### Mean-variance optimisation

**Concepts**
- **Mean-variance optimisation (MVO)**: identify portfolio allocations that maximise return for every level of risk

**Assumptions**
- Assume investors are risk adverse → prefer more return for the same level of risk

**Approach to find the most efficient portfolio**:

- Utility maximisation: \( U_i = E(R_i) = 0.5 \times \lambda \times \text{Var}_i \)
- \( U_i \) = investor's utility from investing in portfolio with asset allocation \( i \)
- \( E(R_i) \) = expected return of portfolio with asset allocation \( i \)
- \( \lambda \) = investor’s risk aversion coefficient
- \( \text{Var}_i \) = variance of portfolio with asset allocation \( i \)

- \( \lambda \): Investor's preference for risk - return trade off
  - Higher expected return for same level of risk: Higher \( \lambda \)
  - Lower expected return for same level of risk: Lower \( \lambda \)
  - Range of \( \lambda \): From 1 to 30, with risk neutral investor's \( \lambda = 0 \).
  - Average \( \lambda = 4 \)

**Common constraints**:
- Budget constraints/utility constraint: Sum of weights of all asset classes = 100%
- Non-negativity constraint: Weight of each asset class is between 0% and 100%

### Criticisms of MVO

1. **Garbage-in-garbage-out (GIGO)**: Quality of output is sensitive to quality of inputs
2. **Concentrated asset allocation**: MVO often identifies efficient portfolios that are highly concentrated in a subset of asset classes, and zero allocation to others → lowest standard deviation does not mean diversification
3. **Skewness / Kurtosis**: Asset returns are not normally distributed, but MVO ignores skewness and kurtosis
4. **Risk diversification**: MVO diversifies asset allocation across asset classes, but may not diversify sources of risk
5. **Ignore liabilities of investors**
6. **Single-period framework**: Ignore interim CF/skew/correlation of asset returns from each period → ignore potential costs/benefits of rebalancing

### Improve inputs quality - Reverse optimisation

**Black Litterman model**: extension of reverse optimisation, with implied returns are adjusted to reflect investor’s view of future returns

**Black Litterman model**

**Inputs**
- Assumed optimal asset allocations
- Variances
- Covariances (Correlation)
- Risk aversion factor

**Reverse MVO**
- Maximise utility

**Output**
- Adjusted implied returns
- Variances
- Covariances (Correlations)

### Black Litterman model

**Inputs**
- Revised optimal asset allocations
- Portfolio expected return

**Reverse MVO**
- Maximise utility

**Output**
- Adjusted implied returns
- Variances
- Covariances (Correlations)

### Improve inputs quality - Add more constraints

**Adding more constraints**: to include / exclude certain asset classes

**Examples**:
- Specify a fixed allocation to one or more assets (e.g.: human capital, nontradable assets)
- Set asset allocation range for asset class
- Set upper limit allocated for asset class to address liquidity issues
- Specify relative allocation between 2 or more classes
- Include constraints to require allocation to assets that hedge the liability in liability-relative setting

### Improve inputs quality - Resampled MVO

**Step 1**: Best estimates of expected returns, sigma, correlation → MVO → Efficient frontier of Optimal allocations

**Step 2**: Monte Carlo simulations to generate random variations for inputs around initial estimates → Efficient frontier + asset allocation for each point in the frontier

**Step 3**: Average simulated efficient frontier + asset allocation

### Improve inputs quality - Non-normal distributions (Skewness and Kurtosis)

Directly incorporate skewness / kurtosis in utility function, using asymmetric definition of risk (Value-at-Risk) instead of variance
Approaches to Tactical asset allocation

