Risk Management and Investment Management

FRM二级培训讲义-强化班

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Topic Weightings in FRM Part II

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Framework

Risk Management and Investment Management

- Factor Investing
- Portfolio Construction
- Portfolio Risk Measures
- Portfolio Risk Management
- Performance Measurement and Evaluation
- Hedge Funds

Reading 1

Factor Investing

Framework

- Factor Theory
- Factors
- Alpha and Low-Risk Anomaly

Multifactor Model

- The **factor theory** is trying to explain the phenomenon:
  - Investors exposed to losses during bad times are compensated by risk premiums in good times.
- Multifactor models recognize that bad times can be defined more broadly than just bad returns on the market portfolio.
  - The first multifactor model was the arbitrage pricing theory (APT), developed by Stephen Ross (1976).
  - While the CAPM captures the notion of bad times solely by means of low returns of the market portfolio, each factor in a multifactor model provides its own definition of bad times.

Why Inefficient

- **In a rational explanation**, high returns compensate for losses during bad times. This is the pricing kernel approach to asset pricing.
  - The key is defining those bad times and deciding **whether these are actually bad times** for an individual investor.
    - ✓ Certain investors benefit from low economic growth even while the majority of investors find these to be bad periods.
- **In a behavioral explanation**, high expected returns result from agents' under-or overreaction to news or events. Behavioral biases can also result from the inefficient updating of beliefs or ignoring some information.
- For some risk premiums, the most compelling explanations are rational (as with the volatility risk premium), for some behavioral (e.g., momentum), and for some others **a combination of rational and behavioral** stories prevails (like value/growth investing).

Factors

- **There are two types of factors.**
  - The **first type** is macro, fundamental-based factors, which include economic growth, inflation, volatility, productivity, and demographic risk.
  - The **second type** is investment-style factors like the market factor of the capital asset pricing model (CAPM). To be more specific, investment-style factors can be divided into
    - ✓ **Static factors**, like the market factor in CAPM, which we simply go long to collect a risk premium;
    - ✓ **Dynamic factors**, which can only be exploited through constantly trading different types of securities.

Macroeconomic Risk Factors

- Economic growth:
  - Risky assets generally perform poorly and are much more volatile during periods of low economic growth. However, **government bonds** tend to do well during these times.
- Inflation:
  - High inflation tends to be bad for both stocks and bonds. The **exception** exists when it refers to commodities.
- Productivity Risk
  - When productivity slows, stock return tends to be low.
- Demographic Risk
  - Labor income is mostly earned and saved in young and middle age and dis-saved when retired.
- Political Risk(sovereign risk)
  - Mainly in emerging countries.
  - In financial crisis, developed countries have political risk as well.

Macroeconomic Risk Factors

- Volatility:
  - The negative relation between volatility and returns is called the **leverage effect**. When stock returns drop, the financial leverage of firms increases since debt is approximately constant while the market value of equity has fallen. This makes equities riskier and increases their volatilities.
  - There is another channel where high volatilities lead to low stock returns: **an increase in volatility raises the required return on equity demanded by investors, also leading to a decline in stock prices.**

Mitigating Volatility Risk

- Investors who dislike volatility risk can buy volatility protection
  - Buying or selling volatility protection can be done in option markets, but traders can also use other derivatives contracts, such as **volatility swaps**.
  - assets that pay off during high volatility periods, like **out-of-the-money puts**, provide hedges against volatility risk.
  - Bonds offer some but not much respite during periods of high volatility, as the correlation between bond returns and VIX changes is only 0.12. Thus, bonds are not always a safe haven when volatility shocks hit.

Challenges to Manage Volatility Risk

- Investors who like volatility risk can sell volatility protection
  - **Selling volatility is not a free lunch**, however. It produces high and steady payoffs during stable times. Then, once every decade or so, there is a huge crash where sellers of volatility experience large, negative payoffs.
  - Unfortunately, some investors who **sold volatility prior to the financial crisis** failed to anticipate that a crash like the one of 2008 would materialize.
  - Constructing valuation models with volatility risk can be tricky because the relation between volatility and expected returns is **time varying** (sometimes can be negative or uncorrelated) and switches signs and is thus very hard to pin down.

Dynamic Risk Factors

- The best-known example of a tradeable multifactor model applied to present dynamic factors is introduced by **Fama and French.**
- The Fama–French (1993) model explains asset returns with three factors. There is the traditional CAPM market factor and there are two additional factors to capture a size effect and a value/growth effect:

$$E(r_i) = r_f + \beta_{i,MKT}E(r_m - r_f) + \beta_{i,SMB}E(SMB) + \beta_{i,HML}E(HML)$$

  - **SMB factor**, which refers to the differential returns of small stocks minus big stocks.
  - **HML factor**, which stands for the returns of a portfolio of high book-to-market stocks minus a portfolio of low book to market stocks.
  - These two factors are usually positive.

Value and Size Investment Strategies

- **Size strategy is to go long small cap stocks and short large cap stocks**
  - The risk is that some small cap companies can be large cap companies eventually.
- **Value strategy is to go long value stocks and short growth stocks**
  - The risk of the value strategy is that although value outperforms over the long run, value stocks can underperform growth stocks during certain periods.
  - Value stock company has **high and asymmetric adjustment cost**.
    - ✓ In the bad time, value companies can hardly shift to more profitable activities, nor can they cut back on capital because they can't sell their specialized equipment.
    - ✓ However, growth companies can easily divest since they employ hotshot young employees and the great bulk of their capital is human capital.

Momentum Investment Strategies

- **Momentum** is the strategy of buying stocks that have gone up over the past six (or so) months (winners) and shorting stocks with the lowest returns over the same period (losers).
  - In 1993, **Jagadeesh and Titman** identified a momentum effect, which is then introduced by Carhart in his Four-Factor model.
  - The momentum effect refers to the phenomenon that winner stocks continue to win and losers continue to lose, just like "**Matthew Effect**".
  - Implementation of Momentum strategy
    - ✓ Price **rebounds in the short run.**
    - ✓ Price **eventually reverses** in the long run.
  - The cumulated profits of momentum has been significantly larger than that of size or value strategies.

Value and Momentum Investment Strategies

- **Same**:
  - The momentum strategy, like size and value, is a **cross-sectional strategy**, meaning that it compares one group of stocks against another group of stocks in the cross section, rather than looking at a single stock over time.
- **Difference**:
  - Value is a **negative feedback strategy**, where stocks with declining prices eventually fall far enough that they become value stocks.
  - Momentum is a **positive feedback strategy**. Stocks with high past returns are attractive, momentum investors continue buying them, and they continue to go up!

Low-risk Anomaly

- **The risky anomaly—**that stocks with low betas and low volatilities have high returns—appears to be a strong source of alpha relative to standard market-weighted benchmarks and value-growth, momentum, and other dynamic factors.
- **The low risk anomaly is a combination of three effects**
  - Volatility is negatively related with future returns.
  - Realized beta is negatively related with future returns.
  - Minimum variance portfolios do better than the market.

Volatility Anomaly

- **Data evidence:**
  - Lagged Volatility and Future Returns(negative correlation)
  - Contemporaneous Volatility and Returns(negative correlation)
  - Lagged Beta and Future Returns(negative correlation but insignificant)
  - Contemporaneous Beta and Returns(positive correlation)
- **Conclusion**
  - Volatility and return: The most volatile stocks currently lose money (which we cannot forecast), and they also tend to lose money in the future as well (which is predictable).
  - Beta and return: The positive relationship is of little use cause we have such difficulty in predicting future betas, especially with past betas.

Risk Anomaly Explanations

- Data Mining
- Leverage Constraints(can't take more risk as they are leveraged)
- Agency Problems(Many institutional managers can't or won't play the risk anomaly)
- Preferences(If asset owners simply have a preference for low-volatility and low-beta stocks)

Impact of Benchmark Choice on Alpha

- **Failing to adjust the benchmark for risk can make a huge difference in the alpha!**
  - Example:
    - ✓ Take the R1000 index as a benchmark to get an alpha=0.0150

$$r_t = 0.0150 + r_t^{R1000} + \varepsilon_t$$

    - ✓ Take the combination of R1000 and risk free asset to get an alpha=0.0344

$$r_t = 0.0344 + 0.2728 r_t{}^f + 0.7272 r_t^{R1000} + \varepsilon_t$$

Further Study: Factor Regression

- **The first approach:** Estimate the risk-adjusted factor benchmark
  - CAPM Benchmark

$$r_{it} - r_{ft} = \alpha + \beta(r_{mt} - r_{ft}) + \varepsilon_{it}$$

  - Size and Value-Growth Benchmarks

$$r_{it} - r_{ft} = \alpha + \beta(r_{mt} - r_{ft}) + sSMB_t + hHML_t + \varepsilon_{it}$$

  - Adding Momentum

$$r_{it} - r_{ft} = \alpha + \beta(r_{mt} - r_{ft}) + sSMB_t + hHML_t + uUMD_t + \varepsilon_{it}$$

Further Study: Factor Regression

- **The second approach:** Mimic portfolio
  - Without risk free asset: A benchmark is a passive portfolio of index funds in stocks and bonds

$$r_{it} = \alpha + \beta_s r_{st} + \beta_b r_{bt} + \varepsilon_{it}$$

  - Adding real estate

$$r_{it} = \alpha + \beta_{REIT} REIT_t + \beta_s r_{st} + \beta_b r_{bt} + \varepsilon_{it}$$

Fundamental Law of Active Management

$$IR \approx IC \times \sqrt{BR}$$

- IR is the information ratio;
- IC is the information coefficient, which is the correlation of the manager's forecast with the actual returns (how good the forecasts are);
- BR is the **breadth** of the strategy (how many bets are taken). Breadth is the number of securities that can be traded and how frequently they can be traded.

- **Limitations**
  - It ignore transactions costs, restrictions on trading, and other real-world considerations
  - It ignores downside risk and other higher moment risk while assuming that all information is used optimally.
  - A crucial assumption is that the forecasts are independent of each other.

