Factor Theory

- Factors
  - Market, interest rate, investing styles (value/growth, low volatility, momentum)
  - Fundamental: macroeconomic factors: inflation, economic growth
- Factor risk
  - Exposures to **bad times**, and must be compensated for with risk premium
- Principles
  - **Factors** are important, not assets
  - **Assets** represent bundles of **factors**
    - Equity and government bonds – can be factors
    - Corporate, private equity, hedge funds contain many factors
  - Investors have **differing** optimal risk **exposures**
    - Volatility, economic growth
- CAPM
  - **Covariance** with market portfolio, beta = cov(x,M) / Var(M)
  - Hold the factor, not individual asset
    - Mean-variance efficient portfolio, efficient frontier
    - Capital allocation line (CAL)
    - Mean-variance efficient (MVE) market portfolio, Sharpe ratio
  - Investors have their **own** optimal factor risk exposures
    - Along CAL, a combination of MVE and risk-free
  - **Average** investor is **fully** invested in the market
    - 100% hold MVE
  - Exposure to factor risk must be rewarded
    - When all investors invest in the same MVE, CAL -> capital market line (CML)
    - $\mathrm{E}(\mathrm{R_M}) - \mathrm{R_F} = \gamma \times \sigma_M^2$
      - $\mathrm{E}(\mathrm{R_M}) - \mathrm{R_F}$ is market risk premium
      - γ is sthe risk aversion
  - Risk is measured as **beta** exposure
    - SML
    - $\mathrm{E}(\mathrm{R_i}) - \mathrm{R_F} = \beta_\mathrm{i} \times (\mathrm{E}(\mathrm{R_M}) - \mathrm{R_F}) = \gamma \times cov(R_i, R_M)$
    - Higher beta -> lower diversification benefits
  - Valuable assets have **low** risk premium
  - Losses during low market returns -> high beta and should have high risk premiums
  - **Positive** payoff when market performs poorly, valuable -> **low beta -> lower expected return**
- CAMP limitations
  - Break in illiquid, inefficient markets
  - Investors only have **financial** wealth
    - Income and liability
  - Investors have **mean-variance** utility (symmetric)
    - Asymmetric view of risk, disliking losses
  - Investors have a **single** period investment horizon
    - Optimal is rebalance, multi-period strategy

    - Investors have **homogeneous** (identical) expectations
        - Have heterogeneous
    - Markets are **frictionless** (no taxes or transaction costs)
        - Illiquid, cost is high
    - All investors are price **takers**
        - Investors are price setters, large trade on special knowledge and move the market
    - Information is free and available to everyone
- Multifactor models
    - Arbitrage pricing theory (APT)
- Pricing kernels
    - Bad times over multiple factors using a pricing kernel, SDF
    - Index of bad times
        - $\mathrm{m} = \mathrm{a} + \mathrm{b} \times \mathrm{R_M}$
    - predict asset price
        - $\mathrm{P_i} = E[m \times payoff_i]$
    - Marginal utility
- EMH
    - **APT**
        - Systematic factors cannot be removed, and should be compensated
    - **Market near-efficient and information is costless**
        - Active managers search for inefficiency in illiquid market -> make it more efficient
        - Circular argument: free -> no need to collect -> not fully reflected in price
    - **Market efficiency**
        - Beat market by saving txn costs
        - Identify areas of inefficiency
    - Vs CAMP
        - imperfect information, various costs, behavioural biases
    - Behavioural
        - Rational: **losses during bad** times -> high return
            - Not bad for all (short)
        - Behavioural
            - Agents' **reaction** (under/over) -> high return
            - Barriers to the entry of capital make it difficult
                - Structural barriers (investors cannot, persist for long)
                - Regulatory barriers (minimum credit rating)

Factors

- **Compensate losses in bad times**
- Economy-side
    - Inflation, volatility, productivity, economic growth, demographics
- Tradable investment style
    - Value investing, small size investing, momentum
- Value-growth
    - Book-to-market (B/P, net asset/shares, price per share)

    - Long value short growth
- Macro-Economic
    - Not the level of factors but the **shocks**
    - Growth, inflation, volatility
    - Growth
        - **Business cycle (expansion), High real GDP and high consumption**
        - recession
            - Equity -> worse, bonds -> well
            - Can weather a downturn -> buy equity -> good in long term
            - Cannot bear losses -> buy bond -> worse in the long
        - Expansion
            - Equity (small > big) > bond
            - High-yield bond (indifferent, slighter higher)
    - Inflation
        - Bad for stock and bond
        - Inflation lowers real bond return
    - Volatility
        - Inverse
        - Leverage effect
            - **Increased volatility increase leverage because**
            - Equity market value fall, debt stays approx. the same
            - Leverage increase, equity risker and volatility increase
        - Two paths to lower return for high volatility
            - leverage effect -> negative relationship
            - CAPM: volatility -> discount increase -> stock price decline -> future return higher (compensate)
    - Other
        - Productivity shocks: positive correlation
        - **DSGE**: investment, preferences, inflation, monetary, spending, labor supply
        - Demographics: a shock to labor output
        - OLG: overlapping generation.
        - Risk aversion increases with age, average age increase, equity risk premium increase
    - Political risk: once thought in emerging market. But affected both developed and undeveloped countries
- Volatility risk
    - Invest in less volatile asset link bond
    - **Buy put options**: out-of-money put
- Volatility premium
    - Asset have positive premium -> long it
    - Volatility have **negative** premium -> short out-of-money put
        - But it can have massive loss in crisis
        - Only who can withstand massive losses should sell
- Dynamic risk factors
    - Macro factors (except volatility) are **not** tradeable
    - **Tradeable** mode Fama and French model

