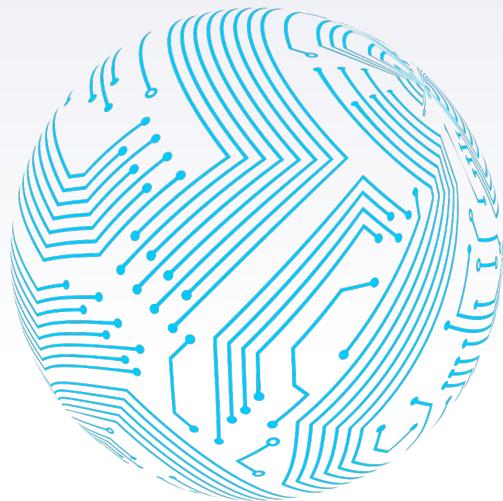


Sponsored by:



DATA SCIENCE INSTITUTE

The World Data Science Institute is a Specialized Consulting Agency offering DSaaS (Data Science as a Service)



Meet Cohort Team 1

Anade Davis - Data Science Manager - [LINKEDIN](#)

Christopher Rutherford - Data Scientist - [LinkedIn](#)

Tanjeel Ahmed - Data Science Researcher - [LinkedIn](#)

Gabe Smithline - Quantitative Analyst- [LinkedIn](#)

Berkalp Altay - Data Analyst - [LinkedIn](#)

Zain Dwiat - Data Scientist - [LinkedIn](#)

Table of Contents

[Advanced Fixed Income Trading Concepts](#)

[Advanced Greeks in Finance](#)

[Advanced Statistics](#)

[Advanced Volatility Modeling in Complete Markets](#)

[Alternative Investments](#)

[Arbitrage Pricing Theory](#)

[Basel III](#)

[Basket Options Pricing](#)

[Bill Miller](#)

[Binomial Model for Asset Prices](#)

[Black-Litterman Model](#)

[Black-Scholes Model](#)

[Bob Rodriguez \(First Pacific Advisors\)](#)

[Calibration and Data Analysis](#)

[Call Options](#)

[Capital Asset Pricing Model](#)

[Capitalization-Weighted Index](#)

[CDS Pricing, Market Approach](#)

[Classical portfolio theory of Markowitz](#)

[Collateral and Margins](#)

[Computational Finance](#)

[Copula-Based Factor Model for Credit Risk Analysis](#)

[Core Satellite Models](#)

[Credit Risk and Derivatives](#)

[Derivatives](#)

[Derivatives Market](#)

[Differential Equations in Finance](#)

[Dividend Capture Strategies](#)

[Early Exercise and American Dividends](#)

[Econometric Models \(ARCH Framework\)](#)

[Ed Thorp](#)

[Federal Interest Rate](#)

[FINRA](#)

[Financial Arbitrage](#)

[Financial Engineering](#)

[Financial Structuring](#)

[Finite-Difference Methods](#)

[Fixed Income Investment](#)

[Fixed-Income Products and Market Practices](#)

[Emerging Market Funds](#)

[Emerging Market Stocks](#)

[Empirical Stylized Facts](#)

[Fourier Transforms](#)

[Franklin Templeton](#)

[ETF](#)

[Functions of a Complex Variable](#)

[Futures](#)

[Exotic Options](#)

Table of Contents

[George Michaelis \(Source Capital\)](#)

[Girsanov's Theorem](#)

[Globex Trading System](#)

[Governance and SRI](#)

[Grey Market Bonds](#)

[Gross Profit Margin](#)

[Hazard Rate](#)

[Health, Jarrow, and Morton](#)

[Hedging and the Greeks](#)

[Hedge Fund](#)

[Hierarchical Risk Parity](#)

[High Frequency Data](#)

[High Frequency Trading](#)

[Implementation of Copula Models](#)

[Interest Coverage](#)

[Itô's lemma quantitative finance](#)

[Jean Marie Eveillard](#)

[Jump Diffusion](#)

[Kolmogorov Equation in Finance](#)

[Langevin Equation and Fokker-Planck Equations](#)

[Leverage Finance](#)

[Libor Market Model](#)

[Linear Algebra in Finance](#)

[Liquidity Asset Liability Management](#)

[Long Position](#)

[Low Frequency Trading](#)

[Low Latency](#)

[Manipulating Stochastic Differential Equations](#)

[Margin Calls](#)

[Martingale Theory for Pricing](#)

[Marty Whitman](#)

[Modern Portfolio Theory](#)

[Moodys](#)

[Monte Carlo Simulation](#)

[Mortgage Bond \(Mortgage Backed Security\)](#)

[Mutual Fund](#)

[Naked Put Options](#)

[NASDAQ](#)

[Net Asset Value - NAV](#)

[Net Profit Margin](#)

[Non-Probabilistic Volatility model](#)

[Operating Profit margin](#)

[Options pricing Models](#)

[Option Strategies](#)

[Partial Differential Equations](#)

[Portfolio Optimization Model for Portfolio Selection](#)

[Portfolio Management](#)

[Probabilistic method for interest rates](#)

[Put Options](#)

[Quantitative Risk and Return](#)

Table of Contents

[Quick Ratio](#)

[Random Behavior of Assets](#)

[Ray Dalio](#)

[Reduced form model](#)

[Reduced Form Credit Model](#)

[Revenue per Employee](#)

[Risk Management](#)

[Risk of Default](#)

[SABR\(stochastic alpha beta rho\) Model](#)

[SEC](#)

[Sharpe Ratio \(Market Price of Risk\)](#)

[Short Position](#)

[Simple Stochastic Differential Equations](#)

[SRI Investments](#)

[Standard & Poor 500](#)

[Stochastic Calculus in Finance](#)

[Stochastic Interest Rate Models](#)

[Stochastic Volatility](#)

[Structural Models of Credit Risk](#)

[Tactical Asset Allocation Models](#)

[Taylor Series](#)

[Trade on a Margin](#)

[Trading and Pricing of Derivatives](#)

[Transition Density Functions](#)

[Treasury Bills](#)

[Ultra High Frequency Trading](#)

[U.S. Treasury Inflation Protected Bonds](#)

[Value at Risk and Expected Shortfall](#)

[Volatility Arbitrage Strategies](#)

[Volatility Filtering \(GARCH Family\)](#)

[Volatility Models: The ARCH Framework](#)

[Win Rate](#)

[X-Valuation Adjustment \(XVA\)](#)

[Yield, Duration, and Convexity](#)

[References](#)

Advanced Fixed Income Trading Concepts

- ▶ Individuals generally choose fixed income investments for two basic reasons:
 - (1) for a **stable income stream**, and
 - (2) to attempt to **protect principal value**.
- ▶ Advanced Fixed Income Trading Concepts include:
 1. Equity-Linked Note (ELN)
 2. Credit-Linked Note (CLN)
 3. Interest Rate Swap



Advanced Fixed Income Trading Concepts

1. Equity-Linked Note

- ▶ An equity-linked note (ELN) is an investment product that combines a fixed-income investment with additional potential returns that are tied to the performance of equities. Equity-linked notes are usually structured to return the initial investment with a variable interest portion that depends on the performance of the linked equity.

Advanced Fixed Income Trading Concepts

2. Credit-Linked Note

- ▶ A credit-linked note (CLN) is a security with an embedded credit default swap permitting the issuer to shift specific credit risk to credit investors. Credit-linked notes are created through a special purpose vehicle (SPV), or trust, which is collateralized with AAA-rated securities. Investors buy credit-linked notes from a trust that pays a fixed or floating coupon during the life of the note.
- ▶ In return for accepting exposure to specified credit risks, investors who buy credit-linked notes typically earn a higher rate of return compared to other bonds.

Advanced Fixed Income Trading Concepts

3. Interest Rate Swap

- ▶ An interest rate swap is a forward contract in which one stream of future interest payments is exchanged for another based on a specified principal amount.
- ▶ Interest rate swaps usually involve the exchange of a fixed interest rate for a floating rate, or vice versa, to reduce or increase exposure to fluctuations in interest rates or to obtain a marginally lower interest rate than would have been possible without the swap.

Advanced Greeks in Finance

- ▶ Greeks: A set of risk measures so named after the Greek letters that denote them, which indicate how sensitive an option is to time-value decay, changes in implied volatility, and movements in the price its underlying security.
- ▶ Simple and main Greeks include Delta, Gamma, Rho, Theta, Vega. They are defined in the slide titled "Hedging and the Greeks".
- ▶ Some advanced and minor Greeks are lambda, epsilon, vomma, vera, speed, zomma, ultima.
- ▶ These Greeks are second- or third-derivatives of the pricing model and affect things such as the change in delta with a change in volatility and so on. They are increasingly used in options trading strategies as computer software can quickly compute and account for these complex and sometimes esoteric risk factors.

Advanced Statistics

- ▶ Financial Statistics is the application of statistical methods to analyze financial markets data.
- ▶ Advanced statistical techniques include:
 1. Copulas
 2. GARCH models
 3. Factor models



Advanced Statistics

1. Copula

- ▶ The copula is a probability model that represents a multivariate uniform distribution, which examines the association or dependence between many variables.
- ▶ The interdependence of returns of two or more assets is usually calculated using the correlation coefficient. However, correlation works best with normal distributions, while distributions in financial markets are often non-normal in nature. The copula, therefore, has been applied to areas of finance such as option pricing and portfolio value-at-risk to deal with skewed or asymmetric distributions.

Advanced Statistics

2. GARCH has been covered in the slide titled "Volatility Filtering (GARCH Family)".

3. Factor Model

- ▶ Modeling **attributes** that are associated with higher returns. There are two main types of factors that have driven returns of stocks, bonds, and other factors: macroeconomic factors and style factors. The former captures broad risks across asset classes while the latter aims to explain returns and risks within asset classes.

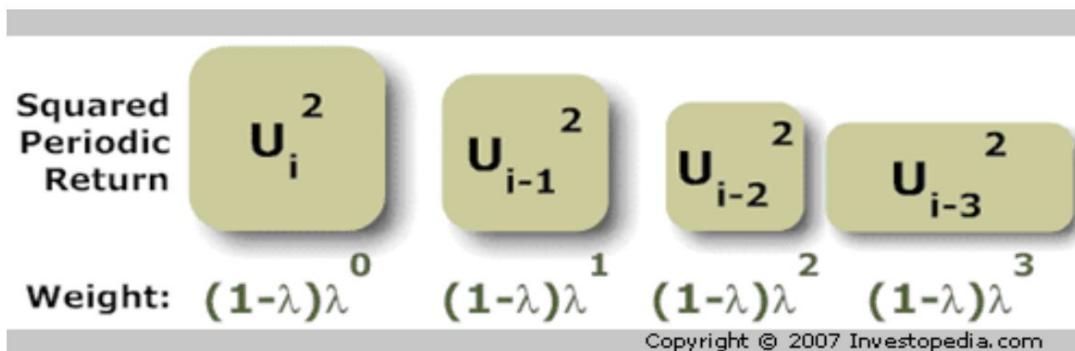
Advanced Volatility Modeling in Complete Markets

- ▶ Volatility Modeling is used for modelling the stochastic error term that makes our observations deviate from the expected values.
- ▶ There are several useful advanced volatility models:
 1. Exponentially Weighted Moving Average (EWMA)
 2. Generalized Autoregressive Conditional Heteroskedasticity (GARCH)
 3. Autoregressive Conditional Heteroskedasticity (ARCH)
 4. Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH)

Advanced Volatility Modeling in Complete Markets

1. What is Exponentially Weighted Moving Average (EWMA)?

- ▶ **The EWMA Improves on Simple Variance**
- ▶ The exponentially weighted moving average (EWMA) introduces lambda, which is called the smoothing parameter. Lambda must be less than one. Under that condition, instead of equal weights, each squared return is weighted by a multiplier as follows:



Advanced Volatility Modeling in Complete Markets

2. GARCH has been covered in the slide titled "Volatility Filtering (GARCH Family)".
3. ARCH has been covered in the slide titled "Econometric Models (ARCH Framework)"
4. What is EGARCH?
 - ▶ Similar to GARCH, there is a stylized fact that the EGARCH model captures that is not contemplated by the GARCH model, which is the empirically observed fact that negative shocks at time $t-1$ have a stronger impact in the variance at time t than positive shocks.
 - ▶ This asymmetry used to be called leverage effect because the increase in risk was believed to come from the increased leverage induced by a negative shock, but nowadays we know that this channel is just too small.

Alternative Investments

- An alternative investment is a financial asset that does not fall into one of the conventional equity/income/cash categories.