Example

- Given the formula below, where gamma, γ, is the risk aversion of the average investor and σ_m^2 is the variance of the market return:

$$E(r_m) - r_f = \bar{\gamma}\sigma_m^2$$

- Which of the following statements is TRUE about the relationship between returns (or earned premiums) and volatilities?
  - A. In theory, the risk aversion coefficient is negative; but in data, the risk aversion is always positive
  - B. Pure derivatives volatility trading takes a stance on expected returns; i.e., is necessarily directional
  - C. Rebalancing as a portfolio strategy is a short volatility strategy which earns a volatility risk premium
  - D. Selling volatility protection through derivatives markets is ultimately a low-risk strategy due to long-term mean reversion
- **Correct answer: C**

Example

- The Fama-French three-factor model is given by the following formula

$$E(r_i) = r_f + \beta_{i,MKT}E(r_m - r_f) + \beta_{i,SMB}E(SMB) + \beta_{i,HML}E(HML)$$

- Which of the following statements about Fama-French model is TRUE?
  - A. Unlike the size factor, the value premium is robust and outperforms over the long-run
  - B. Since 1965 to roughly the present, the size factor (size effect) in Fama-French has been significant and robust
  - C. Although the size effect continues to be robust and significant, small stocks do NOT have higher returns, on average, than large stocks
  - D. The salient feature of value stocks is their tendency, both in theory and in the data, to outperform growth stocks especially during bad times for the economy
- **Correct answer: A**

Reading 2

Portfolio Construction

Framework

1. Portfolio Construction Inputs
2. Portfolio Construction Techniques

Inputs to the Portfolio Construction Process

- **Portfolio construction requires several inputs:**
  - The current portfolio: of these inputs, we can measure only the current portfolio with near certainty.
  - Alphas
  - Covariance estimates
  - Transactions cost estimates
  - Active risk aversion: Most active managers will have a target level of active risk that we must make consistent with an active risk aversion.

Refining Alphas

- With alpha analysis, the alphas can be adjusted so that they are in line with the manager's desires for risk control and anticipated sources of value added.
  - Scale the alphas:$\alpha = \sigma \times IC \times Score$
  - Trim alpha outliers: Data cleaning
  - Neutralization
    - ✓ Benchmark- and Cash-Neutral Alphas
    - ✓ Risk-Factor-Neutral Alphas

Transactions Cost

- **Implications Transaction Costs have on Portfolio Construction**
  - Transactions costs force greater precision on our estimates of alpha.
  - **Rebalancing** incurs transaction costs.
- **Frequent revision or less frequent revision**
  - If a manager knows how to make the correct trade-off between expected active return, active risk, and transactions costs, frequent revision will not present a problem.
  - If manager is unsure of ability to correctly specify alphas, active risk, and transactions costs, **a crude but effective cure is to revise the portfolio less frequently.**
- **Dispersion:** The difference between the maximum return and minimum return for separate account portfolios.
  - Trade off between dispersion and rebalance cost

Portfolio Rebalancing

- **Decide whether to trade**

$$MCVA_n = \alpha_n - 2 \times \lambda_A \times \varphi \times MCAR_n$$

  - $MCVA_n$: Marginal contribution to value added for stock *n*
  - $MCAR_n$: Marginal contribution to active risk of asset n.
  - λ_A: risk aversion of investor
  - φ: active risk
- **Optimal No-Trade Region**
  - As long as the $MCVA_n$stays within the negative cost of selling and the cost of purchase, the portfolio will remain optimal, and we should not react to new information.

$$-SC_n \leq MCVA_n \leq PC_n$$

Practical Issues

1. **Determination of Optimal Risk Aversion**

$$\lambda_A = \frac{IR}{2 \times TEV}$$

2. **Incorporation of Specific Risk Aversion**
   - Classify risk aversion into specific risk aversion and common-factor risk aversion.
3. **Proper Alpha Coverage**
   - If we forecast returns on stocks that are not in the benchmark, we can always handle that by **expanding the benchmark** to include those stocks, albeit with zero weight.
   - If there is a lack of forecast returns in the benchmark, **adjust alphas to make benchmark neutral.**

Exercise

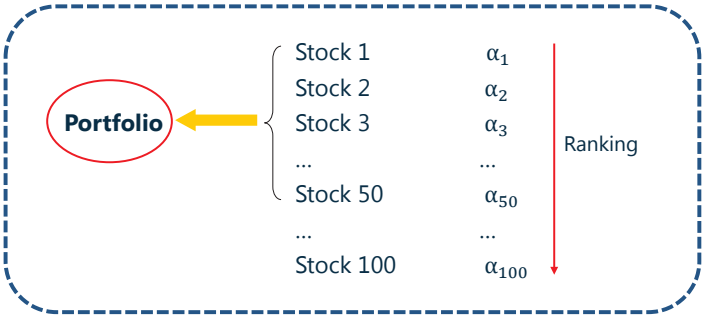
- Which of the following is correct with respect to adjusting the optimal portfolio for portfolio constraints?
  - A. No reliable method exists.
  - B. By refining the alphas and then optimizing, it is possible to include constraints of both the investor and the manager.
  - C. By refining the alphas and then optimizing, it is possible to include constraints of the investor, but not the manager.
  - D. By optimizing and then refining the alphas, it is possible to include constraints of both the investor and the manger.
- **Correct Answer: B**

Portfolio Construction Techniques

- **Four portfolio construction techniques**
  - Screens
  - Stratification
  - Linear programming
  - Quadratic programming

Portfolio Construction Techniques

- **Screens**
  - Rank the original 100 stocks by alpha.
  - Choose the first 50 stocks (for example).
  - Equal-weight (or capitalization-weight) the stocks



Portfolio Construction Techniques

- **Strength**
  - Easy to implement and understand.
  - It **enhances return** by selecting high-alpha assets and controls risk by having a sufficient number of assets for **diversification.**
  - Clear link between cause (membership on a buy/sell list) and effect (portfolio membership).
  - Robust in that **extreme estimates** of alpha will not bias the outcome.
- **Weakness**
  - **Ignores** all information in alphas aside from ranking. Do not protect against biases in alpha
  - **Excluding those categories** of assets that tend to have low alphas.

Portfolio Construction Techniques

- **Stratification**
  - Stratification is "glorified" screening.
  - Divide the stocks in categories (e.g., economic sectors, big/medium/small) and mimic the screening exercise.
- **Major strength over screens**
  - ignoring biases in the alphas across categories.

Portfolio Construction Techniques

- **Linear Programming**
  - The linear programming approach characterizes stocks along dimensions of risk, e.g., **industry, size, volatility, and beta**.
  - The linear program will then attempt to build portfolios that are reasonably close to the benchmark portfolio in all of the dimensions used for risk control.
  - **Strength**
    - ✓ Takes all the information about alpha into account and controls tracking risk by keeping the characteristics of the portfolio close to the characteristics of the benchmark.
  - **Weakness**
    - ✓ Has difficulty producing portfolios with a pre-specified number of stocks.
    - ✓ The risk-control characteristics may conflict with the alphas.

Portfolio Construction Techniques

- **Quadratic Programming**
  - **Ultimate** in portfolio construction
  - Explicitly considers all three elements: **alpha, risk, and transactions costs**.
  - Requires a great many more inputs than the other portfolio construction techniques. **More inputs mean more noise**.

Reading 3

Portfolio Risk Measures

Framework

1. Diversified and Undiversified VaR
2. MVaR, IVaR and CVaR

Portfolio VaR

- **Individual VaR**
  - This is the VaR of an individual position in isolation.
  - Where W is portfolio value and ω(i) is the weight assigned to individual position, individual VaR is given by:

$$VaR_i = Z_c\sigma_i|V_i| = Z_c\sigma_i|\omega_i|V$$

- **Diversified VaR and Undiversified VaR**
  - The two-asset variance is given by:

$$\sigma_p{}^2 = \omega_1{}^2\sigma_1{}^2 + \omega_2{}^2\sigma_2{}^2 + 2\omega_1\omega_2\rho_{12}\sigma_1\sigma_2$$

  - Diversified VaR accounts for diversification effects.

$$VaR_p = Z_c \times \sigma_p \times V$$

  - Undiversified VaR is simply the sum of the individual VaRs.

$$VaR_p = VaR_1 + VaR_2$$

  - If correlation <1, diversified VaR is less than Undiversified VaR. **The difference is called diversification effect.**

Portfolio VaR

- **Marginal VaR**
  - The change in portfolio VaR resulting from taking an additional dollar of exposure to a given component. It is also the partial derivative with respect to the component position.

$$MVAR_A = \frac{\partial VaR_p}{\partial V_A}$$
$$= z_\alpha \times \frac{Cov(R_A, R_P)}{\sigma_p}$$
$$= z_\alpha \times \rho_{A,P} \times \sigma_A$$
$$= z_\alpha \times \beta_{A,P} \times \sigma_P$$
$$= \frac{VaR_p}{V_p} \times \beta_{A,P}$$

Portfolio VaR

- **Incremental VaR**
  - Change in VaR owing to a new position.
  - Differs from marginal VaR: amount added or subtracted can be large.
  - Incremental VaR requires a full revaluation of the portfolio VaR with the new trade:

$$Incremental\ VaR = VaR_{a+p} - VaR_p$$

  - Approximate computation:

$$Incremental\ VaR_A \approx MVaR_A \times V_A(any\ amount)$$

Portfolio VaR

- **Component VaR**
  - Is a partition of the portfolio VaR: how much does portfolio VaR change approximately if the given component was deleted?
  - In a large portfolio with many positions, the approximation is simply the marginal VaR multiplied by the dollar weight in position i:
  - By construction, component VaRs sum to portfolio VaR.

$$CVaR_A = MVaR_A \times V_A$$
$$\frac{CVaR_A}{VaR_P} = \omega_A \times \beta_{A,P}$$
$$\sum_{i=1}^{N} \omega_i \beta_{i,p} = 1$$

Exercise 1

- A risk manager is evaluating a pairs trading strategy recently initiated by one of the firm's traders. The strategy involves establishing a long position in Stock A and a short position in Stock B. The following information is also provided:
  - 1-day 99% VaR of Stock A is USD 100 million
  - 1-day 99% VaR of Stock B is USD 125 million
  - The estimated correlation between long positions in Stock A and Stock B is 0.8

  Assuming that the returns of Stock A and Stock B are jointly normally distributed, the 1-day 99% VaR of the combined positions is closest to?

  A. USD 0 million
  B. USD 75 million
  C. USD 160 million
  D. USD 225 million

- **Correct Answer: B**

Exercise 2

- Given the following information, what is the percent of contribution to VaR from Asset A? There are two assets in a portfolio: A and B.

Asset A marginal VaR	0.05687
Asset A value	$7,000,000
Asset B marginal VaR	0.17741
Asset B value	$4,000,000

  A. 64.04%
  B. 24.27%
  C. 35.94%
  D. 63.64%

- **Correct Answer: C**

Exercise 3

- A portfolio has USD 2 million invested in Stock A and USD 1 million invested in Stock B. The 95% 1-day VaR for each individual position is USD 40,000. The correlation between the returns of Stock A and Stock B is 0.5. While rebalancing, the portfolio manager decides to sell USD 1 million of Stock A to buy USD 1 million of Stock B. Assuming that returns are normally distributed and that the rebalancing does not affect the volatility of the individual stocks, what effect will this have on the 95% 1-day portfolio VaR?

