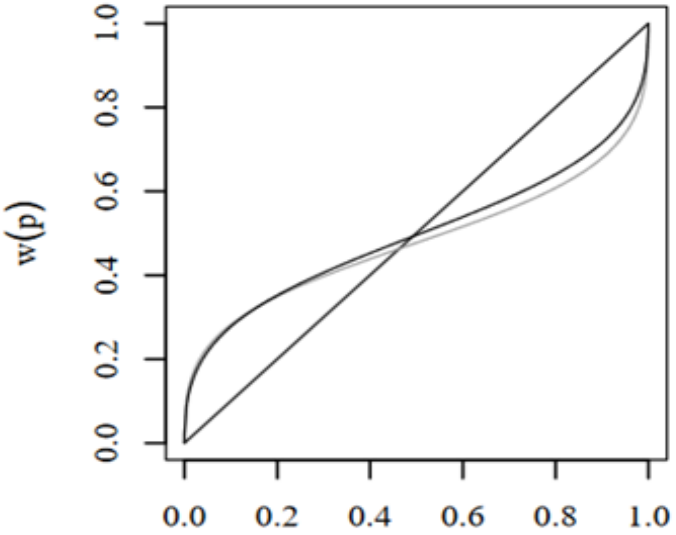
Tversky and Kahneman (1992) weighting function:

$$w(p) = \frac{p^{\gamma}}{(p^{\gamma}+(1-p)^{\gamma})^{1/\gamma}}$$

Prelec (1998) weighting function:

$$w(p) = e^{-\beta(-lnp)^{\alpha}}$$



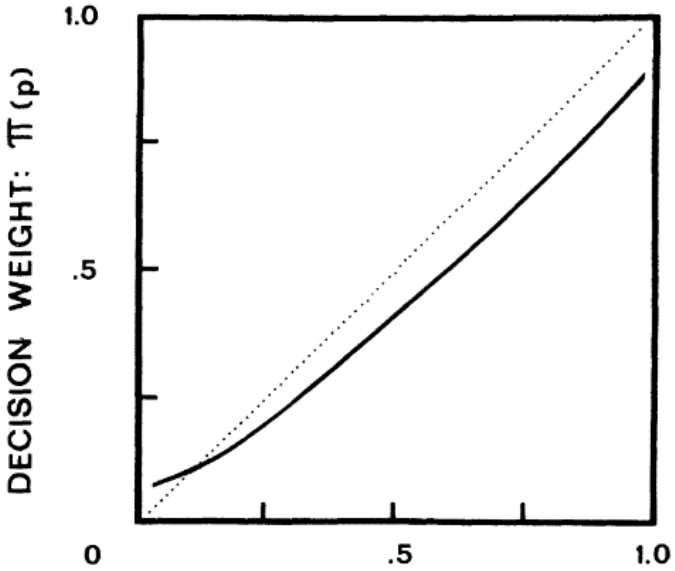


- In most applications, the probability weighting function shape tends to be inverse S-shape.

- This is consistent with the fourfold pattern, that is, risk seeking for low probability gains, but risk averse for high probability gains. You can compare the decision weights with the dichotomous line to understand this.
- There can be exceptions though as shown above, look at the S-shape graph.

Note that Kahneman and Tversky (1979) initially did not specified a specific probability pattern by allowing a discontinuity at the end points of the probability graph.

"… the simplification of prospects can lead the individual to discard events of extremely low probability and to treat events of extremely high probability as if they were certain. Because people are limited in their ability to comprehend and evaluate extreme probabilities, highly unlikely events are either ignored or overweighted, and the difference between high probability and certainty is either neglected or exaggerated. Consequently $\pi(p)$ is not well-behaved near the end-points."