1. Discretionary:
   - Rely on qualitative assessment of macroeconomic variables
   - to increase returns in rising market + hedge risks in falling markets by forecasting ST deviations from expected returns for an asset class
   - Data to be used:
     - Macroeconomic data: bond yield, credit spreads, monetary policy, GDP growth, earnings, inflation
     - Fundamental data: deviation of PB / PE / dividend yield from historical means
     - Economic sentiment: using consumer confidence index
   - Assess of market sentiment:
     - Margin borrowing: ↑ margin purchase → ↑ price → bullish; margin purchase too high → bearish sign
     - Short interest: ↑ short interest → ↓ price → bearish; very high short interest → market is at low
   - Volatility index: calculate using bid-ask spread on index option, indicate fear level. More put purchase → increase volatility; more call purchase → decrease volatility

2. Systematic approach: earn excess return using strategies with predictable + persistent history

3. Value approach: earn excess return of value stocks over growth stocks
   - Value equities: identified using dividends yield / CF yields
   - Value currencies: identified using ST interest rate difference
   - Value commodities: identified using roll yield
   - Value fixed income: identified using yield spread over risk free rate

4. Momentum approach: assume trend will persist
   - Most recent 12m trend: assume this trend will persist for the next 12m
   - Moving-average crossover: ST moving average cross above LT moving average → uptrend; and vice versa

Behavioral issues

1. Loss aversion: dislike same loss > like same gain
   - Solution: goal-based investing (high priority goal is funded with less risky assets, and vice versa)

2. Illusion of control: overestimate the ability to control events
   - Frequent trading / tactical allocation for market timing
   - Actively security selection by instutional investors, who believes that their resources give them superior asset selection skills
   - Above average use of short selling and leverage
   - Shift assets allocation without consensus opinion
   - Concentrated position → not diversify
   - Use biased risk/return forecasts → inappropriate allocation
   - Solution:
     - market portfolio should be created from basic CAPM mean-variance
     - Allocation shift should have formal review process

3. Mental accounting: separate assets/liabilities to different groups based on subjective criteria → suboptimal asset allocation + mismatch of asset goals
   - Solution: goal-based investing

4. Representative bias / Recency bias: perceive recent data more important than old data → shift allocations towards that have performed well recently
   - Solution: strong governance + objective asset allocation process

5. Framing bias: the way information is presented affect the decision
   - Solution: provide full range of relevant information. E.g.: Risk (standard deviation, VaR, shortfall probability)

6. Availability bias: personal experience is more influenced in decision making

7. Familiarity bias: familiar event → more influenced in decision process

8. Home bias: over allocate in domestic securities → missing opportunities in international securities

Investment governance

Effective framework:

- Clear ST + LT objectives
- Logical allocation of responsibility for asset allocation based on skills and workload
- Process for develop + approve IPS
- Process for develop + approve strategic asset allocation
- Framework to monitor + report performance relative to specified goals / objectives
- Periodic audits
### Factors for / against fully hedge

1. Short time horizon → hedge
2. High risk aversion → hedge
3. Client with no concern of opportunities costs → hedge
4. High ST income needs + high liquidity needs → hedge
5. Significant foreign currency bond exposure → hedge
6. Low hedging costs → hedge
7. Client with doubt of benefits of discretionary management → hedge

### Active strategies

#### Economic fundamentals

1. Assumptions: Currency value will return to fair value in LT
2. Factors that increase value of currency in ST:
   - Currency is undervalued relative to fundamental value
   - Currency with highest rate in increase of fundamental value
   - Currency with higher real / nominal interest rates
   - Currency with lower inflation
   - Currency with decreasing risk premium

#### Technical analysis

1. Principles:
   - Past price data reflect fundamental + other information → could predict future price movement
   - Human react similarly to similar events → past price pattern will repeat
   - Only necessary to know where the currency will trade. Not necessary to know its fundamental value
2. Typical patterns:
   - Overbought / Oversold: market has gone too far up / down → price will reverse
   - Support level: price falls to support level will reverse + bounce higher
   - Resistance level: price rise to resistance level will reverse + bounce lower
   - If market break through resistance / support level, the current trend will continue
   - Moving average: ST moving average cross LT moving average → trigger signal

