Foundation Of Risk Management
Introduction to financial risk management.
Definition of Risk

- It is the possibility of something unpleasant happening or the chance of encountering loss or harm

- Dictionary definition: “exposure to peril”

- Investor definition: “uncertainty of returns”.
Types of Risks

- **Interest Rate Risk:**

  Interest rate Risk is the risk of an adverse effect of interest rate movements on a firm’s profits or balance sheet.

- **Credit Risk:**

  The risk that arises due to dishonourment of cash flows by the counterparty.

- **Liquidity Risk:**

  Risk of not being able to quickly liquidate a position at a fair price.
  - Asset Liquidity: Large positions affecting asset prices.
  - Funding liquidity: Inability to honor margin calls, capital withdrawals. Ex: Lehman.
Types of Risks

- **Internal Business Risk**
  It refers to the degree of operational efficiency the management has with the unanticipated future.

- **External Business Risk**
  It is the result of external environment in which the business is in existence.

- **Financial Risks**
  It is the risk emanates from the composition of the financing of the operations. The level of debt as a proportion of the total liabilities determines the risk.
Types of Risks

- **Market Risk**

  Market Risk is the risk of the value of a firm’s investments coming down as a result of market movements. It is also referred to as price risk.
  - Basis risk: Risk that the price of the asset and the hedged instrument are not perfectly correlated.
  - Volatility risk: Risk of loss from changes in implied volatility of the market.

- **Personnel Risk**

  Many industries are service industries which depend mostly on the quality of their staff for success.
Types of Risks

- **Country or Sovereign Risk:**
  
  This refers to the risk that a country won't be able to honor its financial commitments. When a country defaults it can harm the performance of all other financial instruments in that country as well as other countries it has relations with.

- **Technology Risk:**
  
  The risk arising due to technology failure.

- **Operational Risk:**
  
  The risk of operational malfunction or break down.
  - Risk arises due to inadequate monitoring, systems failure, management failure, human error.
  - Operational Risk includes Model risk, people risk, legal and compliance risk.
Types of Risks

- **Foreign Exchange Risk:**

  The risk that arises due to changes in exchange rate, affecting the value of firm.
Risk Management Process

- **Risk Management** is the process of measuring, or assessing risk and developing strategies to manage it.
Approaches to Risk Management

- Risk Avoidance
- Loss Control
- Combination
- Separation
- Risk Transfer
- Risk Retention
- Risk Sharing
Approaches to Risk Management

- **Risk Avoidance** – Avoid it altogether. Can be done by not undertaking the activity that entails risk.

- **Loss Control** – Refers to the attempt to reduce either the possibility of a loss or the quantum of loss.

- **Combination** – Refers to the technique of combining more than one business activity in order to reduce the overall risk.
Approaches to Risk Management

- Risk Transfer – Risk is transferred when the firm originally exposed to a risk, transfers it to another party which is willing to bear the risk.
- Risk Retention – Risk is retained when nothing is done to avoid, reduce or transfer it.
- Risk Sharing – Combination of Risk Retention and Risk Transfer.
Value at Risk (VAR)

- VAR is defined as the maximum loss over a defined period of time at a stated confidence level, given normal market conditions.
- For example, if a portfolio of stocks has a one-day 5% VAR of $1 million, there is a 5% probability that the portfolio will fall in value by more than $1 million over a one day period, assuming markets are normal and there is no trading.
Value at Risk

Stress testing:
- Stress testing involves how a portfolio would have performed under the some of the most extremes market moves seen in the last 10-20 yrs.
- For example, using oct. 1987 downfall of s& p moved by 22.3 standard deviations.
- Stress testing can be considered as a way of taking into account extreme events that do occur from time to time but are virtually impossible according to the probability distributions assumed for market variables.
- For example a 5 std deviation daily move in a market is an extreme event.
VALUE AT RISK

Stress testing:

- The stress event under the normal distribution would happen once in a 7,000 yrs but in reality it happens more frequently.
- Var calculations must be back tested. How often the actual losses exceeded var. If its 1% of the days then probably var methodology is right otherwise a suspect.
VALUE AT RISK

