HEURISTICS & BIASES

And their implications for financial decision-making

Part one

The Original Three Heuristics

EE434 SEM 1/2022

Sunsiree Kosindesha

"Traditional models in economics and finance is formulated as if the typical decision-maker were an individual with unlimited cerebral RAM.

Such a decision-maker would consider all relevant information and come up with the best choice under the circumstances in a process known as constrained optimization."

max EU over time

s.t. lifetime budget const.

CAPM : capital asset pricing model

- In order to make appropriate portfolio decisions, CAPM assumes that investors are capable of studying the universe of securities in order to come up with all required model inputs.

- CAPM assumes that investors should know:
  - expected returns and variances for all securities
  - covariances among all securities.

$$ER_i = R_f + \beta_i (ER_m - R_f)$$

Traditionally ⇒ no cognitive fatigue
no cognitive laziness
unlimited cognitive resource

How do people make decisions with limited time , limited cognition and limited information in a world of uncertainty ?

Heuristics

- A heuristic is a decision rule that utilizes a subset of the information set.
- It is a mental shortcut, used when individuals need to decide amidst limited attention and limited processing capacity.
- **"rule of thumb"**
- People cannot analyze all contingencies and try to economize mental resources.

Heuristics

fear → flight

- Heuristics have evolutionary foundation. Evolutionary forces have equipped us with a good set to meet the challenges of survival.
  - Survival, but might not be optimal
  - Heuristics have been part of our toolkit for centuries, while many of the problems that we must deal with in a financial realm are recent.
  - Heuristics used outside of their natural domain, may stumble.

Heuristics and biases is where Kahneman and Tversky's research collaboration began.

Tversky and Kahneman (1974)

probability judgement

Judgment under Uncertainty: Heuristics and Biases

Biases in judgments reveal some heuristics of thinking under uncertainty.

Amos Tversky and Daniel Kahneman

Many decisions are based on beliefs concerning the likelihood of uncertain events such as the outcome of an election, the guilt of a defendant, or the future value of the dollar. These beliefs are usually expressed in statements such as "I think that . . . ," "chances are . . . ," "it is unlikely that . . . ," and so forth. Occasionally, beliefs concerning uncertain events are expressed in numerical form as odds or subjective probabilities. What determines such beliefs? How do people assess the probability of an uncertain event or the value of an uncertain quantity? This

mated when visibility is good because the objects are seen sharply. Thus, the reliance on clarity as an indication of distance leads to common biases. Such biases are also found in the intuitive judgment of probability. This article describes three heuristics that are employed to assess probabilities and to predict values. Biases to which these heuristics lead are enumerated, and the applied and theoretical implications of these observations are discussed.

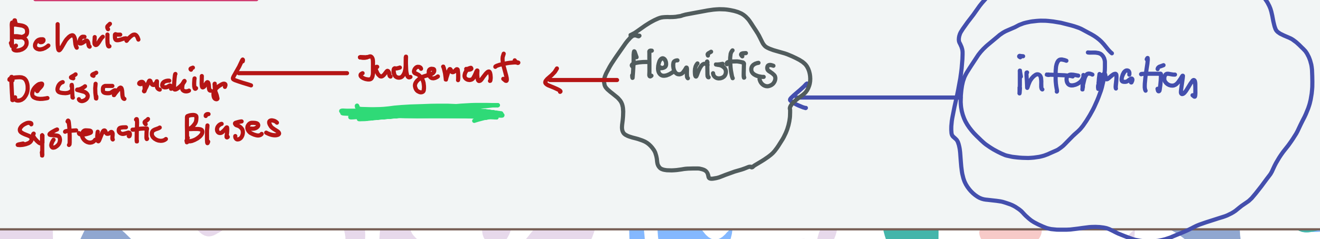
Representativeness

occupation from a list of possibilities (for example, farmer, salesman, airline pilot, librarian, or physician)? How do people order these occupations from most to least likely? In the representativeness heuristic, the probability that Steve is a librarian, for example, is assessed by the degree to which he is representative of, or similar to, the stereotype of a librarian. Indeed, research with problems of this type has shown that people order the occupations by probability and by similarity in exactly the same way (*1*). This approach to the judgment of probability leads to serious errors, because similarity, or representativeness, is not influenced by several factors that should affect judgments of probability.