Arbitrage Pricing Theory

- ▶ Created in 1976 by American economist, Stephen Ross, the Arbitrage Pricing Theory (APT) is a theory of asset pricing that holds that an asset's returns can be forecasted with the linear relationship of an asset's expected returns and the macroeconomic factors that affect the asset's risk.
- ▶ The Arbitrage Pricing Theory operates with a pricing model that factors in many sources of risk and uncertainty, unlike Capital Asset Pricing Model (CAPM) which takes only one factor into account.

$$ER(x) = R_f + \beta_1 RP_1 + \beta_2 RP_2 + \dots + \beta_n RP_n$$

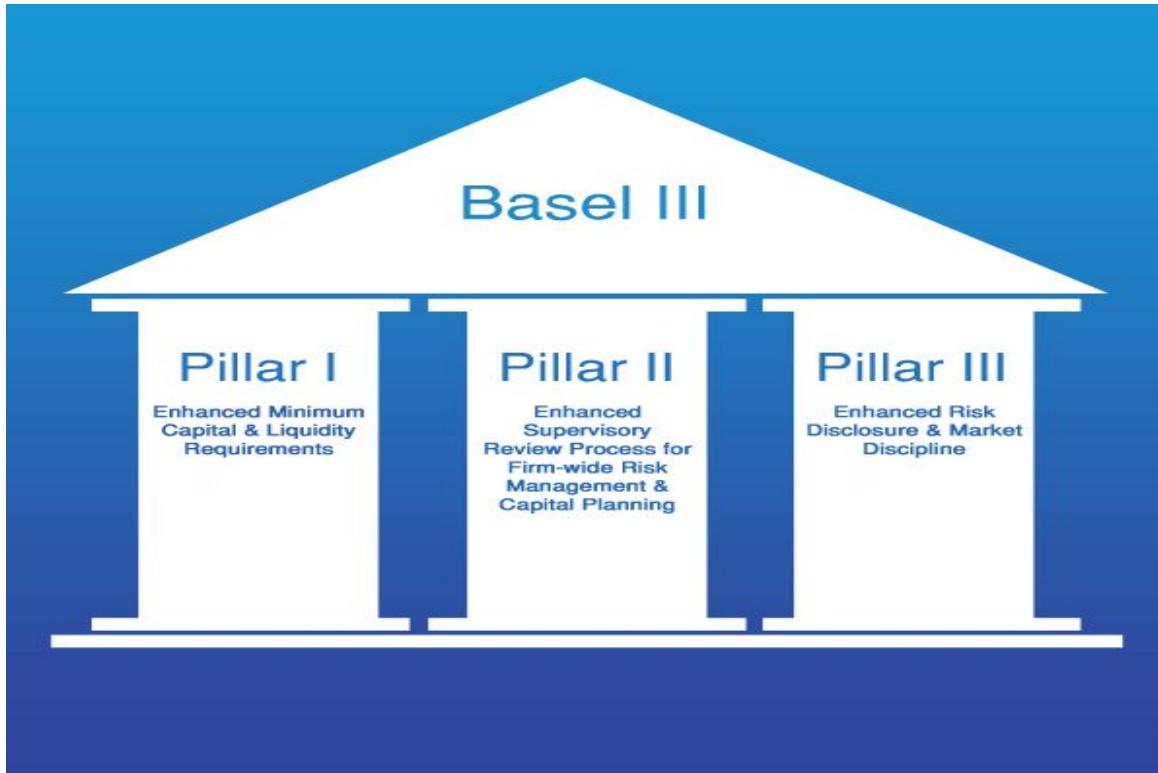
Where:

- $ER(x)$ – Expected return on asset
- R_f – Riskless rate of return
- β_n (*Beta*) – The asset's price sensitivity to factor
- RP_n – The risk premium associated with factor

Basel III

- ▶ A consortium of central banks, Basel Committee on Banking Supervision, from 28 countries published **Basel III** in 2009, largely in response to the credit crisis resulting from the 2008 economic recession.
- ▶ Basel III is an international accord introducing a set of reforms designed to improve the regulation, supervision, and risk management within the banking sector.

Basel III



Basket Options Pricing

- ▶ A basket option is a type of financial derivative where the underlying asset is a group, or basket, of commodities, securities, or currencies. As with other options, a basket option gives the holder the right, but not the obligation, to buy or sell the basket at a specific price, on or before a certain date.
- ▶ Basket Options Pricing can be complicated since a basket or portfolio does not react in the same way its individual components do. This makes sense because investors often structure diversified portfolios so that component assets do not correlate. Therefore, a basket may not necessarily react to changes in volatility, time, and price level in the same way as its components do individually.

Basket Options Pricing

- ▶ Pricing Example: Suppose company A wants to hedge against the risk of devaluation of CAD and AUD against USD. Thus, it buys put option. It also decides that it has more exposure to CAD than AUD and thus decides on a weight of 60/40. The current exchange rates are follows:

$$\text{CAD/USD} = 0.76 \quad \& \quad \text{AUD/USD} = 0.69$$

Then, the current index value is $0.6*(0.76) + 0.4*(0.69) = 0.732$

Assuming that the strike price is 0.72 for the basket and CAD and/or AUD fall to 0.73 and 0.65, the new index value would be $0.698 ((0.73 \times 0.6) + (0.65 \times 0.4))$. The buyer of the put option would use the put since he/she can sell at 0.72 and not the current value of 0.698.

Bill Miller

- ▶ American Investor, Fund Manager, and Philanthropist
- ▶ Served as CIO of Legg Mason Capital Management
- ▶ Known for being a “Value Investor”, meaning anything has value as long as it trades at a discount to its intrinsic value.
- ▶ This actually led him to underperform the S&P 500 for 3 years in a row
- ▶ His approach involves the idea that the fund will lever from 1 - 3 times the investment
- ▶ Beat the S&P for 15 years straight leading up to 2005



Binomial Model for Asset Prices

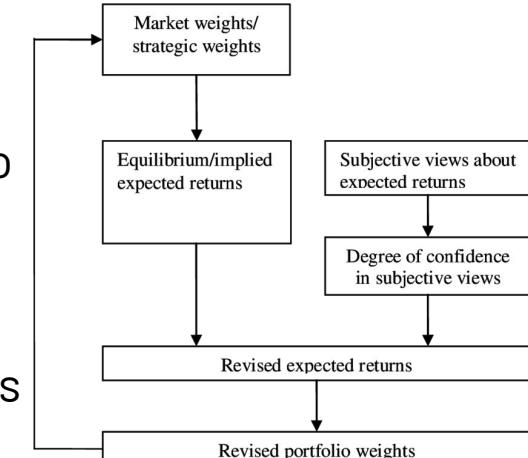
- ▶ A relatively simple model used to help investors with pricing assets
- ▶ There are only two outcomes for the prediction of the future price - either it goes up to a certain value, or down to a certain value
- ▶ Predicted prices can extend to multiple time points in the future, extending the binomial tree as far as the investor sees fit
- ▶ Its simplicity is also a bit of a drawback, as a lot of realism is lost since only two prices are considered



Copyright © 2007 OptionTradingPedia.com

Black-Litterman Model

- ▶ Developed by Fisher Black and Bob Litterman in the 1990s to improve upon modern portfolio theory
- ▶ A model used to optimize how assets in an investor's portfolio are allocated based on risk tolerance and market outlook
- ▶ Using historical market data and given risk tolerance, the model provides investors with potential investment outcomes and how risky the portfolio is
- ▶ This method does require investors/managers to predict the risk-free rate of return, but this helps provide more accurate and reasonable return estimates



BL model flowchart

https://www.researchgate.net/publication/264046825_An_equilibrium_approach_for_tactical_asset_allocation_Assessing_Black-Litterman_model_to_Indian_stock_market

Black-Scholes Model

- ▶ Consists of two key parts: The Black-Scholes equation and the Black-Scholes formula
- ▶ The Black-Scholes equation is a differential equation that describes the price of an option over time and can be used to maximize profit
- ▶ The Black-Scholes formula calculates the price of European options
- ▶ There are several underlying assumptions that the model has
 - ▷ Asset prices follow a random walk (geometric Brownian motion)
 - ▷ The ability to buy/sell/borrow/lend any amount of money
 - ▷ No transaction fees
 - ▷ Every investment has some sort of risk associated with it

Black-Scholes Model: Example

- In this model, $N(d_1)$ is used to calculate the call option's delta and $N(d_2)$ is used to calculate the probability that the option will be exercised at expiration. N is the standard normal distribution
- Suppose the stock is currently at \$45, and we purchase a call option that exercises at \$50 in 60 days. The stock has a volatility of 28% and a risk-free interest rate of 3%
- Solving for d_1 gives us -0.828 and d_2 is -0.941
 - $N(d_1) = 0.2041$, $N(d_2) = 0.1734$
- Plugging in these values in yields $C=0.557$, or \$0.56

$$C = S_t N(d_1) - K e^{-rt} N(d_2)$$

where:

$$d_1 = \frac{\ln \frac{S_t}{K} + (r + \frac{\sigma_s^2}{2}) t}{\sigma_s \sqrt{t}}$$

and

$$d_2 = d_1 - \sigma_s \sqrt{t}$$

where:

C = Call option price

S = Current stock (or other underlying) price

K = Strike price

r = Risk-free interest rate

t = Time to maturity

N = A normal distribution

Black-Scholes Model

- So long as all of these are present:
- **Price of underlying asset (S)** is a current market price of the asset
- **Strike price (K)** is a price at which an option can be exercised
- **Volatility (σ)** is a measure of how much the security prices will move in the subsequent periods. Volatility is the trickiest input in the option pricing model as the historical volatility is not the most reliable input for this model
- **Time until expiration (T)** is the time between calculation and an option's exercise date
- **Interest rate (r)** is a risk-free interest rate
- **Dividend yield (δ)** was not originally the main input into the model. The original Black-Scholes model was developed for pricing options on non-paying dividends stocks.
- Then you can use this formula:

----- To price a call or a put

$$C = Se^{-\delta T}N(d_1) - Ke^{-rT}N(d_2)$$
$$P = Ke^{-rT}N(-d_2) - Se^{-\delta T}N(-d_1)$$

Bob Rodriguez (First Pacific Advisors)

- ▶ First Pacific Advisors, FPA, is a Los Angeles-based institutional money management firm practicing a disciplined approach to value investing, prudently seeking superior long-term returns while maintaining a focus on capital preservation.
- ▶ As of June 30, 2020, FPA manages approximately \$24 billion across multiple strategies. Independently owned FPA has 88 employees, with 31 investment professionals.
- ▶ Bob Rodriguez is the CEO and Manager Partner at FPA.
- ▶ He was the only fund manager in the United States to win the Morningstar Manager of the Year award for both an equity and a fixed income fund and is tied with one other portfolio manager as having won the most awards.



Calibration and Data Analysis

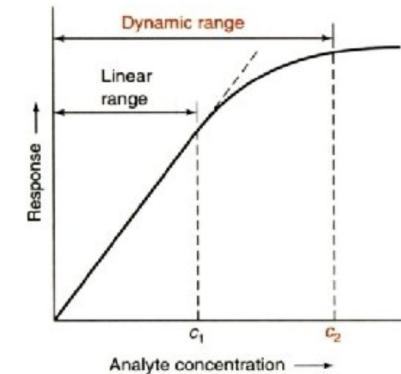
- There is a conventional 2-step method in which the first step is to use measurements of standards to estimate a calibration curve and the second step is to calibrate the data using the calibration curve.

Calibration Curve

- 1.) **Calibration curve:** shows a response of an analytical method to known quantities of analyte

Procedure:

- Prepare known samples of analyte covering convenient range of concentrations.
- Measure the response of the analytical procedure.
- Subtract average response of blank (no analyte).
- Make graph of corrected response versus concentration.
- Determine best straight line.



Calibration and Data Analysis

- ▶ Calibration can be used to provide correction of measured data or perform uncertainty calculations. Generally, calibration data can be of different types and different levels of complexity.
- ▶ For most of the cases user acquires error in each axis, e. g. using a calibrated standard. This value can be used for data correction. Similarly, the value of uncertainty is mostly determined for each axis from calibrated standard certificate and from measurement process uncertainty budget.

Call Options

- ▶ Call options are financial contracts that give the option buyer the right, but not the obligation, to buy a stock, bond, commodity or other asset or instrument at a specified price within a specific time period. The stock, bond, or commodity is called the underlying asset. A call buyer profits when the underlying asset increases in price.
- ▶ The specified price is known as the strike price and the specified time during which a sale is made is its expiration or time to maturity.



