Behavioral Economics

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Lecture 3: Ambiguity

Today's Topics

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3. Three psychological phenomena.
   - Ellsberg paradox: Two urns.
   - Ellsberg paradox: One urn.
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1. Exam-like question.
2. Traditional model: Subjective expected utility.
3. Three psychological phenomena.
    - Ellsberg paradox: Two urns.
    - Ellsberg paradox: One urn.
    - Home bias.
4. Behavioral model: Prospect Theory and Source Functions.
5. Behavioral model: Max-min Expected Utility

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- **Answer:**
  - No
  - The probability of winning 60 Euro was $3/37$.
  - So, the expected value is $60 \cdot 3/37 \approx 4.86$.
  - She would not have bet if she used EV.

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  - A risk averse agent always prefer the EV of a lottery to the lottery itself.
  - In the Casino, she paid €5 (more than the EV) for the lottery. Therefore, she preferred the lottery rather than the EV.
  - Consequently, Marloes was not risk averse. (She was risk seeking), and is not possible that she used EU with a concave utility function.

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  - Recall the fourfold pattern of risk.

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  - Unmeasurable (or subjective) uncertainty.
    - No objective probabilities

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        - Savage proposed a subjective version of Expected Utility

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$$SEU = P(E_1) \cdot u(x_1) + P(E_2) \cdot u(x_2) + ... + P(E_n) \cdot u(x_n),$$

where P is a subjective probability measure over S.

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- This makes subjective uncertainty objectively measurable.

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$$\Rightarrow u(x) = x = P(\text{Dutch qualified}) \cdot 100$$

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  - or use all possible information?
  - how to aggregate information?

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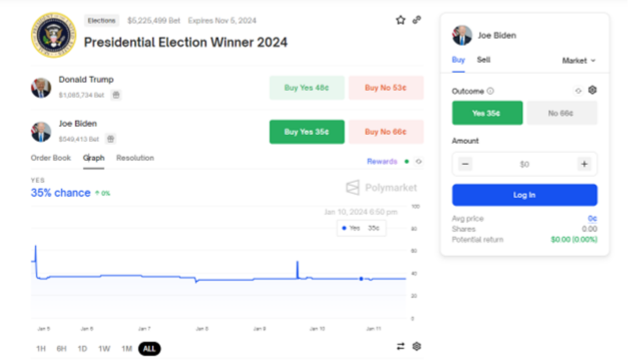

Figure: Prediction market for Presidential Election Winner 2024

- Taken from polymarket.com

Measuring Subjective Probabilities

- Prediction markets can be used in big companies to aggregate information.
- Google:
  - http://tinyurl.com/bdhsfrrj
- Other corporations:
  - http://tinyurl.com/5x4k49hn

Measuring Subjective Probabilities

- **Question 2** Consider the following two bets:
  - winning 1000 Euro if the next Dutch government falls within a year
  - winning 1000 Euro with a probability p.
- For which probability p would you be indifferent between these two bets?

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    $$\Rightarrow P(\text{next Dutch government falls within a year}) = p$$

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- Ellsberg one: One urn.
- Home bias.

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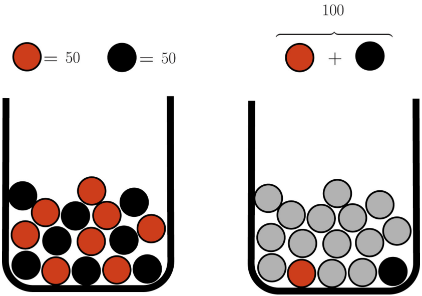

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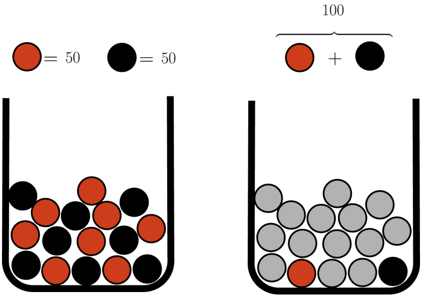
Ellsberg Paradox: Two Urns



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  - Known urn (K): 50 red balls and 50 black balls.