Source: Kahneman and Tversky (1979)

Explaining the Allais paradox-Subproportionality

Let's see again the Allais paradox problems mentioned earlier:

For the first problem (B preferred over A):

$$\pi(0.8)u(4000) < \pi(1)u(3000) \Rightarrow \frac{\pi(0.8)}{\pi(1)} < \frac{u(3000)}{u(4000)}$$

For the second problem (C preferred over D):

$$\pi(0.2)u(4000) > \pi(0.25)u(3000) \Rightarrow \frac{\pi(0.2)}{\pi(0.25)} > \frac{u(3000)}{u(4000)}$$

The above inequalities imply:

$$\frac{\pi(0.8)}{\pi(1)} < \frac{\pi(0.2)}{\pi(0.25)}$$

Explaining the Allais paradox-Subproportionality

The last inequality reveals a property of probability weighting, called subproportionality:

$$\frac{\pi(pq)}{\pi(p)} < \frac{\pi(pqr)}{\pi(pq)}, 0 < p, q, r \leq 1$$

Hence, when we have a fixed ratio of probabilities (like the “common ratio effect”), the ratio of the weights is closer to one when the probabilities are low than when they are high.

This could serve as an explanation for the Allais paradox based on probability weighting.

A NYC taxi drivers example

- Economic models stipulate that individuals face a choice between leisure and labour (the opportunity cost of leisure is the wage rate).

- Hence, changes in wages affect leisure: when wages are high people work more and they have less time for leisure; when wages are low people might work less and enjoy more leisure (labor-leisure trade-off).

- Camerer et al. (1997) examined this claim of economic theory using data from New York City taxi drivers.

- They find that wages are correlated within each day and not correlated across days. This implies that taxi drivers make their decisions daily and they do not substitute labor and leisure across time.

- Daily targeting implies that taxi drivers set their wage relative to a reference point (which in turn implies a gain-loss utility which is subject to how one sets the wage target).

- There is a word for such type of targeting: narrow framing (take each decision separately and without considering other related risks, say in a consequence of decisions).

This could be the case with other professionals with flexible working hour (vendors, delivery cyclists).

An application from agricultural economics

- We examine now an application from the field of agricultural economics where risk preferences are elicited from small-cattle farmers in West Africa, Mali and Burkina Faso (Liebenehm and Waibel, 2014).

- Such studies in developing countries aim to understand the investment decisions of these developing countries so that to better help them in the development process of these nations.

- Note that these decisions might be different from decisions in developed nations, e.g., livestock diseases , like the African animal typanosomosis (AAT) is a major threat for the livelihood of these people.

Table 5. Model Estimates of Parameters without Individual Characteristics

Parameter	Estimate	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
Probability weight (α)	0.133***	0.022	0.089	0.177
Risk aversion (σ)	0.112***	0.006	0.101	0.123
Loss aversion (λ)	1.351***	0.262	0.837	1.865
Time preference (δ)	0.001***	0.0001	0.0004	0.0008
Present bias (β)	0.942***	0.028	0.888	0.997
Test	p-value			
H0: $\alpha = 1$	0.000			
H0: $\lambda = 1$	0.1804			
H0: $\delta = 0.078$	0.000			
H0: $\beta = 1$	0.0375			
N = 23210 (Number of clusters = 211)				

Note: Single, double, and triple asterisks (*, **, and ***) denote $p < 0.10$, 0.05, and 0.01, respectively.
Source: Own survey.

These are the results of the homogeneous model. Notice that there is loss neutrality ($\lambda = 1$) and a very steep weighting function.

Table 7. Model Estimates of Risk Preference Parameters with Individual Characteristics

	Probability weight (α)	Risk aversion (σ)	Loss aversion (λ)
Variable	Estimate	Estimate	Estimate
Burkinabé	0.598	0.016	28.909
L1 Age	0.062	−0.005***	−0.184
Education	−0.051	0.03***	−0.319
Religion	−0.067*	0.038***	−1.161*
L1 Household size	0.010	−0.023	−0.054
L1 Children in school	−0.492	0.259***	17.309
L1 Motorbikes	0.063	0.03	−0.593
L1 Cattle	0.021***	0.009	0.245***
L1 Trypanotolerant	−0.299*	0.076	0.225
L1 Extension	0.303	0.041	4.828*
L1 Expenditures for curative drugs	−0.002*	0.0005**	−0.064
L1 Expenditures for preventive drugs	−0.005	0.0005	−0.094**
Interaction term of curative and preventive drugs	0.00001**	−0.0000001	0.0004***
L1 Income	0.85**	−0.039	−8.684
L1 First income quintile	0.121	−0.088	−2.221
L1 Third income quintile	−0.781**	0.229**	−20.214*
L1 Fifth income quintile	−1.449***	0.234**	5.826
L1 AAT	−2.079***	−0.057	−15.617
N = 22210 (Number of clusters = 202)		Pseudo-Log Likelihood = −11431.71	

Note: The ML model also includes village dummies. Single, double, and triple asterisks (*, **, and ***) denote $p < 0.10$, 0.05, and 0.01, respectively.
Source: Own survey.