Insensitivity to prior probability of outcomes. One of the factors that have no effect on representativeness but should have a major effect on probability is the prior probability, or base-rate frequency, of the outcomes. In the case of Steve, for example, the fact that there are many more farmers than librarians in the population should enter into any reasonable estimate of the probability that Steve is a librarian rather than a farmer. Considerations of base-rate frequency, however, do not affect the similarity of Steve to the stereotypes of librarians and farmers.

The lecture

- In 1968-1969, in Daniel Kahneman's grad class, Amos Tversky gave a guest lecture about judgement and decision-making.
- Kahneman and Tversky began to collaborate on a research program to identify **the psychological processes, the presumably-simple heuristics that actually generated judgments.**
- The research program has two steps:
  - **Biases:** Identify systematic biases relative to the normative model.
  - **Heuristics:** Hypothesize (and test) a heuristic that can explain the biases.



The original three heuristics

The Representativeness Heuristics

The Availability Heuristics

The Anchoring&Adjustment Heuristics

The Original Three Heuristics

Representativeness: People draw inferences based on **the degree of similarity** between features of a sample and features of a population from which it might have been drawn.

Availability: People judge the probability of an event by **the ease with which instances can be brought to mind.**

Anchoring-and-adjustment: People make estimates by **starting from an initial value** (perhaps suggested by the problem, or a partial computation) **and then adjusting,** often insufficiently in the direction of the correct answer.

fast & frugal heuristics :

Why not taking the mental shortcut?

Possible result of using heuristics is susceptible to **probability judgment error**: thinking some event is more (or less) likely than it actually is.

(x, p)
- → don't know obj. prob. p
- → "probability estimation"
- → "probability judgement"
- → denote the judged / estimated / assessed prob. as $\hat{p}$

If heuristics,

$\hat{p} < p$

$\hat{p} > p$

} systematic biases

$\hat{p} \not\to p$

If rational,

$\hat{p} \longrightarrow p$

Many financial decisions are based on probability assessment.

- How likely is it that a particular company will continue to post earnings increases?
- What is the probability that interest rates will rise by 100 basis points over the next quarter?
- How likely is it that some firm's current round of R&D will bear fruit?

The problem is that many people have great difficulty understanding probability.

The Representativeness Heuristics

Linda

Linda is thirty-one years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice and also participated in antinuclear demonstrations.

What is more probable for Linda?

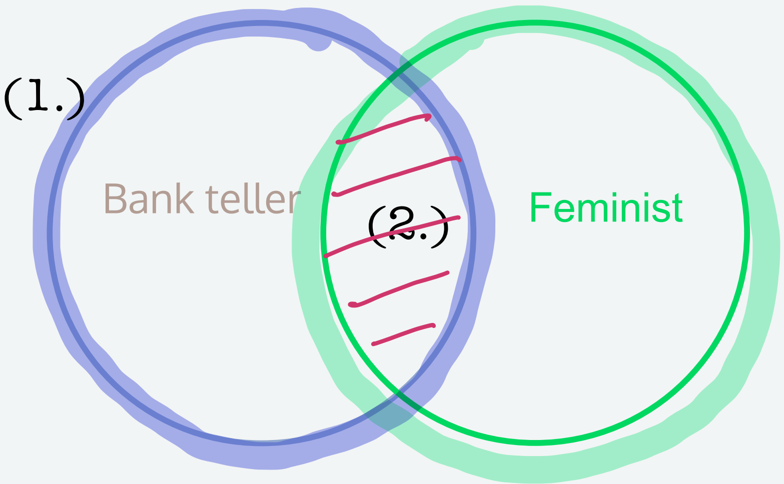
(1.) She is a bank teller.

(2.) She is a bank teller and active in the feminist movement.

Linda Problem

Nearly 90% of respondents chose (2.). (N = 86)

But, (1.) must be more likely because (2.) is a subset of (1.).