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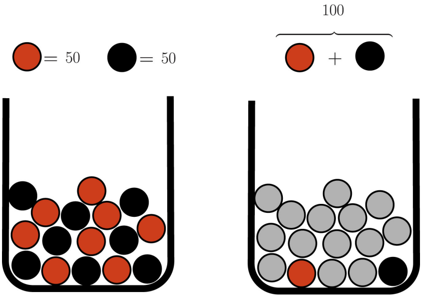

- **Question 3** Consider two urns.
  - Known urn (K): 50 red balls and 50 black balls.
  - Unknown urn (U): 100 balls red and black with unknown proportion.

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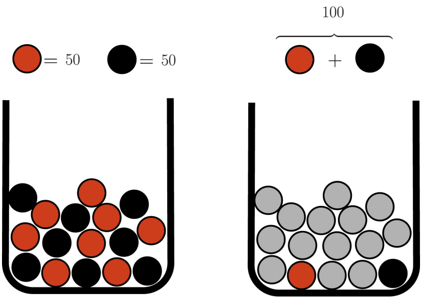

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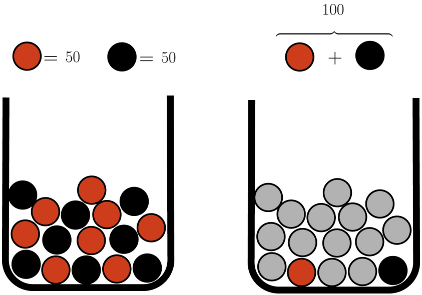

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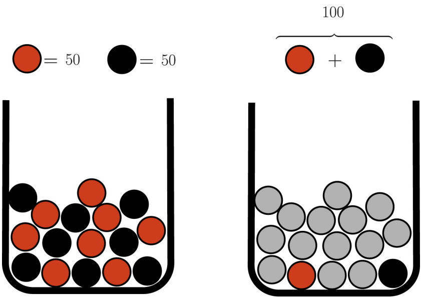

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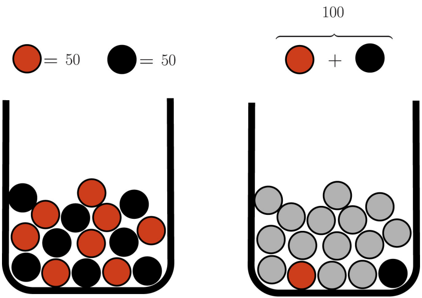

- A ball is to be drawn at random from one of the urns.
- **In which urn would you rather gamble 10 Euros on the following events?**
  - **A drawn ball being red**
  - **A drawn ball being black**
- Betting on an event implies winning 10 Euro if the event occurs, and zero otherwise.

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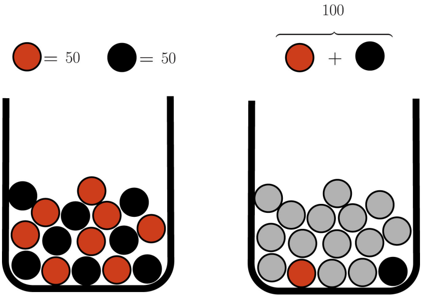

- Most individuals have a higher willingness to bet on urn K. **(73% of you on black and 73% on red)**

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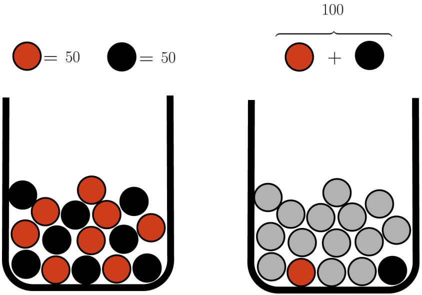

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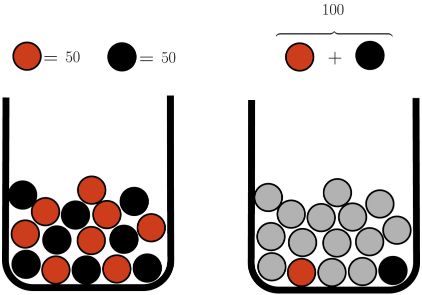

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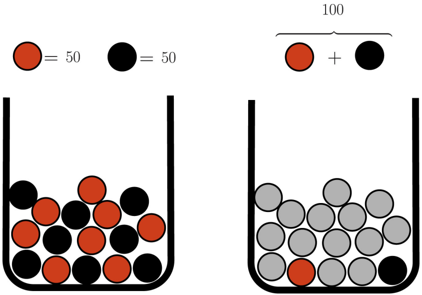
$$\frac{1}{2}u(10) > P(R_U)u(10),$$