What the findings reveal?

Probability weighting parameter is positively related to income indicators (cattle and income), religion has a negative impact on probability (having a strong faith implies an inverse S-shape pattern), expenditures for curative drugs have a small negative impact.

On utility curvature: richer farmers are associated with lower levels of risk aversion, education and more children in school lead to lower risk aversion (education makes people more likely to take risks), elderly farmers are more risk averse than younger farmers.

On loss aversion: religion has a negative impact (more religious people are less loss averse) and cattle, an income indicator, leads to higher levels of loss aversion. Expenditures for preventive drugs also lower loss aversion.

Insurance

- An important application of non-linear probability weighting can be found in the field of insurance.
- Kunreuther et al. (1978) show that demand for insurance declines a lot when the probability of losses declines.
- Apparently, many people do not really grasp low probabilities. In the words of Camerer and Kunreuther (1989): "… individuals seem to buy insurance only when the probability of risk is above a threshold".
- This is in accord with the claims of Kahneman and Tversky (1979) that people might ignore extreme probabilities.

An example about flood insurance

- Robinson et al. (2020), in a survey in Netherlands, examine the parameters behind flood insurance demand. Among other things, they examine a threshold of concern model according to which people ignore risks if they perceive the probability of risk to be below a threshold level of concern (which is subjective).
- The authors hypothesize that if that threshold is low enough, this can lead to lower flood insurance demand.

- The results confirm that individuals who use a threshold of concern model, exhibit lower insurance demand (this model is related to probability under-weighting discussed earlier).
- Note however, that probability is just one factor that could influence the purchase of insurance: other parameters, with psychological dimension (internal locus of control and anticipated regret about losses due to being uninsured) can affect positively flood insurance demand.

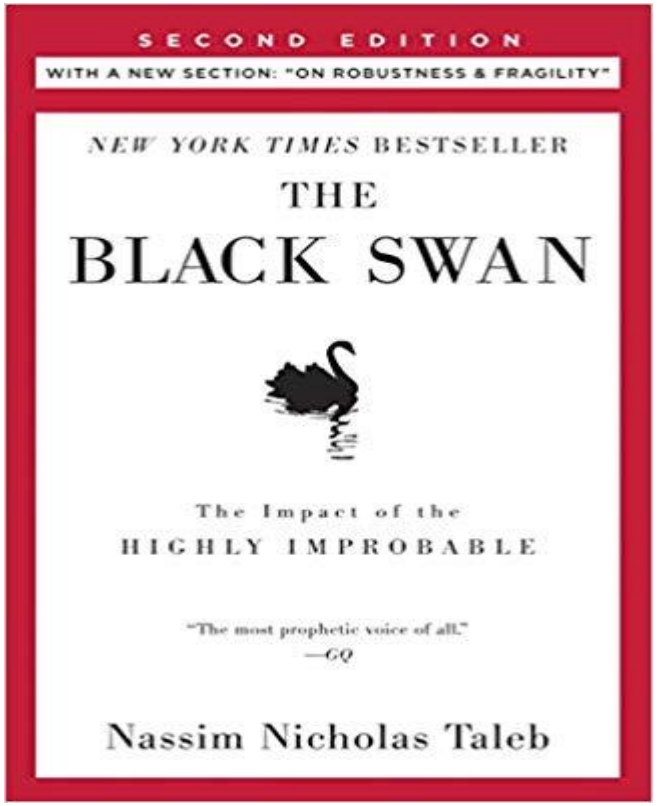
- If you want to read more about low probability events you might want to consult these two books, The Black Swan and The Fat Tail (they are not economics books though).