Capital Asset Pricing Model

- ▶ The Capital Asset Pricing Model (CAPM) describes the relationship between systematic risk and expected return for assets, particularly stocks. CAPM is widely used throughout finance for pricing risky securities and generating expected returns for assets given the risk of those assets and cost of capital.

$$ER_i = R_f + \beta_i(ER_m - R_f)$$

where:

ER_i = expected return of investment

R_f = risk-free rate

β_i = beta of the investment

$(ER_m - R_f)$ = market risk premium

Capitalization-Weighted Index

- A capitalization-weighted index is a type of market index with individual components, or securities, weighted according to their total market capitalization. Market capitalization uses the total market value of a firm's outstanding shares.

Example:

Total Market Value of Index
\$103 million (25+45+33)

Company A 2.5 million shares outstanding Share price: \$10
\$25 million Weight: 24.27%

Company B 3 million shares outstanding Share price: \$15
\$45 million Weight: 43.69%

Company C 1.5 million shares outstanding Share price: \$22
\$33 million Weight: 32.04%



Capitalization-Weighted Index

✓ Pros

- Market-cap indexes provide investors with access to a wide variety of companies both large and small
- Large well-established companies have a greater weighting providing steady growth for the index
- Small companies tend to have a lower weighting, which can reduce risk if the companies don't survive

✗ Cons

- As a stock price rises, a company can have an excessive amount of the weighting in an index
- Companies with larger weightings can have a disproportionate impact on the fund's performance
- Fund managers can often add shares of overvalued stocks assigning a larger weighting and create a bubble

CDS Pricing, Market Approach

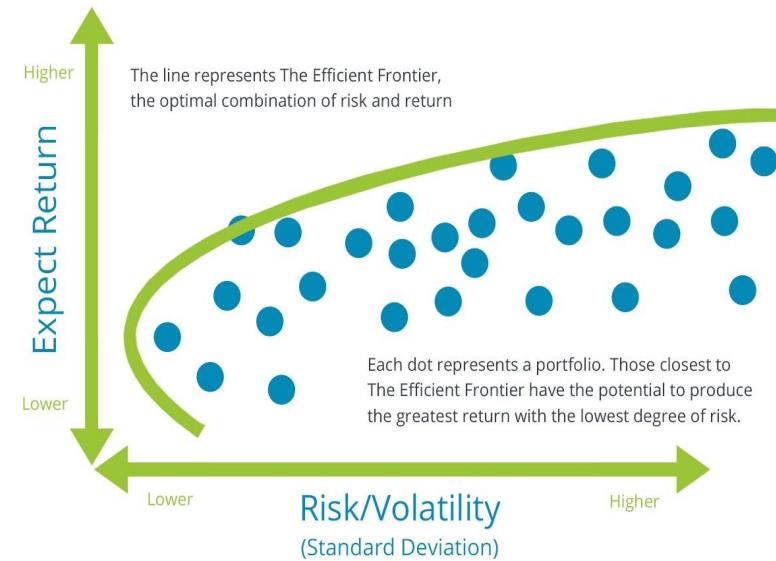
- ▶ A credit default swap (CDS) is a derivatives instrument that provides insurance against the risk of a default by a particular company. This contract generally includes three parties: first the issuer of the debt security, second the buyer of the debt security, and then the third party, which is usually an insurance company or a large bank.
- ▶ The third party will sell a CDS to the buyer of the debt security. The CDS offers insurance to the buyer of the debt security in case the issuer is no longer able to pay. In the case of a default, the seller of the CDS is obligated to buy the debt security for its face value from the buyer of the CDS.

CDS Pricing, Market Approach

- ▶ Valuation of a CDS is determined by estimating the present value of the protection leg, which is the payment from the protection seller to the protection buyer in event of default, and the present value of the payment leg, which is the series of payments made from the protection buyer to the protection seller.
- ▶ Any difference in the two series results in an upfront payment from the party having the claim on the greater present value to the counterparty.

Classical portfolio theory of Markowitz

- ▶ Developed by Markowitz, Modern portfolio theory (MPT) is a theory on how risk-averse investors can construct portfolios to maximize expected return based on a given level of market risk.
- ▶ MPT can also be used to construct a portfolio that minimizes risk for a given level of expected return.



Classical portfolio theory of Markowitz

- ▶ The expected return of the portfolio is calculated as a weighted sum of the individual assets' returns. If a portfolio contained four equally weighted assets with expected returns of 4, 6, 10, and 14%, the portfolio's expected return would be:

$$(4\% \times 25\%) + (6\% \times 25\%) + (10\% \times 25\%) + (14\% \times 25\%) = 8.5\%$$

- ▶ The portfolio's risk is a complicated function of the variances of each asset and the correlations of each pair of assets. To calculate the risk of a four-asset portfolio, an investor needs each of the four assets' variances and six correlation values, since there are six possible two-asset combinations with four assets.

Collateral and Margins

- ▶ **Collateral** refers to an asset that a lender accepts as security for a loan. Collateral may take the form of real estate or other kinds of assets, depending on the purpose of the loan.
- ▶ If the borrower defaults on their loan payments, the lender can seize the collateral and sell it to recoup some or all of its losses.

TYPES OF COLLATERAL



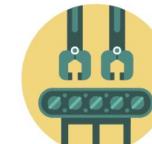
Automobiles



Real estate (including equity in your home)



Valuables and collectibles



Machinery and equipment



Investments



Insurance policies



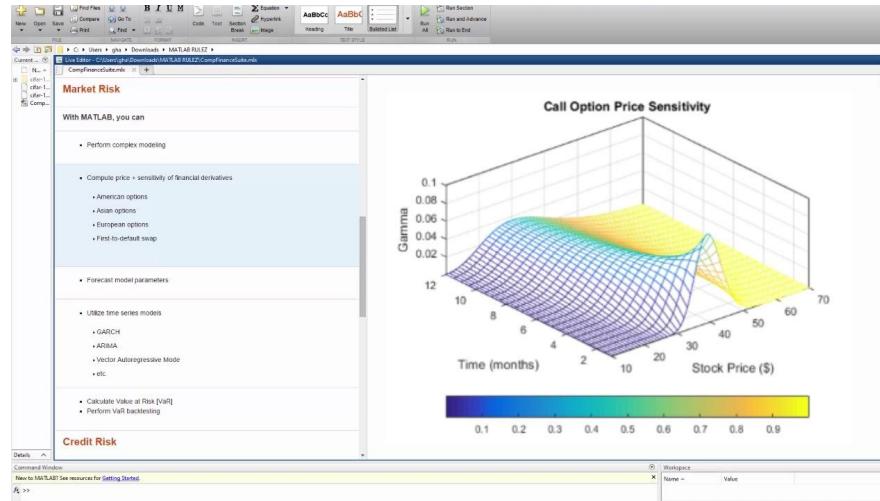
Cash accounts

Collateral and Margins

- ▶ **Margin** is the money borrowed from a brokerage firm to purchase an investment. It is the difference between the total value of securities held in an investor's account and the loan amount from the broker.
- ▶ The practice includes buying an asset where the buyer pays only a percentage of the asset's value and borrows the rest from the bank or broker. The broker acts as a lender and the securities in the investor's account act as collateral.

Computational Finance

- ▶ **Computational finance** is a branch of applied computer science that deals with problems of practical interest in finance.
- ▶ Two major areas are efficient and accurate computation of fair values of financial securities and the modeling of stochastic price series.



Copula-Based Factor Model for Credit Risk Analysis

- ▶ A standard quantitative method to assess credit risk employs a factor model based on joint multivariate normal distribution properties.
- ▶ One-factor Gaussian copula model with constant correlation structure and constant recoveries.

- ▣ One-factor non-standardized Gaussian copula model

$$U_i = \alpha_i Z + \sqrt{1 - \alpha_i^2} \varepsilon_i \quad i = 1, \dots, N.$$

- ▣ Z : systematic factor, ε_i : idiosyncratic factors.
 - ▣ Z and ε_i are independent, and ε_i are uncorrelated among each other, $i=1, \dots, N$.
 - ▣ U_i : the proxies for firm asset and liquidation value.
 - ▣ Correlation coefficient between U_i and U_j is

$$\rho_{ij} = \frac{\alpha_i \alpha_j \sigma^2}{\sqrt{\alpha_i^2(\sigma^2 - 1) + 1} \sqrt{\alpha_j^2(\sigma^2 - 1) + 1}}.$$

Copula-Based Factor Model for Credit Risk Analysis

- The default indicator

$$\mathbf{I}\{\tau_i \leq t\} = \mathbf{I}[U_i \leq F^{-1}\{P_i(t)\}] .$$

- τ_i indicates the default time of each obligor.
- $F^{-1}(\cdot)$ donates the inverse cdf of any distribution.
- $P_i(t)$: hazard rate and marginal probability that obligor i defaults before t .
 - ▶ From Moody's report.
 - ▶ Extract from Credit spreads.
 - ▶ Extract from Credit default swap spreads.

Copula-Based Factor Model for Credit Risk Analysis

- Portfolio loss for each obligor

$$L = \sum_{i=1}^N G_i \mathbf{1}\{\tau_i \leq t\} = \sum_{i=1}^N G_i \mathbf{1}[U_i \leq F^{-1}\{P_i(t)\}] .$$

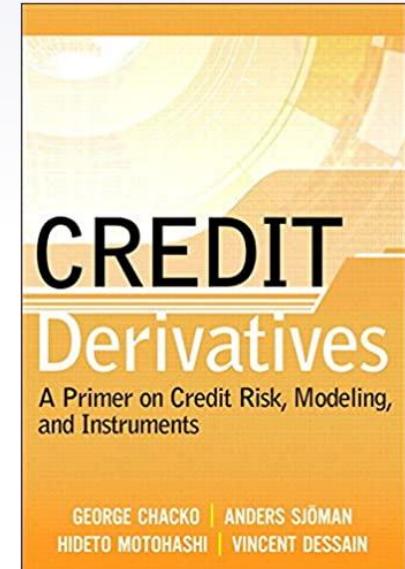
- G_i is the loss given default (LGD) (i -th obligor's exposure = 1).

Core Satellite Models

- Method of portfolio construction to minimize costs, taxes, and volatility while also trying to outperform the market.
- Mostly consists of investments that track major indices.
- Designed to be managed passively
- How it works:
 - There are passively managed assets and actively managed assets in the portfolio
 - A passively managed asset could be an Index Fund for example
 - This portfolio construction primarily consists of passively managed assets
 - More passive assets means lower costs (index change infrequently so transaction costs will be low, and capital gains taxes are also minimized)
 - Volatility is minimized because of the basis on a large index and this portfolio style has generally better returns than the market because there is an actively managed portion

Credit Risk and Derivatives

- A credit is an asset that allows parties to handle their exposure to risk
- It consists of privately held negotiable contract between the creditor and debtor.
- It allows for the transfer of risk to a debtor.
- It is a way to mitigate risk, risk management is key in Quantitative Finance



Derivatives

- Essentially securities that derive value from underlying benchmarks
- A contract between two parties whose value mirrors its underlying benchmark
- These are very popular financial products

Financial Derivatives

**-Futures
-Forward
-Swap
-Options**



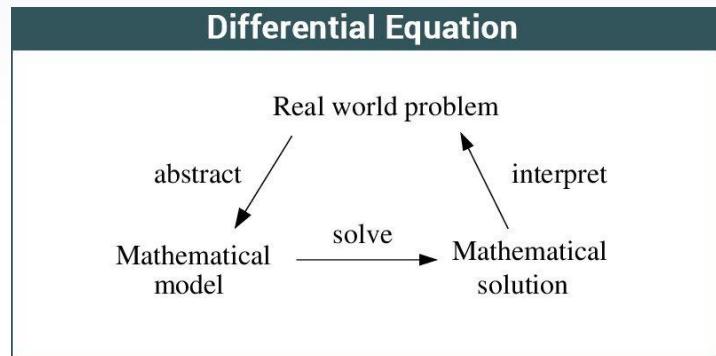
Derivatives Market

- Financial market for Derivatives
- Divided into two markets
 - Exchange traded derivatives
 - Over the counter derivatives
- Examples
 - Futures contracts
 - Options
 - Swaps
 - Warrants



Differential Equations in Finance

- Used to figure what a financial asset or instrument will do over time
- Maybe you want to know how different things operate and change together
- Used to model risk
- When something changes, for example if a threshold has been met or if there is a large market change
- Discretization to make sense organize tangible things happening in the market into numbers.



