Summary

-Behavioural and Experimental Finance-

Foundations of Finance (AD ch. 1&2)

Neoclassical Economics assume the existence of the Homo Economicus (HE), who has rational preferences, wants to maximise utility, and makes independent decisions based on all relevant information.

The HE is rational, which means he has consistent beliefs, consistent preferences, and consistent actions. Consistent beliefs mean that you perceive things correctly, or otherwise are aware of the fact that you have perception errors, and that you process information accurately. Consistent preferences are complete, transitive, stable, independent, continuous, and monotonic. Consistent action means that the HE can decide what the optimal choice is, and that he has the willpower to implement this optimal choice now.

When utility functions are about wealth, we generally assume that utility increases with wealth, but that marginal utility decreases.

Expected Utility Theory (EUT) is a normative theory, focusing on how individuals should act when confronted with decision-making under uncertainty in a certain way. There is a difference between risk and uncertainty. Risk means that one can assign probabilities to known outcomes, while under uncertainty it is not possible to assign probabilities to outcomes and/or one cannot come up with a list of possible outcomes.

<u>Notation of prospects</u>

Earn w_1 with probability q, or earn w_2 with probability 1-q → $P_i(q, w_1, w_2)$

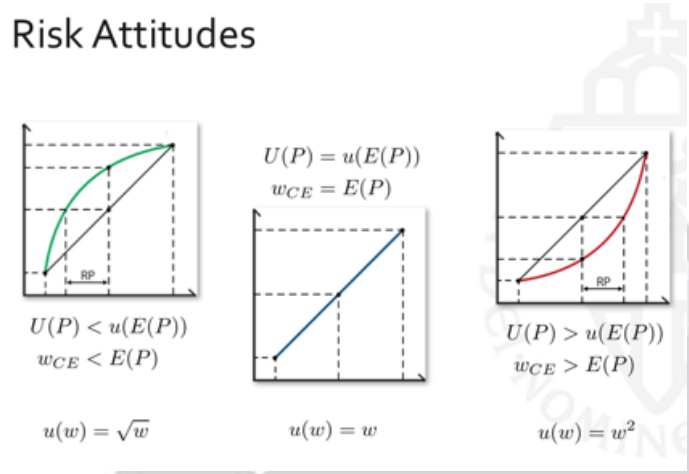
EUT has evolved from a number of axioms on prospects, of which the most important ones are the Neumann-Morgenstern-axioms:

1. Completeness: $P_1 \succcurlyeq P_2$ or $P_2 \succcurlyeq P_1$ or $P_1 \sim P_2$. You can compare the prospects.
2. Transitivity: If $P_1 \succcurlyeq P_2$ and $P_2 \succcurlyeq P_3$ then $P_1 \succcurlyeq P_3$. If you prefer 1 over 2 and 2 over 3 you also prefer 1 over 3.
3. Continuity: If $P_1 \succcurlyeq P_2$ then there is a q such that$qP_1 + (1-q)P_3 \sim P_2$. If there are 3 prospects you can weigh them for 2 to be indifferent with regard to the other one
4. Independence of irrelevant alternatives: If $P_1 \succcurlyeq P_2 \succcurlyeq P_3$ $qP_1 + (1-q)P_i \succcurlyeq qP_2 + (1-q)P_i$ for arbitrary P_i. If you add another option, the order of preference with other prospects you already had will not change.

Although we would assume to always base our decision on the expected payoff, the Saint-Petersburg Paradox shows us that at some point expected utility comes into play (Saint-Petersburg paradox: The expected pay-off is an infinite amount of money). According to EUT, people should act as if they are maximising their expected **utility**, not the expected **value**. In calculations it is important to note that the order of expected utility is used, and not the order of monetary outcomes.

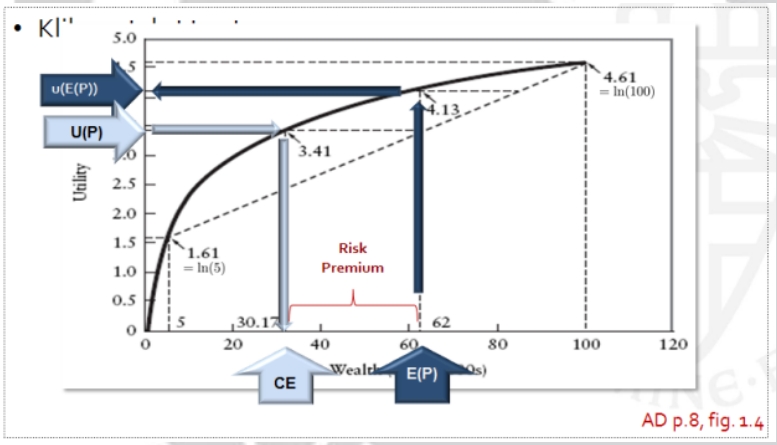
People tend to be risk averse as most people, most of the time, are not willing to accept a fair gamble. People have a tendency to dislike taking risks. This risk aversion implies concavity. The difference between expected utility and the utility of the expected value can now be shown, as the expected utility is smaller than the utility of the expected value in the case of risk averse subjects. The value of the prospect given the expected utility of the prospect is the wealth level which leads the decision-maker to be indifferent between a particular prospect and a certain wealth level (certainty equivalent or CE). The decision maker will be indifferent between the prospect and the fair game value plus a risk premium. This risk premium is the difference between the CE and the fair game value (expected value). The risk premium is therefore the amount to pay the decision maker to make him accept the bet.

We can find the certainty equivalent by setting the natural logarithm of the CE equal to the expected utility of the prospect.



The left graph shows the properties of a risk averse person, the middle graph is for a risk neutral person, while the right graph is for a risk loving type. Therefore, risk loving people would be willing to pay the risk premium to offer the game.

To read the graph on the left: We have an expected value of a prospect (E(P)). With this, we can calculate the utility of the expected value (u(E(P))), which is 4.13 in this case. Furthermore, we can calculate the expected utility of our prospect (U(P)), which is lower than the utility of the expected value. If we calculate the certainty equivalent (monetary amount), we get to a number of 30.17. This amount is lower than the expected value of the prospect and hence, we are dealing with a risk averse person and a risk premium. Thus, to read: Find U(P) and u(E(P)) and compare. Also, use U(P) to find CE and compare to E(P).



Kahneman and Tversky (1979) show that people typically choose one prospect in the first choice, but when offered a similar choice with different irrelevant alternatives, the subjects would choose the other prospect. This is called the Allais Paradox. People violate the axiom of independence of irrelevant alternatives with this behaviour, and this is called the common consequence effect.

A number of violations of EUT have been discovered, of which the Allais Paradox is the most famous one. This led scholars to develop alternative theories to account for these violations. The Prospect Theory developed by Kahneman and Tversky is the most comprehensive one.

The investor's utility function is typically given by $U(R) = E(R) - \frac{1}{2} A\, Var(R)$ in which A is the risk aversion parameter of the investor. When A is zero, people are risk neutral, and the higher A

becomes, the higher the relevance of the variance, and thus the more risk averse people are. Thus, the utility of investors is reduced by variance of stock returns.
Using Mean Variance Analysis (MVA), optimal portfolio selection and two fund separation, we can identify the most optimal allocation of capital. Mean variance analysis consists of two parts:

1. Find the optimal portfolio of risky securities (which stocks to buy, this is independent of your risk aversion)
2. Find the best combination of risk free and risky assets (this is related to your risk aversion)

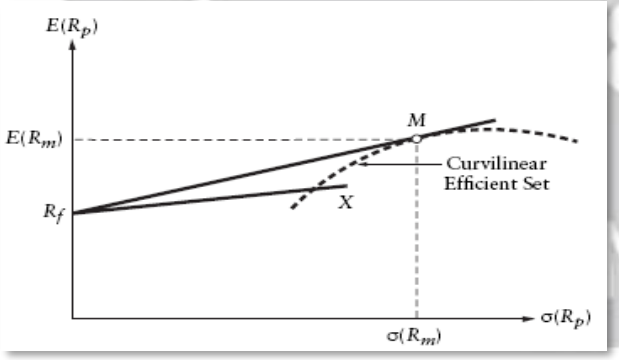
MVA has some basic assumptions:

- Returns are normally distributed (not the case in real life)
- Investors only care about mean return and variance of return (represented by the utility function)
- Assets need to be tradable whenever you want
- No transaction costs

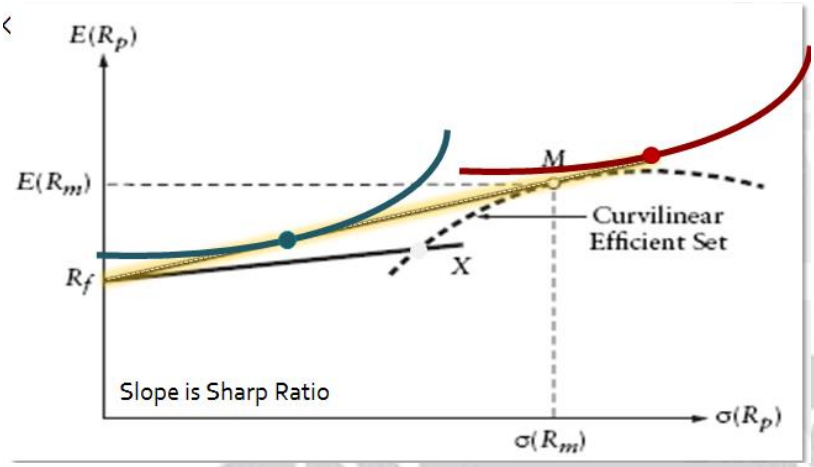
Note: The variance of portfolio is lower than the variance of the securities (due to diversification)
In the end, all the efficient portfolio's make up the efficient frontier, which give the portfolio's with the highest return for every level of variance. Diversifiable or non-systematic risk can be eliminated, but non-diversifiable or systematic risk cannot be eliminated.

We have the optimal combinations of stocks in a portfolio. However, now we can add a risk free asset (treasure bills into the mix). Thus, we have the portfolio of risky assets (that were previously selected) and risk free assets. We will make a combination of the two to fully satisfy our needs and create a complete portfolio we want. This leads to a capital allocation line (we have not yet done anything with risk preference yet).

The expected return from this optimal capital allocation is given by the Capital Allocation Line (CAL): $E(R) = R_f + \left[\frac{R_p - R_f}{\sigma_p}\right] * \sigma$. The second part of the equation is the risk premium (thus, it says how much money you will gain on top of the risk free rate per unit increase in the risk of the portfolio). The price of risk in this CAL $\left[\frac{R_p - R_f}{\sigma_p}\right]$ is also called the Sharpe Ratio, and this is the return premium per unit of portfolio risk. The Sharpe ratio is often used in finance since it calculates a portfolio's required return given the risk (variance) of such a portfolio.



The Capital Market Line (CML) is the optimal CAL, as the CML is tangent to the efficient set of portfolios, and therefore has no superior CAL (the sharpe ratio/risk premium is maximized). In the graph above it is the line that is tangent to point M. The portfolio that is at this tangency point is portfolio M. Portfolio M can be found by maximising the Sharpe Ratio. It is also known as the market portfolio (CAPM), as it includes all risky assets weighted by their value (all investors regardless of their risk preference should pick this portfolio as their market portfolio of risky assets). The combination of risk free assets and the market portfolio that an individual investor will now pick depends on their risk preference.



Investors that are relatively risk averse pick a combination of risk free assets and the market portfolio (the left point). Aggressive investors borrow at the risk free rate and buy a lot of the risky market portfolio (the right point). The aggressive investors have a higher expected return at the cost of a higher variance.