#### Carry trade

1. Definition: borrow @ lower interest rate currency + invest @ higher interest rate currency
2. Uncovered interest rate parity:
   \[ \frac{F}{S} = \frac{1 + i_d}{1 + i_f} \]
   - Currency with higher interest rate → Decrease in value → trade @ forward discount
   - Currency with lower interest rate → Increase in value → trade @ forward premium

**Goal:** Carry trade exploits violation in UIPR. In fact:
- Higher interest rate currency depreciation < predicted by UIPR → carry trade contract
- Small % of time (e.g.: hyperinflation, economic crisis), higher interest rate currency depreciate much more than predicted in UIPR → carry trade suffer large loss

### Volatility trading

1. Definition: earn profit from predicting changes in volatility of currency
2. Term:
   - Delta: change in option price due to change in underlying value
   - Vega: change in option price due to change in volatility of underlying
3. Method:
   - Delta hedging: create delta-neutral position (δ = 0) → option price only changes with change in volatility, not with change in underlying price
   - Expect volatility to increase → long straddle (long at-the-money call + put)
   - Expect volatility to decrease → short straddle (short at-the-money call + put)

### Advantages of forward over future in currency hedging

- Can be customised (future are standardised)
- Available for nearly all currency pair (future only available or limited number of currencies)
- Future require margin → more complex + require periodic CF
- Trading volume of forward is much more than futures → more liquidity

### Static hedge / Dynamic hedge

**Static hedge:** no rebalance
**Dynamic hedge:** rebalance periodically

#### Methods for dynamic hedge:
- **Method 1:** purchase 1-month forward contract + rollover at expiration → Realise G/L + CF settlement @ expiration → hedge is static over the month but dynamic at rollover
- **Method 2:** long/short forward contract for the remaining period

#### Considerations:
- Shorter-term contracts / Dynamic hedge with frequent rebalancing → higher transaction costs, but better hedging results
- Higher risk aversion → more rebalancing
- Lower risk aversion + strong manager view → allow greater discretion around strategic hedging policy
### Concepts

<table>
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<td>Risk deduction / Risk management process / Risk governance</td>
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<td>Risk reduction: recognise + reduce / eliminate / avoid unnecessary risks</td>
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#### Risk management process:
- Top level management set policies + procedures to manage risk
- Define risk tolerance to various risks
- Measure current level of risk
- Adjust level of risk (upward where firm has advantage \(\rightarrow\) increase return; downward in other cases)
- Execute transactions to change level of risk
- Identify most appropriate transaction for any given objective
- Consider cost of any transaction
- Execute transaction

#### Risk governance:
- Develop & apply risk management system. Risk governance should be (1) transparent, (2) create clear accountability, (3) cost efficient, (4) effective in achieving desired outcomes
- Decentralised risk governance system: Each unit is responsible to execute
- Centralised risk governance system (Enterprise risk management - ERM): 1 central unit is responsible to execute

### Value at Risk (VaR)

\[ \text{Value at Risk (VaR)} = - \frac{\text{Average annual return}}{12} \]

\[ \text{Monthly VaR} = \text{Value at Risk} \]

\[ \text{Weekly VaR} = \text{Value at Risk by 52} \]

\[ \text{Daily VaR} = \text{Value at Risk} \]

#### Financial risks / Nonfinancial risks

1. Financial risks
   - Market risk: risk related to change in interest rates, FX rate, equity price, commodity price, etc. \(\rightarrow\) tie to market supply / demand
   - Credit risk: Counterparty / debtor fail to make promised delivery
   - Liquidity risk: possible loss from inability to liquidate a position quickly at fair price: Indicators include:
     - Bid-ask spread: apply for small transactions only
     - Average / Typical trading volume