Ellsberg Paradox: Two Urns



- Under SEU, a preference to bet on red being drawn in K implies:

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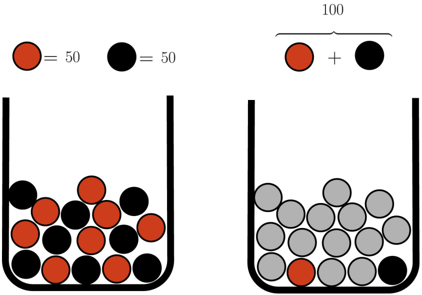

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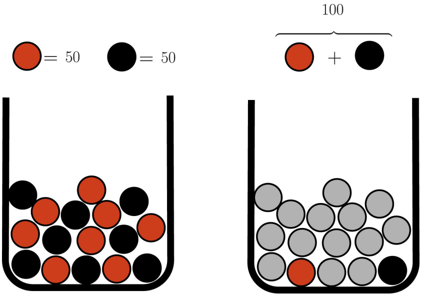

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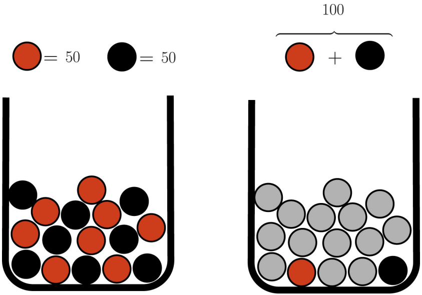

- Behavior as just described violates subjective expected utility:
- it implies that $P(B_U) + P(R_U) < 1$.

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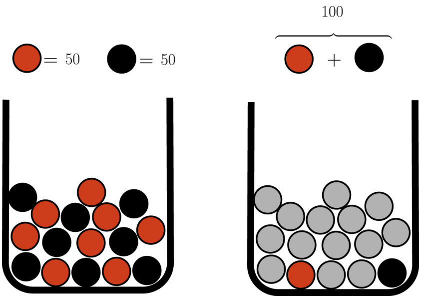

- Behavior as just described violates subjective expected utility:
- it implies that $P(B_U) + P(R_U) < 1$.
- This cannot be because $P(B_U \cup R_U) = 1$.

Ellsberg Paradox: One urn

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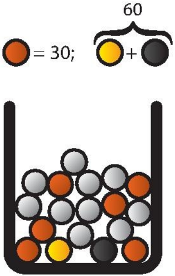
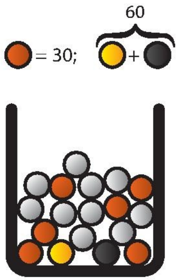


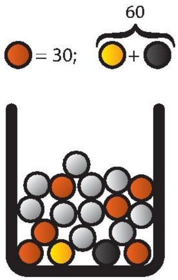
- **Question 4** Consider an urn containing 90 balls

Ellsberg Paradox: One urn



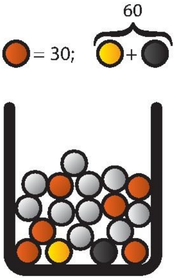
- **Question 4** Consider an urn containing 90 balls
  - 30 Red balls.
  - 60 Black or Yellow.

Ellsberg Paradox: One urn



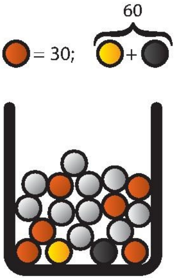
- **Question 4** Consider an urn containing 90 balls
  - 30 Red balls.
  - 60 Black or Yellow.
- A ball is to be drawn at random from the urn

Ellsberg Paradox: One urn



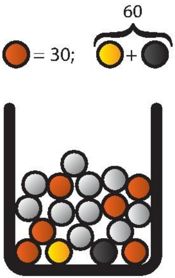
- You are offered between different bets:

Ellsberg Paradox: One urn



- You are offered between different bets:
  - Betting on the drawn ball being red, or
  - Betting on the drawn ball being black.
- Betting on an event implies winning 10 Euro if the event occurs, and zero otherwise.
- What do you prefer?