The Capital Asset Pricing Model, or CAPM, is an equilibrium model that brings together all investors, and it specifies a relation between expected rates of return and covariance of all assets. It has some assumptions: No transaction costs, assets are tradable and divisible, no taxes, perfect competition. Investors only care about return and risk, unlimited short sales, borrowing, lending and there are homogeneous expectations.

CAPM states that only the risk related to market movements is priced by the market. Therefore, it needs to use a measure to specify the non-systematic risk of an asset. This cannot be the variance of returns of a stock, because that also takes into account the systematic risk. The used risk measure is beta, as it only measures the firm-specific risk for a security ($\beta = \sigma_{i,M}/\sigma_M$). The Beta is the only risk parameter that matters according to CAPM. This is the case, because people want their portfolio to be the general market portfolio. It is the covariance of a stock's return and the market return relative to the variance of the market return.
The CAPM relationship between a security and the market is $E(R_i) = R_f + \beta_i(E(R_M) - R_f)$. This is also called the Security Market Line (SML). Returns from all asset are on the SML, which differs from the capital market line (CML).

Fama (1970) was the first to mention efficient markets in academic literature. According to Fama, efficient markets fully reflect all available information. Malkiel (1992) added some criteria to this by stating that security prices would be unaffected by revealing information from a certain information set to all participants, and that it is impossible to make economic profits by trading on the basis of that information set.
There are three forms of market efficiency:

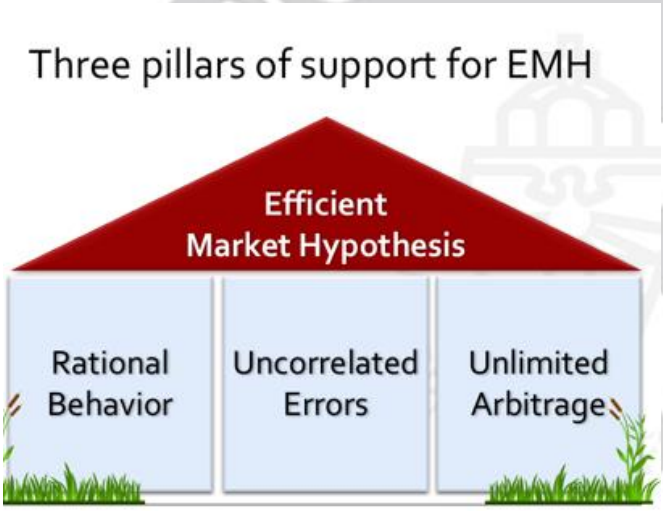
1. Weak-form efficiency: prices reflect all information contained in historical returns
2. Semi-strong form efficiency: prices reflect all relevant publicly available information
3. Strong-from efficiency: prices reflect even insider information

The idea of efficient markets is that no investor can consistently make excess returns. If markets are actually efficient, active money management would be useless, as there is no excess return to be earned. Furthermore, ex post simulated strategies would fail to consistently earn an excess return. If a strategy would succeed, there is evidence against market efficiency. Stock markets would be assumed to follow a Random Walk if markets are efficient.

Every test of market efficiency has two maintained hypotheses, one stating that markets are efficient, the other that a fair return on a security or portfolio is from a particular model. However, when you reject, this might mean that markets are not efficient, that the model is wrong, or both. It is impossible to show which one is rejected, and this problem is called the joint hypothesis problem. Thus, if you test whether a stock exhibits abnormal returns, you must first estimate what the normal return of that stock should be. If you then find that the stock exhibits abnormal returns it might be the case that the market is inefficient, but it might also mean that your model which you use to test the hypothesis is simply wrong.

Three Pillars of EMH (AD ch 4)

There are three pillars that support the Efficient Market Hypothesis (EMH). The first pillar, rational behaviour, assumes that there are rational investors trading at efficient prices. However, if this is not the case, the second pillar assumes that all errors are uncorrelated, i.e., irrational investors 'cancel each other out'. In the unfortunate situation that this does not hold, the third pillar assumes unlimited arbitrage, which would mean that there are rational investors to 'arbitrage away' the mispricing resulting from the correlated errors. Unlimited arbitrage means that when an arbitrage opportunity exists (thus a security is mispriced) investors see this and immediately capitalize on this mispricing so that it grows away immediately and the market becomes efficient once more. In this sense, the name is paradoxical for when unlimited arbitrage exists there should not really be arbitrage opportunities. Only one of these three pillars needs to hold in order for the efficient market hypothesis to hold. However, the idea of behavioural finance is to kind of break down these pillars.



Rationality or rational behaviour has to conform to a certain number of criteria before we can actually call it rational. First of all, decisions have to be made in line with the axioms of EUT, and individuals should make unbiased forecasts (Thaler, 1999). Furthermore, Barberis and Thaler (2003) believe that agents should make choices that are normatively acceptable, consistent with Savage's notion of subjective utility theory (SUT), and that they update their beliefs correctly when new information arrives (Bayesian updating).
However, Fischer Black states in 1986 that "people sometimes trade on information in the usual way (…) on the other hand, people sometimes trade on noise as if it were information". This means that there are so-called noise traders in the market. Noise exists when trades are based on misinformation (or irrelevant information), and this noise is not necessarily a bad thing, as it provides liquidity to markets, and without it there would be too less trading, and rational investors would lack counterparties (if you want to buy an asset, someone else has to sell it. If everybody would know the correct price, nobody would sell it for less). Empirical evidence on irrational investor behaviour can be found in the home bias (failure to diversify and invest too much in home country), active trading (people trade too much), people expect trends to continue for too long (if something goes up they expect it to continue for a long time), people overreact to bad/good news, people consider good

companies to always be good investments (regardless of the price) and disposition effect. **Thus, investors are not all rational.**

Even if there are irrational traders, according to the EMH these would cancel each other out. However, it might be possible that people trade on noise because they believe they have useful information, or just because they enjoy trading. For example, some behaviour may be socially driven, such that social media and social networks strengthen hypes in the market, a rumour provided by a neighbour or friend can be mistaken for information and fake news may play a role. People are also subject to relatively similar biases, and therefore tend to deviate from the fundamental price in the same way, in the end leading to sentiment driving prices further and further away.
The point is that when people follow the same direction it is called sentiment. All people are somewhat on the same page. In that point of view, people might drive the price further and further away from the fundamental value.
Sentiment = noise that is correlated among investors.

A consequence of these uncorrelated errors are price bubbles: everybody is enthusiastic and they all buy stocks increasing the price even further. Then, due to fear when the price goes down. Everybody also sells because they all have the same sentiment again and the price decreases immensely.
Overconfident investors are one of the sources of systematic deviations from the fundamental price of an asset, as these investors are now willing to pay prices above their own valuation, because they believe in the future someone will pay even more for it. This behaviour typically leads to noise trading. Over-extrapolation is the typical driving force of all bubbles. It is the tendency to extrapolate past price increases too far into the future.
Feedback trading is one of the better-known results from correlated errors in the market. The initial price increase comes in response to good news, and feedback traders buy the asset, pushing up the price. This increase is seen by more feedback traders, who buy more of the asset, leading to further price increases, etc. Arbitrage does not always occur in this type of situations, as it might be more interesting for the informed investors to ride the bubble.
In other cases, investors can make their trading decisions not on the basis of fundamental values, but on market sentiment. Market sentiment is noise that is correlated among investors. Typical examples of this behaviour are technical trading and herding. Technical trading methodology is based on looking at the historical prices and trying to find a pattern and invest at the good moments where you think the prices will increase. Herding means that people observe the action of others and then follow these people disregarding their own information.
Why do managers follow the herd?

- managers are forced to invest in high sentiment stocks (because clients want to invest in those stocks)
- Ride the bubble as others do
- Mimic investment choice of first movers regardless of own private information or when information gathering is too costly
- Reputational damage from being wrong when others are right (if you get it wrong, you are the only one and this is bad for your reputation)

Errors are not necessarily uncorrelated. However, even then, the rational investors may still be able to arbitrage this away and the markets can be efficient.

In case these correlated errors would lead prices to deviate from fundamental values, the EMH still assumes there are rational traders that are able to perform unlimited arbitrage, which would lead to irrational traders being taken advantage of and losing money. This would mean that, in the end,

irrational traders leave the market, and that prices are forced back to the underlying fundamentals. The idea of unlimited arbitrage is that, if assets are **underpriced**:

1. Rational agents spot the mispricing immediately
2. They buy to make a profit when prices recover
3. The price will increase due to the higher demand until prices are "right" again

However, two steps are implicit in this case, namely that mispricing creates arbitrage opportunities, and that the opportunity is immediately taken by rational investors.
When assets equal their fundamental value, we say that the 'price is right' and that there is 'no free lunch'. However, one does not necessarily imply the other. The price is right principle means that asset prices will fully reflect the available information. The no free lunch principle says that market prices are impossible to predict, and that it is therefore hard for any investor to beat the market, taking into account the risk he takes. This means that when the price is right, there are no arbitrage opportunities that can be exploited. However, when there is no free lunch in the market, this doesn't necessarily mean that the prices are right, as it is possible that the prices aren't right, but that the arbitrage opportunities cannot be exploited.
The idea of unlimited arbitrage therefore does not hold, and the limits to arbitrage imply that the last pillar of the EMH also doesn't hold. Arbitrage is seldom clean and riskless as suggested in textbook finance. Potential problems with arbitrage: fundamental risk, noise trader risk and implementation costs. We will return to this later.

Given the fact that people might not be rational, irrational people might behave in the same way, and that arbitrage is not unlimited, we can call the efficiency of the market into question. "Behavioural finance argues that some financial phenomena can plausibly be understood using model in which some agents are not fully rational" (Barberis & Thaler, 2003). The field of behavioural finance has two building blocks, limits to arbitrage, and psychology.

Experimental Finance
To evaluate market data to see if people have home bias or something, you make certain assumptions. However, in the market some things may not be valid. To make a correlation between preferences/beliefs and their behaviour it is better to do experimental finance. The idea is that you conduct a controlled experiment. You make use of a treatment effect. You have the same situation twice and make one change in between the two situations. Thus, one is slightly different than the other. For economists it is harder to conduct a controlled experiment than for other researchers (biology/chemistry). It is important that just one treatment variable is changed in the experiment, all else must remain equal. Experiments have a high internal validity.

Controlled economic environment in which subjects make decision, that the experimenter records for the purpose of scientific analysis is called a lab. To ensure that it reflects the economic reality there are monetary incentives. Therefore, there is a real economic effect and the decision people make actually reflects the monetary reward they get (just like in real life, if you make a bad investment, you earn less money (or lose money)). This raises the external validity.
Surveys or simulations are by no means economic experiments.

In economic experiments you can test theories, look for facts. Sweden implemented a tax on the sale of financial assets. However, this ended up not to work, for all transactions were just replaced to London. In an experimental setting a researcher can test several means of transaction taxes (on the buyers side, sellers side, both, etc.).

Experiments are useful, because they allow researchers to isolate and manipulate one variable at a time. This way, they do not need complex econometric techniques to filter out other variables.

Furthermore, experiments allow the researchers to observe independent and dependent variables that might be unobservable otherwise.

A demonstration: You take a model and let people make decisions. Then, you see whether people behave in line with the model. A demonstration examines behaviour within a single setting. A quasi-experiment is also not a real experiment. A quasi-experiment happens when you do not randomly assign people to a treatment. Randomization is important for an experiment.
Experiment: You have two settings and change one variable.