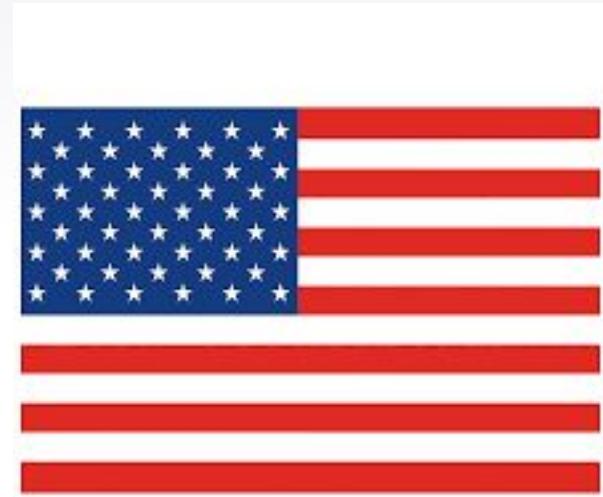
Dividend Capture Strategies

- Income focused stock trading strategy that is popular with day traders
- It is centered on buying and holding stable dividend stock to generate steady income streams
- It is a very active trading strategy
- Dividends are usually paid annually or quarterly, it is generally easier



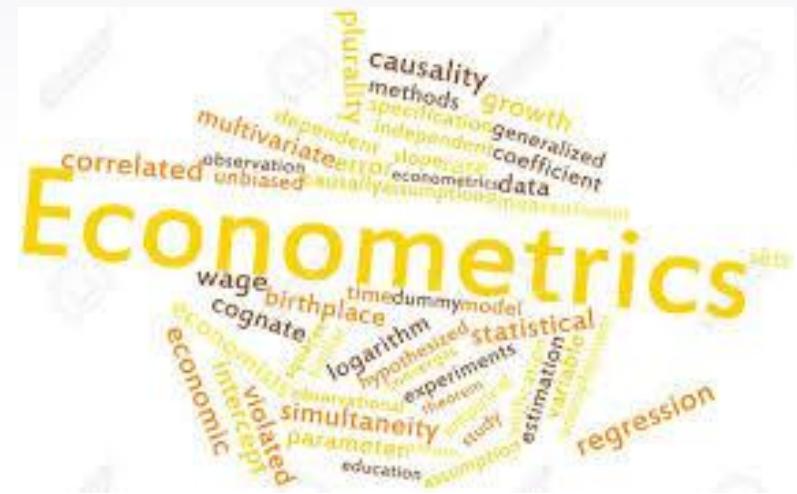
Early Exercise and American Dividends

- Unlike European options on American Options one can exercise them early
- This causes American options to always be more expensive
- Should never exercise early an american option especially if its is non-dividend paying



Econometric Models (ARCH Framework)

- Autoregressive Conditional Heteroskedasticity or ARCH is one of the main tools used to model and forecast volatility
- Applied in a Bayesian Framework it is one of the most basic tools to forecast correlations and covariances



Ed Thorp

- Famous American Mathematics Professor, hedge fund manager, and black jack researcher.
- He actually built the world's first wearable computer to beat roulette
- He is a pioneer in probability theory focusing on the harnessing of very small correlations
- Author of Beat The Dealer which mathematically proved you can beat the dealer by card counting
- Has developed and applied many hedge fund trading techniques
- Known as the father of information theory



Ed Thorp

- One of Wall Street's first Quants
- He realized the stock market is a game of imperfect information, and he utilized the strategy of getting information before everyone else then using it, speed was a key reason why he was so successful
- He also considered the most extreme questions, like what is the market dropped 50% in one day
- Asked if the market is inefficient and can we take advantage of this
- Utilized proper risk management
 - Asked himself if you can't handle the worst case scenario then you need to leverage less

Federal Interest Rate

- ▶ The interest rate is the rate financial institutions lend money and excess reserves to each other without collateral.
- ▶ The interest rate the financial institutions charge each other is considered the federal Interest rate
- ▶ The Federal Interest Rates can influence short-term rates on loans and credit cards.
- ▶ A low federal interest discourages investors because they get a lower return on their money investing in bonds, savings accounts, and Certificate Deposits offered by the bank.

Federal Interest Rate

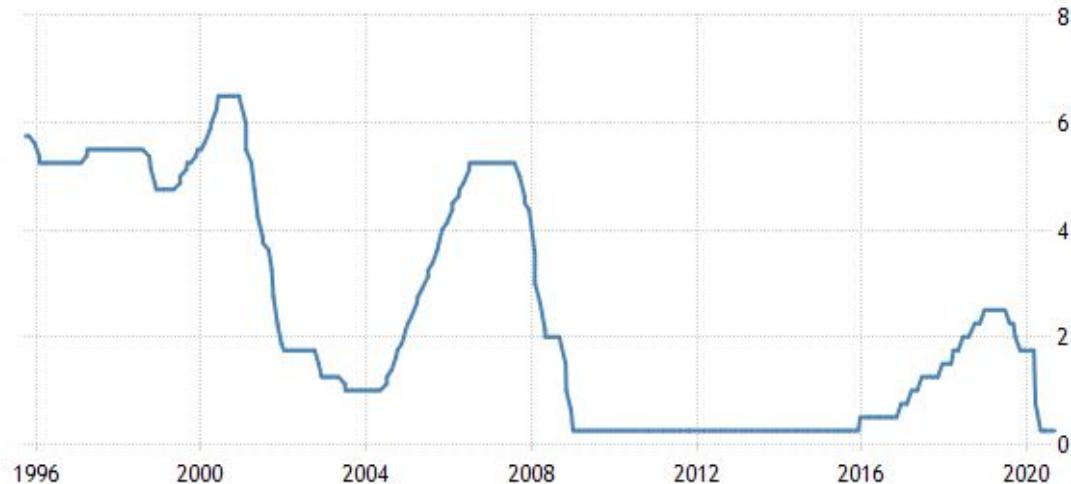
- ▶ A low interest rate signifies a struggling economy because low interest rates are meant to encourage more spending in an economy.
- ▶ A low interest rate means more money for consumers and less interest that has to be paid.
- ▶ A low interest rate is good for people who want to get a loan because less interest is expected to be paid on that loan.
- ▶ The downside is Banks know this so they make it harder to obtain credit so it becomes a double edged sword.

Federal Interest Rate

- ▶ A Low interest rate is good for companies and businesses because it allows them to reinvest and stimulate economy instead of paying it in interest.
- ▶ A low interest rate also is a form of deflation because it slows down the flow of money.
- ▶ A High Interest rate encourages banks to lend with leniency because they expect to make the money back on interest.
- ▶ **A Low Federal Interest Rate** = Anything less than 5%
- ▶ **A High Federal Interest Rate** = Anything over 6%
- ▶ The Average Federal Interest Rate is 5.59%

Federal Interest Rate

- ▶ The Current Federal Interest Rate is .25%
- ▶ The Highest Federal Interest Rate was 20%



SOURCE: TRADINGECONOMICS.COM | FEDERAL RESERVE

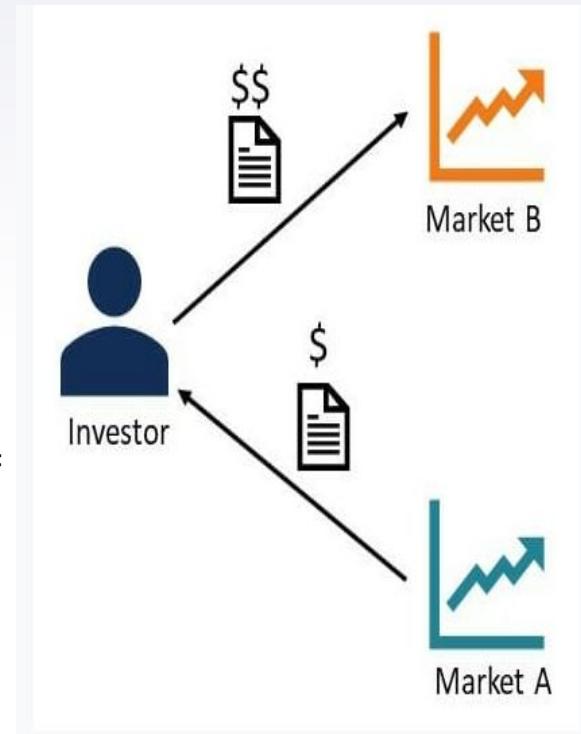


FINRA

- ▶ Financial Industry Regulatory Authority
- ▶ Non Profit Organization Authorized by Congress to oversee Investors
- ▶ There are many tests and examinations giving by FINRA to allow individuals and Corporations to be licensed Advisors and Broker-Dealers.

Financial Arbitrage

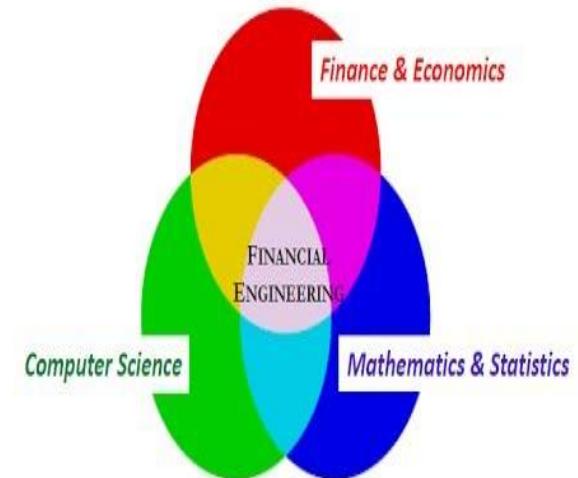
- # When we buy and sell products/asset to make a profit from different market price, that's called financial arbitrage.
- # Security, currency or commodity can be bought and sold as a type of arbitrage.
- # Financial arbitrage gives us a chance to take advantage of high and low prices of market.
- # Market efficiency and liquidity for trading are the result of arbitrage and it's also legal all over the world.



Financial Engineering

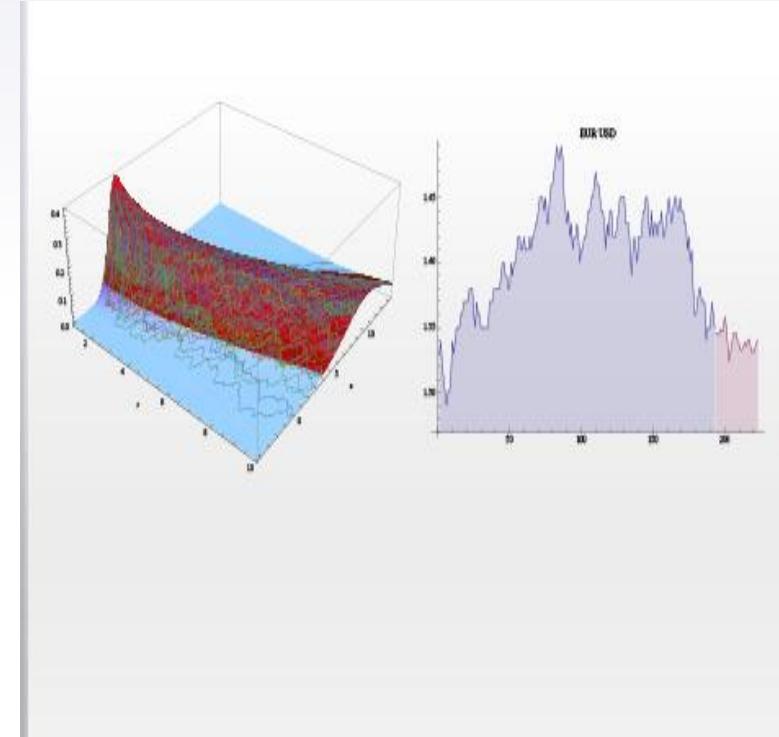
- # Financial engineering was introduced when we started to use mathematics to solve financial problems.
- # Financial engineering is an integrated topic consist of statistics, economics, computer science and mathematics.
- # Commercial banks, investments banks, insurance agencies all of them use financial engineering to do quantitative analysis.