Ellsberg Paradox: One urn



- Many prefer betting on red to betting on black **(55% of the class)**.

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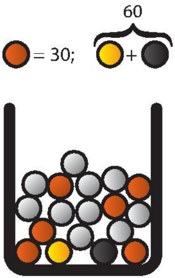

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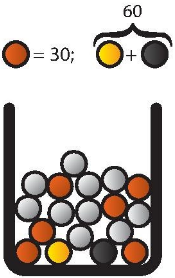

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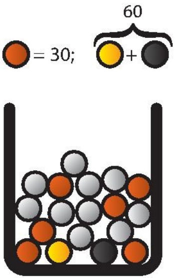

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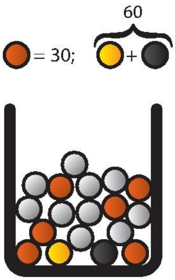
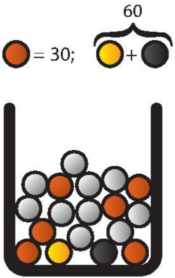


- Now, you are offered the following bets:
  - the drawn ball being red or yellow, or
  - the drawn ball being black or yellow.
- What do you prefer?

Ellsberg Paradox: One urn



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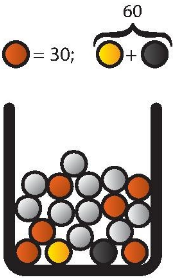
Ellsberg Paradox: One urn



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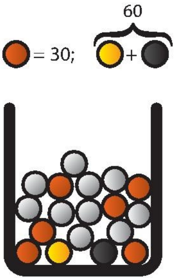

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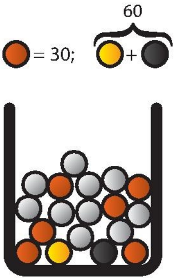

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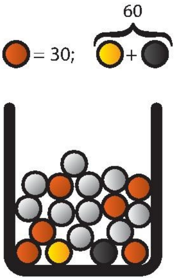

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- These choices generate a contradiction !

Home Bias

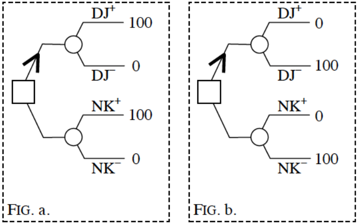
- An American investor can choose between investing on the Dow Jones index (DW), or the Nikkei Index (NK).

Home Bias

- An American investor can choose between investing on the Dow Jones index (DW), or the Nikkei Index (NK).
- He could gain money from that investment.
  - He gains money if the index goes up tomorrow.
  - For simplicity let 100 be the gain from investment.

Home Bias

FIGURE 10.1.2. Home Bias



Arrows indicate majority preferences in the United States.

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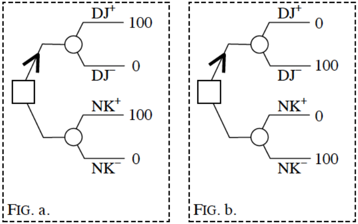

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- He prefers to invest on the DJ index
- If the choice is between gaining if the DJ index or the NK index *does not* go up tomorrow, the American investor also prefers to "bet" on the DJ indext.

Home Bias

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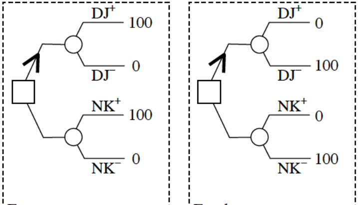

FIG. a.   FIG. b.

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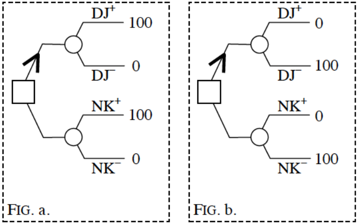

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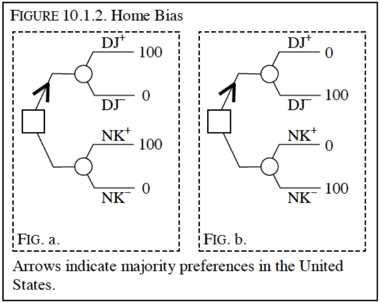

- This behavior cannot be accommodated by SEU.
- These choices imply $P(DJ^{+}) > P(NK^{+})$ and $P(DJ^{-}) > P(NK^{-})$
- They violate the property $P(DJ^{+} \cup DJ^{-}) = 1$ and $P(NK^{+} \cup NK^{-}) = 1$

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  - Especially if you take into account that your wages are likely to depend on the domestic economy.