    - MKT, SMB, HTML
        - MKT -> average around one, SMB&HML: average around zero
- SMB (disappear reasons)
    - Data mining
    - Investor actions
        - Bid up prices of small-cap stocks
    - Maybe illiquid
- Value investing (HML, value-growth)
    - Value premium explanation
    - Rational
        - Beta increase during bad times
        - Value: old firms, most in fixed asset
        - High and asymmetric adjustment cost
    - Behaviour
        - **Overextrapolation and overreaction**
            - Overextrapolation: past growth will continue
            - Expect high -> bid up prices
            - once fail to meet, prices drop -> lower return
        - **Loss aversion and mental accounting**
            - More like gains over losses
            - Consider case-by-case rather on portfolio
    - Strategy
        - Riding the yield curve
        - Roll return
        - Carry in exchange
- Momentum/trend Investing
    - WML, UMD
    - Negative feedback: value investing
    - Positive feedback: momentum
    - Risk
        - Destabilizing, can lead to crash
        - Monetary and government risk
        - Macro factors
    - Explanation
        - **Overreaction** to good news
            - Overconfidence -> overreact -> push up prices
        - **Underreaction** to good new

Alpha

- Excess return/active return
    - $R_t^{ex} = R_t - R_t^b$
- Alpha
    - $\sigma = \frac{1}{T}\sum R_t^{ex}$
- Tracking error (std of excess return)
    - $\sigma = STD(R^{ex})$
- Information Ratio

- $\mathrm{IR} = \frac{\alpha}{\sigma}$
- When benchmark is risk-free
  - $\sigma = R - R_F$
- benchmark
  - well-defined
    - no ambiguity, verifiable
  - tradable
  - replicable
  - adjusted-for-risk
- fundamental law of active management
  - $\mathrm{IR} \cong \mathrm{IC} \times \sqrt{BR}$
  - IC: correlation between predicted and actual value
  - Breadth: number of investments
  - Not a tool for searching high IR
  - Either play **smarter** or play **often**
  - Ignore downside risk and assume independent
  - AUM increase, IC decrease
- **Regression**
  - CAMP
    - $\mathrm{R_i} = \alpha + \mathrm{R_f} + \beta \times (R_m - R_f)$
    - $\mathrm{R_i} = \alpha + (1 - \beta) \times \mathrm{R_f} + \beta \times R_m$
  - Fama-French -factor regression
    - $\mathrm{R_i} = \alpha + (1 - \beta) \times \mathrm{R_f} + \beta \times R_m + \beta_{smb} \times (SMB) + \beta_{HML} \times (HML)$
    - $\beta_{smb} > 0$: small else big
    - $\beta_{hml} > 0$ value else growth
  - Not tradable: No way to trade SMG and HML stocks
  - Factors are static
- **Style analysis**
  - Benchmark factor exposure over time
  - Use **tradeable** indexes
  - This process uses estimates that incorporate information up to time t. Every new month (t + 1) requires a new **regression** to adjust the factor loadings. This means that the beta factors will change over time to reflect changes in the real world.
- **Nonlinear Alpha**
  - Alpha appear exists but not true
  - Distribution is not normal, negative skew
  - This will increase loss potential in the left-hand tail and make the middle of the distribution appear thicker. Skewness is not factored into the calculation of alpha, which is an issue for nonlinear payoff strategies.
- **Volatility Anomy**
  - Standard **deviation** increase -> **average** return decrease and **Sharpe** ratio decrease
  - The low-risk anomaly violates the CAPM and suggests that low-beta stocks will outperform high-beta stocks.
- **Beta anomy** (Sharpe Ratio)

    - High beta -> high standard deviation -> **Sharpe** ratio decrease
    - **Does not** suggest that stocks with higher betas have **low return**
- **Risk Anomy Explanation**
    - **Data mining** -> not supported
    - **leverage** constrained investors
        - cannot borrow money, invest in leverage built-in in the form of high beta,
        - more people but implicit-leverage4, bid up the price
    - Institutional managers also have **constraints**
        - Against **short selling**
        - Have **tracking error** constraint
        - Cannot capture positive alpha
    - **preference** 单一商品，一致性减少回报
        - for high-volatility and high-beta stocks
        - more people buy increase price and decrease return
    - **heterogeneous** preferences 不一致,增加 inverse
        - heterogeneous preferences (disagreeing on investment potential) and having investment constraints could explain a portion of the risk anomaly.
        - when disagreement is low and investors are long-only constrained, then the CAPM holds the best.
        - When disagreement is high, some investments become **overpriced** and future returns are decreased.
        - Significant disagreement can lead to an inverse relationship between beta and returns.