FINANCIAL ENGINEERING
is the application of **Mathematics & Statistics** to the study of **Financial Markets** using sophisticated **Computer Science** techniques



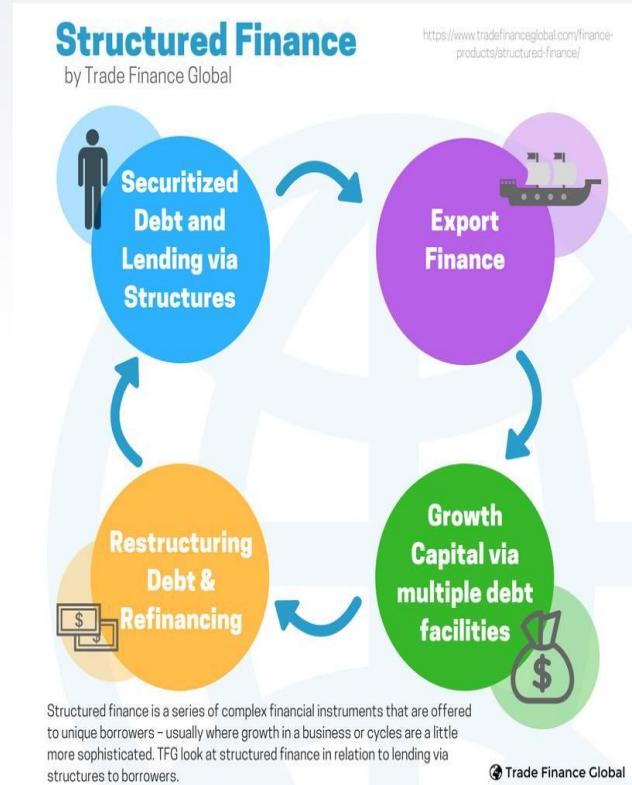
► Financial Engineering

- # Financial engineering can be used to invent new investment tools and methods.
- # Although financial engineering has great influence in market but it also played a role in 2008 financial crisis.



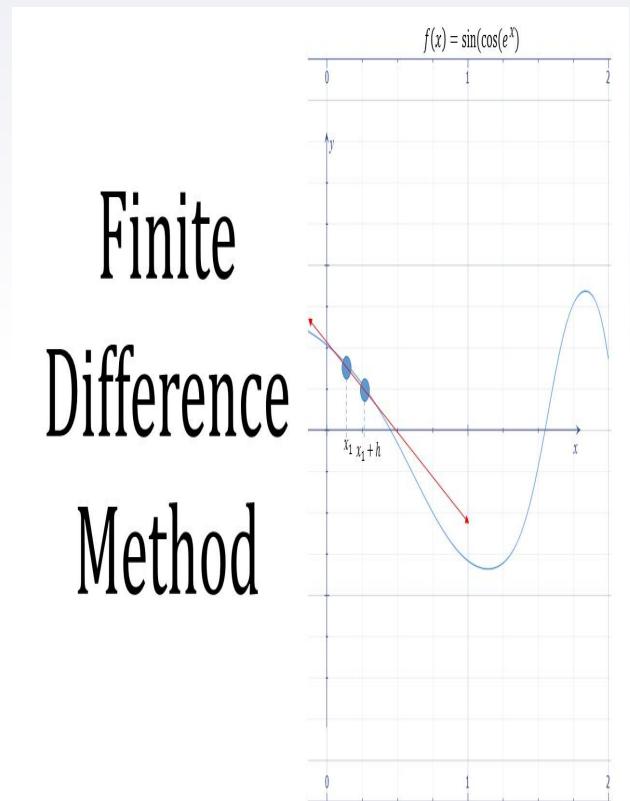
Financial Structuring

- # It can be said that financial structure is the main structure of a business firm or company.
- # Financial structuring includes managing private and public business and the options to make profit comes with it.
- # It manages risk and value of a company.
- # Optimization of debt and equity completely depend on financial structuring.



Finite-Difference Methods

- # Finite-difference method can be defined as a method for solving partial differential equations.
- # We can use this method to solve a wide range of problems.
- # We use it to solve linear, non-linear, time dependent and independent problems.
- # Although this method is old aged but the use of this method is quite new in the sector of finance.



Fixed Income Investment

- # When an investment returns consistent income and the possibility of loss is very low then we can define that as a fixed income investment.
- # It returns income on a fixed schedule through dividends and coupons.
- # Various types of fixed income investments are bonds, bonds mutual funds, money market funds, certificates of deposit, blue-chip stocks.



Fixed-Income Products and Market Practices

- # Fixed income products are those where investors invested money is safe and he will get profit on a fixed interest.
- # People with vast amount of property normally interested in fixed income because they don't want to gamble their huge investment where there's a chance of profit and loss both.
- # Some fixed income products are government and corporate bonds.
- # Because of lower risks and rewards fixed income method is less diversified

Emerging Market Funds

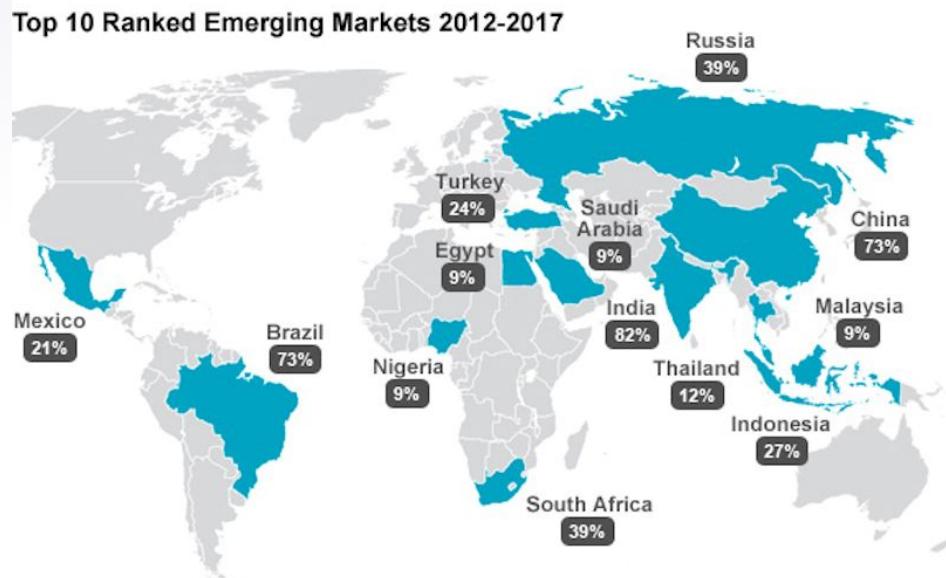
- A fund that invests a majority of its assets in securities from countries with economies that are considered to be "emerging".
- Funds that specialize in emerging markets ranging from mutual funds to ETFs.
- Often a higher growth phase and more potential with greater risk

EMERGING MARKET ECONOMIES IN 2019



Emerging Market Stocks

- Certain equities from companies that are based in emerging markets
- Stocks from companies in emerging markets
- Examples
 - Alibaba
 - Telkom Indonesia
 - Arcos Dorados



*Source: Global Intelligence Alliance, Business Perspectives on Emerging Markets 2012-2017 Survey,
Qn: Which are the top 5 Emerging Markets for your industry over the next 5 years? N=34*

Empirical Stylized Facts

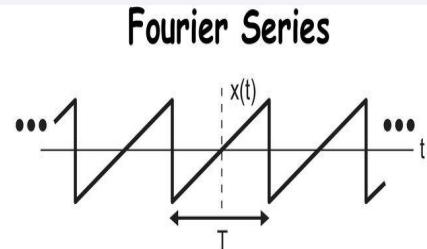
- Stylized Facts are obtained by taking a common denominator among the properties observed in different markets and instruments.
- Formulated in terms of qualitative properties of asset returns and may not be enough to distinguish between different parametric models.
- Goal is to explain a certain economic or financial event
- Essentially a simplified representation of an economic finding
- These facts are considered to be “truths” and in many academic communities developing theories must fit them

Fourier Transforms

In Financial Economics, Fourier transform is one of the most used techniques.

It can calculate real time pricing by analyzing realistic structure of asset returns and takes into account about excessive kurtosis and stochastic volatility.

Fourier transform has become popular in recent years because of it's applied benefits in financial sector.



- The Fourier Series is compactly defined using complex exponentials

$$x(t) = \sum_{n=-\infty}^{\infty} \hat{X}_n e^{jn\omega_0 t}$$

$$\hat{X}_n = \frac{1}{T} \int_{t_0}^{t_0+T} x(t) e^{-j n \omega_0 t} dt$$

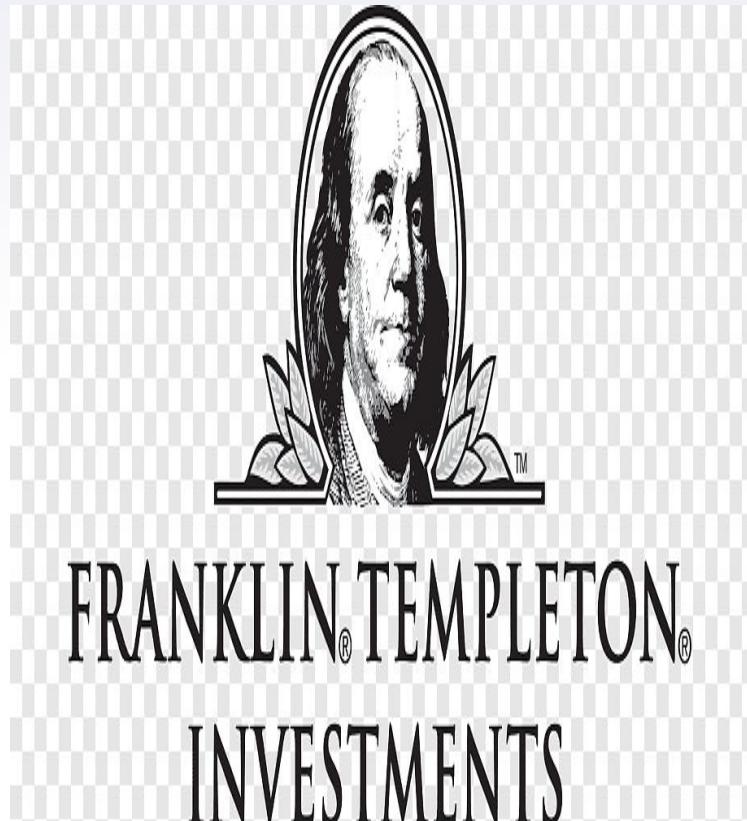
- Where:

$$\omega_0 = \frac{2\pi}{T}$$

$$\hat{X}_n = A_n + jB_n$$

Franklin Templeton

- # Franklin Templeton was founded in 1947 as investment company.
- # It's an American based worldwide mutual funds investment company.
- # Its workspace is directly involved with 17 countries and planning to increase more in future.
- # Franklin Templeton Investments is the biggest multinational fund management group in the world.



ETF

- ▶ ETF stands for Exchange Traded Funds
- ▶ An ETF is a collection of Securities, Assets, and Stocks
- ▶ ETFs typically are made to mimic Index Funds
- ▶ ETFs allow investors to invest in a group of stocks for a bargained price

Functions of a Complex Variable

- # Complex variable function is a widely used theory that can be applicable to many scientific research areas.
- # It can describe real-life complex situations too by using complex variables.
- # We can show many indicators and factors of economic using complex variables.
- # To build new economic and financial models we can use complex variables functions theory.
- # It's proved that the models built with complex variables functions are more accurate than the models of real variables.

ADDING & SUBTRACTING

complex
numbers + complex
numbers

complex
numbers - complex
numbers

Futures

- # A trader can lock the price of an underlying asset or commodity and this process is called futures. It's also known as futures contract.
- # Futures contracts have expirations date and set prices.
- # For example, a November gold futures contract expires in November.
- # The term futures tend to give us an overall view of the market.



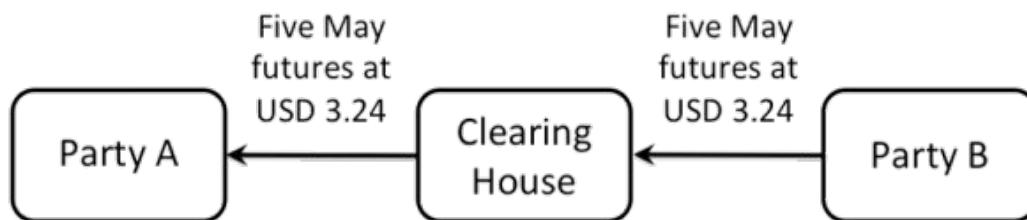
Futures

Two parties transact a futures contract.

Here is a picturized definition of Futures contract.



It is implemented as two contracts.



Futures

The comparison between futures and forwards will give us another point of view to look more closely.

FUTURES

A contract in which the parties agree to exchange the asset for cash at a fixed price and at a future specified date, is known as future contract.

It is a standardized contract.

Organized stock exchange.

On maturity date.

High

As they are private agreement, the chances of default are relatively high.