- After the 1997-99 crisis, the var models have lost credibility.
- They are not reinsuring enough in time of stress.
- Bank managers who believe in their var models can pile up more risks assuming that the risks are well controlled.
- Using similar models many banks pursue similar strategies- trend behavior.
- A key input to the var model is historical volatilities and correlation. A crisis represents a break away from the historical data and makes var in operational.
Var Concepts For Portfolio

- **Individual VaR**: is the Var of an isolated position.
  \[ \text{VaR} = Z \text{ value} \times \sigma \times \text{Portfolio value} \times \text{Position weight age} \]

- **Diversified Portfolio VaR**: = \( Z \text{ value} \times \sigma_P \times \text{Portfolio value} \)

- **For uncorrelated assets**: VaR of the portfolio = \( \text{Sqrt(VaR}_1^2 + \text{VaR}_2^2) \)

- **For a portfolio with different assets but all having same volatility**: VaR of the portfolio = \( \sigma_P = \sigma \text{Sqrt}(1/N + (1-1/N)p) \), where \( p \) = Correlation between them.

- **For perfectly correlated assets**, we have: VaR of the portfolio = \( \text{VaR}_1 + \text{VaR}_2 \)

- **Marginal VaR**: is the change in the portfolio VaR for an additional investment in an position.
  \[ \text{Marginal VaR} = \frac{\text{VaR}_P \times \beta_i}{\text{Portfolio Value}} \]

  Portfolio VaR can be reduced by reducing allocation to those positions which have a high Marginal VaR.

- **Incremental VaR** is the increase in VaR from the addition of a new position in a portfolio.

- **Component VaR** is the amount of risk a position contributes to a Portfolio.
Example

A portfolio has 10 positions of 3 million USD each with standard deviation/volatility for each position being 20%. The correlation between each pair is 0.3, and we need to calculate VaR using a-z value of 2.5.

Solution: $\sigma_P = \sigma \sqrt{\frac{1}{N} + (1-\frac{1}{N})\rho}$

= 0.2 $\sqrt{\frac{1}{10} + (1-\frac{1}{10})0.3}$

= 12.16%

VaR of the portfolio = 2.5 x 12.16 x 10 x 3 million USD

= 9.12 million USD

Ex. 2. FRM Exam 2003

Based on 90% confidence level, how many exceptions in back testing a VAR would be expected over a 250 day trading year.

a) 10
b) 15
c) 25
d) 50

Answers: c) 25
RAROC

- This approach allows comparisons between assets of varying sizes and capital allocated to it.

- Raroc was introduced by bankers trust in the late 1970s, it allocates capital on the basis of maximum expected loss (at 99% confidence interval) over one year on an after tax basis.

- The higher capital allocation implies that the transaction has to generate cash flows large enough to offset the volatility of returns which results from the credit risk, market risk and other risks taken.

- The raroc process estimates the asset value that may prevail in the worst case scenario and then equates the capital cushion to be provided for the potential loss.
Risk Management Tools

- Forward
- Futures
- Options
- Hedging
- FRA
- Swaps
- Hybrid Debt Securities
- Credit Derivatives
Forward

- A forward contract is an agreement to buy or sell a specified quantity of an asset at a specified price, with delivery at a specified time and place.
Futures

- A futures contract is an exchange-traded contract to buy or sell a predetermined quantity and quality of an asset on a predetermined future date at a predetermined price.
Payoff profile of futures contracts
Options

- An option is a contract, which gives the holder, the right but not the obligation to buy or sell, an agreed amount of financial instrument on or before an agreed future date, at an agreed price.

**CALL OPTIONS:**

- Call options provide the holder with the right to acquire an underlying at an exercise or strike price. The holder pays a premium for the right to benefit from the appreciation in the underlying.

**PUT OPTIONS:**

- Put options provide the holder with the right to sell the underlying at an exercise price or strike price throughout the option term. The holder gains as the market price of the underlying falls below the strike price.
Payoff profile of Call options

![Graph showing the payoff profile of a Call option with a strike of 100 and a premium of 5. The graph plots the profit/loss against the price, with lines representing the buyer and writer.]
Payoff profile of Put options