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  - The Home bias is documented among others by French and Poterba (1991).
- They indicate ambiguity aversion.
  - Preferences over bets not only depend on utility and beliefs but also on confidence about those beliefs.

4. Behavioral model: Prospect Theory and Source Functions.

Generalization of SEU

- Many models have been proposed to generalize SEU so as to represent ambiguity aversion

Generalization of SEU: PT

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    for the known urn, and

$$PT = w_U(P(R_U))u(x_1) + (1 - w_U(P(R_U)))u(x_2),$$

    for the unknown urn.
  - Where w_K is the weighting function when probabilities are known (urn K) and w_U when the probabilities are unknown (urn U).

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  $(R_K, 10; B_K, 0)$ is preferred to $(R_U, 10; B_U, 0)$

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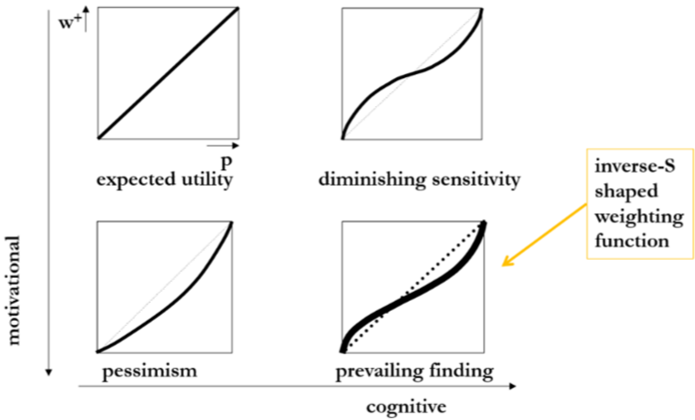
- We can still have $P(R_K) = P(R_U) = P(B_K) = P(B_U) = 1/2$.
- But we learn that $w_K(1/2) > w_U(1/2)$

Typical Weighting Function for Gains



Weighting functions for K and U

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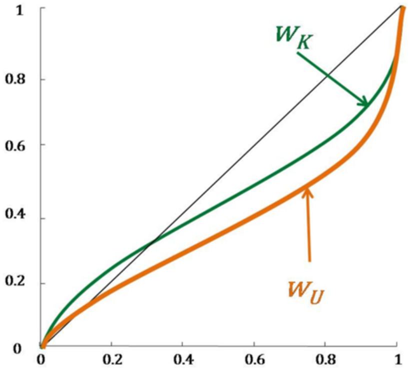
Two dimensions:



(a) Pessimism

Weighting functions for K and U

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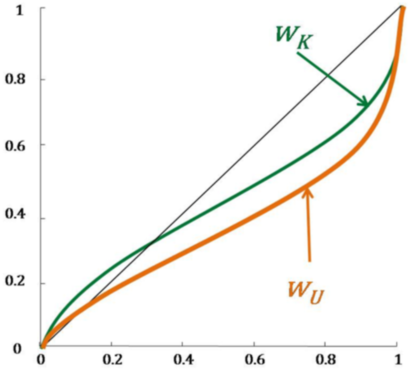

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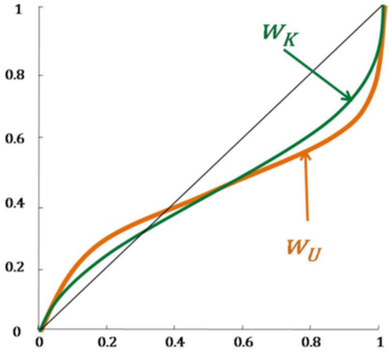

(b) Sensitivity

Weighting functions for K and U

Two dimensions:

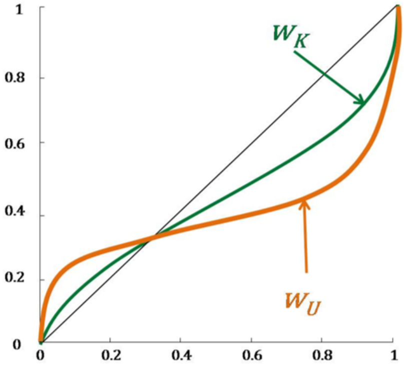

Figure: Pessimism and Sensitivity

What it was found in an experiment

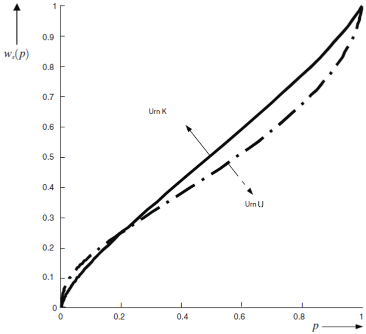

Figure 3. Median Source Functions in K and in U

Figure: Taken from Abdellaoui et al. (2011) " The rich domain of uncertainty: source functions and their experimental implementation."

Sources of Uncertainty

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  - Whether they feel competent or not.
  - ...
- "Source of uncertainty" a set of events generated by the same type of uncertainty

In another experiment, it was found...

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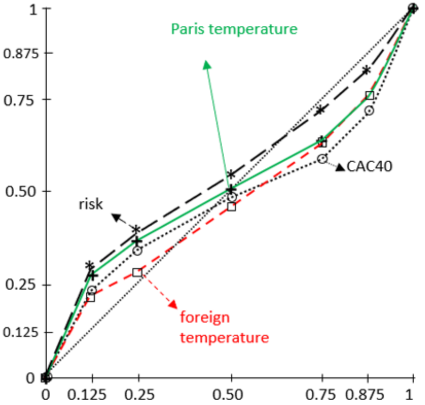

- Various weighting functions for various sources of uncertainty:

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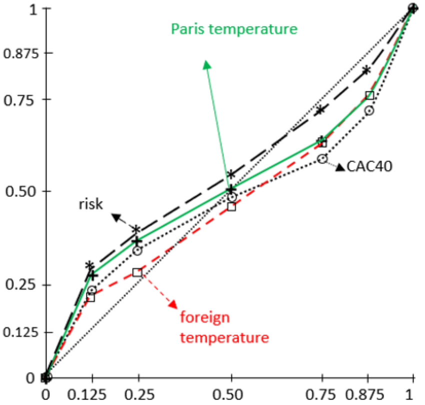

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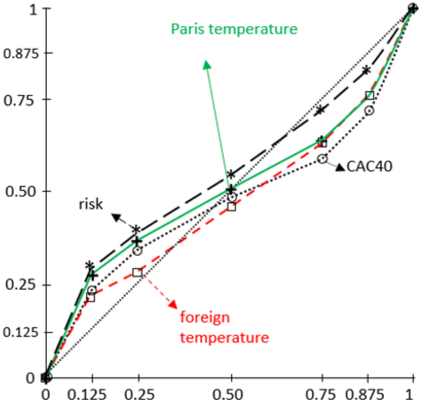

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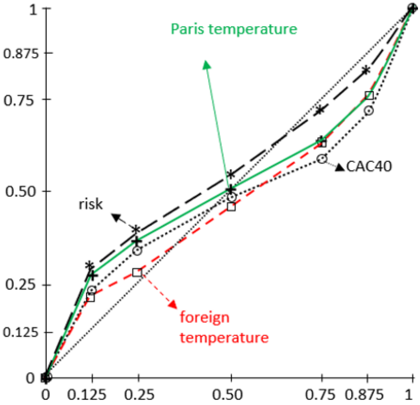

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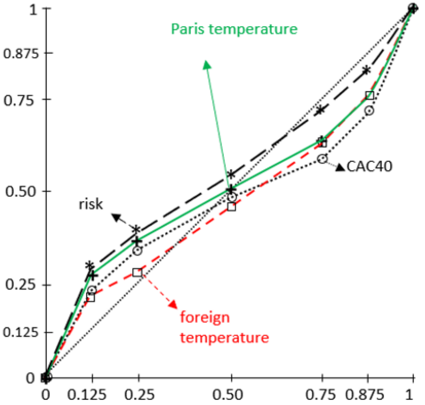
  - the French stock index.

In another experiment, it was found...