Basic Elements:

- Objects of interest
  - Preferences, beliefs (risk aversion, evaluations, etc.)
  - Decision rules (rational or heuristics?)
  - Mapping from institutions to outcomes (what is the result of short sales for example?)
- Replication
  - Same experimental design = equal result distribution (if you conduct the same experiment again you should see approximately the same results)
- Causality – Ceteris paribus consideration
  - Comparing treatments by variation of one parameter. Thus, if you only change one variable, you can make a deduction of the causality.

The role of theory
Theory organizes data and suggests new experiments. Thus, you start with a theory and an idea of what the data should look like. Then, you conduct the experiment and you test whether the theory actually holds. Do the data permit causal inferences? Internal validity. The question is whether we can generalize the results to the real world? External Validity.
No experiment (no empirical result even) can prove that under the same circumstances the same thing will happen again. However, if certain conditions are met we can be reasonably sure it will happen.

To implement an economic model in experimental economics there is the induced value theory. You take people in the lab and you give them an endowment of cash and shares and in the end you end up with some experimental currency unit and convert them to euros. Thus, if you do well, you get more money in real life.

Smiths Axioms:

- Monotonicity: More reward better than less
- Salience: Reward depends on the choices and institutions. It matters what choice you make, if you make the right ones, you get more money (should be high enough to actually inspire people to make well thought decisions)
- Dominance: Subjects preferences depend on rewards, other influences are negligible.

Experiments in financial economics
Analytical models provide implications of fundamental assumptions on individual or aggregate behavior.

- Market performance predictable? Testable hypothesis
  How to test? Mainstream: Archival Data analysis. Thus, in general people use a lot of data, run regressions and see whether the theories hold.

Problems:

- Omitted variables → model incorrectly omits relevant variables.
- Self-selection →individuals select themselves into a group.
- Unobservable variables → relevant variables are missing.
- Data-mining (find data to prove your point instead of the other way around)

How to test? Experiments

- You can make clear inferences, known fundamentals and field experiments. In our example, we knew the expected value of the asset. In the market normally you would not know this (this belongs to the known fundamentals).

- Problems:
  - External validity (is it generalizable to the real world?)
  - Market Size (the market size is normally really small in an experiment)
  - Subject pool (what people do you use in your experiments?
  - Experience (do the participants have experience or not?)

Financial Decision Making

Financial decisions are influenced by a variety of factors:

- Design of information
- Cognitive errors
- Mood (such as football matches, weather, etc.)
- Financial Literacy
- Cognitive ability (how smart are you?)
- Risk literacy
- Numeracy
- Priming (boom or bust information may trigger certain responses)
- Ethical concerns

Is an experiment added value to the knowledge base?

It helps to evaluate the descriptive validity of economic theory

How well does the theory forecast absolute levels of observed variables. Thus, does the experiment reflect the absolute values as predicted by the theory?

How well does the theory forecast the relative levels of observed variables. Thus, does the situation change as the theory predicts when you use the treatment effect in the experiment.

Control is never perfect (influence of the environment on behaviour, such as weather, Christmas time). There is self-selection (which students sign up for the subject pool?). Experiments are never general, they are always just examples. Thus, hard to derive a general conclusion. This makes their external validity lower.

There are several objectives:

- Test theories
- Establish regularities (prospect theory). It is about equilibria, it might be that there are multiple ones, which one do we choose? It helps to develop new theories, such as bounded rationality.
- Institutions/environments: Which institution works best? Does it work in all settings? Etc.
- Policy/wind-tunnel: You test a design that the government wants to implement and see whether it actually works
- Education: Experiments help to find out about cognitive errors; they help to make better decisions in the future.

How to conduct experiments?

What is a good experiment?

- What is the question you'd like to answer? (should be simple)
- What do you know already about possible answers? (What is in the literature?)
- What are the various ways of finding an answer? (Both experimental and other methods. Online survey, data available online, etc.)
- What are advantages/disadvantages of using an experiment to find the answer? (effort involved in doing an experiment, is there no other way?)
- What are the chances that the answer will surprise you or others? (Do you change beliefs or just confirm it)
- How do you conduct the experiment? (Design)
- Is your design the simplest possible design to answer the question? (If it is too complex, you do not get to the central question. The point is to make things as simple as possible)

Terminology:

- Treatment
  - Particular condition of an experiment. "treatment" (1 variable changed) vs. "control" (starting point)
- Independent observation
  - You are not influenced by someone else. When you see what other people do, the decision is probably not independent.
- One-shot vs. repeated one-shot
  - Do we only play the game once, or do we play the game more often? You might get experience etc. Also, you can observe dynamics and you get more observations. It does take longer though
- Partner vs. stranger matching
  - Groups fixed vs. subjects randomly assigned before each round.
- Finite vs. Infinite
  - Fixed number of periods, backward induction possible, end game effect (you know it is the last one, so might take extra risk), super game effect. You make choices depending on the realization that you only have 10 games to play.
  - Random number of periods as if infinite.
- Individual decision making vs. group decision making vs. markets
  - You make the decision alone, no interaction
  - Interaction in the sense that you can see what other people do, you might even make a decision together
  - Interaction in terms of trades
- Hot vs. cold
  - Reaction on others or strategy elicitation. You observe something and you make a decision based on this or you just hold on to your own strategy.
- Treatment variable
  - Variable of interest
- Focus vs. Nuisance variables
  - Variables you want to observe/record vs. variables you must record to control (sex, race, education)
- Confounding effects

    - Avoid by using controlled variation. Treatment variable should be only varied one by one. So, if you change two variables between two settings, you do not know which variable triggered the change in the outcome.
- Between subjects designs vs. within subjects design
    - Compare control vs. treatment across groups
    - Compare control vs. treatment within groups

Design issues of an experiment
- Incentives
    - Monetary incentives vs. non-monetary incentives.
- Learning trials (in complex environments)
    - You provide people the opportunity to get to know the environment.
- Paper and pencil vs. computerized experiments
    - Flexibility, low costs, natural environment, visibility/credibility (advantages of paper and pencil)
    - Better control, interaction with experimenter, less complex, fewer mistakes, more standardized, automatic data collection (pros and cons computers)
- Subjects
    - # of students, type of subject, selection bias.
- Instructions
    - Simple language
    - Neutral framing vs. concrete framing (stay neutral in framing the experiment)
    - Complete description of the rules
    - Different ways to explain the payoff function
    - Formula, verbal explanation, table, figure
    - Comprehensive questions
    - Don't be suggestive with examples (like winning strategy or losing strategy or something)

Experiments we ran
The incentives in our experiments were the lottery tickets (kind of like a monetary reward).
The lottery with loss potential was a demonstration, the investment game was an experiment (a variable was changed, such as Short selling)

We could use risk aversion, sex, nationality and numeracy as control variables. We only want to know whether the treatment effect is there, we do not want to capture the effect of other variables.
Theoretical prediction is that short sales should reduce overpricing for example.

How to analyze data?
Organizing data
When you have the data, you can start to get a first glance of the data (a rough overview). You can use different plots, for example a scatter plot. You could also use a frequency distribution (a histogram). A third option could be cumulative distribution (accumulation of distributions). A final option is a time series graph. This is done in order to get a first glance at some results.

Descriptive statistics can be used to further the insights into the data at first glance (mean, median, mode, standard deviation, min-max range, rank correlation coefficients).

Level of aggregation
- Subject level: Decision in period t

    - Aagregate for each subject
- Cohort level: Decision in each cohort
    - Aggregate for each cohort
- Treatment level: Decision in the treatment
    - Aggregate for each treatment situation

Hypothesis testing

- Hypothesis
    - Null hypothesis corresponds to the absence of a regularity. Thus, the effect that you expect is not present.
    - The alternative hypothesis corresponds to a regularity that is suggested by a well-founded conjecture. Thus, the effect that you expect is present. When literature states that an effect is positive/negative, you should include this direction in your alternative hypothesis.

- Two error types:
    - Alpha error (type 1): Rejection of H0 even though it is true in real life. This is a false positive. 1 - alpha states the general confidence level.
    - Beta error (type 2): Failure to reject H0 even though it is false. False negative. 1 – beta shows the general power of the model.

If the H0 is true, there is a p-percentage chance we would see the observed difference just based on noise. We want that this p-percentage is below our alpha, which makes the alpha an upper-bound for the error probability p.

Appropriate tests

- Nominal (classified observations) (Mode, frequency, binominal tests, chi-square)
- Ordinal (ranked observations)
- Interval (ranked observations with a measure of distance)(Mean, median, variance, randomization tests and parametric tests)

Structure of data?

- One sample -> Compare to theoretical benchmark
- Two (or more) related samples
    - Multiple observations from single subject (within group)
- Two (or more) independent samples
    - Multiple observations from several independent subject (between group)
- Parametric (assume normal distribution) or non-parametric tests

Names of tests:

- Fisher's exact test
- Binomial test
- Median test
- Mann-Whitney U-test
- Permutation test
- Rank correlation analysis (Spearman, Perason)

Prospect Theory (AD ch 3)

Expected Utility Theory gives us the normative baseline on how individuals should act when confronted with decision-making under risk. The main assumptions of EUT are the completeness, transitivity, continuity, and independence of preferences, which are discussed earlier. The Allais

paradox shows us a well-known deviation from EUT. One of the solutions to deal with this kind of observed phenomena that go against the rational assumptions of EUT is Prospect Theory (PT), proposed by Kahneman and Tversky (1979). Kahneman and Tversky show that a number of violations of the axioms of EUT exists readily in subject's behaviour.
A few of these violations are: the common ratio effect; reflection effect; isolation effect; and the certainty effect.
There are multiple irrationalities that investors show:

- Investors trade too much.
- Investors fail to diversify.
- Investors hold on to losing stocks for too long.
- Investors extrapolate past performance.
- Investors trade based on mood.
- Investors trade based on irrelevant information.
- Investors have non-EUT preferences.
- Investors make mistakes when processing information.

The common ratio effect shows us that the substitution axiom is violated, which asserts that if L is preferred to K, then any probability mixture (L,p) must be preferred to the same mixture (K,p). As this is not the case, it shows that probabilities are not linear in decision making.
100% 6000 is chosen over **80% 8000**, but **20% 8000** is chosen over **25% 6000**, which is weird.
This common ratio effect violates the substitution axiom of the Expected Utility Theory. This in the end means that probabilities are not linear in utility theories. People are not consistent with the probabilities that they prefer.

The reflection effect shows us that subjects are risk averse in the gain domain, while being risk seeking in the loss domain. Reflection at zero therefore reverses the preference order. Thus 100% of 3000 over 80% of 4000. However, people also choose 80% of -4000 over 100% of -3000.

The isolation effect shows that people see choices differently depending on how it is shown to them, even if in the end it is the same choice. Sequential framing of the same decision task shows us very neatly how this works. It consists of Separation or Integration
You do not take into account the 1000 or 2000 effect. You separate the two choices.