Strike 100 Premium 5

Profit/Loss

-15
-10
-5
0
5
10
15

Price

Buyer
Writer
<table>
<thead>
<tr>
<th>CALL OPTION BUYER : LONG CALL</th>
<th>CALL OPTION WRITER (Seller) : SHORT CALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pays premium</td>
<td>• Receives premium</td>
</tr>
<tr>
<td>• Right to exercise and buy the shares</td>
<td>• Obligation to sell shares if exercised</td>
</tr>
<tr>
<td>• Profits from rising prices</td>
<td>• Profits from falling prices or remaining neutral</td>
</tr>
<tr>
<td>• Limited losses, Potentially unlimited gain</td>
<td>• Potentially unlimited losses, limited gain</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>PUT OPTION BUYER : LONG PUT</th>
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</tr>
</thead>
<tbody>
<tr>
<td>• Pays premium</td>
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</table>
Introduction

- **Forward Rate Agreement (FRA)** is a forward contract in which one party pays a fixed interest rate and receives a floating interest rate equal to a reference rate (the underlying rate).

- The payments are calculated over a notional amount over a certain period and netted i.e. only the differential is paid. It is paid on the *effective date*.

- FRAs are over-the-counter derivatives.

- The payer of the fixed interest rate is known as the borrower or the buyer.

- Receiver of the fixed interest rate is the lender or the seller.
**USERS**

- Banks and Large Corporations use FRAs to hedge future interest rate exposure.

- Other users of FRAs are speculators purely looking to make bets on future directional changes in interest rates.
CALCULATION OF INTEREST

Payment = Notional Amount * (Reference Rate – Fixed Rate) * \( \alpha \)

\[ 1 + \text{Reference Rate} \times \alpha \]

- The Fixed Rate is the rate at which the contract is agreed.
- The Reference Rate is typically Euribor or LIBOR.
- \( \alpha \) is the \textit{day count fraction}, i.e. the portion of a year over which the rates are calculated.
Hedging

What is Hedging?

☑ Hedging means making an investment to reduce the risk of adverse price movements in an asset.

☑ Any technique designed to reduce or eliminate financial risk; for example, taking two positions that will offset each other if prices change.
HEDGING USING OPTIONS

- Options can be used as insurance against losses if you’re nervous about a stock dropping.
- For example, if you felt a stock might drop, but didn’t want to sell, you could buy a put option at or just below the market price.
- The put option would give you the right to sell the stock at that price.
- If the stock does fall, you can exercise the option and sell at the higher price for a profit or sell the put back to the market at a profit to reduce your cost basis in the stock.
- If the stock does not fall, you could sell it for something near the end of its contract period and recover some of your cost.
**Example: Hedging a Portfolio With Puts and Calls**

- Since the value of a call option rises when an asset price rises, what happens to the value of a portfolio containing both shares of stock of XYZ and a negative position in call options on XYZ stock?

- If the stock price is rising, the call option value will also rise, the negative position in calls will become greater, and the net portfolio should remain approximately constant if the positions are held in the right ratio.

- If the stock price is falling then the call option value price is also falling.

- The negative position in calls will become smaller.

- If held in the proper amounts, the total value of the portfolio should remain constant!

- The risk (or more precisely, the variation) in the portfolio is reduced!

- The reduction of risk by taking advantage of such correlations is called hedging.
HEDGING USING FUTURES

☐ The Hedging in futures is used to remove the unwanted exposure i.e. unnecessary risk.
☐ The hedged position will make less profits than the unhedged position.
☐ In simple words, Operators, who wants to transfer a risk component of their portfolio.
☐ Futures can be used in more effective risk-management tool.
☐ One should not enter into a hedging strategy hoping to make excess profits for sure.
Example Hedging: Long Security, Sell Futures

- Suppose Sanjay holds the shares of Bharti Airtel Ltd. and gets uncomfortable with market movements in the short run. The stock price falling from Rs.350 to Rs.290.
- To minimize the risk component, all he need to do take on a short futures position.
- Assume that spot price of the Bharti Airtel Ltd. he holds is Rs.290.
- Two-month futures cost him Rs.302. For this he pays initial margin.
- Now if the price of the security falls any further, he will suffer losses on the security he holds.
EXAMPLE (CONTINUED…)

- However, the losses he suffers on the security, will be offset by the profits he makes on his short futures position.
- Take the instance that the price of his security falls to Rs. 250.
- The fall in the price of the security will result in a fall in the price of futures.
- Futures will now trade at a price lower than the price at which he entered into short futures position. He will start making profits.
- The loss of Rs.40 incurred on the security he holds, will be made up by the profits made on his short futures position.
USE OF HEDGING IN INDEX FUTURES