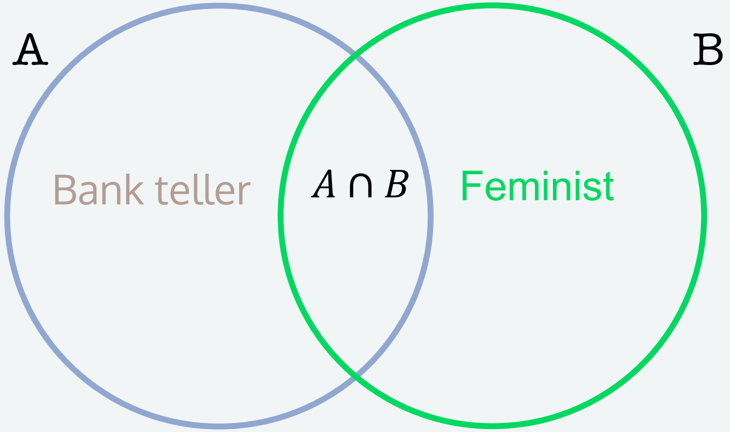
Conjunction Fallacy

- One difficulty with understanding probability is with the difference between simple probabilities (probability of A) and joint probabilities (probability of both A and B).

Conjunction Fallacy

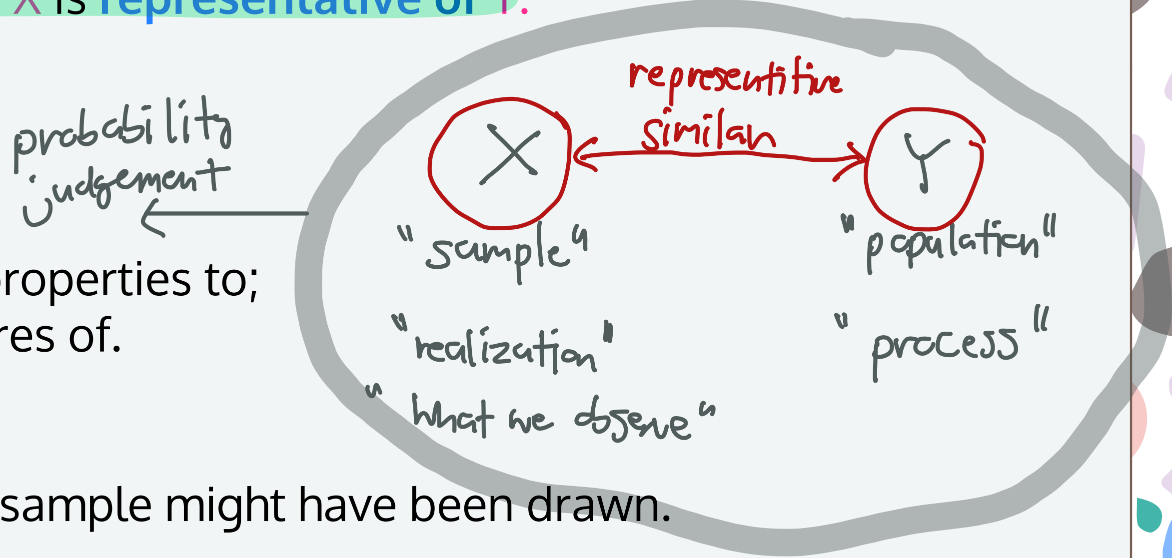
Suppose that:
A denotes the event of being bank teller
B denotes the event of being feminist.
The corresponding probabilities are $P(A)$ and $P(B)$.
$P(A \cap B) \leq P(A)$

Conjunction fallacy is judging that $P(A \cap B) > P(A)$, instead of following a fact that $P(A \cap B) \leq P(A)$



The Representativeness Heuristics

- Definition: "Probabilities are evaluated by the degree to which X is **representative of** Y.
- Being **representative of** means:
  - being resemble;
  - being similar in essential properties to;
  - reflecting the salient features of.



X can be "sample",
Y can be "population" from which the sample might have been drawn.

X can be a possible consequence or realization coming from a system or a process,
Y can be the system or the process.

The Representativeness Heuristics

- When X is highly representative of Y,

the probability that X originates from Y is judged to be high.

- On the other hand, if X is not similar to Y,

the probability that X originates from Y is judged to be low."

The Representativeness Heuristics

The representativeness heuristics can be used to explain:

- "The conjunction fallacy"
  The description of Linda is more representative of/similar to B.
- "Base rate neglect"
- "The law of small ~~nunber~~ number"
- "The gambler's fallacy"
- "The hot hand fallacy"

Base Rate Neglect

- In a study by Kahneman&Tversky(1973) “On the psychology of prediction”, subjects were shown personality sketches, allegedly from a group of professionals made up of **engineers and lawyers.**

- In one treatment, subjects were told that 70% of the professionals were engineers and 30% were lawyers; in another, they were told that 30% were engineers and 70% were lawyers.