V/S

FORWARDS

MEANING

Forward Contract is an agreement between parties to buy and sell the underlying asset at a specified date and agreed rate in future.

WHAT IS IT?

It is a tailor made contract.

TRADED ON

Over the counter, i.e. there is no secondary market.

SETTLEMENT

On a daily basis

RISK

Low

DEFAULT

No such probability.

Exotic Options

- ▶ An option (a contract) in general gives the buyer or seller the right or option to buy an asset and/or security (shares) at a specific price before or on a date.
- ▶ These are a Special type of option with more specialized and complex features.
- ▶ They are traded in the OTC (Over the Counter) Markets and not the regular market.
- ▶ Can be exercised (bought or sold) on Specific Dates.
- ▶ Can be Customized.

Exotic Options

- ▶ There are Several Types of Exotic Options:

Types of Exotics

- ◆ Package
- ◆ Nonstandard American options
- ◆ Gap options
- ◆ Forward start options
- ◆ Cliquet options
- ◆ Compound options
- ◆ Chooser options
- ◆ Barrier options
- ◆ Binary options
- ◆ Lookback options
- ◆ Shout options
- ◆ Asian options
- ◆ Options to exchange one asset for another
- ◆ Options involving several assets
- ◆ Volatility and Variance swaps

Exotic Options

- ▶ These are a Special type of option with more specialized and complex features
 - ▷ Package Options
 - ▷ Non Standard Options
 - ▷ Gap Options
 - ▷ Forward Start Options

Exotic Options

- ▶ These are a Special type of option with more specialized and complex features
 - ▷ Cliquet Options
 - ▷ Compound Options
 - ▷ Chooser Options
 - ▷ Barrier Options (Knock-In and Knock-Out Options)

Exotic Options

- ▶ These are a Special type of option with more specialized and complex features
 - ▷ Binary Options
 - ▷ Lookback Options
 - ▷ Shout Options
 - ▷ Asian Options

Exotic Options

- ▶ These are a Special type of option with more specialized and complex features
 - ▷ Options to exchange one Asset from another
 - ▷ Options involving several Assets Gap Options
 - ▷ Volatility and Variance Swaps
 - ▷ Basket Options (Rainbow Options)

Exotic Options

- ▶ These are a Special type of option with more specialized and complex features
 - ▷ Bermuda Options
 - ▷ Extendible Options
 - ▷ Spread Options (Rainbow Options)
 - ▷ Range Options

George Michaelis (Source Capital)

George Michaelis was the first person to run Source Capital end fund.

"Bulletproof" is the word he used to describe the portfolio of Source Capital.

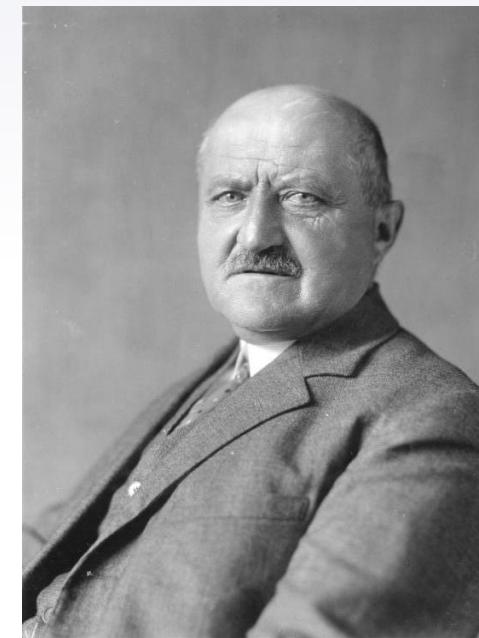
George Michaelis was killed in an accident in 1990s.

Michaelis developed a theory that is known as the Michaelis Total Return Ratio (Yield + Growth)

$\text{YIELD} = (\text{Return on Equity} * \text{Payout Ratio}) / \text{Price to Book Value}$

$\text{GROWTH} = \text{Return on Equity} * \text{Reinvestment Rate}$

$\text{TOTAL RETURN} = \text{YIELD} + \text{GROWTH}$



Girsanov's Theorem

Girsanov's theorem: If Q is a probability measure on which is absolutely continuous with respect to P , then every semimartingale with respect to P is a semimartingale with respect to Q .

It's an important theorem as it gives us the opportunity to process and calculate the result of an absolutely continuous variable with respect to another variable.

Girsanov's theorem tells us that to process a finite variation under P is also a process of finite variation under Q .

In this process local martingales can lose their martingale property.

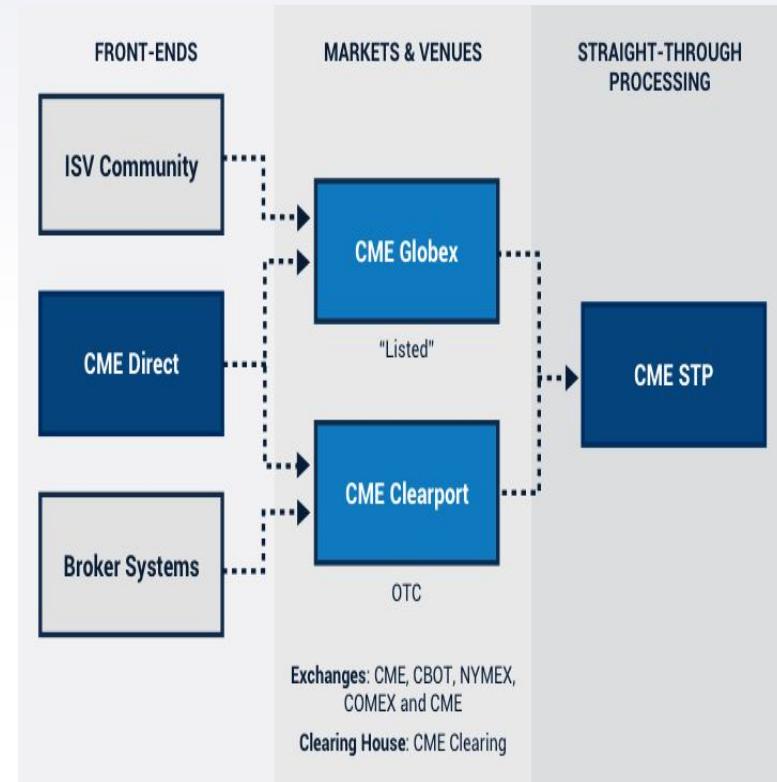
Globex Trading System

Globex trading system is an electronic trading platform.

It's the first of its kind as it can be operable 24 hours a day.

It was developed by Chicago Mercantile Exchange.

It's officially known as CME Globex.

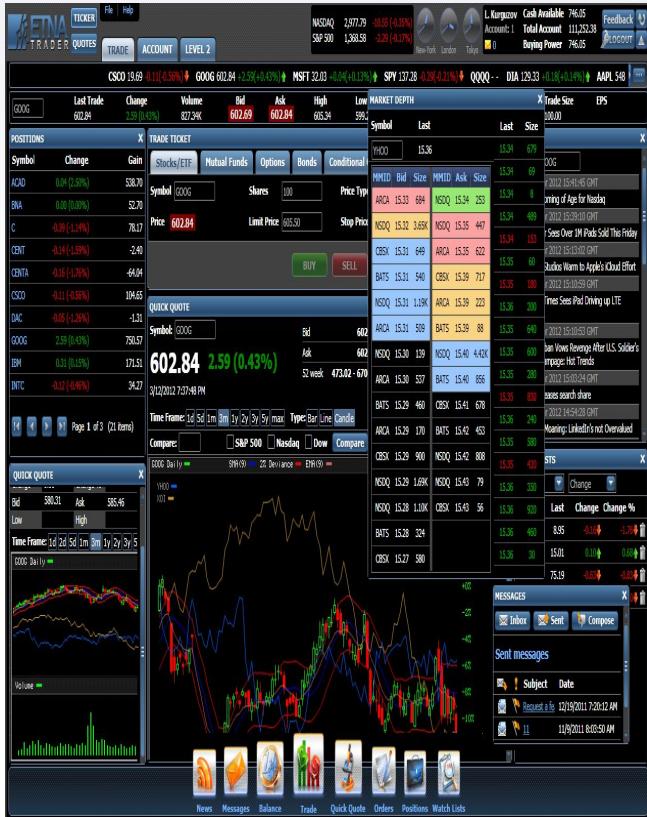


Globex Trading System

CME Globex can operate continuously, unrestricted by geographic borders or time zones.

It's an open-access marketplace that opens in Sunday and closes in Friday.

Traders can directly trade real-time on this platform.



Governance and SRI

Governance

- # When a company starts to flourish and expands it needs a guidance to follow to keep up its financial health and public interest. This guidance can be called as governance.
- # Company's corporate behavior is controlled by governance.
- # The main focus of the board of directors of a company to develop the value of the company and uplift its social interest.

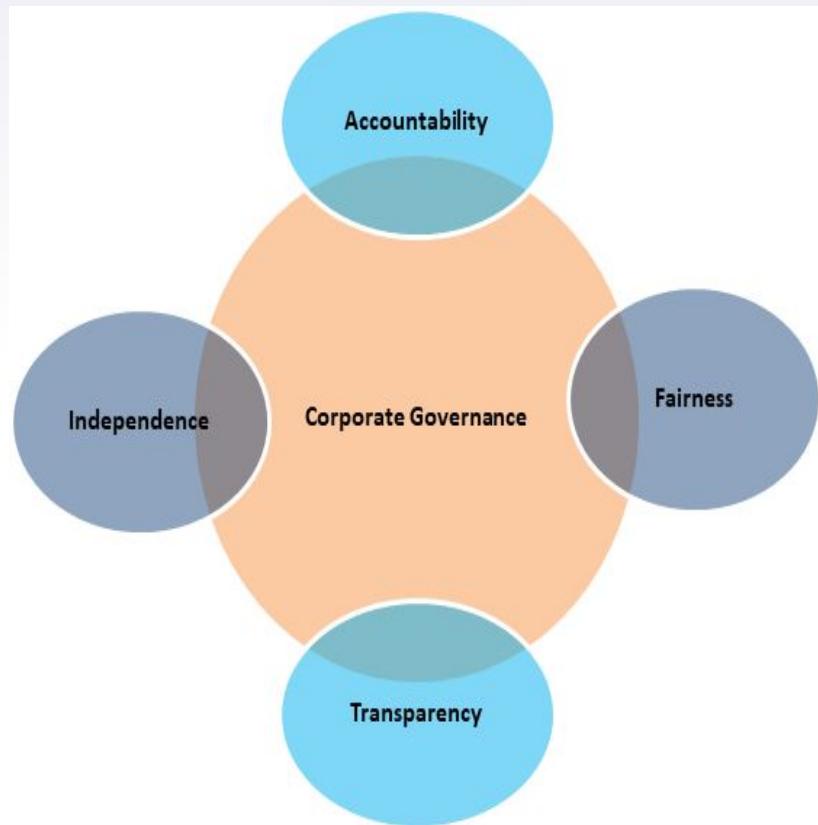
Governance and SRI

GOVERNANCE

It can be said as a management book to run the company.

Board of directors of a company is responsible for the governance of the company.

A company's reliability, integrity, and transparency can be affected by bad corporate governance.



Governance and SRI

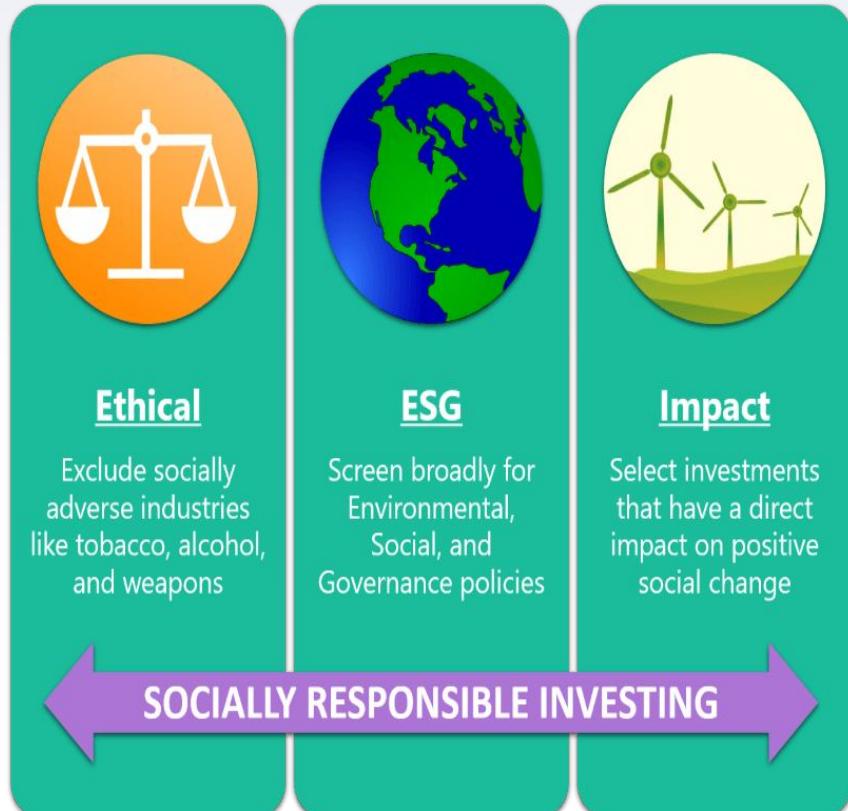
- # SRI is mostly known as social investment.
- # It is called because of its nature that impacts social positiveness.
- # Normally companies that work with social aid projects, SRI means investing money in those types of companies.
- # It's a quite new trend in financial industry.