- Index futures in particular can be very effectively used to get rid of the market risk of a portfolio.
- Every portfolio contains a hidden index exposure or a market exposure.
- This statement is true for all portfolios, whether a portfolio is composed of index securities or not. In the case of portfolios, most of the portfolio risk is accounted for by index fluctuations.
- Hence a position LONG PORTFOLIO + SHORT NIFTY can often become one-tenth as risky as the LONG PORTFOLIO position!
- Suppose we have a portfolio of Rs. 1 million which has a beta of 1.25. Then a complete hedge is obtained by selling Rs.1.25 million of Nifty futures.
INTRODUCTION

- Swap English Dictionary meaning “To trade one thing for another” or “To exchange one thing for another”
- Swap is an agreement between two parties to exchange cash flows in future
- The agreement defines the dates when the cash flows are to be paid and the way in which they are to be calculated.
- The cash flows are calculated over a notional principal amount, which is usually not exchanged between counterparties.
- Unlike standardized options and futures contracts, swaps are not exchange-traded instruments.
- Swaps are customized contracts that are traded in the over-the-counter (OTC) market between private parties.
WHY SWAPS ARE REQUIRED?

- Commercial Needs:
  - Bank pays floating rate of interest on deposits (liabilities)
  - Earns a fixed rate of interest on loans (assets).
  - This mismatches between interest on assets and liabilities which cause tremendous difficulties.
  - For this Bank could use a fixed-pay swap (pay a fixed rate and receive a floating rate) to convert its fixed-rate assets into floating-rate assets to match up well with its floating-rate liabilities.
WHY SWAPS ARE REQUIRED?

- Comparative Advantage:
  - A firm wants to expand its operations in Europe, where it is less well known.
  - To finance the expansion operations in Europe firm will require Euros.
  - The firm will receive more favorable financing terms in where it is well known in the home currency.
  - Than by using a currency swap, the firm ends will get the euros it needs to fund its expansion.
Hybrid Debt Securities

- Hybrid Debt Security is a debt security combined with any other types of derivatives. Convertible bonds are types of Hybrid Debt Securities
INTRODUCTION

- Credit Derivative is a derivative whose value is derived from the credit risk on an underlying bond, loan or other financial asset.
- Credit derivatives are bilateral contracts between a buyer and seller under which the seller sells protection against the credit risk of the reference entity
- Types of Credit Derivatives are as under:
  - Unfunded Credit Derivative
  - Funded Credit Derivative
UNFUNDED CREDIT DERIVATIVES

- Bilateral contract between two counterparties
- Each party is responsible for making its payments under the contract
- No recourse to other assets
- Types of unfunded credit derivatives are as under:
  - Credit Default Swap
  - Total Return Swap
FORMS OF UNFUNDED DERIVATIVES

- Credit Default Swap (CDS):
  - A swap designed to transfer the credit exposure of fixed income products between parties
  - The buyer of a CDS receives credit protection
  - The seller of the CDS guarantees the credit worthiness of the product
  - By entering in the CDS the risk of default is transferred from the holder of the fixed income security to the seller of the swap.
FORMS OF UNFUNDED DERIVATIVES

Example of Credit Default Swap (CDS):

- An investment trust owns £1 million corporation bond issued by a private housing firm.
- If there is a risk the private housing firm may default on repayments, the investment trust may buy a CDS from a hedge fund.
- Investment trust will pay an interest on this credit default swap of say 3% i.e. £30,000 a year for the duration of the contract.
FORMS OF UNFUNDED DERIVATIVES

- If the private housing firm doesn’t default. The hedge fund gains the interest from the investment bank and pays nothing out.