  A. There will be no effect.
  B. It will increase by USD 20,370
  C. It will increase by USD 21,370
  D. It will increase by USD 22,370

- **Correct Answer: D**

Exercise 4

- Suppose a portfolio consists of a USD 1 million investment in Euros and a USD 4 million investment in Mexican Pesos. Additional information is given below:
  - Portfolio beta of Euro = 0.90
  - Portfolio beta of Peso = 1.025
  - Diversified Portfolio VaR = USD 324,700
  - Based on the given information, the marginal VaR and the component VaR of the Euro position are closest to:

	Marginal VaR	Component VaR
A.	USD 0.058	USD 58,446
B.	USD 0.292	USD 292,230
C.	USD 0.084	USD 337,688
D.	USD 0.106	USD 422,110

- **Correct Answer: A**

Reading 4

Portfolio Risk Management

Framework

1. VaR Applications in Risk Management
2. Risk Budgeting

VaR Applications to Different Risks

- **VaR applications to different risks**
  - Absolute Risk vs. Relative Risk
  - Policy mix risk vs. Active management risk
  - Funding Risk
  - Sponsor Risk

Measure Different Risks

- **Absolute Risk vs. Relative Risk**
  - The difference is whether the loss is measured relative to zero or a benchmark.
  - Absolute Risk: risk of a dollar loss over the horizon.
  - Relative Risk: the risk of a dollar loss relative to benchmark. Shortfall measured as dollar difference between the fund return and benchmark return. Relevant return is the tracking error (TE), which is excess return of asset over benchmark.

$$TE = R_P - R_B$$

$$TEV = \sigma(e) = \sqrt{{\sigma_p}^2 - 2\rho\sigma_p\sigma_B + {\sigma_B}^2}$$

Measure Different Risks

- **Policy mix risk vs. Active management risk**
  - The absolute risk can be broken down into two components, one is the **policy mix risk,** the other is **active management risk.**
    - ✓ **Policy mix risk:** the policy mix risk is the risk of a dollar loss owing to the policy mix selected by the fund.
    - ✓ **Active management risk:** the active management risk is the risk of a dollar loss owing to the total deviations from the policy mix.
- **Policy mix return vs. Active management return**
  - The asset return can be decomposed into:

$$R_{asset} = R_{policy\ mix} + R_{active\ mgt}$$

$$= \sum_i {\omega_i}^b {R_i}^b + \sum_i \left(\omega_i R_i - {\omega_i}^b {R_i}^b\right)$$

Risk Types

- **Funding Risk**
  - The risk that assets values will not be sufficient to fund the liabilities.
  - **Surplus** (S) is the difference between the value of the assets (A) and the liabilities (L). The change in the surplus (△S) is equal to the change in assets (△A) minus the change in liabilities (△L).
  - Funding risk should be measured as the potential shortfall in surplus over the horizon, this is sometimes called **surplus at risk**.

$$Expected\ surplus = A \times (1 + R_A) - L \times (1 + R_L)$$

$$\sigma_{Surplus} = \sqrt{V_A{}^2\sigma_A{}^2 + V_L{}^2\sigma_L{}^2 - 2V_A \times V_L \times \sigma_A \times \sigma_L \times \rho_{AL}}$$

$$Surplus\ at\ risk = Z_\alpha \times \sigma_{Surplus}$$

Example

- An analyst reports the following fund information to the advisor of a pension fund that currently invests in government and corporate bonds:

Pension	Assets	Liabilities
Amount (USD million)	180	140
Expected annual growth	6%	10%
Modified duration	14	8
Annual volatility of growth	25%	12%

Example

- To evaluate the sufficiency of the fund's surplus, the advisor estimates the possible surplus values at the end of one year. The advisor assumes that annual returns on assets and the annual growth of the liabilities are jointly normally distributed and their correlation coefficient is 0.68. The advisor can report that, with a confidence level of 95%, the surplus value will be greater than or equal to:
  A. USD -58.2 million
  B. USD -22.0 million
  C. USD 1.0 million
  D. USD 21.0 million

- **Correct Answer: B**

Example

➢ **Explanation:**

- The lower bound of the 95% confidence interval is equal to: Expected Surplus – (95% confidence factor * Volatility of Surplus).
- The required variables can be calculated as follows:

$$\sigma_{Surplus} = \sqrt{V_A{}^2\sigma_A{}^2 + V_L{}^2\sigma_L{}^2 - 2V_A \times V_L \times \sigma_A \times \sigma_L \times \rho_{AL}}$$
$$= \sqrt{180^2 0.25^2 + 140^2 0.12^2 - 2 \times 180 \times 140 \times 0.25 \times 0.12 \times 0.68}$$
$$= 35.764$$
$$Expected\ surplus = A \times (1 + R_A) - L \times (1 + R_L)$$
$$= 180 \times 1.06 - 140 \times 1.10 = USD\ 36.80\ million$$

- Therefore, the lower bound of the 95% confidence interval = 36.80 – 1.645×35.764 = USD -22.032 million.

Measure Different Risks

➢ **Sponsor risk**

- **The sponsor is the owner of the fund,** who is ultimately responsible for the pension fund.
- **The sponsor risk** is measured both the movements in the assets, or even the surplus, and the ultimate effect on the economic value of the firm.
  - ✓ Cash-flow risk: is the risk of year-to-year fluctuations in contributions to the pension fund.
  - ✓ Economic risk: is the risk of variation in total economic earnings of the plan sponsor.
- The pension-plan management should be integrated with the overall financial goals of the plan sponsor.

Risk Budgeting

➢ **Budgeting across Asset Classes**

- Process of allocating and managing risk using a top-down approach to different aspects of the investment process.
- Process intended to systematically allocate return volatility across portfolio components (asset class, managers, and/or securities) to maximize return at a targeted level of risk.
  - ✓ First, **determine the total Value at Risk** (VaR) which can be "budgeted" to the firm.
  - ✓ Second, choose the optimal allocation of assets given the total risk profile.

Risk Budgeting

➢ **Budgeting across Active Managers**

- The traditional method for evaluating active managers is by measuring their tracking error and using it to derive a measure known as information ratio. And the tracking error is the active return minus the benchmark return.

$$IR_i = \frac{expected\ tracking\ error\ of\ the\ manager}{volatility\ of\ the\ manager's\ tracking\ error}$$

$$IR_p = \frac{expected\ tracking\ error\ of\ the\ portfolio}{volatility\ of\ the\ portfolio's\ tracking\ error}$$

- The optimal allocation across managers is:

$$weight\ of\ portfolio\ managed\ by\ manager\ i = \frac{IR_i \times portfolio's\ tracking\ error\ volatility}{IR_p \times manager's\ tracking\ error\ volatility}$$

- **Do not forget benchmark!**

Risk Budgeting

➢ **How to minimize portfolio risk**

- The portfolio manager can decrease portfolio risk by reducing positions with the highest marginal VaR.
- Repeat process until the portfolio risk has reached a **global risk minimum**.
- At this global risk minimum, all of the marginal VaRs must be equal, or all of the portfolio betas, must be equal to 1.

Risk Budgeting

➢ **From Risk Management to Portfolio Management**

- The role of a portfolio manager is to choose a portfolio that represents the best combination of expected risk and return.
- The optimal portfolio has the highest Sharpe ratio:

$$SR = \frac{E(R_P) - R_f}{\sigma_P} \rightarrow \frac{E(R_P) - R_f}{VaR_P}$$

- In order to make this ratio maximized, we have:

$$\frac{Position\ i\ return - risk\ free\ rate}{MVaR_i} = \frac{Position\ j\ return - risk\ free\ rate}{MVaR_j}$$

Exercise

- The pension management analysts at Bing Inc. use a two-step process to manage the assets and risk in the pension portfolio. First, they use a VaR-based risk budgeting process to determine the asset allocation across for broad asset classes. Then, within each asset class, they set a maximum tracking error allowance from a benchmark index and determine an active risk budget to distribute among individual managers. Assume the returns are normally distributed. From the first step in the process, the following information is available.

	Expected Return	Volatility	Asset Allocation	Individual VaR	Marginal VaR
Small cap	0.2%	2.66%	35.0%	6,491	0.055
Large cap	0.15%	2.33%	40.0%	6,497	0.044
Commodities	0.10%	1.91%	16.7%	2,216	0.020
Emerging market	0.15%	2.70%	8.3%	1,570	0.047
	Total VaR:13,322				

Exercise

- Which of the following statements is/are correct?
  - I. Using VaR as the risk budgeting measure, the emerging markets class has the smallest risk budget.
  - II. If an additional dollar were added to the portfolio, the marginal impact on portfolio VaR would be greatest if it were invested in small caps.
  - III. As the maximum tracking error allowance is lowered, the individual managers have more freedom to achieve greater excess returns.
  - IV. Setting well-defined risk limits and closely monitoring risk levels guarantee that risk limits will not be exceeded.
  - A. I and II only
  - B. II,III and IV
  - C. II and III
  - D. I only
- **Correct Answer: A**

Liquidity Considerations

- Liquidity considerations are important because a portfolio's liquidity profile could change significantly in the midst of a volatile market environment or an economic downturn, for instance.
- One potential measure is liquidity duration. It is an approximation of the number of days necessary to dispose of a portfolio's holdings without a significant market impact:

$$LD = \frac{Q}{(0.10 \times V)}$$

where:

LD = liquidity duration for the security on the assumption that the desired maximum daily volume of any security is 10%

Q = number of shares of the security

V = daily volume of the security

Exercise

- A portfolio manager currently holds 20,000 shares of Costiuk Inc. in a particular portfolio. The daily volume of Costiuk shares traded on the stock exchange is 50,000. Additionally, on any given day, the portfolio manager wishes to trade no more than 15% of the daily trading volume of Costiuk. Which of the following amounts is closest to the liquidity duration of Costiuk in this portfolio?

  A. 0.06

  B. 0.375

  C. 2.67

  D. 16.67

- **Correct Answer: C**

Reading 5

Performance Measurement and Evaluation

Framework

1. Performance Measurements
2. Performance Evaluations

Performance Measurement Framework

- **Tool 1: The Green Zone**
  - For prior week, month, year: calculate normalized returns (excess returns/tracking error) and tracking error.
  - Compare actual to target.
  - Policy decisions about deviations. (green/yellow/red)

- **Tool 2: Attribution of Returns**
  - A commonly used tool to measure the quality of returns is performance attribution. This technique attributes the source of returns to individual securities and/or common factors.