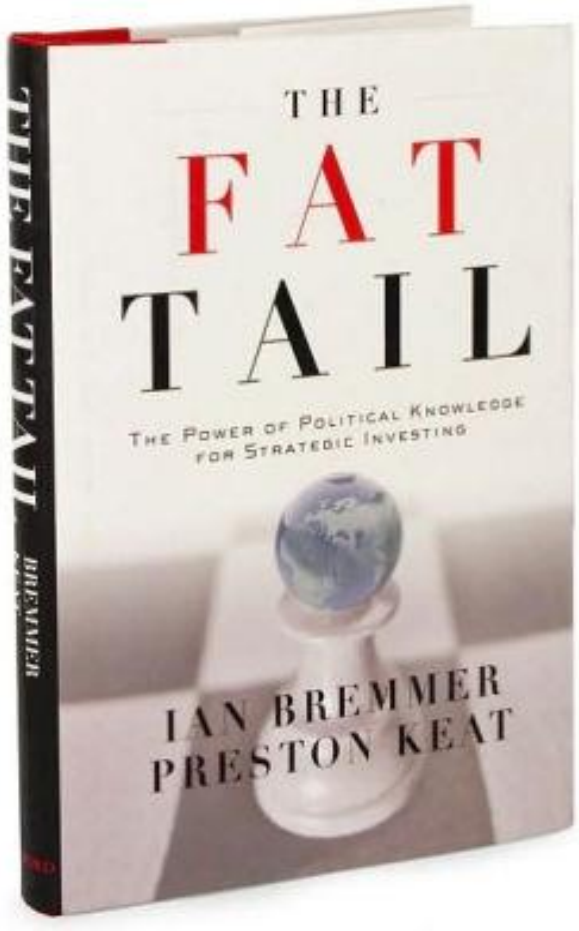
- What is a black swan? The concept refers to highly unexpected events which could have important consequences.

- Taleb (2007) considers events like World War I, the market crash of 1987 and the Soviet Union collapse as black swan events. The link below directs you to a brief video:

https://www.youtube.com/watch?v=BDbuJtAiABA

- The Fat Tail is about political and geopolitical risks terrorism, political instability. These constitute some very important events which cannot always sufficiently analyzed using the tools explained earlier.





Extreme events (the term fat tail is often used to refer to an increased likelihood of extreme events) are also related with the very important problem of climate change: there is deep uncertainty with potentially catastrophic consequences (Weitzman, 2011).

Other applications

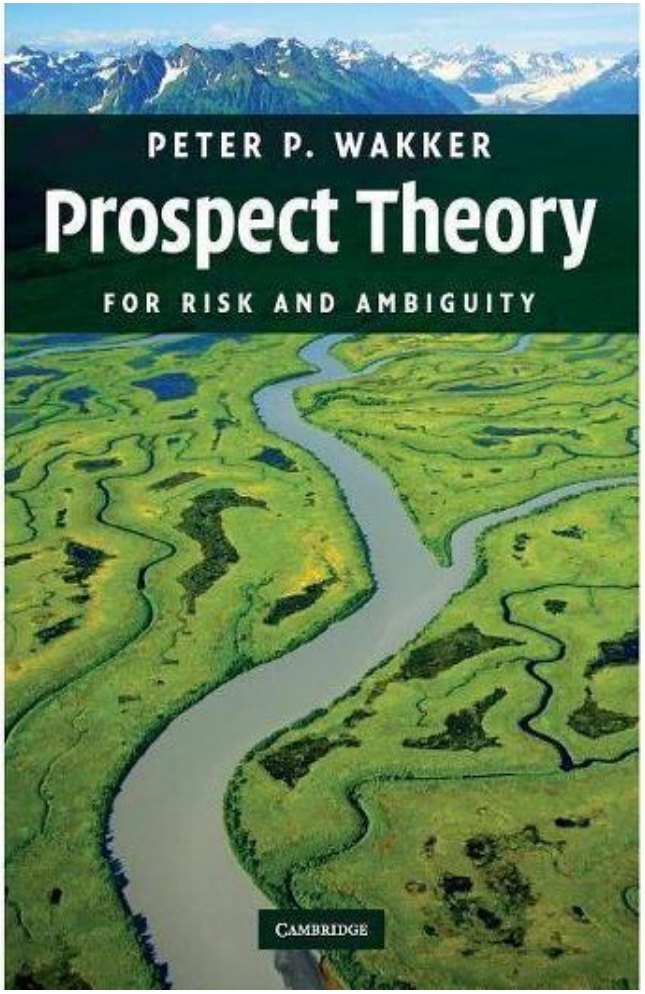
- There are other applications of Prospect Theory (and in particular of loss aversion) in economics.