- Various weighting functions for various sources of uncertainty:
  - the temperature in Paris.
  - the temperature in a foreign country.
  - the French stock index.
  - risk.

5. Behavioral model: Max-min Expected Utility.

Generalization of SEU: MEU

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    - People maximize the minimum expected utility they can get

Generalization of SEU: MEU

- The bet $(E_1, x_1; E_2, x_2, ..., E_n, x_n)$ is evaluated as:

$$MEU = \min_{P \in C}\{P(E_1)u(x_1) + P(E_2)u(x_2) + ... + P(E_n)u(x_n)\}$$

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- She finally chooses the bet that maximizes this minimum.

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- No contradiction!

6. Application and Experiment.

Ambiguity and Finance

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Ambiguity and Finance

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  > "an agent who starts from a position of certainty will invest in an asset if, and only if, the expected value of the asset exceeds the price. The amount of the asset that is bought depends on the agent's attitude to risk. This result holds in the absence of transactions costs whenever it is possible to buy small quantities of an asset. Conversely, if the expected value is lower than the price of the asset the agent will wish to sell the asset short. Consequently an agent's demand for an asset should be positive below a certain price, negative above that price, and zero at exactly that price."

Ambiguity and Finance

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- In the following slides:
  - A small experiment will introduce the idea.
  - And an exam-like exercise will show the intuition of the result with 2 strong assumptions.
    - We can only buy or sell one unit (so buying small quantities is not possible).
    - People are risk neutral (linear utility).

Experiment

Experiment

- Consider the following asset:
  - it yields 1 euro if it rains on January 16 in Rotterdam at (exactly) 1pm and 0 euro otherwise.
- We organize a market for this asset. Each agent can buy or sell one unit of the asset.

Experiment

- For each of the following prices, could you indicate whether you are willing to buy the asset, to sell it, or neither to buy not to sell?

Price	I buy	I don't buy I don't sell	I sell
0	✓		
0.1	✓		
0.2	✓		
0.3	✓		
0.4		✓	
0.5		✓	
0.6			✓
0.7			✓
0.8			✓
0.9			✓
1			✓

Exam-like exercise

Imagine the following situation: we conducted an experiment using the question of the previous slide. The market was organized for real such that some subjects really bought the asset and the other sold it short and had to actually give 1 Euro to the buyers because it rained on January 16. We have observed that for some prices, some people were neither willing to buy nor willing to sell the asset. In another part of the experiment, we have observed that these people had a linear utility (i.e.,$u(x) = x$).

1. Are the subjects with a linear utility risk averse?

Exam-like exercise

Imagine the following situation: we conducted an experiment using the question of the previous slide. The market was organized for real such that some subjects really bought the asset and the other sold it short and had to actually give 1 Euro to the buyers because it rained on January 16. We have observed that for some prices, some people were neither willing to buy nor willing to sell the asset. In another part of the experiment, we have observed that these people had a linear utility (i.e.,$u(x) = x$).

2. For each possible price, indicate what will be the final payments of a buyer if it rains and if it doesn't rain, and the final payments of a seller if it rains and if it doesn't rain. Assume that a subject has a linear utility. For each price (displayed in the table), give the expected utility of buying and of selling if the subject thinks that the probability of rain is
   - 0.3
   - 0.5
   - 0.7 (Hint: use a table)

Exam-like exercise

Imagine the following situation: we conducted an experiment using the question of the previous slide. The market was organized for real such that some subjects really bought the asset and the other sold it short and had to actually give 1 Euro to the buyers because it rained on January 16. We have observed that for some prices, some people were neither willing to buy nor willing to sell the asset. In another part of the experiment, we have observed that these people had a linear utility (i.e.,$u(x) = x$).

3. Can this explain why some people don't want to sell or to buy the asset for some prices?
4. What is ambiguity aversion? How can it be observed? (give one example)
5. Can expected utility represent ambiguity aversion? Cite one model that can represent it.

Exam-like exercise

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6 Assume now that these people's preferences can be represented by Max-min Expected Utility. Further assume that they think the probability of rain is somewhere in [0.3,0.7]. Using the previous table, determine whether, for each price, they are willing to buy or to sell the asset. What can you conclude from the experiment?

The End!

Today's recommendation

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- Chick Corea's "Chick Corea and The Electric Band" (1986).