Illiquid Asset

- Illiquid Characteristics
    - Most asset classes are illiquid
        - Trade infrequently, in small amounts, low turnover
    - Markets for illiquid assets are large
    - Investor holdings of illiquid assets
        - Home
    - Liquidity can dry up
- **Market Imperfections**
    - Market **participation** costs 参与成本
        - Time, money, energy
        - Experience, capital, expertise
        - Clientele effect: only a few investors have expertise, capital, experience
    - **Transaction** costs 交易成本
        - Tax, commissions
        - Due diligence
    - Difficulties finding a **counterparty** (search frictions) 交易对手
    - Asymmetric information 信息不对称
        - Less willing to trade
        - Look for no-predatory counterparty

    - Price impacts
        - Large trade move markets
    - Funding constraints
        - Financed largely with debt
- Return **Biases**
    - Survivorship bias 高估回报
        - Reporting biases
            - Not report because not high, or stop reporting
        - Survivorship biases
            - Leave out funds that no longer exists
        - **High** Return 高估回报
    - Sample selection bias 高估回报和 alpha，低估 beta 和风险
        - Report return when they are high
        - High return, High alpha
        - lower beta, low variance
    - Infrequent trading 低估风险
        - Underestimate risk
        - Returns are **smoothed**, volatility is low
        - **Lower** beta, volatility, correlation
        - De-smooth using filtering algorithms
            - Add noise back to return
- **Risk premium**
    - Across asset classes
        - Rely on manager skills
        - No index, no way to earn index return
        - No way to separate factor risk from fund managers
        - No way to separate passive return from alpha
    - Within asset class
        - Illiquid asset **has** higher return
        - Overpay for illiquid assets (chase illusion of high return)
    - Effects in Treasury markets
        - On-the-run liquid than off-the-run T-bills
    - Effects in corporate bond markets
        - Large bid-ask spread and infrequent trading
    - Illiquidity effects in equity markets
- Harvest illiquid premium
    - **Passive allocation** to illiquid asset classes
    - Choose more **illiquid** assets within an asset class: liquidity security **selection**
    - Acting as a **market maker**
    - Dynamic **factor** strategies at the aggregate **portfolio** level
        - **Long illiquid and short liquid**
        - Easy to implement
- Portfolio allocation
    - Large transaction costs
    - Long time horizon between trades – infrequent trading
        - Reduce optimal holdings
        - Rebalance illiquid assets

        - No illiquidity arbitrages
            - Arbitrage requires **continuously** traded
        - Must consume less, cannot hedge against declining values when cannot be traded
- Conclusions
    - Illiquid assets **do not** deliver high risk-adjusted returns
    - Subject to **agency** problems, difficult to monitor managers
    - Illiquid assets are managed **separately**
    - Face high **idiosyncratic** risks

Portfolio Construction

- Input
    - Current portfolio, alpha, covariance, transaction cost
    - active risk aversion: strength of preference for lower volatility
- refine alpha
    - mean-variance with constraints are complex
    - refine alpha in unconstrainted mean-variance
    - constraints: investor or manager
    - scaling
        - $\alpha = (\text{volatility}) \times (\text{information coefficient}) \times \mathrm{N}(0,1) \sim N(0, volatility \times IC)$
        - volatility is residual risk, IC: linear between forecasted alphas and actual returns
    - trimming
        - remove too large: 3 times,
        - large alpha: if questionable, set to zero; otherwise, reduce to maximum value
- Neutralization
    - Remove bias and undesirable bet from alpha
    - Benchmark - beta
        - Match the **beta (benchmark and active portfolio)**.
            - Alpha of active portfolio is zero
            - $\alpha' = \alpha - \alpha_b \times \beta$, use benchmark α
        - Beta of risk factor match beta of the risk factor in benchmark
    - Risk-factor
        - **Weight** of each industry to those of benchmark
        - $\alpha' = \alpha - \bar{\alpha}$, average alpha of firms in the industry
    - Cash
        - No active cash position
        - Cash and benchmark can exist
- Transaction cost
    - Trading commission and spreads
    - Point in time, benefits are over time.
- Active risk aversion
    - $\textbf{risk aversion} = \frac{\textbf{IR}}{\textbf{2} \times \textbf{active risk}}$
- aversion to specific factor risk