- Some prominent examples include the equity-premium puzzle i.e. the higher returns of stocks over bonds (Benartzi and Thaler, 1995) and modelling a firm's pricing strategies (Spiegler, 2012).

- See Barberis (2013) for a comprehensive and readable assessment of the applications of Prospect Theory in economics and finance.

- An important aspect of Prospect Theory is that it can be expanded and accommodate ambiguity (unknown probabilities) as well, not only objective probabilities (risk).

- “At this moment of writing, 30 years after its invention, Prospect Theory is still the only theory that can deliver the full spectrum of what is required for decision under uncertainty, with a natural integration of risk and ambiguity”, (Wakker, 2010).

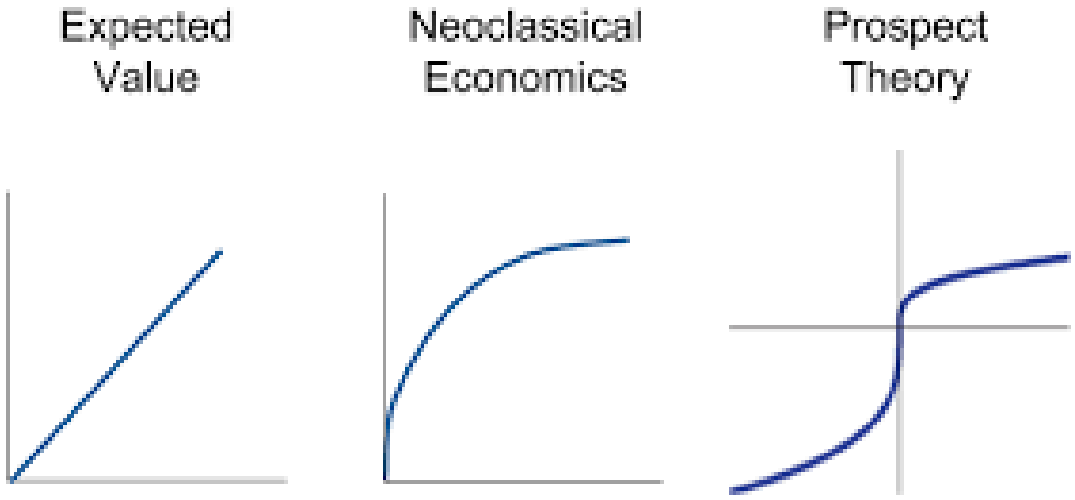


Criticisms of Prospect Theory

- Since Prospect Theory is the most complete decision theory model, then why is the EUT model that dominates the economics literature?
- A first reason is that EUT has a strong normative interpretation (PT is basically a descriptive theory) and it is used extensively to support many important findings in economics.
- Another reason is the absence of a an endogenously determined reference point. This might not always reflect reality and could hinder the precision of estimates.
- Someone could claim that the inclusion of more parameters is obvious that will return better results (kind of overfitting).
- When a theory has many parameters, then interactions among these parameters could appear (e.g., probability and utility curvature coefficients). This hinders the derivation of solid conclusions.

Utility shapes

- In the adjacent graphs, you can see how the shapes of utility have been evolved throughout this lecture series.
- Depending on the model used, different utility shapes can emerge.



There is no definite answer on which should be used in an application. Expected Utility model remains dominant in economics, though.

Other decision theory models

- Many other models for risky choice are available. To mention a few:

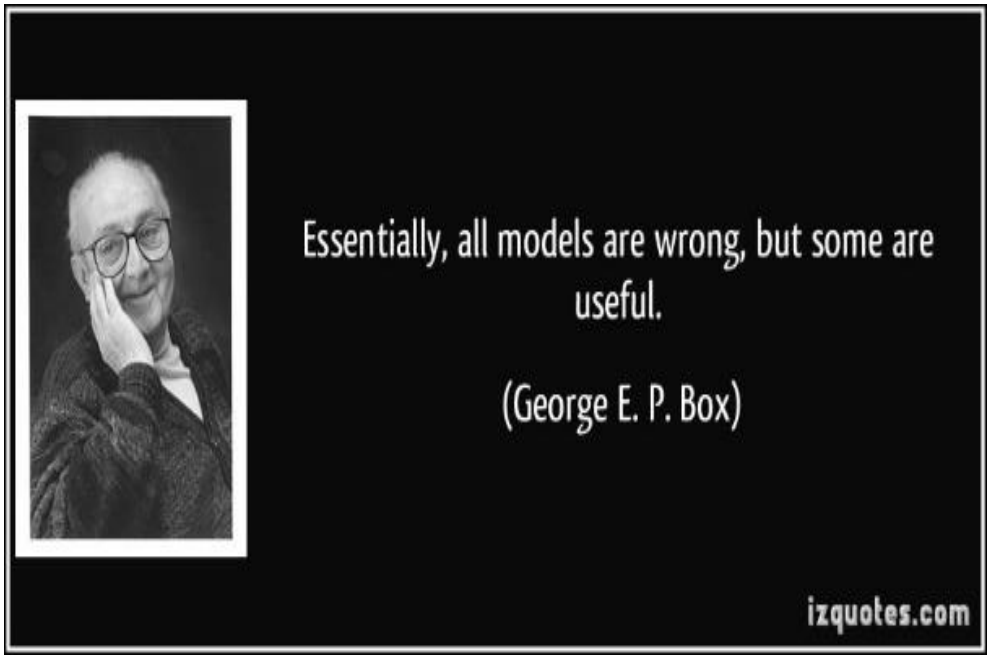
- Subjective Expected Utility
- Dual Theory
- Regret Theory
- Disappointment Aversion

- These models however have limited applicability compared to Expected Utility (primarily) and Prospect Theory (to a lesser extent) though.

- Mixture models can also be applied where two or more decision theory models can be used to describe the data. Such approaches are computationally intensive though.

A final note on models

- One final thing to remember about models: all of them can be wrong.
- Still, this does not mean that they cannot have a degree of usefulness and that they cannot be used for informing policy makers.
- Real world might be complicated enough to be described by a single model.

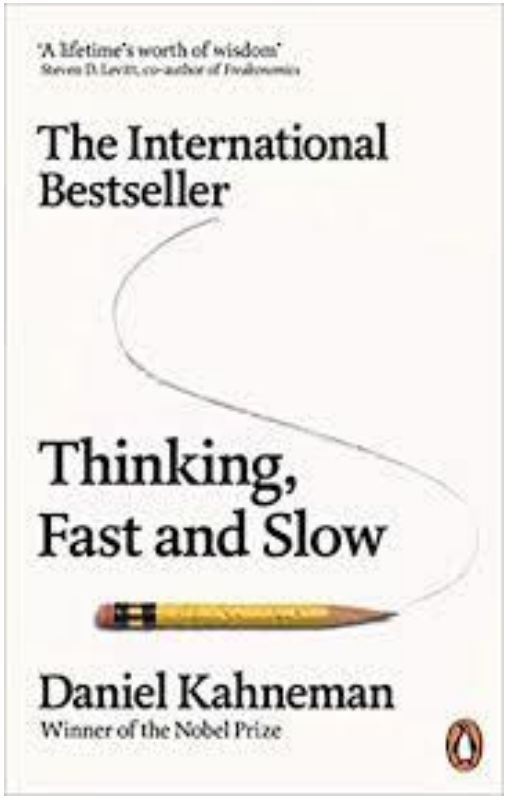


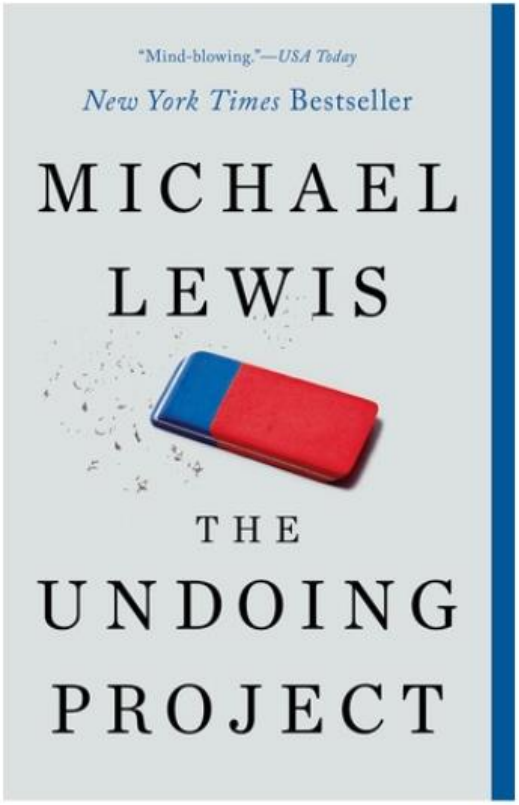
This quote by George Box (a famous statistician) is quite illuminating.

