

Prospect Theory: An Analysis of Decision under Risk

Paper by Daniel Kahneman and Amos Tversky
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The goal of the paper is to formulate a theory that describes decision-making better than EUT

- **Research question: how do real people choose from a set of risky options?**
- Expected utility theory (**EUT**) is a consistent normative (prescriptive) theory.
- However, it fails as a positive (descriptive or predictive) theory.
- People commit systematic (not random) violations of EUT key assumptions.
- Major implication of the Prospect theory (**PT**): prediction of real people's choice under risk, theoretical foundation for nudging.

Expected utility theory is based on three major assumptions

1. Overall utility of a prospect $X = (x_1, p_1; \dots; x_n, p_n)$ is expected utility of its outcomes:

$$EU(X) = \sum_i^n p_i u(x_i)$$

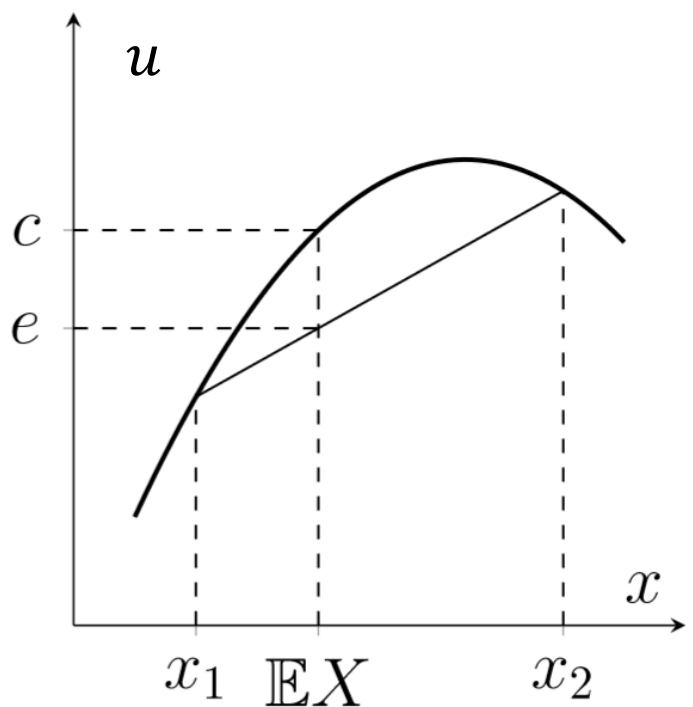
2. Domain of $EU(X)$ is final assets:

X is acceptable at wealth w iff

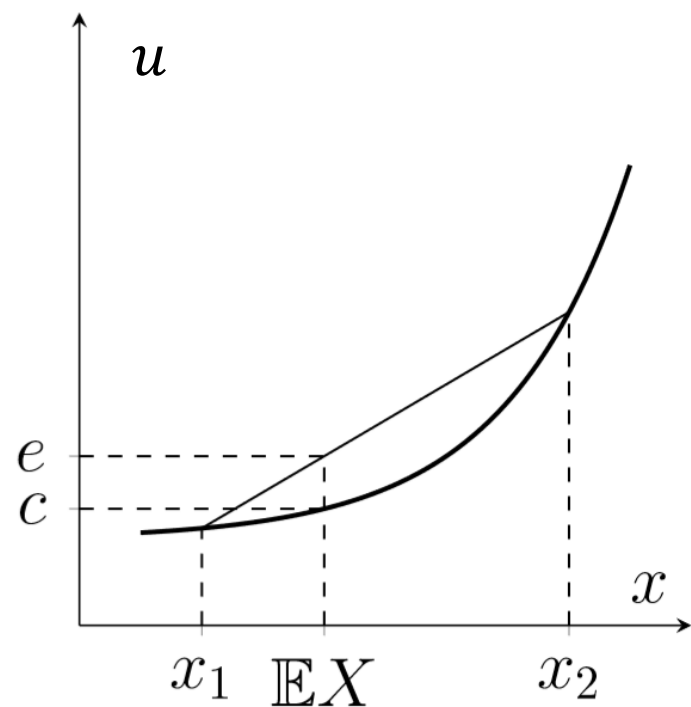
$$EU(w + x_1, p_1; \dots; w + x_n, p_n) > EU(w)$$