        - Potential large losses
        - High risk aversion for specific factor will reduce dispersion
        - High risk aversion increases **similarity** of client portfolios
- alpha coverage
    - stocks not in the benchmark
        - set **benchmark weight** =0 不在 benchmark 里的权值是 0
        - **active weight** can be assigned to create active alpha
    - stock in benchmark without forecast -> set alpha=0
    - rest alpha $\alpha' = \alpha - \sum_i w_i \times \alpha_i / \sum_i w_i$
- rebalance
    - frequent trading and short time -> alpha uncertainty
    - $\text{MC to value added} = \text{alpha} - \text{IR} \times \text{MC to active risk of asset}$
    - no-trade region
        - $-\text{selling cost} < \text{MC to value added} < \text{cost of purchase}$
        - $\text{IR} \times \text{MC} - \text{selling cost} < \text{alpha} < \text{IR} \times \text{MC} + \text{cost of purchase}$
- Portfolio construction
    - Goal: high alpha, low active risk, low txn cost
        - $\alpha - \gamma \times \text{active risk}^2 - transaction\ cost$
    - screen
        - allow some through but not the rest
        - use alpha to select, the top
        - use alpha to assign buy, hold, or sell.
            - Then purchase buy list , sell the sell list
    - Stratification
        - Divide into **mutually exclusive** categories prior to screening
        - Percentage weight of each category **match** benchmark
        - Risk control.
        - Reduce the bias across categories
    - Linear programming
        - Use more risk characteristics: size, sector, beta, volatility
        - No need mutually exclusive
        - Category weight **match** benchmark
    - Quadratic programming
        - Alpha, risks, txn costs, and constraints.
        - Estimation error: n^2 volatility and **covariance**
    - Portfolio return dispersion
        - **Variability** of return across client portfolios
        - Reduce differences in holding and beta
        - Transaction cost
            - High cost -> higher dispersion
        - Higher dispersion
            - More portfolios, high active risk, high cost

Utilization function

- utilization function
    - $\text{active return} - \gamma \times \text{Variance}$, γ is the risk aversion
    - $\text{f}(\vec{w}) = \vec{w} \times \vec{\alpha} - \gamma \times \vec{w} \times \Sigma \times \vec{w}$
- First order derivative

- $\frac{\Delta f}{\Delta \vec{w}} = \vec{\alpha} - 2 \times \gamma \times \Sigma \times \vec{w} = 0$
- $\gamma = \frac{\alpha_1}{2 \times cov\,(1,P)} = \frac{\frac{\alpha_1}{\sigma}}{2 \times cov\,(1,P)/\sigma}$

- **Two assets**
  - $\frac{\Delta f}{\Delta w_1} = w_1 \times \alpha_1 + w_2 \times \alpha_2 - \gamma \times (w_1^2\sigma_1^2 + 2 \times \rho \times w_1 \times \sigma_1 \times w_2 \times \sigma_2 + w_2^2\sigma_2^2)$
  - $\frac{\Delta f}{\Delta w_1} = \alpha_1 - 2\gamma \times (w_1\sigma_1^2 + \rho \times \sigma_1 \times w_2 \times \sigma_2) = 0$
  - $\gamma = \frac{1}{2} \times \frac{\alpha_1}{w_1\sigma_1^2 + \rho \times \sigma_1 \times w_2 \times \sigma_2}$
  - $\gamma = \frac{\alpha_1}{2w_1\sigma_1^2} = \frac{\frac{\alpha_1}{\sigma_1}}{2\sigma_1} = \frac{IR}{2 \times active\ risk}$ (assume r is zero)
  -
- Simple

Portfolio risk: analytical methods

- Diversified portfolio VaR
  - $VaR = P \times Z \times \sigma_p$
- Individual VaR
  - $VaR_i = |P_i| \times Z \times \sigma_p$
- $VaR = \sqrt{VaR_1^2 + 2 \times \rho \times VaR_1 \times VaR_2 + VaR_2^2}$
- Independent VaR
  - $VaR = \sqrt{VaR_1^2 + VaR_2^2}$
- Undiversified VaR
  - $VaR = VaR_1 + VaR_2$
- Equal weight
  - $\sigma_p = \sigma\sqrt{\frac{1}{n} + \left(1 - \frac{1}{n}\right) \times \rho}$
- Marginal VaR
  - $MVaR_i = Z \times \frac{cov(i,p)}{\sigma_p} = \mathrm{Z} \times \frac{1}{\sigma_\mathrm{p}} \times (\Sigma \times \vec{w})_i$
  - $MVaR_i = Z \times \sigma_p \times \beta_i$ (beta to the portfolio)
  - $MVaR_i = Z \times \sigma_i \times \rho_i$
- Marginal VaR vector
  - $\overrightarrow{MVaR} = \mathrm{Z} \times \frac{1}{\sigma_\mathrm{p}} \times \Sigma \times \vec{w}$
- Incremental VaR
  - Full revaluation: time consuming
  - approximation
    - risk factor of new position w
    - vector of factor margin VaR
    - cross product
  - per collar covariance
    - $\Sigma \times \vec{w} \times P$
- Component VaR
  - The amount of contribution of a position
  - $CVaR_i = P_i \times MVaR_i = VaR_p \times w_i \times \beta_i = VaR_i \times \rho_i$

    - Contribution: $\frac{\mathrm{CVaR_i}}{\mathrm{VaR_p}} = \mathrm{w_i} \times \beta_i = \rho_i$
    - Non-elliptical distribution
- Portfolio - Risk Management – MVP (minimize **variance**)
    - Minimize risk: $MVaR_i = MVaR_j$
    - Allocate more to lowest MVaR, lower allocation to highest MVaR
- Portfolio Management - optimal
    - Maximize $\frac{R_i - R_f}{MVaR_i} = \frac{R_j - R_f}{MVaR_j}$ (covariance contribution \Sigma*W vector is constant)
    - Maximize $\frac{R_i - R_f}{\beta_i} = \frac{R_j - R_f}{\beta_j}$ (for elliptical)
    - More to higher