Performance Measurement Framework

- **Tool 3: The Sharpe and Information Ratios**
  - Can be used to measure relative performance vis à vis the competition; e.g., peer group comparisons.
  - They test whether the manager has generated sufficient excess returns to compensate for the risk assumed.

- **Tool 4: Alpha versus the Benchmark**
  - This tool regresses the excess returns of the fund against the excess returns of the benchmark.
  - The outputs of this regression are:
    - ✓ An intercept, often referred to as "alpha", or skill.
    - ✓ A slope coefficient against the excess returns of the benchmark, often referred to as "beta".

Performance Measurement Framework

- **Tool 5: Alpha versus the Peer Group**
  - This tool regresses the manager's excess returns against the excess returns of the manager's peer group.
  - This tool is used to determine whether the manager demonstrates skill over and above what is found in the peer group.
  - The outputs of this regression are:
    - ✓ An intercept, often referred to as "alpha," or skill.
    - ✓ A slope coefficient against the excess returns of peer group, often referred to as "beta."

Conventional Theory for Performance Evaluation

- **Time-weighted returns and dollar-weight returns**
- **Adjusting returns for risk**
  - Sharpe's ratio and M^2
  - Treynor ratio and T^2
  - Jensen's alpha
  - Information Ratio
- **Statistical Significance of Alpha**

Risk-Adjusted Performance Measures

- **Example**

Risk-free rate (T-bill)	5.0%	
	Portfolio P	**Market M**
Average return (r)	25%	20%
Beta	1.2	1.0
Standard deviation	18.0%	15.0%
Tracking error	6.0%	0

$$Sharpe\ Ratio = \frac{25\% - 5\%}{18\%} = 1.11$$

$$Treynor's\ Measure = \frac{25\% - 5\%}{1.2} = 0.1667$$

$$Jensen's\ Alpha = 25\% - [5\% + 1.2(20\% - 5\%)] = 2\%$$

$$Information\ Ratio = \frac{5\%}{6\%} = 0.833$$

$$M^2 = 15\%(1.11 - 1) = 1.65\%$$

Statistical Significance of Alpha

- **Alpha plays a critical role in determining portfolio performance.**
  - In order to assess a manger's ability of generate alpha, we conduct a t-test under the following hypotheses:
    - ✓ H_0: True alpha is zero
    - ✓ H_A: True alpha is not zero

$$t = \frac{\alpha}{\sigma/\sqrt{N}}$$

    - ✓ Where
    - ✓ α = alpha estimate;
    - ✓ σ = alpha estimate volatility
    - ✓ N = sample number of observations

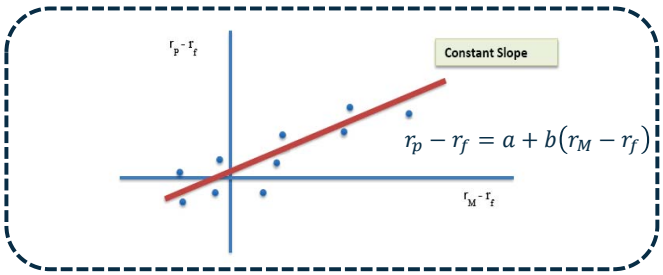
Exercise

- Over the past year, the HIR Fund had a return of 7.8%, while its benchmark, the S&P 500 index, had a return of 7.2%. Over this period, the fund's volatility was 11.3%, while the S&P index's volatility was 10.7% and the fund's TEV was 1.25%. Assume a risk-free rate of 3%. What is the information ratio for the HIR Fund and for how many years must this performance persist to be statistically significant at a 95% confidence level?
  - A. 0.480 and approximately 16.7 years
  - B. 0.425 and approximately 21.3 years
  - C. 3.840 and approximately 0.2 years
  - D. 1.200 and approximately 1.9 years

- **Correct Answer: A**

Market Timing Ability

- **Market Timing**
  - The ability to predict the future direction of market and shifting funds between the market index portfolio and risk-free assets depending on whether the market will outperform the risk-free assets.
- **No Market Timing**
  - Assuming no market timing, and a constant beta, the security characteristic line will be straight line with a constant slope.

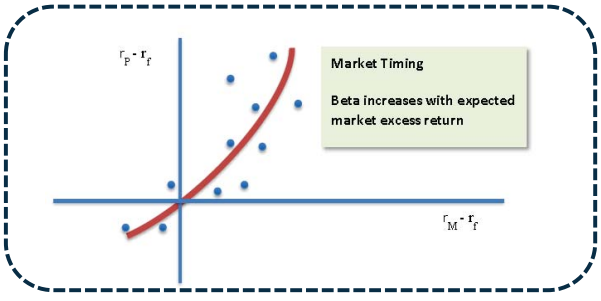


Market Timing Ability

- **Market Timing (Treynor and Mazuy)**
  - As the market returns increase, the portfolio beta will also increase, resulting in a curved line.

$$r_p - r_f = a + b(r_M - r_f) + c(r_M - r_f)^2 + e_p$$

  - The squared term represents the market-timing factor. A positive c is an indication of the fund manager's timing ability.



Market Timing Ability

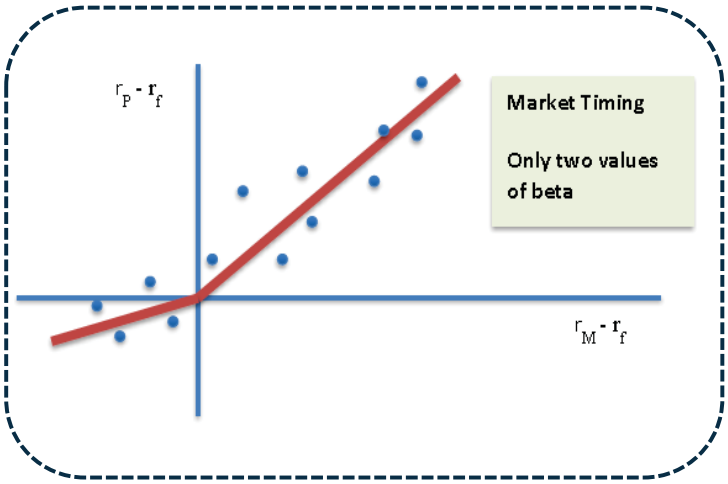
➢ **Market Timing (Henriksson and Merton)**

- This approach assumes that the beta of the portfolio can take only two values: a large value if the market is expected to do well, otherwise a smaller value.

$$r_p - r_f = a + b(r_M - r_f) + c(r_M - r_f)D + e_p$$

- D is a dummy variable. D = 1 when $r_M > r_f$, otherwise D = 0.
- The portfolio's beta is b in bear market and b + c in bull market. A positive c is an indication of the fund manager's timing ability.

Market Timing Ability



Value Market Timing Ability

➢ **Call Option Model**

- To see the value of information as an option, suppose that the market index currently is at S_0 and that a call option on the index has an exercise price of $X = S_0(1+r_f)$.

	$S_T < X$	$S_T > X$
Bills	$S_0(1+r_f)$	$S_0(1+r_f)$
Option	0	$S_T - X$
Total	$S_0(1+r_f)$	S_T

✓ The value or appropriate fee for perfect foresight should equal to the price of the call option on the market index.

Performance Attribution

- **Performance Attribution**
  - Identify the sources of value addition to the portfolio.
  - How much of the performance (excess returns above benchmark) is attributable to the selection of the risk asset classes.
  - How much is attributable to selection of right sector or security within an asset class.

Exercise

- A risk manager runs a performance attribution analysis on an actively managed portfolio using a selected benchmark. The weights and performance of the different market sectors within the portfolio and the benchmark are given below:

	Benchmark		Portfolio	
Market Sector	Weight	Annual Return	Weight	Annual Return
Equity	20%	8%	40%	6%
Fixed Income	50%	4%	55%	5%
Cash	30%	2%	5%	3%

Exercise

- What conclusion can be drawn from the data above by using common performance attribution analysis?
  - A. The portfolio outperforms the benchmark primarily because of the contribution of asset allocation.
  - B. The portfolio outperforms the benchmark primarily because of the contribution of security selection within market sectors.
  - C. The portfolio underperforms the benchmark primarily because of the contribution of asset allocation.
  - D. The portfolio underperforms the benchmark primarily because of the contribution of security selection within market sectors.

- **Correct Answer: A**

Reading 6

Hedge Fund

Framework

1. Introduction of Hedge Funds
2. Evolution of the Hedge Fund Industry
3. Hedge Fund Strategies
4. Risk Management of Hedge Fund
5. Due Diligence

Introduction of Hedge Funds

➢ **Hedge Funds versus Mutual Funds**

- Private versus public
  - ✓ Historically, hedge funds are private investment vehicles not open to the general investment public.
  - ✓ Consequently, hedge funds face less regulation than publicly traded mutual funds.
- Ability to take short positions
  - ✓ Typically hedge fund managers generate profit from both long as well as short positions.
- Freedom to use high leverage
- Ability to employ derivatives

Introduction of Hedge Funds

- **Basic Features**
  - To keep other traders from mimicking or "front running" their trades, they offer very **little transparency**, even to their investors.
  - **A typical hedge fund charges a fixed management fee based on the value of assets they manage**. The lower end of this range is comparable to the management fees charged by actively managed mutual funds. However, unlike mutual funds, hedge funds generally charge an incentive fee which are only payable when new profits are made. Sometimes, the incentive fee is paid after the performance exceeds a hurdle rate, such as LIBOR.

Introduction of Hedge Funds

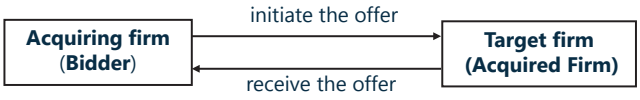
- **Bias in Hedge Fund Databases**
  - **Survivorship Bias**
    - ✓ Few hedge-fund databases maintain histories of funds that have shut down, partly for legal reasons, and partly because the primary users of these databases are investors seeking to evaluate existing managers they can invest in.
  - **Self-Selection Bias**
    - ✓ If a manager operates several hedge funds, it is questionable whether the poor performing ones will find their way into databases. In other words, there may well be a tendency to "put the best face forward"
  - **Backfill Bias**
    - ✓ A related and important form is sometime referred to as the "instant history" bias.
    - ✓ When a new fund enters the database some of its performance history during its incubation period is incorporated without clear distinction from the live performance data going forward.