For a general reading

If you wish to learn more about the topics we discussed today, you could grasp these two books (of general interest).

The second book (The Undoing Project) is a chronicle of the collaboration between Kahneman and Tversky. Their collaboration was instrumental for the emergence of the field of behavioral economics.





There is an expert on risk analysis at the University of Warwick:

Professor Graham Loomes

Professor of Behavioural Science

Behavioural Science Group

Warwick Business School

He is a highly cited researcher and the co-author of Regret Theory (1982).
As of June 20th 2022, the paper had been cited 5006 times in Google Scholar.

REGRET THEORY: AN ALTERNATIVE THEORY OF RATIONAL CHOICE UNDER UNCERTAINTY*

Graham Loomes and Robert Sugden

The main body of current economic analysis of choice under uncertainty is built upon a small number of basic axioms, formulated in slightly different ways by von Neumann and Morgenstern (1947), Savage (1954) and others. These axioms are widely believed to represent the essence of rational behaviour under uncertainty. However, it is well known that many people behave in ways that systematically violate these axioms.[1]

We shall initially focus upon a paper by Kahneman and Tversky (1979) which presents extensive evidence of such behaviour. Kahneman and Tversky offer a theory, which they call 'prospect theory', to explain their observations. We shall offer an alternative theory which is much simpler than prospect theory and which, we believe, has greater appeal to intuition.

The following notation will be used throughout. The ith *prospect* is written as X_i. If it offers increments or decrements of wealth $x_1, \ldots, x_n$ with probabilities $p_1, \ldots, p_n$ (where $p_1 + \ldots + p_n = 1$) it may be denoted as $(x_1, p_1; \ldots; x_n, p_n)$. Null consequences are omitted so that the prospect $(x, p; 0, 1-p)$ is written simply as (x, p). Complex prospects, i.e. those which offer other prospects as consequences, may be denoted as $(X_i, p_i; \ldots; X_n, p_n)$. We shall use the conventional notation $\succ$, $\succcurlyeq$ and $\sim$ to represent the relations of strict preference, weak preference and indifference. We shall take it that for all prospects X_i and X_k, $X_i \succcurlyeq X_k$ or $X_i \preccurlyeq X_k$; but we shall not in general require that the relation $\succcurlyeq$ is transitive.

I. KAHNEMAN AND TVERSKY'S EVIDENCE

Kahneman and Tversky's experiments offered hypothetical choices between pairs of prospects to groups of university faculty and students. Table 1 lists a selection of their results, which reveal three main types of violation of conventional expected utility theory:

(*a*) The 'certainty effect' or 'common ratio effect', e.g. the conjunction of $X_5 \prec X_6$ and $X_9 \succ X_{10}$ and the conjunction $X_{13} \prec X_{14}$ and $X_{15} \succ X_{16}$. There is also a 'reverse common ratio effect', e.g. the conjunction of $X_7 \succ X_8$ and $X_{11} \prec X_{12}$.

(*b*) The original 'Allais Paradox' or 'common consequences effect', e.g. the conjunction of $X_1 \prec X_2$ and $X_3 \succ X_4$.

(*c*) The 'isolation effect' in two-stage gambles, e.g. the conjunction of $X_9 \succ X_{10}$ and $X_{17} \prec X_{18}$.

* We particularly wish to thank Michael Jones-Lee, Mark Machina and two anonymous referees for many helpful suggestions and criticisms.

[1] For a survey and discussion of much of the evidence, see Allais and Hagen (1979) and Schoemaker (1980, 1982).

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