VaR and Risk Budgeting in Investment Management

- Risk budgeting
    - Top-down process

Figure 1: Sell Side and Buy Side Characteristics

Characteristic	*Sell Side*	*Buy Side*
Horizon	Short-term (days)	Long-term (month or more)
Turnover	Fast	Slow
Leverage	High	Low
Risk measures	VaR Stress tests	Asset allocation Tracking error
Risk controls	Position limits VaR limits Stop-loss rules	Diversification Benchmarking Investment guidelines

- Investment process
    - Step 1: long-term strategic asset allocation
        - Goal: MVP (balance return and risk)
    - Step 2: choose manager who passively or actively manage
        - Skill: tracking error
    - Globalization, complexity, dynamic
- Hedge fund
    - Leverage -> similar to seller side
    - Liquidity:
        - lower correlation
    - Lower level of Transparency
- Absolute risk and relative risk
- Policy mix and active risk
    - Return = policy mix return + active risk return
    - VaR != policy mix VaR + active risk VaR (some correlation)
- **Funding risk**

    - Surplus relative to asset (growth: expected and worst case)
        - $\mathrm{SaR} = \mathrm{VaR} - \mathrm{u} = \mathrm{z} \times \alpha - \mathrm{u}$
    - Surplus deficit: ending surplus
- Plan sponsor risk
    - Economic risk
    - Cash-flow risk
- Monitor
    - Taking more risk
    - The same style
    - Market more volatile
- Global custodian
    - Consolidated picture
    - Less custodians but more features
    - Use VaR in the system
- Applications
    - Investment guidelines
    - Investment process
        - Asset allocation
        - Trading level: not standalone VaR, but marginal VaR
            - Choose the lower MVaR between a few positions
            - Look for the highest return-to-MVaR
- Risk budgeting
    - Determine the total amount of risk
    - Optimal allocation of assets
- Risk Allocation
    - $\mathrm{u_p} = \sum_i w_i \times u_i$ (portfolio return), u_i is excessive return
    - $\sigma_\mathrm{p}^2 = \sum_i w_i \times \sigma_i^2$ (portfolio variance - assume independence)
        - σ_i is std of $(u_i - \bar{u})$
    - Maximize $\mathrm{IR_p} = \frac{u_p}{\sigma_p}$
    - First order Derivative
        - $\frac{\partial \mathrm{IR_p}}{\partial w_i} = \frac{u_p' \sigma_p - \mu_p \sigma_p'}{\sigma_p^2} = \frac{u_i \times \sigma_p - \mu_p \times w_i \sigma_i^2 / \sigma_p}{\sigma_p^2} = 0$
        - $\rightarrow u_i \times \sigma_p - \mu_p \times \frac{w_i \sigma_i^2}{\sigma_p} = 0$
        - $\rightarrow \mathrm{w_i} = \frac{u_i / \sigma_i^2}{u_p / \sigma_p^2} = \frac{\mathrm{IR_i}/\sigma_i}{IR_p/\sigma_p}$
    - Weight do not sum to 1, the rest is allocated to the benchmark

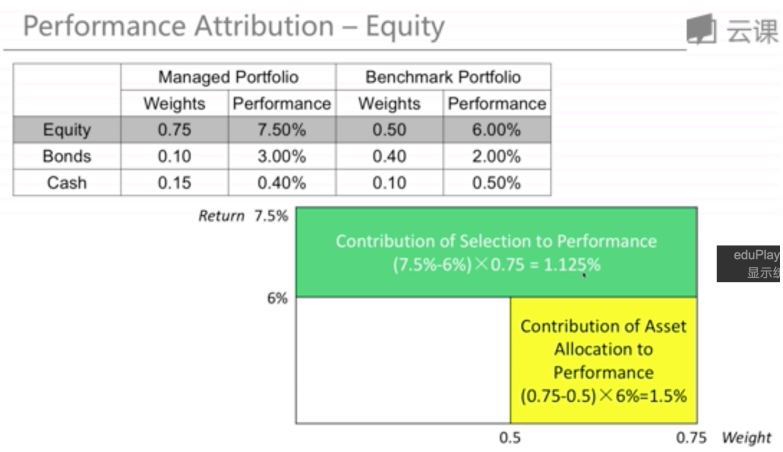
Risk Monitoring and performance measurement

- Risk measures
    - VaR and TEV
- Risk planning
    - Expected return and volatility
    - Quantitative measure of success or failure
        - ROE or RORC
    - Risk capital

        - Minimum acceptable RORC
        - sensitivity analysis
        - simulating portfolio
    - Events cause ordinary damage vs serious damage
    - Mission critical resources
- Risk Budgeting
    - Quantifies the plan
    - Minimum RORC and ROE
    - Mean-variance to determine weights
- Risk monitoring
    - Check variance deviation from budget
- Sources of Risk consciousness
    - Banks
    - Boards of investment clients, senior management, plan sponsors
    - Investors become knowledgeable about choices
- RMU
    - Gather data
    - Monitor trends
    - Promote discussion
- Monitoring
    - TEV consistent with target?
    - Risk capital allocated to expected areas?
        - Break down -> style drift
- Liquidity considerations
    - Liquidity duration
    - $\mathrm{LD} = \frac{\mathrm{Q}}{0.1 \times \mathrm{V}} = 10 \times \frac{\mathrm{Q}}{\mathrm{V}}$
        - Q: total shares
        - V: daily volume
- Performance measures
    - Compare with benchmark and peer group
    - Green zone, yellow zone, red zone
    - Return attribution
        - Factors. Variance analysis
    - Sharpe and IR
    - Compare with benchmark and peer groups
        - Linear regression of excessive return to excessive return to benchmark -> alpha (skill) and beta (leverage)
        - Peer group