Governance and SRI

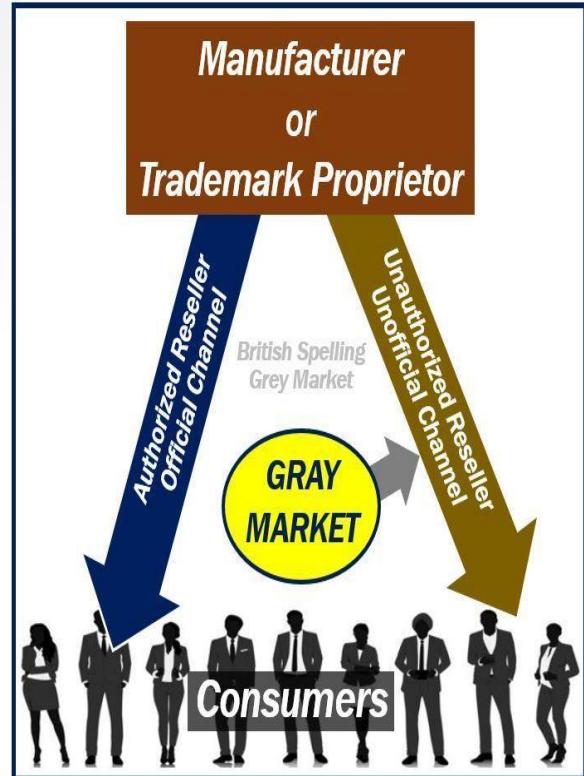
Although social investment mainly focuses on social impact but still it is an investment so the investor should be concerned for its return.

For example we can say that investing in companies that are engaged in social justice, environmental sustainability, and alternative energy/clean technology efforts



Grey Market Bonds

- # Grey market can be described as a market where a manufacturer company gives their consent to sell their products outside their distribution channels.
- # It may seem to be unlawful but it's perfectly legal all over the world.
- # From the share markets view it can be described differently. A grey market is a market where a company's shares are announced to be sold before they come to the market or they are issued in an initial public offering (IPO).



Grey Market Bonds

The trade is binding in grey market trading but it can't be sold until official trading begins.

The high cost of popular and branded prescription medications in the U.S. has created a large grey market.

Grey Market Products

PRODUCT BREAKDOWN

* REVIEW FOR EDUCATIONAL AND RESEARCH PURPOSES ONLY

DIGITAL	DRUGS	SERVICES	NOT ALLOWED
<ul style="list-style-type: none">INFORMATION<ul style="list-style-type: none">E-BOOKSGUIDESFRAUD<ul style="list-style-type: none">ACCOUNTINGCARDINGDOCUMENTSECURITYSOFTWARE	<ul style="list-style-type: none">DISSOCIATIVESSTIMULANTSBENZOSSTEROIDSPHARMACEUTICALSALCOHOLHARM REDUCTIONTOBACCOCANNABISBARBITURATESOPIOIDS ETC.	<ul style="list-style-type: none">HACKINGDOCUMENTMONEYOTHERS	<ul style="list-style-type: none">CHILD PORNFENTANYLCARFENTANYLWEAPONS

Gross Profit Margin

We can define gross profit margin as a tool to analyze a company's financial condition by calculating the amount of money left after the product sales.

We have to subtract COGS(cost of goods sold) from it.

We can calculate gross profit margin as the gross profit as a percentage of net sales.

The Formula for Gross Profit Margin

Gross Profit Margin = $(\text{Net Sales} - \text{COGS}) / \text{Net Sales}$



Gross Profit margin

$$\frac{\text{Gross Profit}}{\text{Sales}} \times 100$$


Hazard Rate

- This rate is trying to answer the question: If some item lasted till some specific moment in time, will it also survive the next.
- Simply, it is the rate of death for a specific item at some age(x).
- This rate can be acquired using this method:
- The takeaway is everything has a rate at which it becomes dead or not as compatible as it once was and this formula tries to address this.

Health, Jarrow, and Morton

- ▶ The Heath-Jarrow-Morton Model (HJM Model) is used to model forward interest rates. These rates are then modeled to an existing term structure of interest rates to determine appropriate prices for interest rate sensitive securities. It is used mainly by arbitrageurs seeking arbitrage opportunities, as well as analysts pricing derivatives.
- ▶ The formula:

$$df(t, T) = \alpha(t, T)dt + \sigma(t, T)dW(t)$$

where:

$df(t, T)$ = The instantaneous forward interest rate of zero-coupon bond with maturity T , is assumed to satisfy the stochastic differential equation shown above.

α, σ = Adapted

W = A Brownian motion (random-walk) under the risk-neutral assumption

Hedging and the Greeks

Hedging

- # It can be described as an insurance of your investment.
- # It can also be said as a risk management strategy.
- # People use hedging to minimize any unexpected event that can happen to his investment.
- # We can secure our investment well enough to almost zero risk if we use proper hedging .
- # For example, we make insurance of our cars so that when an accident happens it can minimize our losses.



Hedging and the Greeks

Greeks

Greeks tell the trader to get a close look at the options to move or the risks involved with that investment.

Some main greeks are

- i) Delta
- ii) Theta
- iii) Gamma
- iv) Vega
- v) Rho

Name	Symbol	Derivative
Delta	Δ	$\frac{\partial V}{\partial S_0}$
Gamma	Γ	$\frac{\partial^2 V}{\partial S_0^2}$
Rho	ρ	$\frac{\partial V}{\partial r}$
Theta	Θ	$\frac{\partial V}{\partial t}$
Vega	ϑ	$\frac{\partial V}{\partial \sigma}$

Hedge Fund

- ▶ A type of investment fund only available for Accredited Investors.
 - ▷ Accredited Investors must have a net worth of \$1 million or income of at least \$200,000 a year for at least 2 years.
- ▶ This type of Fund is legally allowed to have 35 unaccredited Investors
- ▶ The purpose of a Hedge Fund is max returns in a short time with liquid investments
 - ▷ Currencies
 - ▷ Stocks & Bonds
 - ▷ Precious Metals
 - ▷ Mutual Funds

Hierarchical Risk Parity

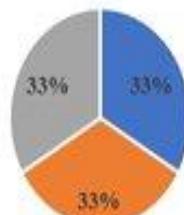
We use different types of risk parity to build balanced portfolios.

Machine learning algorithm can be used in hierarchical risk parity.

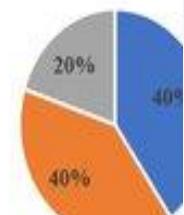
The main focus of hierarchical risk parity will be

- i) Inverse variance weighting
- ii) Mean-variance
- iii) Equal weighting
- iv) Minimum-variance

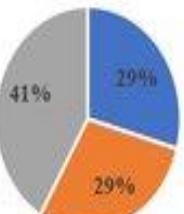
Equal Weights Portfolio:
Allocations



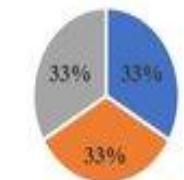
Equal Weights Portf
Contributions



ERC Portfolio: Allocations



ERC Portfolio: Risk
Contributions



High Frequency Data

- ▶ This data goes along with High Frequency and Ultra High Frequency Trading
- ▶ This data is used to make decisions based on milliseconds and microseconds
- ▶ This type of Data is extremely helpful for Quantitative Analysis and Day Trading

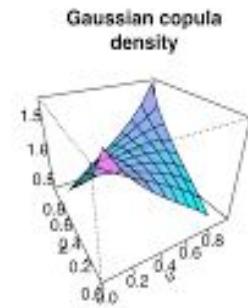
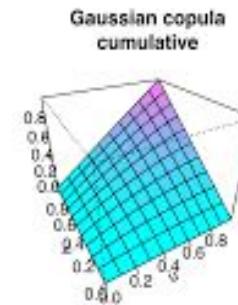
High Frequency Trading

- Large Automated trading platform many financial institutions use to analyze, and execute trades at a very high rate
- They use algorithms to analyze market data spot trends in almost real time
- Some people though view high frequency trading as an unfair advantage, firms closest to the markets, with the best tech and data do the best



Implementation of Copula Models

- Mathematical tools used to identify risk, market risk, and operational risk
- It is a probability model that represents a multivariate distribution that examines the dependence between many variables.
- It is widely used in finance because the markets do not follow a normal distribution
- It falls under stochastics quations



Interest Coverage

- This is a debt ratio and profitability ratio used to determine how easily can pay interest on its debts
- Calculated by dividing EBIT by the company's interest payments due that same period
- Metric to analyze investment financially

$$\text{Interest Coverage Ratio} = \frac{\text{Earnings before Interest and Taxes (EBIT)}}{\text{Interest Expense}}$$

Itô's lemma quantitative finance

- Identity used in Ito's calculus to find the differential of a time dependent stochastic function (which are greatly used in quantitative finance)
- It's the stochastic calculus version of the chain rule
- Key for manipulating stochastic equation
- Stochastic equations are used for modeling in quant finance

Itô's lemma quantitative finance

- Example

$$dX_t = \mu X_t dt + \sigma X_t dW_t$$

and this can be solved easily by applying Itô's lemma with

$$f(x) = \ln(x)$$

That's the BnB example:

$$f'(x) = \frac{1}{x}$$

$$f''(x) = -\frac{1}{x^2}$$

and by Itô:

$$d(\ln(X_t)) = \frac{1}{X_t} dX_t - \frac{1}{2X_t^2} d < X_t >$$

$$d(\ln(X_t)) = \mu dt + \sigma dW_t - \frac{\sigma^2}{2} dt$$

$$d(\ln(X_t)) = \mu dt + \sigma dW_t - \frac{\sigma^2}{2} dt$$

$$d(\ln(X_t)) = (\mu - \frac{\sigma^2}{2})dt + \sigma dW_t$$

And then,

$$\ln(X_t) - \ln(X_0) = \ln\left(\frac{X_t}{X_0}\right) = (\mu - \frac{\sigma^2}{2})(t - 0) + \sigma W_t$$

$$X_t = X_0 \exp^{(\mu - \frac{\sigma^2}{2})t + \sigma W_t}$$

This means that X_t is log-normally distributed...

Jean Marie Eveillard

- French investor who now works as the Senior Investor for First Eagle Funds
- In 2001 he was Morningstar's "Stock Manager of the Year"
- His investing strategy is simple
 - Very similar to Warren Buffet and closely follows him
 - Known as the preeminent value investor
 - Accounting is key for him
 - Focus on qualitative side
 - Value and growth are joined at the hip



Jump Diffusion

- A stochastic model that is used for financial asset pricing and option pricing
- It is a form of mixture model that is popular in credit risk and short rate models
- Used for modeling extra properties like random fluctuations, skews in distributions, and greater kurtosis than normal distribution



Kolmogorov Equation in Finance

- This equation addresses the problem when we have the state x of the system at time t , we want to know the distribution of the state at a later time s .
- It is a type of run test used in finance. A run test is a test used by statisticians to examine whether a string of data is random or following some type of distribution.
- The Kolmogorov is really a goodness of fit test that demonstrates if the sample data is being tested represents a normal distribution or if it is skewed.