2. Nonfinancial risks
   - Operational / Operations risk: Loss due to failure of company's systems / external events outside of company's control
   - Settlement risk: when funds are being exchanged, one party could make a payment, while other party in the process of completing and fail to deliver
   - Model risk: models are only as good as their construction and inputs
   - Sovereign risk: Ability of the government to pay + Willingness of the government to pay the obligations
   - Regulatory risk: not clear how the transaction will be regulated / not sure if the transaction is legal
   - Tax, Accounting, Legal / Contract risk: Tax, Accounting and Legal risk in the transaction stage
   - Political risk: risk related to change in government
   - ESG risk: company decision may cause environmental / social issues / poor governance policies
   - Performance netting risk: A owe B, B owe C, C owe D \(\rightarrow\) A default trigger a chain of default
   - Settlem nt netting risk: Ability of the government to pay + Willingness of the government to pay the obligations

### Value at Risk (VaR)

#### VaR computation

1. **Analytical VaR**
   - Based on normal distribution + one-tail confidence intervals
   - VaR = (\(R - z \times \sigma\)) \times V
   - Monthly VaR = Divide annual return by 12
   - Weekly VaR = Divide annual return by 52
   - Daily VaR = Return = 0

   - **Advantages**
     - Single number \(\rightarrow\) Easy to understand
     - Allow modelling correlations of risks
     - Can apply for shorter / longer time periods
   - **Disadvantages**
     - Mostly related to assumption that returns are normally distributed
     - May have skewed return. Long option \(\rightarrow\) positive skew (small frequent losses of premium + large occasional gain of deep in-the-money). Short option \(\rightarrow\) negative skew
     - May have higher number of extreme return events than normal distribution \(\rightarrow\) fat tails

2. **Historical VaR**
   - Calculate 5% VaR = collect past return, rank from highest to lowest \(\rightarrow\) identify lowest 5% returns

   - **Advantages**
     - Easy to calculate + understand
     - Not assume normal distribution of returns
     - Can apply to different time period
   - **Disadvantages**
     - Assume that past pattern will repeat in the future. Many securities change characteristics over time

3. **Monte Carlo VaR**
   - Use software to generate possible outcomes \(\rightarrow\) rank from highest to lowest \(\rightarrow\) determine results at any given probability