Portfolio Performance evaluation

- Dollar-weighted return (IRR)
- Time-weighted return (compound growth)
    - Geometric mean
    - Not affected by cash flow
- Risk-adjusted performance measure
    - Universe comparisons

        - Investment style and then rank return
    - Sharpe ratio
        - Use the total risk
    - Treynor
        - Use the beta (systematic risk)
    - Portfolio
        - Well-diversified-> S and T are the same
        - Not-diversified -> S < T
    - Jensen's alpha
        - Alpha = real return – CAPM return
    - Information ratio
        - Benchmark not risk-free
        - Surplus return and its std
    - M^2
        - Compare return with benchmark and adjust variance
        - $\mathrm{M}^2 = R_F + \frac{R_p - R_f}{\sigma_p} \times \sigma_m - R_m$
    - Rank
        - M^2 = Sharpe
        - Alpha = Trey
    - Statistical significance of alpha
        - $t = \frac{\alpha}{\sigma/\sqrt{N}} = \frac{\alpha}{\sigma} \times \sqrt{N} = IR \times \sqrt{N}$
- Measuring Hedge fund
    - Complicated
        - Nonlinear, data smoothing (illiquid),
- Dynamic risk levels
- Marketing timing
    - With regression
    - Call option
- Style analysis
    - Regression with portfolio return against mutually set of asset classes
        - Weight non-negative and summing to 1
    - Performance attribution
        - Allocation: R^2
        - Selection: 1-R^2
    - 

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Hedge fund

- Compare with Mutual fund
  - Private, less regulated and structured, highly leveraged (short and long)
  - Take larger bets
  - Privacy, little transparency
- Evolution
  - Selection bias/ self-reporting bias
  - 2001: dot-come bubble
    - 20% net asset inflow, more **institutional** investors
  - 1997-2007 shift
    - Private wealth -> institutions
    - Bearing credit and emerging market
- Alpha-beta
  - **Distinguishing** alpha and beta
    - How much from active management
    - How much from risk (beta)
  - **Separating** alpha and beta
    - **Pursuit** alpha while keeping a target beta
    - Use **derivative** to limit beta
  - Strategy
    - Managed future (timing, lookback straddle)
      - Market **timing** funds, switch between stocks and treasuries
      - Both long and short
      - Payoff function: **lookback straddle**, lookback call and put
      - High leverage because of futures
      - No net long or net short bias
    - Global macro fund (betting, directional)
      - **Directional** movement in IR, FX, stock
      - **Dynamic** asset allocation, betting on risk factor over time
    - **Managed future and global macro**
      - **Trending** following (directional styles)
      - **Asset allocation**: make bets in different markets
      - **Low** return correlation to **equities**
    - Merge/risk arbitrage
      - Risk: deal risk (fail to close)
    - Distressed
      - In the middle of bankruptcy
      - **Long** bias (long to low credit rating)
      - Tail risk: big move in short-term rates
      - Similar to **high-yield** bonds
    - **Merge/risk arbitrage and distressed**
      - **Event-driven**, nonlinear return, tail risk
      - Hurt by **extreme** market movements
    - Fixed income arbitrage

- Exploit inefficiencies and price anomalies
- Swap spread trade
  - Bet on fixed spread side > floating spread
- Yield-curve spread
  - Price deviate in short time
  - **Revert** to normal spreads over time
- Mortgage spread
  - **Prepayment** rate
- Fixed income volatility trades
  - **Implied** volatility of interest rate > realized volatility
- Capital structure or credit arbitrage trades
  - Capitalize on **mispricing** different type of securities

- Convertible arbitrage
  - Long convertible securities, short common stock
  - Return: liquidity premium paid to convertible bonds
- Long/short equity
  - Directional exposure
  - Long small-cap, short large-cap
- Dedicated short
  - Net short in equities
  - Selling forward
  - Take offsetting long and stop-loss position
  - Negatively correlated to equities
- Emerging markets
  - **Long** bias, more difficult to short
- Equity market neutral

- Performance
  - Still deliver alpha relative to equities
- **Convergence** of risk factors
  - Converge to risk factors
  - Market-wide funding crisis, difficult to spread among funds
  - Credit-driven tail risk
    - Can use managed futures
- Risk sharing asymmetry
  - Principal/agent conflict
  - Close
    - Harm track record
    - Reputational
  - solution
    - Manager **invest** a good portion of his own
- Impact of institutional investors
  - Greater demands for operational **integrity** and governance
  - **Differentiate** themselves
  - Some for absolute performance, other for alternative sources of returns beyond equities