Hedge Fund Strategies

- **Directional Strategies: Trend Followers (Managed Futures) and Global Macro**
  - **Managed Futures**
    - ✓ Managed futures funds typically focus on investing in listed bond, equity, commodity futures and currency markets, globally.
    - ✓ Managed futures fund managers tend to employ systematic trading programs that largely rely upon historical price data and market trends.
  - **Global Macro**
    - ✓ Global macro funds typically focus on identifying mis-pricings in equity, currency, interest rate and commodity markets.
    - ✓ Managers typically employ a top-down global approach to analyze how political trends and global macroeconomic events may affect the valuation of financial instruments.

Hedge Fund Strategies

- **Event-Driven Strategies: Risk Arbitrage & Distressed Securities**
  - **Risk Arbitrage:** As known as Merger Arbitrage.



    - ✓ The principal risk is usually deal risk, should the deal fail to close.
  - **Distressed Securities**
    - ✓ Invest across the capital structure of companies subject to financial or **operational distress or bankruptcy proceedings**. Such securities often **trade at discounts** to intrinsic value due to difficulties in assessing their proper value, lack of research coverage, or an inability of traditional investors to continue holding them.
    - ✓ The strategy may focus on mispricing caused by expected restructuring, reorganization, legal or regulatory issues, or corporate transactions.

Hedge Fund Strategies

- **Relative Value and Arbitrage-like Strategies:**
  - **Fixed Income Arbitrage**
    - ✓ Strategies may include leveraging long and short positions in similar fixed income securities. For instance, long swap and short Treasuries with same duration.
  - **Convertible Arbitrage**
    - ✓ Managers typically build long positions of convertible and other equity hybrid securities and then hedge the equity component by shorting the underlying stock or options of that company.
    - ✓ **Net long gamma and vega**
  - **Long/Short Equity**
    - ✓ Invest in both long and short sides of equity markets, often with a specific focus on certain sectors, regions or market capitalizations.
    - ✓ Have flexibility of shifting from value to growth stocks, small cap to large cap stocks, and net short to net long position.

Hedge Fund Strategies

- **Niche Strategies: Dedicated Short Bias, Emerging Market and Equity Market Neutral**
  - **Dedicated Short Bias**
    - ✓ Take more short positions than long positions and earn returns by maintaining net short exposure in long and short equities.
  - **Emerging Market**
    - ✓ Invest in currencies, debt instruments, equities and other instruments of developing countries' markets.
  - **Equity Market Neutral**
    - ✓ achieving almost zero beta(s) against a broad set of equity indices.

Hedge Fund Strategies

- **Funds of Hedge Funds**
  - A fund of hedge funds are portfolios of hedge funds, which add value by providing automatic diversification and careful selection of styles and investment managers.
  - A major objective of the fund of hedge funds is optimal diversification.
  - Funds of funds charge additional management fees on top of those levied by the underlying funds, typically around 1%.

Exercise 1

- An acquisition has been announced by Company A to merge with Target Company T. Before the announcement, Acquirer A's shares traded at $21 and Target T's shares traded at $6 price. The proposed share-for-share exchange ratio was 1:2. Subsequent to the announcement, Acquirer A's shares trade down to $20 and Target T's shares trade up to $8. At this time, a merger arbitrage hedge fund takes a short position in Acquirer's A's stock hedged by a long position in Target T's stock. The merger is successful and the prices close at $28 (Acquirer) and $14 (Target). What is the gain per each single shorted share of Acquirer A?
  A. Zero per share of Acquirer A
  B. -$2 loss per share of Acquirer A
  C. +$1 gain per share of Acquirer A
  D. +$4 gain per share of Acquirer A

- **Correct Answer: D**

Exercise 2

- How would the risk in a merger arbitrage strategy best be characterized?
  A. The arbitrage can be structured so there is a gain no matter the outcome.
  B. The arbitrageur's loss if the deal does not go through is much greater than the gain if the deal goes through.
  C. The arbitrage can be structured as riskless, assuming no other bidders come forward after the initial offer.
  D. The arbitrageur's gain on the deal if it does go through is much greater than the loss if the deal does not go through.

- **Correct Answer: B**

Exercise 3

- Hedge fund managers following a convertible arbitrage strategy are said to be:
  - A. long gamma and short vega
  - B. short gamma and short vega
  - C. long gamma and long vega
  - D. short gamma and long vega

- **Correct Answer: C**

Exercise 4

- The Big Bucks Hedge fund has the following description of its activities. It uses simultaneous long and short positions in equity with a net beta close to zero. Which of the following statements about Big Bucks are correct?
  - I. It uses a directional strategy.
  - II. It is an Equity Market Neutral strategy.
  - III. This fund is exposed to idiosyncratic risks.
  - A. I and II
  - B. II and III
  - C. I and III
  - D. II only

- **Correct Answer: B**

Exercise 5

- Samantha Moore manages a hedge fund for a mid-sized money management firm. The fund frequently changes styles according to identified profit opportunities. At the beginning of the year, the fund took a long position in 10-year subordinated 8% coupon debt issued by a firm expected to undergo reorganization under Chapter 11. Moore felt that analysts had been paying too little attention to the issuer. Six months later, the fund completed a second transaction involving a long position in Swiss Francs and a short position in Japanese Yen based on forecasted movements in interest rates in the two countries. What two hedge fund strategies are most likely being employed by Moore's hedge fund?
  - A. Distressed securities strategy and equity long/short strategy.
  - B. Fixed-income arbitrage and global macro strategy.
  - C. Distressed securities strategy and global macro strategy.
  - D. Fixed-income arbitrage and equity long/short strategy.
- **Correct Answer: C**

Risk Management of Hedge Fund

➢ **Risk Management Challenges**

- Are heterogeneous
- Hedge funds invest in illiquid assets
- Most employ leverage
- Some have high turnover
- Exhibit a lack of transparency
- Survivorship bias is a major consideration when hedge funds are evaluated as a group. This could significantly exaggerate their returns.

Risk Management of Hedge Fund

➢ **Hedge fund risks**

- Liquidity risk
  - ✓ Low correlations and Low volatility
  - ✓ Positive serial autocorrelation in returns.
- Leverage Risk(Crowded trade risk)
- Agency Risk(principle-agent problem)
  - ✓ High water marks.
  - ✓ The cost of fund closure being very high.
  - ✓ Fund managers invest a sizeable amount of their own wealth
- Style Drift Risk: Reasons for Style Drift are important.
- Fraud risk
  - ✓ **Due diligence**

Exercise 1

➢ The Peyton Formika Fund is a global macro asset allocation hedge fund designed to provide low correlations with U.S. assets. Dominic James is a fund of hedge funds manager that is analyzing the Peyton Formika Fund for signs of style drift. James makes note of the following findings about the fund:

I. The R^2 of the fund versus the global macro peer group has changed from 0.72 to 0.78 over the past 12 months.

II. Due to outstanding returns, assets in the fund have increased from $70 million to $430 million over the past 12 months.

III. The fund made a major shift in allocation by moving 40 percent of its holdings from Eastern European equities to Asian equities.

IV. After a recent trip to India, the fund manager gained confidence in his existing Indian equity holdings and levered his existing 5% weighting in India only by a 10 to 1 ratio.

➢ Which of James' findings are indicators that the Peyton Formika Fund is at risk for style drift?

A. II and IV only
B. I and II only
C. II and III only
D. I, III and IV only

➢ **Correct Answer: A**

Exercise 2

- A useful measure for assessing liquidity risk for hedge funds is the Q-statistic. Which of the following statements is true regarding the statistical significance of the Q-statistic measure?
  - A. Smaller p-values indicate that autocorrelations are more statistically significant.
  - B. We will be 99% confident that we can reject the null hypothesis of no correlation when the test statistic has a p-value of 0.1
  - C. The null hypothesis of positive autocorrelations can be rejected when each lagged autocorrelation is close to zero.
  - D. Larger p-values indicate that autocorrelations are more statistically significant.
- **Correct Answer: A**

Due Diligence

- **Reasons for the Failures of Funds in the Past**
  - Funds can fail as a result of **bad investment decisions.**
  - Funds can also fail due to all sorts of **frauds,** including accounting frauds, valuation frauds, or misappropriation of funds.
  - Funds can fail due **to excessive leverage, improbable probabilities, unexpected events, and tail risk.**
  - Fund can get **caught in squeezes by other hedge funds.**
  - Funds can fail as a result of **a lack of supervision or compliance controls related to insider trading.**
  - Fund can fail due to **a flood of unanticipated withdrawals of capital at the least opportune time.** Funds can fail when liquidity dries up, and they can't meet redemptions.
  - Funds can fail because of their own actions or the acts of other.

Due Diligence Process

- **The due diligence process**
  - Investment process
  - Related risk controls
  - Operational Environment
    - ✓ Internal Control Assessment
    - ✓ Documents and Disclosures
    - ✓ Service Provider Evaluation
  - Model Risk and Fraud Risk

Exercise

- Lisa Tahara, FRM, is considering an institutional investment in a hedge fund that has experienced volatile and generally positive returns in the past. Which of the following considerations about the fund's track record is least relevant for consideration in her investment decision?
  - A. Size of investment assets
  - B. Absolute level of past returns.
  - C. Verification of returns by a third party.
  - D. Employment continuity of the investment team.

- **Correct Answer: B**

It's not the end but just beginning.

If you have people you love, allow them to be free beings. Give and don't expect. Advise, but don't order. Ask, but never demand. It might sound simple, but it is a lesson that may take a lifetime to truly practice. It is the secret to true Love. To truly practice it, you must sincerely feel no expectations from those who you love, and yet an unconditional caring.

如果你有爱的人，允许他们自由随意的存在。给予而不指望；建议而不命令；请求而不要求；可能听起来简单，但这需要一辈子去实践。这就是真爱的秘诀。真正去实践它，你必须对那些你爱的人没有期望，并给予无条件的关爱。

问题反馈

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- **如何告诉我们？**
  - 将您发现的问题通过电子邮件告知我们，具体的内容包含：
    - ✓您的姓名或网校账号
    - ✓所在班级（eg.1905FRM一级长线无忧班）
    - ✓问题所在科目（若未知科目，请提供章节、知识点）和页码
    - ✓您对问题的详细描述和您的见解
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Framework

Current Issues

- 1.The Impact of Blockchain Technology on Finance
- 2.FinTech and market structure in financial services
- 3.Fintech credit markets around the world
- 4.Implications of fintech developments for banks and bank supervisors
- 5.The Rise of Digital Money
- 6.Big Data
- 7.Machine Learning
- 8.Artificial intelligence and machine learning in financial services
- 9.Climate Change and Financial Risk
- 10.Beyond LIBOR

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1. The Impact of Blockchain Technology on Finance

A. Blockchain Technology Basics

Blockchain

- Computerised ledger; relies on cryptographic techniques; consensus to capture and secure the data.
- The ledger is shared among distrusting participants; no one has control.
- A growing chain of ledger links the history; past records cannot be rewritten.