Isolation effect:

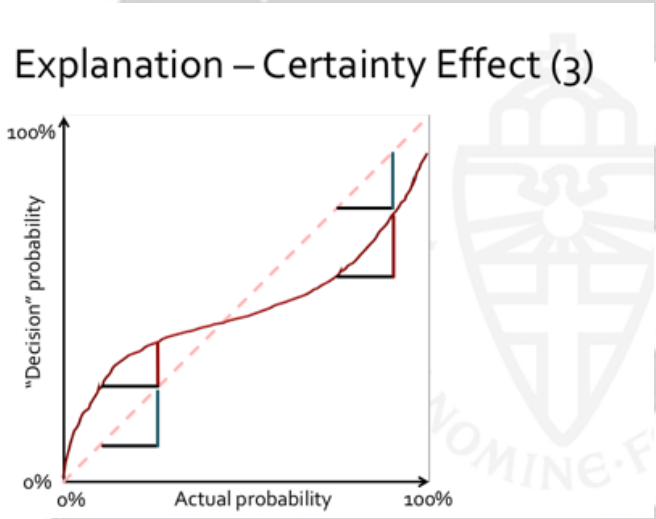
- One stage game(1S)
  - Choose between two prospects P(0.2,4000) or P(0.25,3000)
- Two stage game (2S)
  - Stage 1: 75% nothing, 25% reach stage 2
  - Stage 2: Choose between P(0.8,4000) and P(3000)

With a 1 round game, people chose the first one over the second one. With a two round game people opt for the second option. This is weird, because in the end, the two prospects are virtually the same if we take the first round into account. However, it turns out that people do not take the first round into account.

The certainty effect gives an idea of how people act near the very end of the probability distribution. If the probability of winning is substantial, people will typically choose the higher probability. However, when the probability is negligible, people will typically choose the lower probability with the higher outcome. According to EUT probabilities are linear, and the change in probability is independent from the starting point. However, observed behaviour in real decision making shows that this is not true. People seem to be more sensitive to differences in extreme probabilities. In

essence, people weight probabilities instead of mapping them one-to-one. This results in the s-shaped probability weighting function as shown on the slide.
We overweight outcomes that we perceive to be certain, relative to outcomes which we merely perceive to be probable.

The explanations for most of these effects can be found in the different approaches to the influence of the reference point. According to EUT, people care about their total wealth when making decisions. However, PT states that people typically evaluate change in wealth level, and therefore care about the deviations from their current wealth, giving the reference point a far larger impact on their decision. This can also explain why people are risk averse for gains and risk seeking for losses, because people are loss averse, and therefore feel them stronger than gains. Another important aspect in the explanation of the mentioned effects is integration/separation. The isolation effect exists because people simplify the choice between alternatives, and therefore they disregard components that alternatives share in order to focus on components that distinguish them. This leads to inconsistent preferences as a pair of prospects can typically be decomposed in common components and distinctive components in more than one way.



The graph on the left shows the actual probability (the dotted line) and the perceived probability (the full line). As you can see, for small probabilities the perceived probability is too high and for high probabilities the perceived probability actually is too low. It is also the case that the value of 1% is not equal in the graph. In more extreme probabilities, the value of 1% is much higher than more moderate probabilities.

Summary: Key aspects of observed behavior
1. People sometimes exhibit risk aversion and sometimes risk seekingness, depending on the nature of the prospect (gain or loss)
2. Peoples' valuations of prospects depend on gains and losses relative to a reference point.
3. People are averse to losses because losses loom larger than gains (the effect of losses is larger than the effect of gains).

In order to make sense of all these phenomena going against the rationality assumptions of EUT, Kahneman and Tversky presented a theoretical framework for their Prospect Theory. The choice process in PT consists of two phases, the editing phase and the evaluation phase.

<u>Editing phase</u>
The function of the editing phase is to organise and reformulate the options so as to simplify subsequent evaluation and choice. The editing phase consists of a number of operations, of which the major ones are: coding; combination; segregation; cancellation; simplification; and detection of dominance. Coding is the first step, and this entails the consideration of the location of the reference point and the consequent coding of outcomes as gains and losses. Prospects can also be combined or segregated, depending on what they look like exactly. For example, it might be that there are two probabilities with the same outcomes, or that there is a riskless component in the prospect.

Cancellation is an operation in which the decision maker ignores certain parts of the choice, or they discard common constituents in a certain prospect pair. In some cases, it is possible for a subject to simplify a complex situation, for example when the numbers in a certain prospect are close to some prominent numbers, it is highly likely that the subject will see these complex figures as the closest prominent numbers. Furthermore, the detection of dominance is important, as subject will discard immediately every prospect that is dominated by all others.

Evaluation phase

Once the editing phase is finished, the decision maker moves on to the evaluation phase. In the evaluation phase, the subject will evaluate every prospect using two scales, π and υ. The first scale, π, associates which each probability p a decision weight $\pi(p)$, reflecting the impact of p on the overall value of the prospect. The second scale, υ, assigns to each outcome x a number $\upsilon(x)$, which reflects the subjective value of that outcome. These two scales are the basis for, respectively, the weighting function and the value function. The overall value of a prospect can thus be defined as follows: $V[P(p_1, x, p_2, y)] = \pi(p_1)\upsilon(x) + \pi(p_2)\upsilon(y)$.

An important feature of the value scale in PT is that the carriers of value are changes in wealth rather than final wealth states. This is because people are more prone to evaluating difference rather than absolute magnitudes. The essence of the value function is that it is defined on the deviations from the reference point, it is concave for gains and convex for losses, and it is steeper for losses than for gains. The concavity in the gain domain is due to the risk aversion of people in gains, while they are risk seeking in losses, and therefore the value function is convex in the loss domain. This is the reason why the graph has an S-shape curve. The reference points where one starts the evaluation phase is typically the current asset position of the subject. Because people are loss averse, losses loom larger than gains, and therefore the value function is steeper for losses than for gains.

The weighting function relates a decision weight to the probability of a given outcome. Typically, people overweight certain outcomes (certainty effect), leading to a steep function when probabilities approach certainty. However, people also overweight small probabilities, which means the weighting function is also steep close to the origin. The reflection effect shows us that people are risk seeking in the loss domain and risk averse in the gain domain. *However, when we are working with small probabilities, people are risk seeking in the gain domain, and risk averse in the loss domain. This phenomenon is due to the overweighting of small probabilities.*

In 1992 Kahneman and Tversky mathematically formulated the Cumulative Prospect Theory, in which they employ cumulative decision weights, and uncertain and risky outcomes.

$$V(z_1, p_1; \dots; z_n, p_n) = \sum_{i=1}^{k} \pi_i^- \upsilon(z_i) + \sum_{i=k+1}^{n} \pi_i^+ \upsilon(z_i)$$
$$(for\ z_1 \leq \cdots \leq z_k \leq 0 \leq z_{k+1} \leq \cdots \leq z_n)$$

This is a brief overview of the mathematical process:

1. Order outcomes (gains and losses separate, from smallest probability to highest).
2. Determine decision weights for losses.
3. Determine decision weights for gains.
4. Determine value.
5. Merge.

where z_i is any monetary outcome (similar to x and y in evaluation phase).

Kahneman and Tversky estimate the forms and coefficients for the value function and the weighting function. A PT value function should reflect concavity for gains and convexity for losses, as well as loss aversion. The functional form chosen by Kahneman and Tversky consistent with these properties is:

$$v(z) = \begin{cases} z^{\alpha} & 0 < \alpha < 1 \qquad if\ z \geq 0\ (gain) \\ -\lambda(-z)^{\beta} & \lambda > 1\,, 0 < \beta < 1 \qquad if\ z < 0\ (loss) \end{cases}$$

This functional form is called a two-part power function. Kahneman and Tversky get the following estimations from their empirical data: $\alpha = \beta = 0.88\,, \lambda = 2.25$
Kahneman and Tversky also propose a weighting function based on their estimates:

$$\pi(p) = \begin{cases} \dfrac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{1/\gamma}} & \gamma > 0 \quad if\ z \geq 0 \\ \dfrac{p^{\chi}}{(p^{\chi} + (1-p)^{\chi})^{1/\chi}} & \chi > 0 \quad if\ z < 0 \end{cases}$$

Estimating γ and χ led to the following figures: $\gamma = 0.61\,, \chi = 0.69$
Outcomes are now ordered such that: $z_1 \leq \cdots \leq z_k \leq 0 \leq z_{k+1} \leq \cdots \leq z_n$, with probabilities: $p_1, p_2, p_k, p_{k+1}, \ldots, p_n$. Determining the decision weights looks as follows:

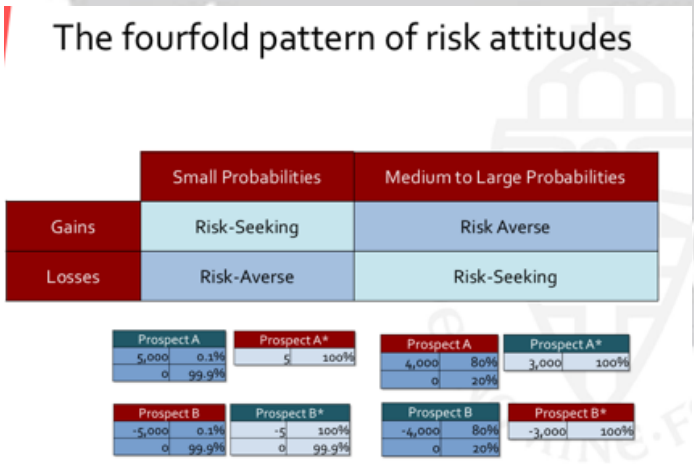
$\pi_1^- = w^-(p_1)$
$\pi_i^- = w^-(p_1 + \cdots + p_i) - w^-(p_1 + \cdots + p_{i-1}) \qquad 2 \leq i \leq k$
$\pi_n^+ = w^+(p_n)$
$\pi_i^+ = w^+(p_i + \cdots + p_n) - w^+(p_{i+1} + \cdots + p_n) \qquad k+1 \leq i \leq n-1$

Determining the values goes according to the following scheme:

$$v(z_i) = \begin{cases} -\lambda(-z)^{\beta} & if\ 1 \leq i \leq k \\ z^{\alpha} & if\ k+1 \leq i \leq n \end{cases}$$

The common consequence effect (people switch up their behaviour) is predicted by PT, but EUT does not predict this kind of behaviour. The same goes for the reflection effect and the common ratio effect. PT can therefore be seen as a great improvement to predict investors' behaviour compared to EUT.

The pattern in subjects' behaviour that shows us that people are risk averse in the gain domain, except when dealing with small probabilities, and risk seeking in the loss domain, except when dealing with small probabilities. This pattern is characterised by Kahneman and Tversky as the fourfold pattern of risk attitudes. Given the estimations in their 1992 paper, prospect theory is able to deal with this fourfold pattern of risk attitudes.



Integration and segregation: Example: You lost 150$ at the horse track today, you are considering to take a last bet to bet $10 on a horse with 15:1 odds (win 150 or lose 10). Either you integrate the 150 loss into the prospect (thus you either win 0 or have a loss of 160). Or you segregate (neglect the loss) and have a prospect of 150 gain or loss of 10.

Segregation: Prospect theory argues that you pick the certain 500 in the gain domain. However, you pick the -1000 with a 50% probability in the loss domain.
Integration: Prospect theory argues that you pick the certain 1500 (sure gain of 1500 and thus risk averse).
Integration occurs when positions are lumped together (multiple prospects). Segregations occurs when situations are viewed one at a time. With segregation you always start at the reference point (you view each situation as new). If you integrate your reference point changes, because you take into account other situations (thus, perhaps the loss you have made earlier that day on another bet).

There are some typical effects that occur after gains or losses in for example a casino or horseracing. The break even effect is seen when the risk people take increases after a number of losses, as they want to break even in the end. The house money effect occurs when people increase their risk after gains, because the distance to the loss domain is larger(they are playing with money that they do not really view as their own yet).