DD

- Past fund failures
    - Poor decisions
    - Fraud
    - Extreme events
    - Excess leverage
    - Lack of liquidity
    - Poor controls
    - Insufficient questioning
    - Insufficient attention to returns
- DD
    - Manager evaluation
    - Investment process and controls
    - Operations and business models
- Manage evaluation
    - Strategy
    - Ownership
    - Track record
    - Investment management
        - Background check
        - Reference check
- Risk Management Evaluation
    - Risk
    - Security valuation
    - Portfolio leverage and liquidity
    - Exposure to tail risk
    - Risk reports
    - Consistency of fund terms with investment strategy
- Operational due diligence
    - Internal control assessment
    - Documents and disclosure
    - Service provider evaluation
- Business model and fraud risk
    - Business model risk
        - Cash and working capital, succession plan,
- Fraud risk
- DD questionnaire

The New Era of Expected Credit Loss Provisioning

- ECL (expected credit loss)
- Forward-looking provisions
    - At the **same time** as loan origination
- Procyclicality
- IASB and FASB
    - PD point in time (not economic cycle)
    - LGD and EAD (**neutral**)

    - IASB
        - ECL: three stages
        - **Accrued** interest on delinquent loans
    - FASB
        - ECL: right from start
        - **Cash** basis, **cost recovery** (payments applied to principle, then excess is interest)
- ECL - IASB
    - Performing, underperforming, impaired
    - Stage 1 – 12-month
        - 12-month ECL is computed
        - Interests – original loan
    - Stage 2 life time
        - 30 days past due
        - Interest the same
    - Stage 3
        - Credit impaired
- FASB
    - ECL recorded as provision from the outset
    - Earlier and large recognition of losses
- Implementation
    - EDTF
        - 20% in average
    - Problems
        - Low quality data to compute lifetime default probabilities
        - Insufficient tech resources
- Impact - IASB
    - Impact **stage 2** most
    - More losses in economic downturn
    - No impact for large banks with large capital buffer
    - Smoothing the issuance of loans

Big Data: New ticks for econometrics

- **Overfitting**
    - Less complex model
    - Break into small samples to test and validate
- Regression analysis
    - Loss function with out-of-samples
- Active variable selection
    - Help to decrease overfitting
- Classification
    - Logit regression
    - CART
- **Cross-validation**
    - K-fold cross validation
    - 1 fold for Testing and k-1 fold training set
    - Rotate which fold is the testing

    - Averaged, out-of-sample
- Prune the tree
- **Conditional inference tree (ctree)**
    - Only one tree, no pruning with tuning parameters
    - Test if any independent variables are correlated with the dependent and choose the variable with **strongest correlation**
    - Split variable into **two** data subsets
    - Until **correlation** fall below a threshold
    - Isolate predictors into most specific terms
    - Help to understand if a relationship truly exist
- **Random forest**
    - Bootstrap, tree growth without pruning,
    - majority vote
- Penalized regression
    - Lasso
    - Limit number of parameters
- Collaboration
    - Better explore blurred lines between correlation and causation
    - Better understand time series data (traditional only on cross-sectional)
- Bayesian Structural time series
- Cause inference
- A/B test
    - Lost revenue in control region
    - Contrast could be from external factor
    - Random control group

Machine Learning: A Revolution in Risk Management and Compliance?

- Big data
    - Low-quality, unstructured data
- Machine learning
    - Supervisory approaches are difficult to apply
- Supervised machine learning
- Unsupervised machine learning
- Regression
    - Quantitative, continuous
    - Linear and nonlinear
- Classification
    - Discrete, dependent variables
    - email span, blood type, SVM
- Clustering
    - Anti-money laundering (**AML**)
- Prediction
    - Out-of-sample
    - Good predictive: no need to good at explaining or inferring
- Overfitting
    - Nonparametric, nonlinear tend to complex

    - Fit in specific, not perform well in out-of-sample
    - Model random error rather than underlying relationship in data
- Bootstring
    - **Overweight** instances to train model to easily detect them
- Bagging
    - Run more models on different **subsects**
- + ensemble
    - Improve out-of-sample predictive
- Machine learning
    - High quality, structured
- Deep learning
    - Mimic human brain
    - Each focus on feature (representation)
    - Layers of representations to use a wide range of inputs
        - **Low quality, unstructured**
        - Learned from data
    - Face, NLP
- **Credit** risk and revenue modelling
    - Overly complex and **sensitive** to overfitting data
    - Too **complex** for **regularly** purpose
    - Used in optimizing **existing** models with regulatory functions
- **Fraud** (false positive, data sharing, define, feedback, insufficient history data)
    - Credit card fraud
    - Anti-money laundering or financing of terrorism
    - Clustering, detect anomalies and reduce **false positives**
    - Traditional
        - More **false positive**, human involvement to filter
    - **Challenge**
        - **Data** sharing/usage, entrenched regulatory frameworks hinder the success of machine learning
        - Money laundering is **difficult** to define
        - Banks do not receive adequate **feedbacks** from law enforcement agencies on which txns are truly fraudulent,
        - hard to use **history** data to train.
- Surveillance of conduct and market abuse in trading
    - Rogue/insider trading
    - Early monitoring
        - Trading behaviour, single trade
    - Machine learning
        - Portfolios, connect to other activities (emails/phones)
        - Detect any deviation from normal
    - Challenge
        - **Legal** complexities of sharing **past** breach info
        - Must be auditable, difficult to **explain**
    - Solution
        - Combine with human decisions
        - Less complex and suitable for audit and regulatory