   - **Advantages**
     - Can use any assumptions about return, correlation, etc
   - **Disadvantages**
     - Output is only as good as input
| Equity performance attribution: Macro attribution | 1. 3 main inputs:  
- Policy allocation: sponsor determine assets categories + weight + allocation of total fund among fund managers, based on risk tolerance, LT expectations and liabilities  
- Benchmark portfolio returns: broad market index = benchmark for asset categories; Narrowly focused index = benchmark for investment style  
- Fund returns, valuations, external CF |
| --- | --- |
| 2. 6 sources of changes in MV of fund:  
- Net contributions: external CF made by clients → change in MV, but no value added / value lost  
- Risk-free investment: Fund's return if beginning value and external CF grow at risk free rate  
- Asset categories: Fund's return if beginning value and external CF passively replicate strategic asset allocation with index fund (asset category benchmarks weighted = fund’s strategic policy)  
- Benchmark level: Fund's return if beginning value and external CF are invested in manager benchmarks (tactical asset allocation by sponsor)  
- Investment managers / Active management: Fund's return due to manager not perfectly implemented the policy allocation |
| Incremental return for asset category strategy = $R_{AC} = \sum_{i=1}^{m} (w_i) \times (R_i - R_f)$ |
| Incremental return for benchmark strategy = $R_B = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i \times w_{i,j} \times (R_{b,i} - R_{b,j})$ |
| Incremental return for the investment manager level = $R_H = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i \times (R_{m,i} - R_{m,j})$ |
| Allocation effects: residual returns |
| Equity performance attribution: Micro attribution | Value added return = Portfolio return - Benchmark return = Pure sector allocation + Within-sector allocation + Allocation/Selection interaction |
| 1. Pure sector allocation: performance attributed to difference in sector weighting between portfolio and benchmark  
- Assume manager holds same sectors as benchmark + same securities and securities weight in each sectors  
  \[ Pure \text{ sector allocation} = \sum_{i=1}^{n} (w_{o,i} - w_{b,i}) \times (R_{b,i} - R_{f}) \] |
| 2. Within-sector allocation: impact on performance due to security selection only  
- Assume manager hold same sectors and sector weight as benchmark  
  \[ Within - sector \text{ selection} = \sum_{i=1}^{n} w_{b,i} \times (R_{b,i} - R_{f}) \] |
| 3. Allocation/Selection interaction: joint effect of assigning weights to both sectors and individual securities  
  \[ Allocation - Selection \text{ interaction} = \sum_{i=1}^{n} (R_{m,i} - R_{b,i}) \times (w_{m,i} - w_{b,i}) \] |
| Fundamental factor models vs. Micro Attribution | Strengths  
- Split performance between sectors allocation and securities selection  
- Easy to calculate  
- Need to identify appropriate benchmark (with specified securities and weights) at start of the period  
- Security selection will affect sector weighting |
| Limitations  
- Need to determine exposures to factors at the start of the period  
- Complex |
| Fixed income performance attribution | 1. Changes in external interest rate environment: portfolio return due to shifts and twist in Treasury yield curve → beyond manager's control → not being evaluated  
- Expected interest rate effect: portfolio return if interest rate changes in accordance to forward curve (as planned)  
- Unexpected interest rate effect: portfolio return due to changes in forward rates (not as planned)  
- Manager's contribution: value added/lost due to manager's decision  
- Interest rate management effect: manager's ability to forecast changes in interest rates + adjust portfolio duration and convexity accordingly  
  + Subdivision: (1) duration, (2) convexity, (3) yield-curve shape effects  
- Sector/Quality management effect: portfolio return due to change in yield spreads of actual sectors (C-bond, T-bill) + quality of assets (Investment grade, junk bond) in the portfolio  
  + E.g.: Hold C-bond, C-bond spread narrow → portfolio outperform T-bill only simulation  
- Security selection effect: portfolio return due to change in yield spread of actual securities held  
- Trading effect: residual return |
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<td>- Study shows no serial correlation between past prices ad subsequent changes  \rightarrow consistent with weak form</td>
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<td>- Majority of professional mutual fund managers have negative alpha (negative excess returns) \rightarrow consistent with semi-strong form</td>
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<td><strong>3. Challenges</strong> :</td>
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<td>\rightarrow violate all 3 form of EMH</td>
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<tr>
<td>- Traditional finance : investor can save + invest in early stages for early retirement \rightarrow require self-control</td>
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<tr>
<td>- Behavioral finance : investor mentally account for wealth = current income + currently-owned assets + PV of future income</td>
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<tr>
<td>+ individual more likely to spend from current income than current assets/future income</td>
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<td><strong>2. Behavioural asset pricing</strong> :</td>
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<tr>
<td>- Discount rate = risk free rate + fundamental premium + Sentiment premium</td>
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<td>- Sentiment premium : additional premium based on individual’s opinion</td>
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<td><strong>3. Behavioural portfolio theory</strong> : individuals construct portfolio by layers. Each layer has different expected return and risk. Allocation of funds in each layer depends on :</td>
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<tr>
<td>- Importance of each goal : high return goal is important \rightarrow allocate in high return layer ; low-risk goal is important \rightarrow allocate in low risk layer</td>
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<td>- Asset allocation : done by layer, based on the goal of that layer</td>
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<td>- Number of assets in each layer : based on investor’s risk aversion. Risk-averse \rightarrow larger number of assets in a layer</td>
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<td>- Investor believes they have advantage information \rightarrow more concentrated position</td>
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<td>- Loss-averse investors \rightarrow larger cash position to avoid having to sell at loss to meet liquidity needs</td>
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<td>\rightarrow Overall portfolio : diversified, but sub-optimal (no consideration to correlation between stocks/layers)</td>
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<td><strong>4. Adaptive markets hypothesis</strong> : investment success is due to evolution. No adapt \rightarrow no survive</td>
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<td>- Assumption : investors satisfy, rather than maximize</td>
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<td>- If investors feel they have sufficient information \rightarrow decision to reach goals \rightarrow necessary optimal decision</td>
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<td>- If more people apply same rules \rightarrow information reflected in market prices, impact on expected return</td>
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<td>\rightarrow Overall strategy would work all the time</td>
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<td>\rightarrow Adapt + innovate is must have to continue success</td>
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<td>\rightarrow Survivors change + adapt</td>
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**Challenges** : |
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  + abnormal return for small-cap stocks  |
\rightarrow violate both semi-strong form and strong form |
- Technical anomalies : studies show that |
  + ST moving average above (below) LT moving average \rightarrow buy (sell) signals |
  + Stock rise above resistance level \rightarrow buy signal ; stock price drop below support level \rightarrow sell signal |
\rightarrow violate all 3 form of EMH |
- Calendar anomalies : stocks have abnormally high returns in Jan, last day of each month, and first 4 days of each month \rightarrow violate all forms of EMH
### Effect of Behavioural Factors on Analyst's Forecast