A. Blockchain Technology Basics

A Brief History of Consensus

- Distributed Consensus
  - How multiple computers can reliably agree on common data in the presence of faults?
  - Blockchain uses distributed consensus to agree upon transactions.
- Bitcoin
  - Participants can agree upon a continually updated history of all transactions.
  - Users have control over their bitcoin via a digital signature.
  - Digital signatures are public, cannot be forged, and can be verified by anyone.

A. Blockchain Technology Basics

- The Proof-of-Work Design
  - Miners collect outstanding transactions, while competing to find a randomly chosen string of numbers and letters.
  - Miner broadcasts his findings; claim his reward.
- The Adjustment on the Difficulty of the Competition
  - An algorithm automatically adjusts the difficulty of mining.
  - As more miners join the network, the difficulty rises.
  - Costs: computer hardware, electricity.
- Bitcoin Full Nodes
  - Computers only validate the Bitcoin blockchain, but do not mine new blocks.
  - When accepting a large payment => run a full node to validate the transaction.

A. Blockchain Technology Basics

Blockchain Technology and Distributed Databases

- Permissionless blockchains
  - Anyone can join the Bitcoin network and become a miner.
- Permissioned blockchains
  - Only a limited set of entities allowed to write to the blockchain.
  - ie. distributed ledger technology (DLT)

Smart Contracts

- Enforce the transfer of digital assets.
- Do not require a trusted third party to intermediate.
- The blockchain network enforces the execution of the contract on its own.

A. Blockchain Technology Basics

Tokens

- Companies issue a new token managed by a smart contract underlying an existing blockchain network.
- The blockchain network's computers validate the token's transactions.

A Spectrum of Decentralisation

- On the decentralised end: permissionless systems; no restrictions on who can join the system.
- On the other end: a traditional centralised database
- Costs from Introducing a Blockchain
  - Decentralised security is quite costly.
  - If a trusted third party to secure the ledger => much lower.
  - Must weigh the potential to reduce the 'cost of trust' against the high operational costs of blockchain.

B. Blockchain Technology's Opportunities and Challenges

Impediments to Broad Adoption

- Benefits
  - Participants don't need to trust a particular person to maintain that record.
  - Open the door to peer-to-peer transactions.
  - Reduce overall friction.
- Challenges
  - Blockchains are complex; with attendant latencies.
  - Concerns about privacy and security.
  - Hacking.
  - Who to trust in coordinating the transfer of assets?
  - For software updates, there is no controlling entity.
  - Cryptocurrency speculation.
  - Public policy and legal frameworks.

B. Blockchain Technology's Opportunities and Challenges

A Framework for Understanding Transaction Costs and Trade-offs

- The Trade-offs Worth Consideration
  - Trade-offs between the benefits and costs of centralised market structures vs distributed networks.
  - The financial sector is choosing security and scalability over decentralisation
    - ✓ Most financial sector applications still rely on trusted intermediaries.
- Basic Economic Properties of Blockchains
  - More users, higher benefits of blockchain application.
  - For permissioned blockchains, reduce overall transaction costs.
  - In digital identity or medical records: centralised systems may be inferior because they incur many of the costs.

C. Blockchain Technology and Finance

Where Could Blockchain Technology have an Impact?

- Payments
  - The existing approach to cross-border payments is slow and expensive.
  - Remittances and foreign currency payments were one of the first potential applications of blockchain technology.
- Digital Identity/Know Your Customer
  - Verify numerous data points about their customers.
  - Banks use DLT as the cross-institution source of proof.
- Primary Securities Issuance
  - Blockchain-based systems can issue corporate loans.
    - ✓ All parties have a shared record of the transaction and any updates.
    - ✓ Auto distribution of cash flows.

C. Blockchain Technology and Finance

- Securities Clearing and Settlement
  - A shared ledger may enable real-time clearing and settlement.
- Derivatives Clearing and Processing
  - Many clauses can be coded directly into smart contracts.
    - ✓ Auto execution.
- Post-trade Reporting
  - Distributed ledgers include a full audit trail for each transaction.
    - ✓ Facilitate post-trade regulatory reporting.
- Trade Finance
  - Give lenders greater confidence in the veracity of exporter claims and make letters of credit more available.

C. Blockchain Technology and Finance

Finance Starting at the Centralised End of the Spectrum

- Permissioned blockchains mitigate the governance, privacy and scalability challenges that public blockchains face.
- Critics
  - Closed systems face a security risk because the validators can collude to change the ledger.
  - Members may limit the innovations challenging their business models.

C. Blockchain Technology and Finance

Crypto-finance

- Token Sales
  - Have led to a new means of raising capital for blockchain-based projects.
    - ✓ ICO
  - Purchasers are bearing risk of the eventual success of the new network.
- ICOs
  - VCs see ICOs as a new way to fund start-ups.
  - A high failure rate for ICOs, due to a considerable amount of fraud.
- Cryptoexchanges
  - Enable investors in the tokens to trade.
  - Offer market-making, advisory and custodial services.

2. FinTech and Market Structure in Financial Services

A. Background and Definitions

Financial Innovation Influences Market Structure

- The emergence of providers of bank-like services may impact markets.
- The entry of BigTech firms into financial services => increased competition.
- The reliance on third-party service providers may increase over time.
- A shift to open banking: greater competition.

Key Elements of Market Structure

- Concentration
- Contestability
- Composition

A. Background and Definitions

Tech Innovation Affects these Elements

- Lower barriers to entry.
- Increase competition.
- Incumbents: be constrained by legacy IT systems.
- BigTech firms: possess up-to-date technology and funds => have a competitive edge.
- Unbundle many services offered by incumbents.

B. Financial Innovation and Links to Market Structure

Supply Factors – Technological Developments

- The use of APIs allows different software applications to communicate with each other.
- Mobile devices expand the availability of financial services.
- Cloud computing offers advantages.

Supply Factors – Regulation

- Changes in licensing and prudential supervision frameworks.
- Ensuring contestability and a level playing field is an explicit policy objective.

B. Financial Innovation and Links to Market Structure

Demand Factors – Changing Customer Expectations

- The digitisation of commerce => more convenient experiences across the services.
- Younger cohorts may be more likely to adopt FinTech.
- A desire for higher returns => provide FinTech platforms with a larger investor base.
- The convenience of investing through mobile.

C. The Current Landscape

Impact to Date of FinTech Firms

- FinTech firms have found new niches and underserved clients.
- The Case of Lending Platforms
  - Competitive pressures on incumbent lenders appear limited.
- Cooperation between Incumbents and FinTech Firms
  - Incumbents outsource to FinTech firms their business.
  - FinTech firms can access to incumbents' client base.

C. The Current Landscape

Impact of BigTech Firms

- Client data allows them to carry out risk assessments.
- Acquire market share in the high-revenue area.
- BigTech Firms Differ from FinTech Firms
  - BigTech firms already have established networks and a large customer base.
  - Well capitalised.
  - Have ready access to the forefront technologies to process big data.

C. The Current Landscape

Third-Party Service Providers

- The level of reliance on cloud computing providers may be low.

How Firms Utilise Cloud Computing

- Cloud computing has the potential to improve the security and resilience.
  - Avoid vendor capture.
  - More affordable.
  - Promote greater security.
  - Enable small FIs access to sophisticated architecture.

D. Conclusions on Financial Stability and Implications

Summary of Findings

- Implications for Financial Stability
  - FinTech firms may partner, complement, or compete with existing FIs.
- The Benefits for FinTech Firms
  - Compete more effectively in some narrow product areas.
  - Reduce the stickiness of existing customer relationships.
  - Greater decentralisation of financial services.
  - An enhancement of financial stability through wider access to financial services.

D. Conclusions on Financial Stability and Implications

- Macro-Financial Risks
  - The effects of competition.
  - Disruption of business models on profitability.
  - Loosening of lending standards.
- Micro-Financial Risks
  - Cyber incidents.
  - Heightened legal risk.

D. Conclusions on Financial Stability and Implications

Implications

- Vigilance by Supervisors
  - Monitor the impact of heightened competition on profitability and lending standards.
  - Monitor cyber risk.
  - Understand the incentives and barriers to entry by BigTech firms.
  - Manage third-party risks.

3. Fintech Credit Markets Around the World

A. How does Fintech Credit Work?

Fintech Credit

- Credit activity facilitated by electronic platforms that are not operated by commercial banks.
- Use digital technologies to interact with customers online.
- Lie outside the prudential regulatory perimeter.

P2P

- The online platform provides a low-cost standardised loan application process and facilitates direct matching and transacting of borrowers and lenders.
- The credit platform services the loan in return for ongoing fees.

Risk Spread and Default Risk

- Spread their investments across multiple loans.
- Platforms maintain a contingency fund for borrower defaults.

A. How does Fintech Credit Work?

Revenue Sources

- Retain and attract an investor base to generate fee revenue.
- Some platforms retain loans on their balance sheet.

The Digitalisation of Customers and Loan Origination

- An assessment of borrowers' credit quality: a credit grade => set a loan interest rate.
- Many platforms tend to assess non-traditional data.

How Banks Embrace Fintech Credit?

- Banks' use of new digital techniques is not yet as advanced.
- Fintech is distinct from lower-yielding, but safer, bank deposits.

B. Fintech Credit Market Development

Market Development

- China was by far the largest market.
- But a slowdown in many major jurisdictions.
- Fintech credit represents a very small share of overall credit flows.

The Composition of Fintech Users

- Individuals or institutional investors.

C. What Drives Fintech Credit?

Three major factors

- Fintech credit volume per capita is positively associated with GDP per capita.
- A less competitive banking sector => more fintech credit activity.
- More stringent banking regulation deters fintech credit activity.

D. Implications for Credit Availability and Risk

Benefits

- Promise greater convenience, lower transaction costs and better credit risk assessments.
- Greater financial inclusion.
- Greater diversity in the sources of credit.