- If the private housing firm defaults, then the hedge fund has to pay compensation to the investment bank of £1 million

- Therefore the hedge fund takes on a larger risk and could end up paying £1million
**FORMS OF UNFUNDED DERIVATIVES**

- **Total Return Swap:**
  - Agreement in which one party makes payments based on a set rate, either fixed or variable.
  - Other party makes payments based on the return of an underlying asset, which includes both the income it generates and any capital gains.
  - Underlying asset, referred to as the reference asset, is usually an equity index, loans, or bonds. This is owned by the party receiving the set rate payment.
  - It allows the party receiving the total return to gain exposure and benefit from a reference asset without actually having to own it.
FORMS OF UNFUNDED DERIVATIVES

Example of Total Return Swap:

- Two parties may enter into a one-year total return swap.
- Party A receives LIBOR + fixed margin (2%) on a principal amount of $1 million.
- Party B receives the total return of the S&P 500 on the same amount.
- If LIBOR is 3.5% and the S&P 500 appreciates by 15%,
- Party A will pay Party B 15% and will receive 5.5%.
- The payment will be netted at the end of the swap with Party B receiving a payment of $95,000 ($1 million x 15% - 5.5%)
FUNDED CREDIT DERIVATIVES

- Types of Funded Credit Derivatives are as under:
  - Credit Linked Notes (CLN)
  - Collateralised Debt Obligation (CDO)
FORMS OF FUNDED DERIVATIVES

- Credit linked Note (CLN):
  - It is structured as a security with an embedded credit default swap
  - Allows issuer to transfer a specific credit risk to credit investors
  - Issuer is not obligated to repay the debt if a specified event occurs
FORMS OF FUNDED DERIVATIVES

Example of Credit linked Note (CLN):

- Bank lends money to a company XYZ
- Bank issues credit-linked notes of the loan amounts which are bought by investors.
- The funds raised by issuing notes to investors are invested in bonds with low probability of default
- If company XYZ pays back the loan than bank is obligated to pay the notes in full.
FORMS OF FUNDED DERIVATIVES

- If company XYZ goes bankrupt, the note-holders/investors become the creditor of the company XYZ and receive the company XYZ loan.

- The bank in turn gets compensated by the returns on less-risky bond investments funded by issuing credit linked notes.
**FORMS OF FUNDED DERIVATIVES**

- **Collateralised Debt Obligation (CDO):**
  - Structured asset-backed security (ABS) whose value and payments are derived from a portfolio of fixed-income underlying assets
  - CDOs securities are split into different risk classes, or tranches, whereby "senior" tranches are considered the safest securities.
  - Interest and principal payments are made in order of seniority
  - Junior tranches offer higher coupon payments (and interest rates) or lower prices to compensate for additional default risk.
FORMS OF FUNDED DERIVATIVES

Asset 1
Asset 2
Asset 3
Asset n

Total Principal $100m

SPV

Tranche 1 (equity) Principal: $5m Return = 30%

Tranche 2 (mezzanine) Principal: $20m Return = 10%

Tranche 1 (senior) Principal: $75m Return = 6%
Extreme market movements

- 1971: fixed exchange rate system broke down
- 1973: shocks to prices of oil, high inflation and volatile interest rates
- 1987: black monday, 23% decline in US stock prices
- 1989: japanese stock market bubble deflated
- 2001: sept 11
- 2007-2009: credit crisis resulting from mortgage market meltdown and huge amounts of bank leverage
Markowitz Portfolio Theory

Harry Markowitz developed a portfolio model which takes into account the expected return and the expected risk measured in terms of Variance. This model explains the importance of diversification. The Markowitz Model is based on the following assumptions.

1. Each investment can be described by the probability distribution of expected returns over a period of time.
2. Risk is measured by volatility of expected returns (Variance).
3. Investors base their decision only on expected return and risk.
4. All investors are risk averse, that is, they expect higher returns compared to lower returns if the risk is constant.
5. Investors prefer lower risk compared to higher risk for the same level of returns.

According to Markowitz model, a portfolio is efficient if no other investment can produce a higher expected return with the same or lower risk.
The Efficient Frontier

- A portfolio is considered to be efficient if no other portfolio offers a higher expected return with the same (or lower) risk or if no other portfolio offers lower risk with the same (or higher) return.