1. **Overconfidence**
   - **Reasons**:
     - Illusion of knowledge bias
     - Illusion of control bias
     - Representativeness: judge the probability of a forecast being correct by how the available data fit the outcome → incorrectly combine 1) probability that the data fit a category and 2) probability that the category fit the conclusion
   - **Solutions**:
     - Self-calibration: get immediate feedback via self-evaluations, colleagues, superiors
     - Always seek for counter-argument
     - Consider sample size: small samples → unreliable models
     - Apply Bayes' behavioural biases

2. **The Way Management Presents Information**
   - **Reasons**:
     - Framing: digest same information differently, depend on how it is presented
     - Anchoring & adjustment: anchor to previous forecast
     - Availability bias: data that is easier to recall → more likely to overstate results
     - Recalculate earnings
   - **Solutions**:
     - Focus on verifiable, comparable quantitative data rather than subjective information
     - Check that the information is framed properly
     - Recognise appropriate starting point for data

3. **Analyst Biases in Research**
   - **Reasons**:
     - Confirmation bias: look for confirming information, ignore contradict information
     - Gambler's fallacy (e.g.: in case of tossing a coin, there is 50/50 chance of head or tail. Gambler's fallacy means that if there is a streak of head, gamblers starts to feel an increased chance of tail)
   - **Solutions**:
     - Incorporate new information
     - Apply Bayes' formula
     - Seek contradict information
     - Get prompt feedbacks

### Impact of Behavioural Biases on Investment Committee

1. **Effect**
   - Social proof bias: follows the beliefs of a group → uncomfortable expressing opinion that differs from others
   - Committees includes people with similar background → same point of view on problems

2. **Solutions**
   - Comprise people with different background
   - Comprise members who are not afraid of expressing different opinion
   - Committee chair should encourage members to speak out
   - Mutual respect for all members

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   - **Reasons**:
     - Confirmation bias: look for confirming information, ignore contradict information
     - Gambler's fallacy (e.g.: in case of tossing a coin, there is 50/50 chance of head or tail. Gambler's fallacy means that if there is a streak of head, gamblers starts to feel an increased chance of tail)
   - **Solutions**:
     - Incorporate new information
     - Apply Bayes' formula
     - Seek contradict information
     - Get prompt feedbacks

4. **Values vs. Growth**
   - **Fama and French**: value stock outperform growth stock; Small cap stocks outperform large cap, due to higher risk exposure of companies with particular size and B/V ratio (not reflect in the pricing model)
   - **Other studies**: due to behavioural biases
     - Halo effect: companies with favorable attributes (good record of growth + price performance) → good investment + continued high expected return → good buy
     - Home bias: investor favor domestic securities