70% engineers	30% engineers
30% lawyers	70% lawyers

Consider the following profile sketch

Diego is a 30-year-old man. He is married with no children. A man of high ability and high motivation, he promises to be quite successful in his field. He is well liked by his colleagues.

Q: What is the likelihood that ~~Dick~~ Diego is one of the engineers?

Base Rate Neglect

- This sketch was designed to be neutral and unlikely to push subjects in one direction or the other.
- Subjects saw this description as neutral.
- Median response is 50%, regardless of whether they had been previously told that 70% of the sample were engineers or 70% of the sample were lawyers.
- Subjects were ignoring the base rate, hence the term “base rate neglect”.

Base Rate Neglect

- In terms of representativeness, the description appears representative of a random (50/50) process, so we believe this is indeed the process, ignoring what we know about prior probabilities.

- Base rate can be neglected or insufficiently paid attention.

The rational benchmark: Bayesian Updating

The optimal use of prior and sample information is through using Bayes' rule:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} = \frac{P(B|A)P(A)}{P(B|A)P(A) + P(B|A')P(A')}$$

evidence → $P(B|A)$; prior probability (base rate) → $P(A)$

The Bayes' rule is regarded as an optimal way to update the probability of an event (A) based on knowing that evidence (B) is true.

$$P(A|B) = \frac{P(A \cap B)}{P(B)} = \frac{P(B|A)P(A)}{P(B)} = \frac{P(B|A)P(A)}{P(B \cap A) + P(B \cap A')}$$

law of total prob.

$$P(B|A) = \frac{P(A \cap B)}{P(A)} \Rightarrow P(A \cap B) = P(B|A)P(A)$$

Bayesian Updating: Example

- The probabilities of a rainy day and of a dry day (based on historical frequencies for this time of the year) are as follows: $P(rain) = 40\%$ and $P(dry) = 60\%$. These are the base rates.
- Suppose we also know that:

(1.) conditional on the fact that it did rain, rain was predicted by weather forecasting

90% of the time : $P(rain\ predicted|rain) = 90\%$

(2.) conditional on the fact that it turned out to be dry, rain was predicted by weather forecasting

2.5% of the time: $P(rain\ predicted|dry) = 2.5\%$.

- How should the base rate of 40% chance of rain be adjusted if we know that a weather forecast (sample) is predicting rain?

Bayesian Updating: Example

- The probabilities of a rainy day and of a dry day (based on historical frequencies for this time of the year) are as follows: $P(rain) = 40\%$ and $P(dry) = 60\%$. These are the base rates.
- Suppose we also know that:

(1.) conditional on the fact that it did rain, rain was predicted by weather forecasting

90% of the time : $P(rain\ predicted|rain) = 90\%$

(2.) conditional on the fact that it turned out to be dry, rain was predicted by weather forecasting

2.5% of the time: $P(rain\ predicted|dry) = 2.5\%$.

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} = \frac{P(B|A)P(A)}{P(B|A)P(A) + P(B|A')P(A')}$$

$$P(rain|rain\ predicted) = \frac{P(rain\ predicted|rain)P(rain)}{P(rain\ predicted)} = \frac{90\% \times 40\%}{90\% \times 40\% + 2.5\% \times 60\%} = \frac{36\%}{36\% + 1.5\%} = 96\%$$

ANS: if we know that a weather forecast is predicting rain, there is a 96% chance that it will rain, versus only a 40% chance if we don't know the reading.

"The Law of Small Numbers"

large sample ~ population

- The law of large numbers states that a large random sample from a population will have a distribution that closely resembles the population distribution.

small sample ~ population

- The "law of small numbers" is an incorrect belief such that people exaggerate how likely a small sample will resemble the population distribution.

  - The sample, however small, should look like the population, in the sense that essential features should be shared.

  - For this to make sense, we need to have a fairly strong sense of what the distribution should look like.

The Gambler's Fallacy 

- People expect random sequences to even themselves out, even in a "small" sample.
- Individuals are subject to gambler's fallacy see chance as a self-correcting process.
- People predict that the longer a streak of heads, the more likely a tail because it is due.