- The efficient frontier represents the set of portfolios that will give you the highest return at each level of risk (or, alternatively, the lowest risk for each level of return).
The market portfolio

- The efficient frontier is a collection of portfolios, each one optimal for a given amount of risk.
- A quantity known as the Sharpe ratio represents a measure of the amount of additional return above the risk-free rate a portfolio provides compared to the risk it carries.
- The portfolio on the efficient frontier with the highest Sharpe ratio is known as the market portfolio, it is the tangency-portfolio in the above diagram.
- This portfolio has the property that any combination of it and the risk-free asset will produce a return that is above the efficient frontier—offering a larger return for a given amount of risk than a portfolio of risky assets on the frontier would.
Capital market line

- When the market portfolio is combined with the risk-free asset, the result is the Capital Market Line.
- The CML is derived by drawing a tangent line from the intercept point on the efficient frontier to the point where the expected return equals the risk-free rate of return.
- All points along the CML have superior risk-return profiles to any portfolio on the efficient frontier.
- Additions of cash or leverage with the risk-free asset in combination with the market portfolio are on the Capital Market Line. All of these portfolios represent the highest possible Sharpe ratio. The CML is illustrated above, with return $\mu_p$ on the y-axis, and risk $\sigma_p$ on the x-axis.
Diversification of an Asset

- One method of reducing the risk of a portfolio is to add more and more securities in the portfolio. It has been observed that even if we have a large number of securities, the risk is not completely eliminated. The residual risk left after diversification is called as the systematic risk or non-diversifiable risk, which impacts all the portfolios.

- The risk which we can reduce by diversifying the portfolio is called as the unsystematic risk or the diversifiable risk. Total risk associated with a portfolio can be written as:

- Total risk = Diversifiable risk (or unsystematic risk) + Non diversifiable risk (or systematic risk)
Figure Below represents the impact of adding securities to a portfolio and the impact on the total risk of portfolio.

- One of the measures used for measuring non-diversifiable risk is the beta coefficient ($\beta$). Beta links the movement of an asset with respect to a Security Market Index. In India, the common index used for beta calculation is the BSE–30 Sensex of Bombay Stock Exchange or the CNX Nifty of the National Stock exchange.

- Beta for a security tells us by how much will a security move up or down for 1 percent movement in the index selected.
Beta of a Stock

The following are some of the characteristics of beta.

- The beta coefficient for the market is considered to be equal to 1.
- If beta for an asset is more than 1 then it has higher systematic risk, that is, it is more volatile than the market.
- If the beta for an asset is less than 1, it means it is less volatile than the market and has lesser systematic risk.
- Another way to understand beta is that, it relates to an asset’s co-variance with the market to the Variance of the market portfolio and can be calculated using the equation

\[ \beta_i = \frac{\text{cov}(R_i, R_m)}{\text{Var}(R_m)} \]
Security Market Line

- A line that graphs the systematic, or market, risk versus return of the whole market at a certain time.

- The security market line is a useful tool in determining whether an asset being considered for a portfolio offers a reasonable expected return for risk. Individual securities are plotted on the SML graph.

- If the security's risk versus expected return is plotted above the SML, it is undervalued because the investor can expect a greater return for the inherent risk.

- A security plotted below the SML is overvalued because the investor would be accepting less return for the amount of risk assumed.
Capital asset pricing model (CAPM)

☐ The CAPM is a model which derives the theoretical required return for an asset in a market

\[ R_s = R_f + \beta (R_m - R_f) \]

Where,

☐ \( R_{rf} \) = Risk-free rate
☐ \( R_M \) = Market return
☐ \( \beta_i \) = Beta of the asset
☐ \( (R_M - R_{rf}) \) is also known as the risk premium, because it is the additional return you get for taking risk in comparison to not taking any risk.
Assumptions of CAPM

1. All investors want to be on the efficient frontier and their location on the efficient frontier depends on their risk return utility function.
2. Investors can borrow and lend at the nominal risk-free rate.
3. All investors have the same one period time horizon.
4. There are no taxes or transaction costs and market is in equilibrium
5. All investors have homogeneous expectations.
6. All investments are infinitely divisible; that is, it is possible to trade in fractional shares.
7. There is no inflation or change in interest rate during the period under consideration.
Arbitrage Pricing Theory

- CAPM is criticized because of the difficulties in selecting a proxy for the market portfolio as a benchmark.

- It was observed by many researchers that the return on an asset does not depend only on the beta but many more factors, such as, the GDP, inflation rate, monetary policy, and so on.

- During the mid-seventies, Stephen Ross developed an alternative model to CAPM which assumes that the return on securities is generated by many market wide factors.