Risks

- Could weaken lending standards.
- More procyclical than traditional credit.
- More vulnerable to investor pullback.
- Erode incumbent banks' profitability.
- Higher platform default rates.
  - Investor confidence has also been shaken.

E. Regulatory Frameworks

Regulatory Forms

- Licences to operate fintech credit platforms.
- Minimum capital requirements.
- Prohibit some high-risk business models.
- Mandated filing.

E. Regulatory Frameworks

Forms to Encourage Innovation

- Regulatory sandboxes.
- Innovation hubs.
- Funding support.
- Specific tax incentives.

Impacts on the Supervision of Existing Financial Intermediaries

- Banks interact with platforms => present new reputational and operational risks.
- Monitor potential related macro-financial vulnerabilities.

4. Implications of Fintech Developments

A. Fintech Developments and Forward-looking Scenarios

What is Fintech?

- Technologically enabled financial innovation; result in new business models; with an associated material effect on financial markets and institutions; the provision of financial services.

What Are the Key Fintech Products and Services?

- Three Product Sectors
  - Credit, deposit and capital-raising services; Payments, clearing and settlement services; Investment management services.

A. Fintech Developments and Forward-looking Scenarios

How Big is Fintech?

- Fintech has reached the initial peak of the "hype cycle".
- But volumes are currently still low.

Comparison with Previous Waves of Innovation and Factors Accelerating Change

- The pace of adoption has increased.
- A generation of digital natives is growing up with a technological proficiency.
- The effects of innovation and disruption can happen quickly.

A. Fintech Developments and Forward-looking Scenarios

Forward-looking Scenarios

- The better bank: The incumbent banks digitise and modernise themselves.
- The new bank: Incumbents are replaced by challenger banks.
- The distributed bank: new businesses emerge to provide specialised services without attempting to be universal retail banks.
- The relegated bank: incumbent banks become commoditised service providers and customer relationships are owned by new intermediaries.
- The disintermediated bank: Banks have become irrelevant as customers interact directly with individual financial services providers.
- Future evolutions may be a combination of the five scenarios: with both fintech companies and banks owning aspects of the customer relationship.

B. Implications for Banks and Banking Systems

Opportunities

- Financial inclusion.
- Better and more tailored banking services.
- Lower transaction costs and faster banking services.
- Improved and more efficient banking processes.
- Potential positive impact on financial stability due to increased competition.
- Better Regtech.

B. Implications for Banks and Banking Systems

Key Risks

- Strategic risk: rapid unbundling of bank services to non-bank firms => increases risks to profitability at individual banks.
- High systemic operational risk: more IT interdependencies between market players => cause an IT risk into a systemic crisis.
- High idiosyncratic operational risk: innovative products may increase the complexity of financial services delivery => hard to control operational risk.
- Compliance risk with regard to data privacy.
- Outsourcing risk
- Cyber-risk.

B. Implications for Banks and Banking Systems

Implications of Using Innovative Enabling Technologies

- AI: gain greater insight into customer needs and the provision of more tailored services.
- DLT developments facilitate value transfer exchanges between parties without the need for intermediation.
- Cloud Computing
  - Incumbent banks can develop new solutions and migrate away from legacy systems.
  - New players can fit scenarios that challenge the current banking system.

Focus on Outsourcing and Partnering Risk

C. Implications for Bank Supervisors and Regulatory Frameworks

Increased Need for Cooperation

- Ensure that banks using innovative technologies are complying with the relevant laws.

Bank Supervisors' Internal Organisation

- Ensure that the knowledge, skills and tools of their staff remain relevant and effective.

Suptech Opportunities

- New technologies to improve the supervision methods and processes.

C. Implications for Bank Supervisors and Regulatory Frameworks

Continued Relevance of Regulatory Frameworks

- Supervision of Third-party Service Providers
- Licensing Regimes
  - Consider new regulations related to emerging fintech services.

Facilitation of Innovation

- Eg. innovation hubs, accelerators and regulatory sandboxes.
  - Help companies navigate the supervisory regulations.
  - Help regulatory agencies explore new technologies for internal supervisory purposes.

5. The Rise of Digital Money

A. New Digital Forms of Money

A Taxonomy—The "Money Tree"

- Four Attributes of Payment Means
  - 1. Type
    - ✓ An object: such as cash.
    - ✓ A claim: such as swiping a debit card.
  - 2. Value
    - ✓ Fixed value claims.
    - ✓ Variable value claims.
  - 3. Backstop
    - ✓ Backstopped by the government, or by private?
  - 4. Technology
    - ✓ Is settlement centralised or decentralised?

A. New Digital Forms of Money

Five Different Means of Payment

1. **Central Bank Money**
   - Cash.
   - Central bank digital currency or CBDC.
2. **Crypto-currency**
   - Object-based means of payment.
   - Issued on a blockchain.
   - An example is Bitcoin.

A. New Digital Forms of Money

3. **B-money**
   - Claim-based money.
   - Its redemption guarantee is backstopped by the government.
4. **E-money**
   - A debt-like instrument.
   - The redemption guarantees are not backstopped by governments.
   - Alipay and WeChat Pay.
5. **i-Money**
   - Equivalent to e-money, but offers variable value redemptions into currency.
   - Example: Libra.

B. Adoption of E-money Could be Rapid

How Stable is E-money?

- Cryptocurrency
  - Its value can fluctuate significantly.
- Central Bank Money
  - Cash or CBDC: is perfectly stable.
  - The government's solvency underpins the value.
- i-Money
  - I-money backed by Treasury bills will be less risky than i-money backed by stock market shares.

B. Adoption of E-money Could be Rapid

- E-money
  - Does not benefit from government backstops.
- E-money is Exposed to 5 Types of Risks
  - OP, liq, def, market, fx rate risks
- Options to Minimise Exposure to These Risks
  - Invest in safe and liquid assets.
  - Control the creation of e-money.
  - Sufficient capital.

B. Adoption of E-money Could be Rapid

E-money Adoption Could Be Fast for Its Attractiveness as a Means of Payment

- Why E-money Grows Rapidly?
  - Convenience.
  - Transaction costs.
  - Users trust telecommunications and social media.
  - Network effects.

C. Effects of E-money on the Banking Sector

Risks of Rapid E-money Adoption

- E-money providers may be natural monopolies.
- Risks to monetary policy transmission could emerge from currency substitution.

Scenario 1: e-money and b-money will coexist; the battle will wage on.

Scenario 2: e-money providers could complement commercial banks.

Scenario 3: commercial banks' deposit-taking and credit functions could be split.

D. The Role of Central Banks and Synthetic CBDC

Today's World

- All banks hold accounts at the central bank.

Tomorrow's World

- Some central banks already offer special purpose licenses that allow nonbank fintech firms to hold reserve balances.
  - Allow e-money providers to overcome market and liquidity risk.
- Massive Runs from Bank Deposits into E-money in Times of Crises
  - As clients seek the protection of banks' deposit insurance: flow from e-money to b-money.
  - Uninsured deposits might migrate from banks to e-money providers.

D. The Role of Central Banks and Synthetic CBDC

Potential Advantages

- Benefits from Offering E-money Providers Access to Central Bank Reserves
  - Stability of e-money.
  - Central banks could protect consumers from the growth of e-money monopolies.
  - Monetary policy transmission could be more effective.

Synthetic Central Bank Digital Currency

- The central bank: offer settlement services to e-money providers, including access to central bank reserves.
- E-money providers: all other functions.
- Dual comparative advantages.

6. Big Data

A. Tools to Manipulate Big Data

Why Big Data is Useful?

- More powerful data manipulation tools.
- Variable selection.
- To model complex relationships.

SQL and NoSQL Databases

Cloud Computing

B. Tools to Analyse Data

Pre-Processing Data

Categories of Data Analysis

- Prediction
- Summarisation
- Estimation
- Hypothesis testing

Machine Learning

- To find some function that provides a good prediction of y as a function of x.
- CART, random forests, Neural nets, Deep learning, SVM...

C. General Considerations for Prediction

Overfitting Problem

- Works well in-sample but fails miserably out-of-sample.
- Ways to Deal with Overfitting
  - Simpler models.
    - ✓ Regularisation.
  - Divide the data into training, testing, and validation sets.

D. Classification and Regression Trees

Classification and Regression Trees (CART)

- To predict a 0 or 1 outcome.

Example: Classification for Survivors of the Titanic

- CART vs Logistic Regression
  - Logistic regression: better for smaller data sets.
  - Trees: better for larger data sets.
  - Trees don't work very well for linear relationship.
- Pruning Trees
  - To provide the best out-of-sample predictions.

D. Classification and Regression Trees

Example: Home Mortgage

- Bootstrap: choose with replacement a sample from a dataset.
- Bagging: average across models.
- Boosting: repeat estimation.
- Random Forests
  - Use multiple trees.
  - Produce good out-of-sample fits.
  - A black box.

E. Econometrics and Machine Learning

Collaboration between Econometrics and ML

- Time Series Models
  - Bayesian Structural Time Series model.
- Causal Inference
  - ML dealt with pure prediction.
  - Econometricians: causal inference.
- Causality and Prediction
  - A big difference between correlation and causation.

E. Econometrics and Machine Learning

Model Uncertainty

- Averaging over many small models can give better out-of-sample prediction.
- Model uncertainty: how an estimated parameter varies as different models are used?

7. Machine Learning

A. Introduction

The Driving Forces

- More details of reporting.
- High-frequency, unstructured consumer data.

Machine Learning and Artificial Intelligence

- Model complex, non-linear relationships.

B. Background to ML

Supervised Learning

- Dependent variable y is known.

Unsupervised Learning

- Dependent variable y is lacking.

Non-parametric Analyses

- Flexible to fit any model.
- Hardly make an assumption about the relationship.
- Infer non-linear relationships.

B. Background to ML

Machine Learning Methods

- Regression
  - A supervised ML problem.
  - To predict a continuous dependent variable y.
  - A factor is added to penalise complexity in the model.
- Classification
  - A discrete problem.
- Clustering
  - An unsupervised ML problem.

B. Background to ML

Prediction versus Explanation

- Statistical methods are good for explanation.
- ML is good for prediction.

B. Background to ML

Tackling Overfitting: Bagging and Ensembles

- Overfitting
  - Fit the data sample very well; perform poorly when tested out-of-sample.
  - Having too many parameters.
- Ways to Deal with Overfitting
  - Boosting: overweight scarcer observations in a training dataset.
  - Bagging: a model is run thousands of times, each on a different subsample of the dataset.
    - ✓ Average all the runs.
  - Random forest: a model consisting of many different decision trees.
  - Ensemble: average the resulting model with many other ML models.