Sample

ex 10 fair coin tosses

H T H H T T H H H H

expect to see:

50% of the time should be T

50% " " H

law of small number

Population

Tossing a fair coin 10 millions times

$P(H) = P(T) = 50\%$

sample

$P(H \mid TTTTTTTTT) = 50\%$ Correct probability belief

sample

$\hat{P}(H \mid TTTTTTTTTT) > 50\%$

sample

$\hat{P}(T \mid HHHHHHHHH) > 50\%$

incorrect belief

Gambler's fallacy

→ expect reverse in streak

→ negative autocorrelation

with Hothand stories e.g. lucky coin

$\hat{P}(H \mid HHHHHHH \ldots) > 50\%$ ⇒ incorrect belief

→ expect continuation in streak

→ positive autocorrelation

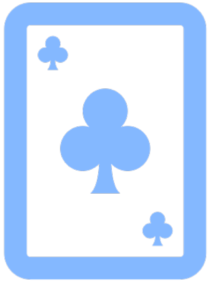
"Hothand fallacy"

The Hot Hand Fallacy

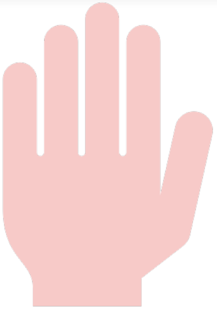
- People perceive independent random signals as having too many streaks for randomess, and invent hot-hand stories to explain the pattern (due to the law of small numbers).

- Gilovich, Vallone, and Tversky(1985) surveyed 100 basketball fans at Cornell and Stanford.
    - 91% believe that a player has a better chance of making a shot after having just made his last two or three shots than he does after having just missed his last two or three shots.
    - The successful rate in the long-term (base rate) is not fully considered, when judging the probability of future success.

Let's think about:



Gambler fallacy



Hot hand fallacy

⊕ H&B part 1 plus

Flipping a coin:
https://www.random.org/coins/?num=10&cur=60-chf.1franc

Not on Midterm exam

The Availability Heuristics

Available, Recent, and Salient

- ❑ Sample data are often given undue importance relative to population parameters.
- ❑ This tendency is accentuated when the data are easy to obtain and process, that is, when they are "available."
- ❑ This is especially so when the events in question have occurred recently and are salient.

The Availability Heuristics

- With the availability heuristic, people judge the probability of an event by the ease with which instances can be brought to mind.

- Events that are called to mind easily are believed to have a greater likelihood of occurring.

The Availability Heuristics

- Events that are called to mind easily because they are:
  - familiar
  - salient
  - vivid
  - recent

- Also, some events are easier to imagine.
- People tended to remember their own behaviors better (egocentric judgement), since it is easier to recall what we did.

The Availability Heuristics: Example

- The overestimation of the probability of a plane crash might follows the recent incidence of plane crash and the horrifying news about the crash.

- The overestimation of the probability of future flood might follow recent experience of flood.

The Anchoring&Adjustment Heuristics

⚓ Anchor & Adjust

- In many situations, people make estimates by starting from an initial value and adjusting it to generate a final estimate.
- Often the adjustment is insufficient.
- The initial value often naturally comes from the frame of the problem.

The Anchoring-and-Adjustment Heuristic

What is 8 x 7 x 6 x 5 x 4 x 3 x 2 x 1?

What is 1 x 2 x 3 x 4 x 5 x 6 x 7 x 8?

The Anchoring-and-Adjustment Heuristic

- In both cases, correct answer is 40,320.
- Median estimate for the first is 2,250.
- Median estimate for the second is 512.

➢ Most people will unconsciously multiply the first few numbers in the sequence before providing the answer.

➢ The use of the product of the first few numbers as an anchor—without regard to the length of the sequence— led to insufficient adjustment.

The Anchoring-and-Adjustment Heuristic

- Anchoring can occur with obviously meaningless irrelevant numbers that appear in the problem frame.

- Anchors can be self-generated.

Why does adjustment tend to be insufficient?

- Lack of cognitive effort, i.e. cognitive laziness
  - While focusing on the anchor is easy, movement away from the anchor is effortful, so for this reason people will often stop too early.
- Decision-makers move their answer away from the anchoring value only until they enter a plausible range of the truth, which they don't know.
  - The greater is the uncertainty, the greater is the plausible range.
- The anchor inherent in the problem frame might act as a kind of conscious or subconscious suggestion by way of primed memory.

THANKS!