Market anomalies
Market anomalies are empirical results that appear, until adequately explained, to run counter to market efficiency. Given that any empirical test of market efficiency needs to be done using an asset pricing model, the problem of joint hypothesis testing occurs. This means that the rejection of the hypothesis may either be due to market inefficiency, or an inappropriate risk-adjustment method, or both.
Market efficiency can be split in three forms: weak form, incorporating all historical information; semi-strong form, incorporating all publicly available information; strong form, incorporating all information, even insider information.
A paradoxical problem with the strong form market efficiency, called the Grossman-Stiglitz Paradox, is that nobody will gather information on any firm when all information is already incorporated in the price. Acquiring information is costly and you cannot make any gain with it. How then, when nobody gathers information, can all information be reflected in the price? Markets can thus not be strong-form efficient, as the agents who collect costly information would have to be compensated with trading profits.
Other challenges to the EMH are posed by market anomalies that provide “evidence” that abnormal returns can be achieved by: using publicly available information from financial reports (violating semi-strong form); using historical information from stock markets (violates weak form).

CAPM states that the expected excess return is a linear function of its sensitivity (beta) to the excess return on the market portfolio, and the only source of systematic risk in this model is the market portfolio. CAPM then looks like this: $R_{i,t} - R_{f,t} = \alpha_i + \beta_{m,i}(R_{m,t} - R_{f,t}) + \epsilon_{i,t}$
Some prominent anomalies showing a deviation from the linear relationship are: size effect, value effect, and momentum. The Fama-French 3 Factor model includes the size effect and value effect as other sources of risk, while the Carhart 4-factor model also includes momentum.

Market anomalies can essentially be split into three categories of anomalies. The first one are fundamental anomalies, which are based on balance sheet information, such as the small firm size effect and the value effect. Secondly there are the technical anomalies, such as momentum and reversals. Calendar anomalies, showing certain return patterns related to calendar dates, are the third type of anomalies.

<u>Calendar effects</u>

Calendar effects occur when average returns at specific time intervals during the year differ from reference returns. A number of these effects are: Halloween effect ("Sell in May and go away"); January effect; Turn of the month effect; Weekend effect/Monday effect; and the Holiday effect. *The "Sell in May and go away" effect* is the effect that stock market returns during the period May-October are systematically lower than the short-term interest rate. The explanations that have been proposed for this effect are: the higher investment flows during the winter months; the lower trading volumes during summer, leading to higher volatility; self-fulfilling prophecy due to media coverage.

The January effect is that returns at the beginning of January are higher than in the rest of the year. Essentially there are two possible explanations. The first one is tax-loss selling, which means that investors sell losers to offset their gains in December, and then they start buying again in January, leading to a rally. This however can be questioned, as the effect is also observed in countries that do not have a capital gains tax. A second proposed explanation is window dressing by portfolio managers. At the end of the year managers sell risky and small firm stocks in their portfolios, which had been there to earn higher returns. They would do this to avoid revealing in them their year-end holding and then buy them back in January.

The Turn of the month effect shows us that returns for the latter half of the month are negative, and that returns on the last day of the month, as well as the four subsequent trading days are relatively high. A proposed explanation is the timing of monthly cash flows received by pension funds, which are invested in the stock market. Another possible explanation is that the effect is caused by important announcements of (macro)economic information which usually happens at the end of a month.

The Weekend effect or Monday effect describes that closing prices on Monday are lower than closing prices on Friday, and average returns on Monday are the lowest throughout the week. A couple of explanations could be the settlement of trades, buying stocks on Monday would lead to paying in this week, while buying stocks later would mean paying in the next week, leading to less demand on Mondays; individual investors obtaining and processing information over the weekend and trading on Mondays; news announcements released over the weekend; wrong econometric methods, as there is no one-size-fits-all explanation.

The holiday effect shows that the return on the preholiday day is higher than usual. This might have to do with short sellers closing their speculative positions on the day before the holiday, which also holds for the weekend effect. Another explanation might be a behavioural effect, assuming people are in a better mood the day before a holiday.

<u>Momentum and reversals</u>
The weak form of the EMH states that lagged returns cannot predict the future (the price of the past cannot predict the future). The question is here whether there are correlations between returns. In the case of momentum, we see that returns are positively correlated with past returns, and in reversals we see that returns are negatively correlated with past returns.

De Bondt and Thaler (1985) show the existence of *long term reversals*. They form a winner and loser portfolio by calculating the market adjusted cumulative excess returns for the 36 months leading up to the formation point. The 35 highest cumulative excess return firms are assigned to the winner portfolio, while the 35 lowest are assigned to the loser portfolio. Over the 60-month evaluation period the authors calculate the cumulative average residual return for each portfolio. This procedure is repeated 16 times for several subsequent years. Taking all of these returns together they get their results, which show the existence of long term reversal. Which means that the winner

stocks become stock with the lowest returns and the loser stocks become the stocks with the highest returns.
Zarowin (1990) argues that the losers in De Bondt and Thaler tend to be small stocks, and therefore are subject to the size effect. When losers and winners of equal size are compared, there is little evidence of return discrepancy, and when winners are smaller than losers, the winners even outperform the losers.
Arnold and Baker (2007) perform the same kind of research, using LSE UK stocks and a 5-year formation period. They find evidence for reversal, but also note that when leaving out small cap firms, the reversal persists, albeit in a weaker form.
Some of the proposed explanations for these reversals are given in De Bondt and Thaler, such as tax loss selling and window dressing. They believe these can be explanations because they also find a clear January effect in their results. Another explanation might be of a behavioural kind, namely overreaction (Barbaris & Vishny, 1997). Investors overreact to good news, and push prices to high levels. After some time they realise what they have been doing and the stock price corrects itself.

Jegadeesh and Titman (1993) find evidence for *medium-term momentum*, using data from the period 1965-1989. They use 4 different formation periods and four different evaluation periods, being 3, 6, 9, and 12 months. The strategy they propose would thus be to buy the winner portfolios and sell the loser portfolios. Proposed explanations for this medium-term momentum can either be reactions to recent earnings announcements, or the existence of positive feedback traders.
The momentum rules tell us to buy most winners of the past 3-12 months, sell (short) most losers of the past 3-12 months and then hold these positions for the next 3-12 months. The contrarian rules tell us to buy most losers of the past 3-5 years, sell most winners of the past 3-5 years, and then hold this portfolio for the coming 3-5 years.

Post Earning Announcement Drift

There are typically three types of reactions to events possible. The first one is overreaction, which means that the price shoots up far higher than would be efficient, and over time this price would correct itself to move back to the truly efficient reaction. The second one is under-reaction, which means that instead of shooting up directly to the efficient reaction price, the stock price will slowly but steadily increase until it reaches the price that would be attained when the reaction was efficient. The third type is obviously the efficient reaction, which means that the stock price would immediately jump to the new efficient price, and no further movement would be observed.
Reactions to information are typically studied using an event study. First it is determined what the event of interest is and what the event sample should be, and then the abnormal returns before and after the event are calculated. Abnormal returns are calculated using the following formula:

$$AR_{it} = R_{it} - E[R_{i,t}]$$
$$CAR = \sum_{t=-35}^{t=0} AR_t$$

The question now is how to define $E[R_{i,t}]$. As it is not possible to directly measure the return expectation in the market, we have to estimate this. The average return prior to event periods could be used: $\bar{R}_i = \frac{1}{s}\sum_{s=1}^{S} R_{t-s}$. The model used most in practice for calculating abnormal returns is however a form derived from CAPM, and the Fama-French 3 factor model could be used as an alternative. The most used model would look like this: $AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{m,t})$. This implies that the return expectation is then given by: $E[R_{it}] = \hat{\alpha}_i + \hat{\beta}_i(R_{m,t}) + \epsilon_{i,t}$. Thus, what they basically do is determine what a normal return should be on any given day and then compare the actual return on the days after the announcement to that "normal" return.

The reaction to earnings announcements has been studied by Rendleman, Jones, and Henry (1982). They rank the earnings announcements in 10 deciles from extreme positive surprise to extreme negative surprise. Surprise are defined by the 'standardised unexpected earnings':

$$SUE = \frac{Earnings\ per\ share - Forecasted\ earnings\ per\ share}{standard\ error\ of\ estimate}$$

Then the cumulative abnormal return path for each of the decile portfolios over the relevant time interval is calculated.
The study shows that the market to some extend anticipates positive and negative announcements, but it also shows a positive drift of deciles with positive announcements, and negative drifts of deciles with negative announcements, while the effects of the earnings announcement reaction should normally be short-term. This therefore violates the semi-strong form of efficiency, as people apparently later on in time still react on publicly available information. Thus, the efficient market hypothesis predicts that stock prices should immediately shoot up or plummet (if information is positive or negative respectively). However, stock prices keep adjusting over a longer period of time meaning that the market is not really efficient.
These findings have been replicated using several methods and several data sets, all showing that the post earnings announcement drift exists. Some explanations proposed are: firms with positive surprises must be riskier; limited attention, investors do not pay adequate attention to the information in the earnings announcements and respond late to new information; institutional investors trade on the post-earnings announcement drift (they know it exists and make use of it) and individual investors take the other side of the market (they're stupid and get abused by the institutional investors).

Small Firm Effect & Value vs Growth

Research into risk-adjusted returns started in the 1960s with the development of CAPM. At this time, it was believed that the excess expected returns are proportional to beta (as explained earlier). In the 1970s and 1980s empirical research started to show that the price pattern is not always in line with CAPM, and that certain anomalies existed. The most important anomalies are the Small Firm effect and the Value vs Growth anomaly. The Small Firm effect is the effect that small companies earn higher risk-adjusted returns than their bigger counterparts, while the Value vs Growth anomaly describes that the excess return of value stocks (low market value relative to fundamentals (such as earnings or cash flows)) exceed growth stocks (high market value relative to fundamentals).
In order to capture the Small Firm effect in the CAPM model, Fama and French (1993) added an additional risk factor to the regression. This variable was called SMB, and it is the difference in return of a small firm portfolio and a big firm portfolio. However, the Small Firm effect varies significantly over time, and using this effect for an investment strategy may only pay off in the long run. The effect appears to vary with the stocks' book-to-market ratio, which is the main factor for the value vs growth anomaly.
In the Value vs Growth anomaly, value stocks are "defined to be stocks with prices that are low relative to such accounting magnitudes as earnings, cash flows, and book value". The growth stocks, also called glamour stocks are "defined to be stocks with prices that are high relative to such accounting magnitudes as earnings, cash flows, and book value". This means that for growth stocks we would be looking at high P/E (Price over earnings/price divided by earnings) ratios and a low book-to-market ratio (book value (value on the balance sheet) divided by market value). The empirical observation for this effect is that there is an excess return that a portfolio of value stock has, on average, over a portfolio of growth stocks. This is an anomaly because the value stocks generally do not command a higher market beta than growth stocks, but they do have different excess returns. Advocates of the rational explanations that return comes as compensation for taking risk can thus be overruled. Another rational explanation could be firm distress, as value firms would fare relatively poorly in times of recession, leading investors to require a higher return for these

firms. However, recent research challenges this argument, given that there is no correlation between bankruptcy risk and return. Some behavioural explanations for this Value vs Growth anomaly exist as well, such as an overweighting of recent past performance, so that growth stocks might be overvalued, while value stocks are undervalued; investors' choice to buy "good companies" and therefore overpay for growth; media attraction of growth stocks convincing investors that growth stocks are better investments.
In order to capture this value effect in the CAPM model, Fama and French add the variable HML, which is the difference between the returns on stocks with a high book-to-market ratio and a low book-to-market ratio. Together with the SMB variable, the Fama-French 3 factor model extension of CAPM can now be constructed:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{m,i}(R_{m,t} - R_{f,t}) + \beta_{SMB,i}(R_{SMB,t}) + \beta_{HML,i}(R_{HML,t}) + \epsilon_{i,t}$$

This regression explains 90% of the variance in the regression, while CAPM only explains about 70%. The Fama and French three factor model differs from the CAPM .