Expected utility theory is based on three major assumptions

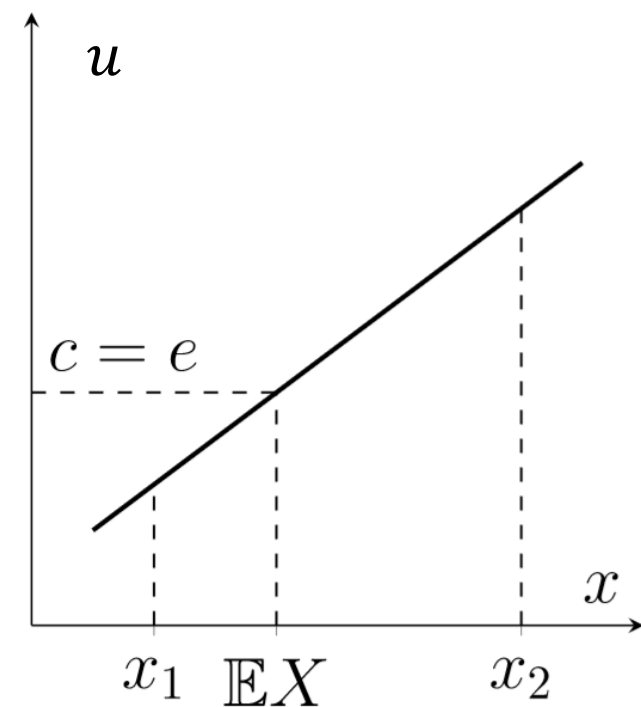
3. Risk aversion (usually assumed): u is concave



Risk aversion



Risk seeking



Neutral attitude

Authors used surveys results instead of revealed preferences approach or laboratory experiments

- Students from Israel, Sweden and the USA were surveyed.
- **Random assignment** eliminated an impact of irrelevant factors.
- Questions dealt with **significant amounts** of money.
- Key assumption: people are reasonably **accurate in predicting** their choices.
- Three major effects were found: certainty effect, reflection effect and isolation effect.

Surveys demonstrated that people systematically violate EUT assumptions regarding probabilities

- *Which option will you choose in each of these problems?*

Problem 1	(A) 50% chance to win a three-week tour of England, France, and Italy	(B) a one-week tour of England, with certainty
Problem 2	(C) 5% chance to win a three-week tour of England, France, and Italy	(D) 10% chance to win a one-week tour of England

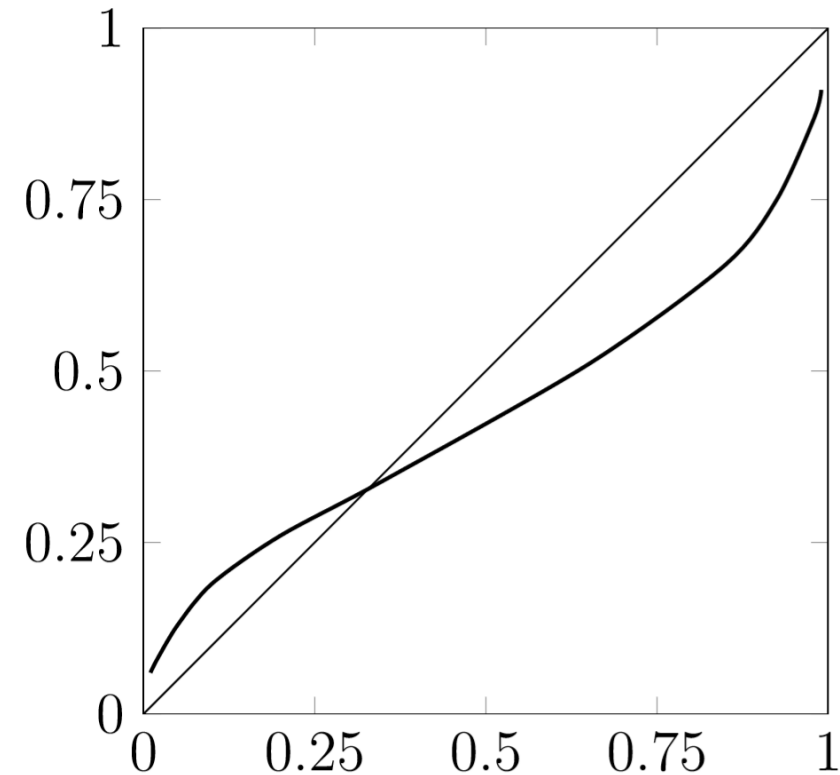
Surveys demonstrated that people systematically violate EUT assumptions regarding probabilities

- **Certainty effect:** proportional change of probabilities affects the decision.