Central Clearing and risk transformation

- Impact
  - Solvency and liquidity
  - Enhance financial stability and reduce systematic risk, eliminated **counterparty** risk
  - Not **completely** eliminate **systemic** risk
- Counterparty risk to **liquidity** risk
  - Cash flow
    - Initial margin
    - MTM P&L settled daily
    - Clearing member be required to contribute more (right of access)
  - Balance sheet and solvency
    - Initial margin: transfer of assets, no impact on solvency
    - Variation margin: liquid to illiquid
    - **Default** contribution: 2% **capital** charge (impact most)
  - Liquidity
    - Initial and variation margins: deposited as liquid assets
    - So reduction in liquidity
  - Overall
    - No solvency impact
    - Liquidity impact: Reclassification of assets between liquid and non-liquid
- CCP **liquidity** resources
  - Hold liquid and low-risk assets
  - Short-term liabilities
  - Losses due to default of a clearing member: CCP need to pay defaulted counterparties
  - Insolvency risk and capital sufficiency are far less relevant
- Loss sequence
  - Initial margin
    - By **each** clearing members
  - Default contribution of defaulting member
  - **Mutualisation** of large losses
    - CCP cover some maximum contribution first (skin in the gam)
    - Other members' default contributions
  - Recovery
    - When the entire default fund insufficient to cover
    - **Right of assessment** – from non-defaulting members
      - Limited to the initial margin
    - Variation margin haircutting (**VMGH**)
      - Variation margin with negative balance
  - Failure resolution
- Margin and **liquidation costs**
  - Market risk: ignore spread, market depth
  - Liquidation costs: high for large positions or concentrated positions
    - Nonlinear to its size

    - Liquidation horizon
    - Default fund: include **liquidity** costs
    - Proportional to **gross** not net
- CCP methods for **recovering** capital
    - Default fund assessment
        - Wrong-way risk
    - VMGH
        - The difference held by CCP to enhance liquidity

The Bank/Capital Markets Nexus Goes Global

- Banks and Capital Markets
    - Link between banks and capital markets are **global**
    - Hair cut 2% -> leverage ½%=50
    -
- Forward deleveraging and covered interest parity
- Forced deleveraging
    - Reduction in leverage
    - Haircut
- VIX as gauge of leverage
    - Low VIX, high leverage
    - Changed
        - Monetary easing
        - Regulation
        - Capitalization
- Covered interest parity (CIP)
    - CIP may oversimplify
    - Insufficient capital
- US dollar as gauge of leverage
    - Weak dollar -> risk appetite is strong
    - strong dollar, risk appetite is weak
- dollar strengthening
    - balance sheet
        - weak dollar -> benefit liability, reduce tail risk
            - borrow more in capital market
            - domestic asset and dollar liabilities benefit most
        - strong dollar -> increase liability and tail risk
    - lending market
    - export
    - foreign currency appreciation (domestic currency depreciation)
        - positive for export
        - negative for borrowing
- international dollar lending
    - dollar appreciation
        - lending decline, increase cost of hedge
    - look at bank lenders in all markets
    - banks magnify shocks rather than absorb them

Fintech

- supply reasons
  - automation in loan grating process
  - non-traditional data
  - timely decisions
  - smaller upfront costs, high level of standardization
  - reduce regulation costs
- demand
  - Borrowers
    - Loss of trust in traditional lenders
    - Interest savvy
  - investors
    - investing higher return and lower risk
- possible impediments
  - use banking online banking
  - economic downturn: uncertainty
  - regulatory
  - reputational
- platforms
  - traditional
    - borrowers and lenders interact **directly**
    - contract between borrower and lender
    - platform
      - fee: loan setup or loan repayment
      - credit rating
      - automated selection to diversify
      - similar to securitization
    - interest rate
      - **lender** make interest rate bids
      - **platform** provide rate
      - **borrowers** are given a rate
    - delinquent
      - insurance or guarantee/provision funds
      - pay expected default rate for covered loans
    - exit
      - pay fee, no exit guarantee
  - notary model
    - **Germany, Korea, US**
    - Fronting bank: provide the loan
    - Germany
      - Only authorized institutions can provide loan
    - Korea
      - No lending
      - Banks: set up loans, platform: transfer funds to banks as collateral
    - US

            - Regulatory restriction, work with lending institution
    - Guaranteed Return
        - Platform: guarantee the principle and/or interest
        - **China and Sweden**
        - Prohibit in the future
    - Balance sheet mode
        - **Australia, Canada, US**
        - China and US: combined with traditional and BS
            - Wealth mgt, trading, insurance
    - Invoice trading model
        - Firms: make credit sales and record receivable
        - Sell for discount
            - Non-Recourse: high discount, transfer the risk
            - Recourse: lower discount, keep the risk
- Lenders
    - Individual and institutional investors
        - US and Canada
- Borrowers
- Micro financial benefits
    - More diversified groups
    - Lower interest rate