1. Rm → return on market portfolio.
2. Rhml → returns growth vs value effect.
3. Rsmb → returns size effect

In 1997, Carhart proposed to add a fourth factor to the FF 3 factor model. This factor would be one to capture momentum, and it would consist of the difference in returns between winner and loser portfolios. This would be the difference of month *t* return, based on the past year's performance. The model would then look like this:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{m,i}(R_{m,t} - R_{f,t}) + \beta_{SMB,i}(R_{SMB,t}) + \beta_{HML,i}(R_{HML,t}) + \beta_{WML,i}(R_{WML,t}) + \epsilon_{i,t}$$

For all the effects mentioned above, it seems to be the case that the effect diminishes after the first publication on finding these effects. Although market anomalies are reoccurring patterns, you never know what happens next, and whether these patterns will persist in the future. Furthermore, as they do not always occur, it is impossible to rely on them to profit from.
The question is whether behavioural finance can explain market anomalies. Assuming market anomalies cannot be explained by rational agents, irrational agents must have a systematic impact on market prices. However, if there is arbitrage and sufficient rational agents, arbitrageurs would exploit the differences. Nevertheless, assuming arbitrage is limited, irrational agents may have an impact.

Limits to Arbitrage
The theoretical idea behind arbitrage is that investors can design riskless, zero-cost approaches to correct mispricing in financial markets. However, in reality these opportunities can be both risky and costly. This leads to arbitrageurs having less incentives/possibilities to exploit the mispricing, and therefore pronounced mispricing might persist, and prices are not necessarily right. There are essentially two reasons why arbitrage is limited. The first one is the risky aspect of arbitrage, and the second one the cost aspect to it. There are four types of risk involved in arbitrage: noise trader risk; model risk; fundamental risk; synchronisation risk. The costs to arbitrage occur because capital might be needed to implement the arbitrage strategy.

<u>Noise trader risk</u>
Noise trader risk refers to the risk that mispricing worsens in the short run, because there is a possibility that pessimistic traders become even more pessimistic about the future. Noise trader risk reflects the risks from other irrational noise traders. Once we grant the possibility that a security's price can be different from its fundamental value, we also have to grant the possibility that future price movements will increase the divergence. Noise trader risk matters for arbitrageurs, as it can force them to liquidate their positions. This has to do with the fact that most real-world arbitrageurs

are money managers using other people's money for their strategies. As investors lack the specialised knowledge to evaluate the arbitrageur's strategy, they simply evaluate the arbitrageur based on returns. So when a mispricing worsens in the short run, the arbitrageur has negative returns, which may lead to investors withdrawing funds, and thus arbitrageurs needing to prematurely liquidate their positions. The consequence of this risk is that the fear of such premature liquidation dampens the incentives to engage in arbitrage strategies in the first place.
One of the advantages of the presence of noise traders in the market is that they provide liquidity, which helps rational traders to find counterparties for their trades. Although Friedman (1953) already argued that irrational traders would be forced out of the market, noise traders can survive in the long-run, which is mainly due to the noise trader risk and short time horizon that arbitrageurs face.
De Long, Shleifer, Summers, and Waldmann (1990) developed a two-period model with investment in *t*, and consumption in *t+1*. There are 2 assets, the safe asset which pays a dividend of *r* and has an infinite supply, and the risky asset, paying a dividend of *r*, with a supply fixed at 1, and the price equals p_t. Two types of traders exist, the arbitrageurs, μ, and the noise traders, $1-\mu$, who misperceive the next period price by ρ_t with $\rho_t \sim N(\rho^*, \sigma_p^2)$. Both types of traders have a mean variance utility function: $E(w) - \gamma Var(w)$, in which the risk parameter gamma determines the influence of variance. The second period wealth of the arbitrageurs is determined by (where λ is investment in *t*):

$$w_{t+1}^a = \lambda_a * (P_{t+1} + r) + (w_t^a - \lambda_a P_t) * (1 + r)$$

For the noise traders we have to add the misperception of the next period price:

$$w_{t+1}^n = \lambda_n * (P_{t+1} + r + \rho_t) + (w_t^n - \lambda_n P_t) * (1 + r)$$

We maximise utility given the following functions for $E(w)$ and $Var(w)$:

$$E(w) = \lambda E[P_{t+1}] + \lambda r + (w - \lambda P_t)(1 + r)$$
$$Var(w) = \lambda^2 Var(P_{t+1})$$
$$\max_{\lambda} \lambda E[P_{t+1}] + \lambda r + (w - \lambda P_t)(1 + r) - \gamma \lambda^2 Var(P_{t+1})$$

The first order condition for this leads to:

$$E[P_{t+1}] + r - P_t(1 + r) - 2\gamma\lambda Var(P_{t+1}) = 0$$
$$\Rightarrow \lambda = \frac{r + E[P_{t+1}] - P_t(1 + r)}{2\gamma Var(P_{t+1})}$$

For noise traders, the term resulting from the misperception of the second period price has to be incorporated in the maximised function as well.

$$\lambda_n = \frac{r + E[P_{t+1}] - P_t(1 + r)}{2\gamma Var(P_{t+1})} + \frac{\rho_t}{2\gamma Var(P_{t+1})}$$

Because supply of the risky asset is equal to one, market clearing $\lambda_a \mu + \lambda_n (1 - \mu) = 1$ leads to:

$$p_t = 1 + \frac{\mu(\rho_t - \rho^*)}{1 + r} + \frac{\mu\rho^*}{r} - \frac{2\gamma}{r}\frac{\mu^2\sigma_p^2}{(1 + r)^2}$$

where 1 is the price without uncertainty, the first term are the fluctuations of price due to variation in misperception, the second term the mispricing due to average bullishness of noise traders, and the last term shows that uncertainty about next period's noise traders' beliefs makes the riskless asset risky. Whether arbitrageurs kick the noise traders out of the market depends on the difference in returns:

$$E[w_{t+1}^n - w_{t+1}^a] = \rho^* - \frac{(1 + r)^2}{2\gamma\mu\sigma_p^2}(p^*)^2 - \frac{(1 + r)^2}{2\gamma\mu}$$

The noise traders have a higher return if the prices are overpriced on average (1st term positive), but not too high (2nd term depends on rho, but is negative), and the variance of the bullish signal is high (2nd term's sigma squared), discouraging arbitrageurs to buy the risky stock.
Everything in this model depends on exogenous parameters and the public information about the misperception of noise traders. The overoptimistic or bullish traders will hold riskier positions and

have higher expected returns, which means they will have more off-springs (evolutionary process), and hence won't die out. The third pillar of support for the EMH, that rational traders will force irrational traders out of the market is thus not supported. The model in the end indicates that it might be the case that not the irrational investors, but rather the arbitrageurs are forced to leave the market.

Model risk

Any model is a simplified version of reality, and therefore the risk that something isn't accounted for always exists. The specific risk for arbitrageurs is that they evaluate returns wrongly, and therefore might find "arbitrage opportunities" according to their model, although the market value is actually correct. Essentially three things can be miscalibrated in this case: belief that an asset is over/undervalued; belief that future dividends follow a certain path or have the right discount factor; belief that assets are close substitutes according to CAPM.

Fundamental risk

The fundamental risk, quite obviously, is the risk that the fundamentals of an asset may actually change. Part of this risk can be hedged by either using substitutes (industry risk) or a correlated index (market risk). However, when something with a specific impact on the firm's fundamentals occurs, there is still no hedge. Moreover, the substitutes might be mispriced, which would only increase the risk.

If a stock is overvalued, the strategy for an arbitrageur should be to short-sell the stock. Suppose the beliefs of the arbitrageurs are correct, then there are still a couple of possibilities that might lead the arbitrageur to close out the position at a loss:

1. Unanticipated information might even raise prices. The arbitrageur will incur a loss (margin call). This means that the real value of the company and thus the stock actually changes.
2. Unexpected high dividends may lead to an additional cash crunch as with short sales borrower has to cover dividend payments.
3. Short squeeze (the amount of stocks that are trading (float) is very low). If people have to cover their short positions and the amount of available stocks to buy is very low, the price will sky rocket (very high demand and low supply).

Synchronisation risk

The synchronisation risk that an arbitrageur faces is the risk that he starts a speculative attack on mispricing, but nobody else wants to or is able to join him. The risk is then that although the stock price is higher than the fundamental value, the price will keep rising because there is not enough downward pressure from arbitrageurs. This would lead the arbitrageur that does go short to close out his position at a loss. Rational arbitrageurs understand that the market will eventually collapse, but they might as well ride the bubble as long as it lasts, and then exit the market just before the collapse. However, this market timing is extremely difficult, partly because of the lack of synchronisation among the arbitrageurs.

Abreu and Brunnermeier look at this situation as if it were a timing game. Arbitrageurs become aware that there is a price bubble, but the question is when they should start to put some selling pressure on the market. If they short sell too early, there is a risk of a margin call, and a premature closing out of the position (they make a loss). However, when they short sell too late, there is no bubble to gain from anymore (the market collapses and they either lose money because they went long or they don't lose, but also don't gain, simply because they didn't do anything yet). The problem that arises here is that the arbitrageurs trying to time the market will lead to delayed arbitrage, and therefore persistence of the bubble.

When a bubble emerges, the dispersion of opinions among arbitrageurs causes the synchronisation problem, making coordinated price corrections difficult, as arbitrageurs time the market and ride the bubble. However, some unanticipated news without any fundamental content might serve as a synchronisation device, leading the market to crash out of the blue.

Implementation costs

There are a number of costs with regard to the implementation of an arbitrage strategy. These are, among others, commissions; execution risk; counterparty risk; market liquidity risk; funding liquidity risk; short sale constraints.

The execution risk is the risk of price movements between buying and selling, as it is generally not possible to do both at the same time. The price can change between the moment of selling and buying.

Counterparty risk is the risk that a counterparty will fail to meet their side of the obligation in the future. For example that the party you agreed upon for an option is unable to deliver on its promise.

Market liquidity risk arises when the liquidity of a usually highly liquid asset worsens when one needs to unwind. Normally the asset is traded a lot, but right when you want to sell it is not traded that often, so that you have to accept a lower price to be able to sell it.

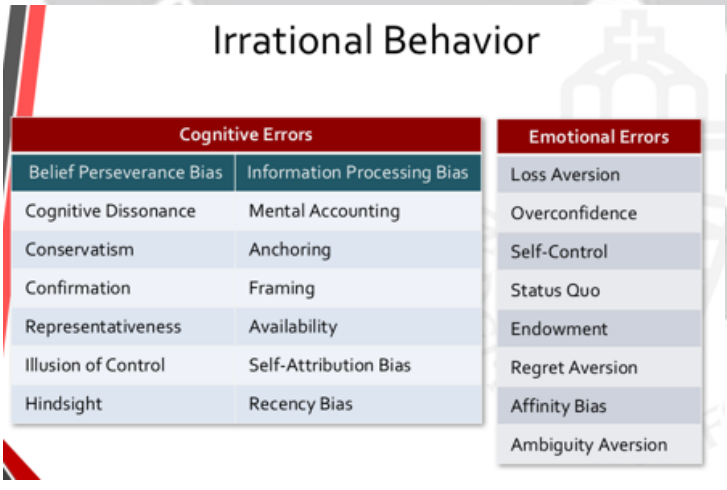
Funding liquidity risk describes the possibility that a trader cannot fund his current position anymore, and therefore has to unload (when investors pull out their money for example).

Short sale constraints are limits on the possibilities of short selling, such as the right of lenders to close out position at any time, the risk of a short squeeze, the costs of borrowing the security, and the provision of collateral. Furthermore, in some countries certain institutional investors simply aren't allowed to short sell.