Problem 1 (72 respondents)	(A) 50% chance to win a three-week tour of England, France, and Italy [22%]	(B) a one-week tour of England, with certainty [78%]
Problem 2 (72 respondents)	(C) 5% chance to win a three-week tour of England, France, and Italy [67%]	(D) 10% chance to win a one-week tour of England [33%]

The probability weighting function was derived from empirical data

- People overweight low probabilities.
- People underweight high probabilities.
- Certainty is perceived correctly:
 $\pi(0) = 0$ and $\pi(1) = 1$



Probability weighting function $\pi(p)$

Also, surveys showed that people systematically violate EUT assumptions regarding utilities

- *Which option will you choose in each of these problems?*

Problem 3	(E) 4000 with 80% chance	(F) 3000 for sure
Problem 4	(G) −4000 with 80% chance	(H) −3000 for sure

Also, surveys showed that people systematically violate EUT assumptions regarding utilities

- **Reflection effect:** transition from gains to losses changes people's decisions.

Problem 3 (95 respondents)	(E) 4000 with 80% chance [20%]	(F) 3000 for sure [80%]
Problem 4 (95 respondents)	(G) −4000 with 80% chance [92%]	(H) −3000 for sure [8%]

The value function was derived from three key empirical results

1. Reference dependence.

People compare gains/losses but not the final assets:

$$v(0) = 0$$

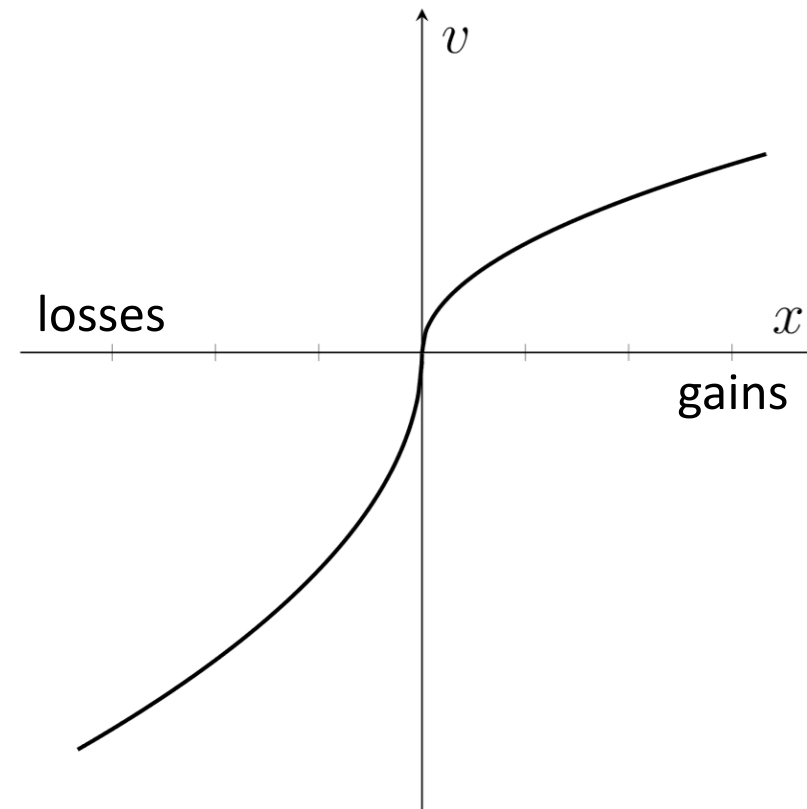
2. Decreasing sensitivity.