- CAPM requires only limited assumptions as given below.
  1. Capital markets are perfectly competitive.
  2. Investors always prefer more wealth to less wealth with certainty.
  3. The security returns can be described by a factor model function of k factors.
Arbitrage Pricing Theory

- Equation below represents the security returns described by a factor model function of k factors.
  \[ R = E(r) + B_1 F_1 + B_2 F_2 + \ldots + B_k F_k + e \]

Where,
- \( E(r) \) = Expected return on the asset
- \( F_i \) = ith factor affecting the return
- \( \beta_i \) = Factor sensitivity of the ith factor
- \( e \) = Error term

- Multiple factors expected to have an impact on all assets:
  - Inflation
  - Growth in GNP
  - Major political upheavals
  - Changes in interest rates
  - And many more….

- Contrast with CAPM assumption that only beta is relevant
Portfolio Theory Cont.…..
Comparison arbitrage pricing theory with CAPM

- The SML and CAPM are often contrasted with the arbitrage pricing theory (APT), which holds that the expected return of a financial asset can be modeled as a linear function of various macroeconomic factors, where sensitivity to changes in each factor is represented by a factor specific beta coefficient.

- The APT is less restrictive in its assumptions: it allows for an explanatory (as opposed to statistical) model of asset returns, and assumes that each investor will hold a unique portfolio with its own particular array of betas, as opposed to the identical "market portfolio“

- Unlike the CAPM, the APT, however, does not itself reveal the identity of its priced factors the number and nature of these factors is likely to change over time and between economies.
Performance Measurement

- **Sharpe Ratio**
  \[
  \text{Sharpe Ratio} = \frac{R_p - R_f}{\sigma_p}
  \]

- **Treynor Ratio**
  \[
  \text{Treynor Ratio} = \frac{R_p - R_f}{\beta}
  \]

- **Jenson’s alpha**:
  \[\alpha = R_p - R_C - R_f = \text{portfolio return}, \ R_C = \text{return predicted by CAPM}\]

- **Tracking Error**:
  (Std. dev. of portfolio's excess return over Benchmark index)
  - Where \(E_p = R_p - R_B\)
  - \(R_P = \text{portfolio return}, \ R_B = \text{benchmark return}\)
  - Lower the tracking error lesser the risk differential between portfolio and the benchmark index.

- **Information Ratio**
  \[\text{IR} = \frac{R_p - R_b}{\text{TE}}\]
  - Higher IR indicates higher active return of portfolio at a given risk level.
Portfolio Theory Cont....

- Financial Disasters
  - Sumitomo
  - LTCM
  - Barring
Case Studies - Sumitomo

- Yasuo Hamanaka - copper trader at Sumitomo manipulated copper prices on London Metal Exchange

- Fall in copper prices in June 1996 after revelation of Hamanaka’s unfair dealings led to ~2.6bn USD loss for Sumitomo

- Positions were so large that company could not liquidate them completely

- Hamanaka used his independence to trade in the market on behalf of the company and manipulated the copper prices by buying physical copper in large quantities and storing in the warehouse thereby creating lack of copper in the market

- He sold put options to collect the premiums as he thought he can push the prices up and thus writing put options was not risky for him.

- Though, he never imagined that he could be susceptible to steep decline of copper prices.

- It had various risk exposures I. such as Operational Risk, Employee/ People Risk, Liquidity Funding Risk, Market Risk.
Case Studies – LTCM

- LTCM was a hedge fund using highly leveraged arbitrage trading activities in fixed income in addition to pairs trading. Before failing in 1998, it had given spectacular returns in 1995-97 periods (upto 40% post-fees). Post Russian default on its ruble denominated debt, LTCM lost more than 4bn USD in 4 month.

- LTCM used proprietary mathematical models to engage in arbitrage trading in U.S., Danish, Russian, European and Japanese Govt. bonds. In 1998, LTCM.s positions were highly leveraged (1:28) with ~ USD 5: 130 billion of equity and assets.

- LTCM.s model assumed maximum volatility of 20% annually. Based on its models, it was expected to losses more than ~500 million USD in once in 20 month.

- It had its bet on convergence of Russian and American G-sec yield, which however diverged after Russian default.. Its failure led to a huge bailout by large commercial and merchant banks under the guidance of Federal Reserve.

- It had various risk exposures I. such as Model Risk, Funding liquidity risk, Sovereign Risk, Market Risk
Thank You