Irrational Behaviour

Thomas Aquinas divided the study of behaviour into the cognitive and affective categories. Following Aquinas, we consider irrational behaviour as behaviour biased by:

- Cognitive errors → how do we understand the world?
- Emotional errors → how we understand the world via emotions and feelings?



The cognitive errors are further divided into belief perseverance biases and information processing biases. The full list of errors discussed in this course can be seen in this slide.

Cognitive psychology is the scientific study of cognition, which can be defined as the "mental processes that drive human behaviour". It describes human thought in term of input, representation, processing, and output.

Belief Perseverance Biases

The belief perseverance bias is the human tendency to cling to ideas, even when we are confronted with evidence to the contrary.

Cognitive dissonance is a situation in which people are motivated to reduce/avoid psychological inconsistencies. It can be seen as a state of imbalance that occurs when contradictory cognitions intersect (people feel uneasy when they have conflicting ideas and information). Cognitive dissonance can lead to irrational decision making as a person tries to reconcile his conflicting beliefs. The consequence of this dissonance is selective perception, which means that one either enhances the affirmative information, or blinds out the contrary information. This will lead to selective decision making by rationalising actions that enable one to adhere to a chosen course. Thus, people often neglect information that is inconsistent with the idea that they had of it. If people really like a politician for example, they neglect the information that he is convicted for fraudulent behaviour. People will take detrimental actions to alleviate the mental discomfort that is due to cognitive dissonance, leading to investment mistakes such as the disposition effect (they hold on too long to losing stocks, because they neglect the information that the stock is actually not a very good one), sunk cost fallacy (you invest even more money in a project you have invested in, even though you realize it is a bad investment) , and get-eventis (you try to get your money back).

Conservatism bias is the tendency to revise your belief insufficiently when presented with new evidence. It's a mental process in which people cling to their prior views or forecasts at the expense of acknowledging new information. Conservatism bias causes the investor to under-react to the new information holding on impressions from the previous information. The typical investment mistakes coming from this bias are: investors behave too inflexibly when presented with new information; investors take a longer time to react to new information, leading to cumbersome adjustment of portfolio; investors experience mental stress when contradicting information arise, simply stick to prior belief to avoid cognitive costs (cognitive dissonance). Thus, people put too much weight on information that they already possessed and too little weight on the information that they have recently acquired.

Confirmation bias is the tendency to search out for evidence consistent with one's prior beliefs while ignoring conflicting data. People have a natural ability to convince themselves of whatever it is that we want to believe. We attach undue emphasis to events that corroborate desired outcomes, and downplay whatever contrary evidence arises. This bias can cause investors to hold under-diversified portfolios, as investors might not want to hear anything negative about favoured investments but seek confirmation that supports decision. It can also cause employees of a company to over-concentrate in companies' stock, "confirm that your company will keep doing well in the future". Thus, the tendency of people to look for evidence that confirms the idea that they already had.

Representativeness bias consists of a number of different biases, being base-rate neglect, sample-size neglect, sub-additivity effect, conjunction fallacy, gambler's fallacy/hot hand belief, regression to the mean.

- *Base rate neglect* describes that people are insensitive to prior probabilities of outcomes, meaning they ignore the pre-existing base rate frequencies. This base rate neglect might lead to investors under-/overestimating cash flows and market performance. It is also known as the base rate fallacy, which is when people use wrong information or subjective impressions/estimates about frequencies rather than base rates.
- *Sample size neglect* arises when people incorrectly assume that small sample sizes are representative of populations (or real data). This is a form of bias because a small sample pattern is not necessarily equal to the population pattern. Traders often judge the likelihood of a particular trade outcome on the basis of a certain sample, and regularly fail to accurately consider the sample size of the data from which they derive their judgments.

- *Sub-additivity effect* is the tendency of people to judge probability of the whole to be less than the probabilities of the parts. People typically prefer an unpacked view of the events over a packed view of possible events. Real world: People are willing to pay more for flight insurance that explicitly list certain events (terrorism, mechanical failure, etc.) than for insurance that covers all events.
- The *conjunction fallacy* is the tendency to see more special conditions as more probable than single general ones. You believe that overlapping events are more likely to occur. This is because people use a heuristic to judge the situation. The options chosen usually seem to be more representative for the situation described. Example:
  Which seems more likely?
  - Jane is a lottery winner.
  - Jane is a happy lottery winner.

  Many pick 2.
  but 1. must have a higher probability! Because if 2 holds, 1 automatically also holds, but if 1 holds, 2 does not always have to hold.

- *Gambler's fallacy* is the fallacious belief that chance will 'correct' a series of 'rare' events, by showing the 'normal' event more often afterwards. For example, a sequence of 6 or 7 times heads will lead people to believe that the chance of tails turning up is larger than 50 per cent. Even though this of course is not true, because the chances are still 50% afterwards. With regard to investment: If a stock has risen repeatedly in the past, it is time to sell it, for it is bound to go down now (Disposition effect). This is often associated with a small sample size bias.
- *Hot Hand Fallacy* is the fallacious belief that a person who has experienced success with a random event has a greater chance of further success in additional attempts. The gambler's fallacy is thus a belief in negative autocorrelation, while the hot hand fallacy is a belief in positive autocorrelation. People are more likely to invest in mutual funds that have performed well in the past years. As the market cannot be predicted it is basically luck and so the previous performance of the fund managers should not matter. But apparently it does, because people believe that fund managers who have done well in the past will continue to do so.
- *Regression to the mean* is the statistical effect that sequences will be in such a way that when it has temporarily been above the mean, it will revert back to the long-run mean. An unusually strong performance will be followed by a more average one, thus it will revert back down towards its average. An unusually poor performance will be followed by a more average one, and thus it will revert back up towards the mean. This has to be taken into account when interpreting data.

The *representativeness heuristic* is the rule of thumb that people will follow when observing a pattern in data or in behaviour. In order to avoid cognitive costs, one follows a representativeness heuristic by extrapolating their pattern based on an observation to a general principle. In general, this means that investors ignore the statistically dominant results to satisfy their need for patterns. People need patterns, because they cannot always do the statistically best outcome, as calculation of this outcome is simply too demanding. As such, they use a rule of thumb.

Illusion of Control Bias is the tendency to believe that outcomes can be controlled or at least influenced, when, in fact, they cannot. The concept that people believe to have control over are in fact chance events. People are willing to pay more for a random draw lottery in which they may make the draw and thus have a feeling of being in control. The most common investment mistakes that can be caused by this bias are: investors invest more than is prudent in order to maintain under-

diversified portfolios (they feel that because they contribute so much to that company that they sort of control the company (which is usually not true)); contribution to overconfidence, leading investors to believe they have control, giving them the feeling of knowing more than others.

Hindsight Bias pushes people into thinking that they knew beforehand what was going to happen. It is the belief that one made an accurate prediction in hindsight. When people look back without having perfect memory, they fill gaps with what they prefer to belief. The hindsight bias gives people the illusion that we understand the past, fostering confidence in our ability to predict the future. People tend to believe that a past event was predictable and completely obvious, whereas in fact, the event could not have been reasonably predicted. This can also cause some investment mistakes with investors. Investors might for example rewrite own memories to portray positive developments as if they were predictable, maybe leading to excessive risk taking. Self-deception due to hindsight bias also prevents investors from learning from their past mistakes. Furthermore, investors may unduly blame/praise their money manager for gaining or losing money.

Information Processing Biases

Information processing biases are biases that lead people to process and use information in an illogical way, with the consequence that they behave irrational in financial decision making. One effect that is due to information processing biases is the stroop effect. This effect is that it is hard to stop well-practiced automatic reading routines from being executed. There is a difference between experts and novices in this though.

Mental accounting is the process that people use to mentally categorise sums of money. Although in fact money is of course money, regardless its source or intended use, people like to have different accounts in their head, such as from where the money is obtained, or what its intended use is. Richard Thaler explains mental accounting as "[describing] people's tendency to code, categorise, and evaluate economic outcomes by grouping their assets into any number of non-fungible mental accounts. The house money effect is one way in which mental accounting expresses itself. It causes people to devalue a dollar as aggregate dollars accumulate. This is because people are playing with so-called "house money", and not with their own. Investors therefore tend to become increasingly more risk seeking. Some investment mistakes that arise from this mental accounting bias are: it causes people to imagine that investments occupy separate mental accounts, leading to suboptimal aggregate portfolio performance; it causes people to take more risks than is prudent when playing with the "house money", people fail to treat all money as fungible; it causes people to hesitate to sell losers, as long as they don't it's only a paper loss, otherwise they realise a loss on their mental account.

Anchoring bias is the effect that arbitrary numbers can have on an estimation or judgment. Anchors lead to an insufficient adjustment and produce biased approximations, as it is easier to estimate relative than absolute figures. Psychological heuristics influence financial decision making, for example, people cling to purchase "points", which are usually arbitrary price levels. This also leads to new information being filtered through a lens, placing emphasis on arbitrary, psychologically determined anchor points. People might see an anchor as helpful to reduce their cognitive costs, especially because a movement away from the anchor is effortful, and therefore people stop too early. People start from an anchor until they reach a plausible range, so that a high anchor reaches the range from above, and a low anchor from below. Because of this anchoring, investors tend to make general market forecasts that are too close to current levels, based on the current anchor, and not on historical standard deviations. Furthermore, investors tend to stick to an initial estimate even when contrary information comes up. Lastly, investors also tend to forecast return based on last year's average.

Framing bias is the effect that people get biased by the way in which questions or decisions are posed to them. This frame is due to the formulation of the problem, and the norms, habits, and personal characteristics of decision making. Framing effects occur when preferences change as a function of some variation in framing. A specific category of this bias is 'narrow framing', which occurs when people focus too much on one or two certain aspects of a problem and exclude other crucial aspects. Due to this framing bias, risk attitude tests can be biased, because the answers to questions are dependant on the loss/gain frame, which may in turn lead to a biased investor profile and thus a misaligned portfolio choice. When trying to attract investors, firms/funds/managers frame recommendations in an optimistic manner, because optimistically worded questions are more likely to get affirmative responses. Due to the narrow framing effect, investors tend to focus on certain points of a problem or investment decision, potentially leading to faulty judgments. Framing and loss aversion can together explain excessive risk aversion. Concluding this bias basically is that people's preferences change when something is formulated in a different way.

Money illusion can best be explained as the framing of value, which is the tendency to think in terms of nominal rather than real monetary values. It has significant implications for economic theory, yet it implies a lack of rationality that is alien to economists.

Availability bias is the wrong use of the availability heuristic, which one uses "whenever he estimates frequency or probability by the ease with which instances or associations could be brought to mind" (Kahneman & Tversky, 1973). People tend to make judgments about how likely an event is, which is usually influenced by one's recollection of the event happening earlier. If one can recall more of those events, which are a vivid memory and preferably happened in the recent past, or are emotionally laden, then the event is often perceived as being especially likely to occur. In essence this availability bias is a rule of thumb or mental shortcut, causing people to estimate the probability of an outcome based on how prevalent or familiar that outcome appears in their lives. The availability bias expresses itself in a number of effects, being retrievability, categorisation, narrow range of experience, and resonance. *Retrievability* leads investors to choose investments based on easily found information rather than on disciplined research. *Categorisation* leads investors to choose investments on the basis of categorical lists available in their memory, for example the home bias. The *narrow range of experience* means that people are more likely to choose investments in line with experience. *Resonance* will typically lead investors to choose investments that resonate with their own personality.