Responsiveness falls with amounts:

$$\begin{cases} v''(x) < 0 & \text{for } x > 0 \\ v''(x) > 0 & \text{for } x < 0 \end{cases}$$

3. Loss aversion. People dislike losses more than they like gains:

$$v(-x) < -v(x)$$



Value function $v(x)$

Prospect theory proposed that decision-making consists of two phases: editing and evaluation

- A person is choosing between two options: $X = (x_1, p_1; \dots; x_n, p_n)$ and $Y = (y_1, q_1; \dots; y_n, q_n)$.
- During the **editing phase** preliminary analysis of the offered prospects takes place:
 - Coding: reference point is chosen, outcomes are identified as gains and losses
 - Combination: probabilities of identical outcomes are combined
 - Segregation: riskless and risky components of a prospect are segregated
 - Cancellation: components common for all prospects are discarded
 - and other
- These operations explain many choice anomalies which are studied by the Behavioral economics.

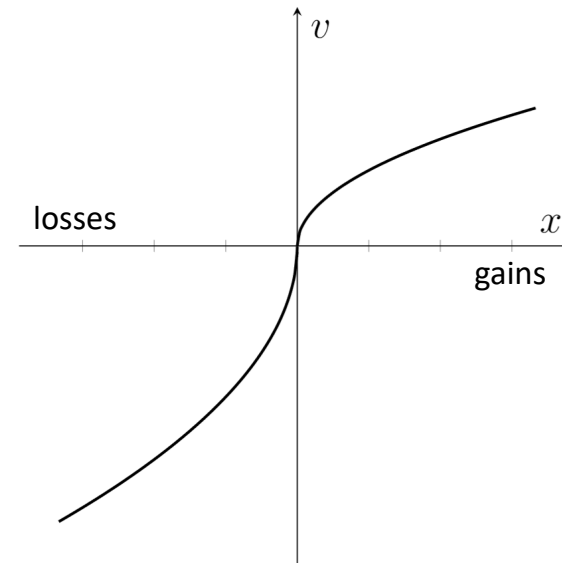
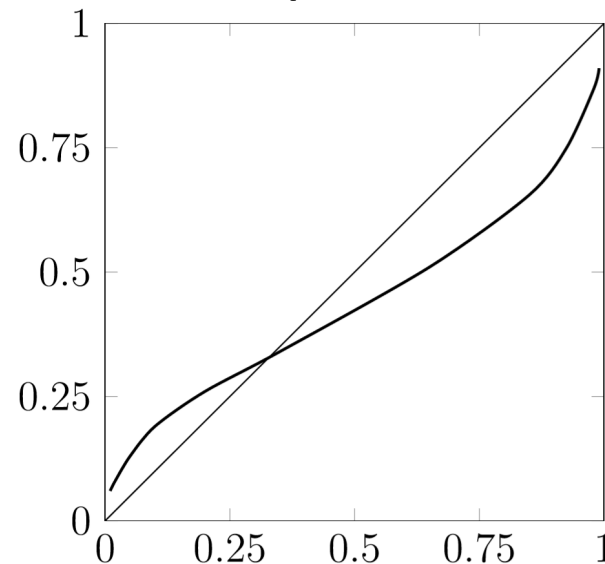
Prospect theory proposed that decision-making consists of two phases: editing and evaluation

- During the **evaluation phase** the values of alternatives are calculated:

$$V(X) = \sum_i^n \pi(p_i) v(x_i)$$

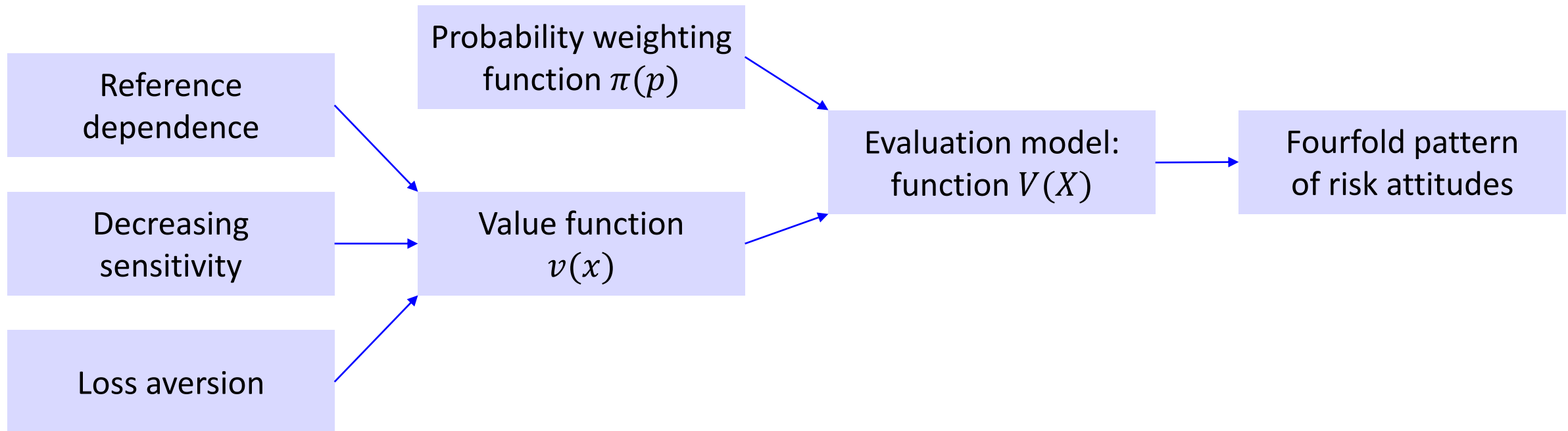
- If $V(X) > V(Y)$ then the person chooses X and vice versa.

Probability weighting
function $\pi(p)$



Value function
 $v(x)$

The Fourfold pattern of risk attitudes can be viewed as the final product of the Prospect theory



Map of the Prospect theory

The Fourfold pattern of risk attitudes is a consequence of the proposed model of choice

- 1st line in each cell indicates which option is preferred (in blue): a certain outcome of a fair gamble. Accordingly, 2nd line stated the attitude towards risk.
- 3rd line contains an example of behaviour predicted by PT.

	Gain ($x = +500$)	Loss ($x = -500$)
High probability ($p = 90\%$)	+450 or (+500, 90%; ± 0 , 10%) Risk Aversion (demand guarantees)	-450 or (-500, 90%; ± 0 , 10%) Risk Seeking (fail to ignore sunk costs)
Low probability ($p = 10\%$)	+50 or (+500, 10%; ± 0 , 90%) Risk Seeking (engage in gambling)	-50 or (-500, 10%, ; ± 0 , 90%) Risk Aversion (buy insurance)

Prospect theory managed to describe the process of decision-making more accurately than EUT

- Decision-making model consists of two phases which are **editing and evaluation**.
- People **do not perceive probabilities correctly**.
- They think in terms of gains and losses (rather than final wealth) and **value gains and losses differently**. This affects attitude towards risk.
- Thus, wordings of choice problems (in terms of gains or losses) can affect decisions (**framing effect**). This is evidence in favor of bounded rationality hypothesis.
- Highly practical result: people take risk when they are likely to lose, this is why it is difficult to ignore **sunk costs**.
- Prospect theory became the foundation of **Behavioral economics**, the field in the intersection of economics and psychology.

Prospect theory does not explain why people's choices diverge. Decision field theory does

- **Variability** of people's choice (why not all respondents choose the same alternative) is not explained in Prospect theory due to the following reasons:
 - **Time** variable is not included in the model: PT is **static** – real-life choice is dynamic. As a result, PT can not explain an inverse relationship between speed and accuracy of choice.
 - **Attention** variable is omitted: PT is **deterministic** – real-life choice is probabilistic (if too much attention is paid to some aspect of choice, it can affect the decision significantly).
 - Variability issue is resolved by the **Decision field theory** (Busemeyer & Townsend, 1993), which in fact is just a dynamic probabilistic version of PT.

Prospect theory has a huge explanatory power but still suffers from some imperfections

- People are reasonably **accurate in predicting their choices** – does this assumption (crucial for Prospect theory) hold in reality?
 - Paper does not comment on whether people make similar choices in the lab as they indicate in surveys. For example, it can turn out that people are more risk-averse while making real choices.
- Fundamentals of PT **lack psychological justification**: what are the reasons for reference dependence, decreasing sensitivity, loss aversion and incorrect perception of probabilities?
 - This is an issue common to all decision-making theories.
 - In the book 'Thinking, Fast and Slow' (2011) Daniel Kahneman suggests that loss aversion provides evolutionary advantages to humans.
- People often minimize potential **regret and disappointment**. Such decision-making can not be explained by Prospect theory.