B. Background to ML

A Theory-free Approach to Analysis?

- ML: not understanding the relationship.
- A backward-looking way of prediction.

Deep Learning and Neural Networks

- Multiple layers of algorithms are stacked to mimic neurones in the layered learning process of the human brain.

Application within Financial Services

- Massive Data
  - High-quality, structured supervisory data.
    - ✓ Conventional ML is applied.
  - High frequency, low quality "big data".
    - ✓ Deep learning.

C. Four Use Cases

1. Credit Risk and Revenue Modeling

- Difficulties in Usage
  - Models can be sensitive to overfitting the data.
  - Hard for any human to understand.

2. Fraud

- Detection of Credit Card Fraud
  - Clear historical data with relevant fraud labels to train classification.

C. Four Use Cases

3. Detection of Money Laundering and Terrorism Financing

- Current Challenges
  - Unable to detect complex patterns of transactions.
  - Significant human capacity is required.
  - Impediments to data sharing.
- ML's Role
  - Money laundering is hard to define.
  - No feedback from law enforcement agencies.
  - Unsupervised learning (clustering) can be used.

C. Four Use Cases

4. Surveillance of Conduct and Market Abuse in Trading

- Application
  - Monitor the behaviour of traders.
- Challenges to Applying ML
  - No labeled data to train algorithms.
  - Black boxes: hard to explain to a compliance officer.
  - Countermeasure: incorporates human decisions.
- Barrier to the Implementation of Automated Surveillance
  - Information from different sources could be mutually incompatible.

8. AI and ML in Financial Services

B. Drivers

On the Supply Side

- FIs benefited from AIML tools developed for other fields.
  - Hardware costs, computing power, algorithms, storage...
- Infrastructure construction
  - E-trading platforms, social media, credit scoring...

B. Drivers

On the Demand Side

- For FIs: cost reduction, risk management gains.
- Regulatory compliance.
- Growth in the number of data sources, data granularity.
- Enhanced data quality.
- Improvement in hardware.
- Open source libraries.

The Legal Framework

- Breaches of personal data
- New data standards & reporting requirements.

C. Selected Use Cases

Customer-focused Uses

1. Credit Scoring Applications
2. Use for Pricing, Marketing and Managing Insurance Policies
3. Client-facing Chatbots

Operations-focused Uses

1. Capital Optimisation Use Case
2. Model Risk Management and Stress Testing
3. Market Impact Analysis

C. Selected Use Cases

Trading And Portfolio Management

1. AIML in Trading Execution
2. Scope for the Use of AIML in Portfolio Management

AIML In Regulatory Compliance And Supervision

1. RegTech: Applications by Financial Institutions for Regulatory Compliance
2. Uses for Macroprudential Surveillance and Data Quality Assurance
3. SupTech: Uses and Potential Uses by Central Banks and Prudential Authorities
4. Uses by Market Regulators for Surveillance and Fraud Detection

D. Micro-financial Analysis

Possible Effects Of AIML On Financial Markets

- Improvement
  - Collect and analyse info on a greater scale.
  - Lower trading costs.
- Concerns
  - Similar AIML programmes => correlated risks.
  - Could be used by insiders to manipulate market.

D. Micro-financial Analysis

Possible Effects Of AIML On Financial Institutions

- Benefiting System-wide Stability
  - Increase revenues and reduce costs.
  - Earlier and more accurate estimation of risks.
  - Collaboration between financial institutions and other industries.
- Drawbacks
  - Miss new types of risks.
  - Black boxes in decision-making.
  - For intermediaries: a lack of clarity around responsibility.
  - Third-party dependencies.

D. Micro-financial Analysis

Possible Effects Of AIML On Consumers And Investors

- A Number of Benefits
  - Consumers: lower fees and borrowing costs.
  - Wider access to financial services.
  - Facilitate more customised financial services.
- Concerns
  - Data privacy and information security.
  - Avoiding discrimination.

Current Regulatory Considerations Regarding The Use Of AIML

- Have a robust development process in place.
- Be consistent with the firm's internal policies and procedures.

E. Macro-financial Analysis

Market Concentration And Systemic Importance Of Institutions

- Affect the degree of concentration
  - A small number of advanced third-party providers.
  - Technologies affordable only to large companies.
- Reduce the systemic importance of large universal banks.
- Universal banks' vulnerability to systemic shocks may grow.

E. Macro-financial Analysis

Potential Market Vulnerabilities

- Greater diversity in market movements.
- Less predictable trading algorithms.
- Increase liquidity.
- More effective hedging strategies.
- Reduce reliance on bank loans.
- Minimise capital => more risk.

Networks And Interconnectedness

- Greater interconnectedness in the financial system.
- Help to share risks.
- But also spread the extreme shocks.

E. Macro-financial Analysis

Other Implications Of AIML Applications

- Reduce the degree of moral hazard and adverse selection.
  - Higher premiums for riskier consumers.
- Entail biases.
- For RegTech and SupTech
  - 'Game' regulatory rules.

9. Climate Change and Financial Risk

A. Introduction

The Early Days of Climate Change in Finance

- Climate change was not a concern for the financial sector.
- The rise of carbon markets increases the knowledge about climate change.

An Important Issue for 'Responsible Investors'

- The development of socially responsible investment (SRI) put CC on the agenda of investors.

The Acceleration

- Since the 2015 COP21 in Paris.

Climate Policy Meets Finance

- The Paris Agreement
  - Fully decarbonise the global economy by 2050.
  - Need capital => the role of the financial system is acknowledged.

B. Climate Change as a New Source of Financial Risk

New Types of Financial Risks

- Transition Risks
  - The financial risks coming in the context of climate change mitigation.
  - Such as climate policies, technology evolutions, consumer preferences.
- Physical Risks
  - Such as temperature rise, variations in rainfalls.
  - Affect the operations of organisations.
  - But the impacts are delayed in the future.
- Indirect Impacts
  - Modifications of the climate regimes: heatwaves, droughts, floods...
  - Related impacts: fires frequency, sea level...
  - Acute risks: cyclone, flood.
  - Chronic risk: see level rise.

B. Climate Change as a New Source of Financial Risk

Are Those New Types of Risk Priced by Markets?

- Not currently captured, mis-priced by financial markets.

1. **Unprecedented Phenomena**
   - No record on how to react.
2. **Radical Uncertainty**
   - Unmeasurable, unquantifiable, and uninsurable.
3. **Non-normal Probability Distributions**
4. **Bounded Rationality**
   - May lead to a collective misread of the reality.
5. **Discrepancy in Time Horizons**
   - Impacts from CC will only happen in several decades.
6. **Climate Change Inefficiently Priced by Markets**

C. The Approaches to Manage Climate-related Financial Risks

Materialisation Channels of Climate-related Financial Risks

- CC can modify a firm's financial performance and risk profile.
- The propagation chain becomes more complex if the company is a multinational diversified one.

Climate Scenario Analysis

- Why Scenario Analysis?
  - A what-if analysis.
  - Avoid attributing scenarios a probability of occurrence.
  - Lie in the comparison of different possible futures.
- The Difficulty for Scenario Analysis
  - How to translate the factors of climate risks into financial variables?

D. Climate Change Risks and Financial Regulation

Reporting and Disclosure of Climate-related Risks

- The Article 173 of the French Energy Transition Act
  - Require reporting on CC.
  - The implementation was unsatisfactory.
- Mark Carney's speech
  - Pointed out self-regulation via risk disclosure.

Beyond Reporting, an Enhanced Prudential Framework

- The European Commission Sustainable Finance Action Plan
  - Mobilise central regulation for CC.
  - Potential methods: through decreasing or increasing capital requirements.

10. Beyond LIBOR

A. Desirable Features of Reference Rates and Main Trade-offs

An Ideal Reference Rate

- Not susceptible to manipulation.
- Derived from actual transactions in liquid markets.
- Serve as a benchmark for both term lending and funding.

A. Desirable Features of Reference Rates and Main Trade-offs

The Practical

- LIBOR Fails to Meet the Criterion
  - Constructed from a survey of banks reporting.
  - Sparse activity in interbank deposit markets.
  - The dispersion of individual bank credit risk.
- The New Reference Rates Should Incorporate those Attributes
  - Shorter tenor
  - Interbank markets -> non-bank wholesale markets.
  - Drawing on secured transactions.

Trade-offs

- O/N RFRs + Risk Premium
  - O/N RFRs will form the backbone.
  - Another rate embeds a credit risk component.

B. A Taxonomy and Properties of the New Overnight RFRs

Alternative RFRs in Five Currency Areas

- US: SOFR, secured by repo.
- UK: SONIA.
- Euro area: ESTER.
  - All transaction-based, all overnight rates.
  - No longer limited to interbank.

Basic Characteristics of Overnight Reference Rates

- Characteristics of O/N Rates
  - Volumes underlying the new benchmark dwarf those of the overnight bank funding rate.

C. Developing RFR-Linked Financial Markets and Term Rates

Users of derivatives markets have been accustomed to using compounded O/N rates.

But participants in cash markets have been accustomed to using rates set for the entire term.

State of Market Development

- IBOR-linked business is still dominant.

C. Developing RFR-Linked Financial Markets and Term Rates

Towards Term Benchmark Rates

- Backward-looking Term Rates
  - Constructed from past realisations of O/N rates.
    - ✓ Less prone to volatility.
    - ✓ Do not reflect expectations about future interest rates.
    - ✓ Lag the actual movements in the O/N rate.
- Forward-looking Term Rates
  - Known at the beginning of the period.
  - Embed market participants' expectations.

C. Developing RFR-Linked Financial Markets and Term Rates

- Forward-looking Term Rates Based on Term Funding Instruments
  - Capture fluctuations in intermediaries' actual term funding costs.
- Forward-looking Term Rates Based on Derivatives
  - Reflect the market-implied expected path of future O/N rates.
  - Do not capture fluctuations in intermediaries' term funding risk.

D. Implications for Banks' Asset-Liability Management

A Benchmark for Term Funding and Lending

- Banks will still lack a benchmark that reflects their marginal funding costs.
- Banks could be exposed to basis risk.

In Search of Credit-sensitive Term Benchmarks

- Unsecured Wholesale Funding Rates
  - Unsecured term funding: bank -> non bank.
- A "Two-Benchmark" Approach
  - Complement the RFRs with reformed local IBOR-type rates.
  - Addresses the scarcity of underlying term transactions.

E. Transition Issues

The most pressing thing: the migration of legacy LIBOR-linked exposures to the new benchmarks after 2021.