Self-attribution bias is the tendency to attribute successes or good outcomes to your own abilities, while blaming failures on circumstances beyond your control. Success will therefore be more often attributed to innate aspects like talent or foresight, while failures are blamed on outside influences like bad luck. The self-attribution bias can be divided into the *self-enhancing bias* and the *self-protecting bias*. The self-enhancing bias is the propensity of one to claim an irrational degree of credit for his success. The self-protecting bias is a similar effect occurring with failures. People tend to irrationally deny their responsibility for failures. Investors tend to belief that a period of successful investing is completely due to their abilities, and this leads to increased risk taking later on (overconfidence). Complementary to this is the more than prudent frequency of trading by investors, as they belief that trading success is attributed to skills rather than luck. Furthermore, investors tend to hear what they want to hear, and neglect information that goes against their brilliance, while overstating information that supports their feeling of brilliance. This may lead to an under-diversified portfolio. A last mistake that can come from the self-attribution bias is the lack of perception of mistakes due to blaming others or circumstances, which prevents learning from prior mistakes.

Recency bias is the tendency to more prominently recall and emphasise recent events and observations than those that occurred in the near or distant past. It is also the tendency to attribute disproportionate salience to recent stimuli or observations. Recent events are thus weighted more than earlier events. The recency effect in recalling things means that items listed at the end of a list are better remembered than items listed in the middle. The *primacy* effect is the opposite, meaning that items listed at the beginning are better remembered than items in the middle. The recency bias causes investors to extrapolate recent patterns and make projections based on historical data sample that are too small to ensure accuracy. It also causes investors to ignore fundamental value and focus on recent prime performance. Furthermore, investors tend to neglect historical facts, although similar patterns have been observed. People also tend to ignore proper asset allocation by focusing on "hip" or "en vogue" assets.

Emotional Errors

Emotions are related to feelings, perceptions, or beliefs about elements, objects, or relations between them. Emotional biases stem from impulse, intuition, and feelings, and they may result in personal and unreasoned decisions. Whereas the cognitive biases were based on faulty cognitive reasoning, such as basic statistical, information processing, or memory errors, the emotional errors are based on impulse or intuition, and they arise as a result of attitudes and feelings. The separation between cognitive biases and emotional errors allows us to get an understanding of how to control or avoid these errors. The cognitive errors might be corrected using bias mitigation techniques, while the causes of emotional errors are deeper and harder to combat.

Loss aversion bias was developed by Kahneman and Tversky in their prospect theory. People tend to feel a stronger impulse to avoid a loss than to acquire gains. On average, people psychologically feel the possibility of a loss as twice as powerful a motivator as the possibility of a gain of equal magnitude. This loss aversion might lead investors to hold losing investments too long, in the hope of getting back what they have lost. However, this will often lead them to hold unbalanced portfolios, and their unwillingness to sell may lead to suboptimal return when considering a long-term goal with proper asset allocation. Furthermore, it may cause the investor to sell winners too early in the fear that their profit will evaporate unless they sell, thus limiting upside potential and possibly leading to too much trading. Investors also take more risk by not eliminating the loser, but only the winning stocks.

A specific type of loss aversion is the *myopic loss aversion* people show. As people are usually not able to look at the full length of their investment horizon, they will typically build in some evaluation points before the end of their investment horizon, potentially leading to false judgments on the performance of their portfolio. Due to the random nature of short-term investments, investors might experience many days of losses over their shorter horizons, wrongly leading them to eliminate certain positions. The equity premium puzzle can be explained using the loss aversion bias. The empirical fact is that the equity premium equals 6.18%, which is too high to be justified by risk aversion alone. Part of this premium can be explained by people being loss averse, and too frequent evaluations of their wealth position. Although losses only become truly losses at the end of the horizon, people typically hate losses and rebalance their portfolio as they don't accept the fact that short-term variability will not hurt them in the long run. People thus require a higher premium to accept this return variability. Thus, if your investment horizon is 10 years, theoretically it does not matter that after 1 year one of your stocks is down 50%, there is more than enough time for that stock to recover. However, due to Myopic loss aversion, people most likely sell that stock, because they fear that it will matter in the end.

Overconfidence is unwarranted faith in one's intuitive reasoning, judgments, and cognitive abilities. People tend to think they are smarter and have better information than they actually have. It is also the tendency for people to overestimate their knowledge, abilities, and the precision of their information, or to be overly sanguine of the future and their ability to control it. Confidence is all about having a positive feeling about your skills, knowledge, etc. Overconfidence, however, is when you have an inflated sense of your abilities. When investors are asked to provide a certain confidence interval for their investment prediction, their range is typically too narrow. This shows that investors tend to overestimate their knowledge (ability to estimate/forecast), and that they tend to believe that their knowledge is more precise than it really is.
The *better than the average effect* is the tendency to have too much accuracy in your own judgments. People typically are overconfident in their own skills, although this is good for their motivation as feeling better than the average increases the self-esteem.
Excessive optimism is another way in which overconfidence expresses itself. People generally assign probabilities to favourable outcomes that are generally too high given historical experience. This also leads to the *planning fallacy*, as people tend to procrastinate their duties because they believe they have enough time to accomplish a task until a certain deadline is due. The overconfidence bias causes the investor to: overestimate their ability to evaluate an investment; become blind to any negative information; trade excessively; believe to have superior or special knowledge that others don't have; underestimate downside risk neglecting historical and fundamental information; under-diversify their portfolios; take more risk. Investors overestimate the precision of their own private signals, leading them to drive prices away from the equilibrium price. When the true value is revealed in the second period, prices adjust back towards the equilibrium price. This gives an argument for negative serial correlation in prices, also known as reversal.
Miscalibration is overconfidence in the sense that your confidence interval is too narrow (you believe your estimate is too accurate).
Over-placement is the belief that you are better in performance in comparison to others.

Self-control bias is the tendency that causes people to fail to act in pursuit of their long-term, overarching goals because of a lack of self-discipline. Some typical investment mistakes that are caused by the self-control bias are as follows. Investors spend more money today at the expense of savings for tomorrow, and thus fail to plan sufficiently for retirement. When realising that they haven't save enough, the investors might have an inappropriate degree of risk in their portfolios. The bias typically leads to investors failing to make proper use of financial principles (such as compounding interest).

Status quo bias is the manifestation of loss aversion in a riskless context. It's an emotional bias that predisposes people facing an array of choice options to select whatever option ratifies or extends the existing condition in lieu of alternative options that might bring about change (you would like to keep things as they are). The more choices a person gets, the bigger the pull factor the status quo has. In business, where sins of commission (doing something) tend to be punished much more severely than sins of omission (doing nothing). The status quo thus holds a particularly strong attraction. The status quo bias causes investors to not take action and hold securities with which they feel familiar or of which they are emotionally fond. When investors face the opportunity to reallocate their portfolio, investors might stick to the status quo to reduce potential regret, which is in line with loss aversion. This also applies to organ donor ship. There are two possibilities: automatically enrolment or you have to specifically sign up for organ donor ship. So, you either have to opt in, or you have to opt out. In countries where you are automatically enrolled for organ donor ship, the level of organ donor ship is way higher (between 90 and 100%) in comparison to 10-30%. People are lazy, so they just stick to the status quo.

Endowment effect is the tendency to value an asset more when holding the property rights to it than when not holding the property rights. The willingness to pay (WTP) is lower than the willingness to accept (WTA) for the same object. It is a mental process in which a differential weight is placed on the value of an object. When giving something away you get a loss feeling, while when receiving something you get a gain feeling. Because losses loom larger than gains (loss aversion), the higher value is felt when holding property rights to an object. This is somewhat in line with the status quo effect. The implications of the endowment effect are that people treat opportunity costs differently than out-of-pocket expenses, and forgone gains are less painful than perceived losses. Rational economic theories expect that the WTP equal WTA, but the endowment effect may influence the value that an investor assigns to a recently purchased security, and after the investors buys the security, they will demand a higher selling price, exceeding the original purchase price. Investment mistakes coming forth from these are that investors hold onto securities that they inherited, regardless of whether retaining those securities is financially wise; behaviour is often result of the "heirs' fear", stating that selling will demonstrate disloyalty to prior generations, selling will trigger tax consequences; holding on to securities that you purchased, demanding an irrational premium on the compensation price in exchange for the disposal of an endowed asset; investors believe to be familiar with the characteristics of the investment.

Regret aversion is the tendency to avoid taking a decisive action because you fear that, in hindsight, what ever course you select will be less than optimal. People try to avoid the emotional pain of regret associated with poor decision making, and while suffering from regret aversion, people generally hesitate most at moments that actually merit aggressive behaviour. Regret aversion doesn't necessarily come into play following a loss fear of selling a climbing stock too early and forgoing a higher gain. People who are regret averse try to avoid distress arising from two types of mistakes, error of commission (purchasing an asset that loses value), and error of omission (not buying an asset that gains value). According to regret theory, people not only base their decisions on expected payoffs, but also on expected regret. Regret aversion can cause investors to: be too conservative in their investment choice; shy away from making bold investment decisions to avoid too high regret (especially after a former loss); only accept low-risk positions (long-term underperformance); shy away, unduly, from market that have gone down, regretting to make a wrong decision when prices go down even further; hold on to losers too long, selling will lead regret to occur immediately (if you sell it and it will go up, you will regret it). Furthermore, it might cause investors to "follow the herd", making similar decisions as others do, because mass consensus limits the potential for future regret. If everybody makes the same mistake, your mistake feels worse.

Affinity bias is the tendency to make irrationally uneconomical investment decisions based on how you believe a certain product or service will reflect your values. Products usually have two types of values, expressive/image-related values, a "personality" for a product; and utilitarian/functional values, the beneficial function of the product. People suffering from the affinity bias will focus on the value-expressive characteristics rather than utilitarian benefits. One of the sub-categories of the affinity bias is the *equity home bias*, which is the tendency to hold modest amounts of foreign equity although observed returns on national equity portfolios suggest substantial benefits from international diversification. The affinity bias causes investors to invest in companies they like, such as home country, green, etc. They however do not examine carefully enough the soundness of the investment characteristics. *Patriotism:* Patriotic investors discriminate in favour of domestic stocks. Patriotic regions invest less in international equities than investors in less patriotic regions. When France said they would not participate in the Iraq war, US demand for French stocks declined significantly.

Ambiguity aversion is the tendency to prefer known risk rather than unknown risk. It is also called uncertainty avoidance. Knightian uncertainty: “uncertainty must be taken in a sense radically distinct from the familiar notion of risk … It will appear that a measurable uncertainty [risk] is so far different from an unmeasurable one that it is not in effect an uncertainty at all.” People seem to prefer the familiar to the unfamiliar, but this does not hold for ambiguous situations. Ambiguity might be categorised as an emotional error as it reflects the tendency of emotions to influence choice in risky situations. Ambiguity aversion is a further explanation for the equity premium puzzle, as investors require a higher equity premium on the market, because the odds at the stock market are estimated on historical values, while the odds in the casino for example, can be mathematically calculated. It can also explain the home bias puzzle a bit further, as the ambiguity about foreign countries will lead people to be more reluctant to invest in those countries.

What to know for the exam

- identify and distinguish the different BF key concepts
- apply BF key concepts to financial decision making
- discriminate between BF key concepts and traditional finance concepts
- research BF key concepts using assigned topics
- apply selected data analysis tools, in particular non-parametric tests
- identify and apply basic concepts of experimental finance

Nijmegen, except and only to the extent provided in regulations of mandatory law, unless indicated otherwise.

Tips and remarks about the summary can be send to secretaris@esvnijmegen.nl.