Langevin Equation and Fokker-Planck Equations

- They are used in finance to model volatility of options
- The Fokker-Planck equation is a partial differential equation that describes time evolution of the probability of a density function (think normal distribution)
- The Langevin equation is a stochastic differential equation that describes the time evolution of a subset of the degrees of freedom of a distribution
- In chemistry it is used to model how particles collide in a solution

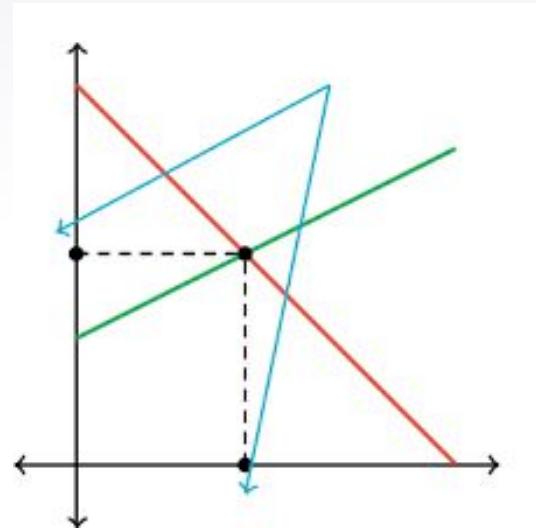
Leverage Finance

- Leverage results from using borrowed capital as funding when augmenting a firm's asset base and to generate returns on risk.
- Essentially it is the practice of using borrowed money to increase potential return on risk.
- So when someone refers to something as "highly leveraged" it means the item has more debt than equity.



Libor Market Model

- LIBOR stands for London InterBank Offered Rate
- It is a benchmark interest rate that many global banks lend to each other in through short term loans in the international market
- The rate is calculated each day by the ICE (Intercontinental Exchange)
- It is based on five currencies: US Dollar, Euro, Pound, Yen, and Swiss Franc
- There are 7 different maturities: overnight, spot, one week, two week, three week, six week, and one year.



Linear Algebra in Finance

- ▶ Linear algebra is used to study financial trading strategies and expectations. Financial conditions are examined via matrix equations, using rank, column space, and null space arguments.
- ▶ For example, it can be used to find arbitrage opportunities for various bonds with known prices and payment schedules. The ability to find arbitrage opportunities easily using linear algebra in software programs eliminates such opportunities. This gives rise to the No Arbitrage Principle.

Liquidity Asset Liability Management

- ▶ This is a concept of managing a company's assets and cash flows to manage the payment of liabilities. The illiquidity of assets such as real estate or interest rate risk (i.e. the risk that interest rates may increase) may risk mismanaging liability payments. Liquidity Asset Liability Management aims to reduce the likelihood of such mismanagement.
- ▶ Asset Coverage Ratio is often used to find out the company's ability to repay its liabilities by converting its assets into cash

$$\text{Asset Coverage Ratio} = \frac{(BVTA - IA) - (CL - STDO)}{\text{Total Debt Outstanding}}$$

where:

BVTA = book value of total assets

IA = intangible assets

CL = current liabilities

STDO = short term debt obligations



Long Position

- The purchase of an asset with the idea that its value will increase over time
- It is the opposite of short position
- The holder owns the asset or option on the asset
- This investment strategy is a measurement of time, generally an individual will hold on to the asset for awhile in the hopes for a greater return in the future

Low Frequency Trading

- ▶ A strategy used to hold Securities (Stocks) longer than a trading day.
- ▶ Considered a Long Term Investment Approach.
- ▶ This could be considered holding a Stock for 2 days, a week, a month, or even years.

Low-Frequency Traders

Once they buy, these mutual funds rarely sell.

Fund	ticker	category	3-year return	5-year return	% rank category 5-year return
Amana Developing World	AMDWX	emerging markets	-0.4	NA	NA
Hennessy Focus	HFCSX	mid growth	16.5	23.1	2
Huber Capital Small Cap Value	HUSIX	small value	15	34.1	2
Mairs & Power Growth	MPGFX	large blend	17	23.2	7

Source: Morningstar. Returns through 3/31/14.

Low Latency

- It is the use of algorithmic trading to react to the markets faster than others to increase profitability
- Opportunities may only be present for milliseconds so it is important to be able to react quickly
- Low latency is the use of high frequency trading strategies and technologies
- People literally make fortunes off this, being able to react first

Manipulating Stochastic Differential Equations

- Many of the calculations derived from security pricing involve formal manipulations
- Why people right as differential form vs. integral form?
 - Makes it easier to simulate sample paths
 - If you write it in differential form you can formal calculations that are not as rigorous



Manipulating Stochastic Differential Equations

Consider a very simple market where at time $t = 0$ it is known that there are only two possible states for the market at a later time $t = T$. In between times $t = 0$ and $t = T$ there is no trading of any kind. This market is described by a probability space $\Omega = \{\omega_1, \omega_2\}$ with probability measure \mathbb{P} given by

$$p_1 = \mathbb{P}(\omega_1) = \frac{2}{3}, \quad p_2 = \mathbb{P}(\omega_2) = \frac{1}{3}.$$

The elementary events ω_1 and ω_2 are the two states of the market. The traded assets in this simple market are a bank account, a stock, and a call option on the stock with

exercise at T and strike $K = 2$. The market outcomes are shown in Table 1.1.

Table 1.1: Assets in the Discrete Time-Space Market

time	$t=0$	$t=T$
bank account	$B_0 = 1$	$B_T = 1$ (interest rate $r = 0$)
stock	$S_0 = 2$	$S_T = \begin{cases} 3 & \text{in } \omega_1 \\ 1 & \text{in } \omega_2 \end{cases}$
call option, $K = 2$	$C_0 = ?$	$C_T = \begin{cases} 1 & \text{in } \omega_1 \\ 0 & \text{in } \omega_2 \end{cases}$

The way to determine the price of the call option, C_0 , is to replicate it with a portfolio of the stock and the bank account. Let V_t denote the value of such a portfolio at time t , so that,

$$\begin{aligned} V_0 &= \alpha S_0 + \beta \\ V_T &= \alpha S_T + \beta, \end{aligned}$$

where α is # of shares and β is \$ in bank. The portfolio V_t will replicate the call option if we solve for α and β so that $V_T = C_T$ for both ω_1 and ω_2 ,

$$\begin{aligned} 3\alpha + \beta &= \alpha S_T(\omega_1) + \beta = C_T(\omega_1) = 1 \\ \alpha + \beta &= \alpha S_T(\omega_1) + \beta = C_T(\omega_2) = 0. \end{aligned}$$

This system has solution $\alpha = \frac{1}{2}$, $\beta = -\frac{1}{2}$. Hence, by the law of one price, it must be that,

$$C_0 = V_0 = \frac{1}{2}S_0 - \frac{1}{2} = \frac{1}{2}.$$

If C_0 does not equal V_0 then there would be an arbitrage in the market.

If such an opportunity is found then an investor could borrow money giving them a wealth of cash. Arbitrage is not always a sound financial model, in real life true arbitrage opportunities disappear quickly.

This is why almost every market assumes efficiency and no arbitrage.

*The example to the left was taken from *Derivative Security Pricing* written by Carl Chiarella, Xue-Zhong He, and Christina Sklibosios Nikitopoulos

Margin Calls

- ▶ A Margin Call occurs when a company demands payment on a debt (Margin)
- ▶ An issuer or a Broker requires a deposit to allow someone to borrow money to buy more securities (Stocks, Shares)
- ▶ Each Brokerage has different rules in how they manage their loans to investors

Margin Calls

- ▶ A Margin Call occurs when a company demands payment on a debt (Margin).
- ▶ An issuer or a Broker requires a deposit to allow someone to borrow money to buy more securities (Stocks, Shares).
- ▶ Each Brokerage has different rules in how they manage their loans to investors
- ▶ You pay a percent as a down payment to buy or sell stocks at a specific price and if you begin to lose money on the Brokers investment they demand payment immediately for you to cover your Margin.

Margin Calls



* Interest charges, commissions, and fees not included

For illustrative purposes only. Not a recommendation of an investment or investment strategy.

Martingale Theory for Pricing

- Martingales theory for pricing is used to price a stocks future value such that its expected value is equal to its present value, taking the history of that stock in consideration.
- This can be obtained using: $E(X_t | X_u, u \leq s) = X_s$

Marty Whitman

American investment adviser and a strong critic of the direction of recent changes in Generally Accepted Accounting Principles.

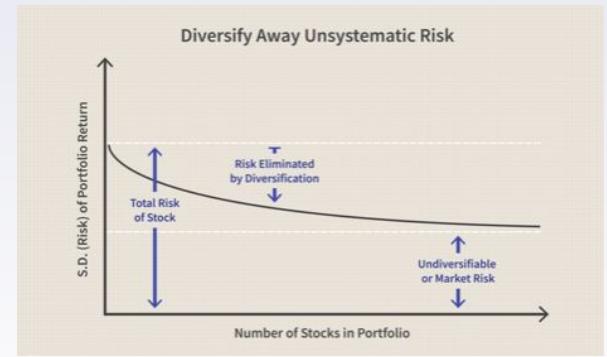
Marty Whitman is a very strategic investor as well as the founder and Co-Chief Investment Officer of Third Avenue Management. He did not want to invest in what every banker was investing in, he went into what he called the “dirty” markets such as stockholder litigations and bankruptcies.

Marty’s niche over the years was value investing which looks deeply into a company's balance sheets and making sure common practices such as low liabilities are present and distressed debt investing, which focuses on looking at companies facing series 11 bankruptcies and turning them around.

He really just took into consideration common practices that were valued pretty highly on the ethical side of business when deciding if he should invest.



Modern Portfolio Theory



- Modern portfolio theory is a theory in finance that uses mathematical formulas to construct a model in which makes the overall value of a portfolio risk averse, so when one security is falling in price another is regaining value at an equal or related pace, keeping the overall portfolio breaking even.
- An example of assessing the overall value of a portfolio with 4 equally weighted assets would be as given:
- $(4\% \times 25\%) + (6\% \times 25\%) + (10\% \times 25\%) + (14\% \times 25\%) = 8.5\%$
- The overall take away from modern portfolio theory is that as the market is rising in totality, the value of the portfolio is rising with the market. So it is maximizing the expected value of the portfolio given a condition on how much risk it can bare.

Moodys

- A holding company that owns Moody investor services (provides investors with credit ratings, risk analysis, and research for stocks, bonds, and government entities) and Moody's analytics (develops software and tools to help capital markets with risk management, credit analysis, and economic research) and what gives Moody its own niche is how it assigns ratings to bonds based on its team of analysts.
- The ratings that moody assigns are incredibly sought after and investors heavily rely on these ratings because it is a weight that is assigned to represents the likelihood of a bond being good or bad(how likely is one going to default? Refer to the chart on the next slide).

Moody's	S&P	Fitch	
Aaa	AAA	AAA	Prime
Aa1	AA+	AA+	
Aa2	AA	AA	
Aa3	AA-	AA-	
A1	A+	A+	
A2	A	A	Upper medium grade
A3	A-	A-	
Baa1	BBB+	BBB+	
Baa2	BBB	BBB	
Baa3	BBB-	BBB-	
Ba1	BB+	BB+	
Ba2	BB	BB	
Ba3	BB-	BB-	
B1	B+	B+	
B2	B	B	
B3	B-	B-	Highly speculative

Monte Carlo Simulation

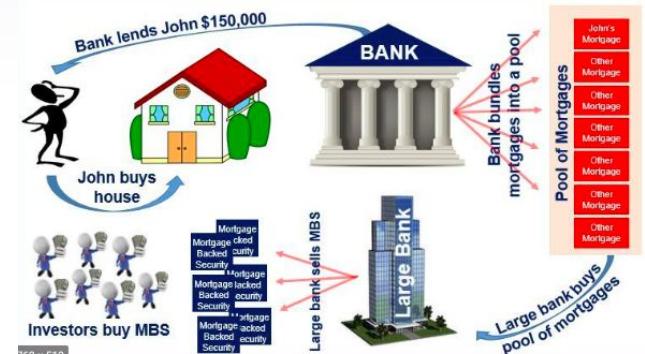
In the face of uncertainty, a monte carlo simulation is an applicable process in random sampling to determine the likelihood of an event happening given independence or in other words a model used to predict the probability of different outcomes with the presence of a random variable .

For example flipping a coin, whatever outcome is produced on the first flip will not interfere with the outcome on the second flip. A $\frac{1}{2}$ chance of getting heads on the first flip will not result in a $\frac{1}{4}$ chance of getting heads on the second flip, the second flip is independent of the result of the first flip, each toss regardless of the previous toss produces a $\frac{1}{2}$ chance that you will either get heads or tails. Though the likelihood of getting heads twice in a row given 2 flips is $1/4 \sim \{H, T, T, H\}$.

In the next slide we will look at some python code to show the possibilities of a coin flip

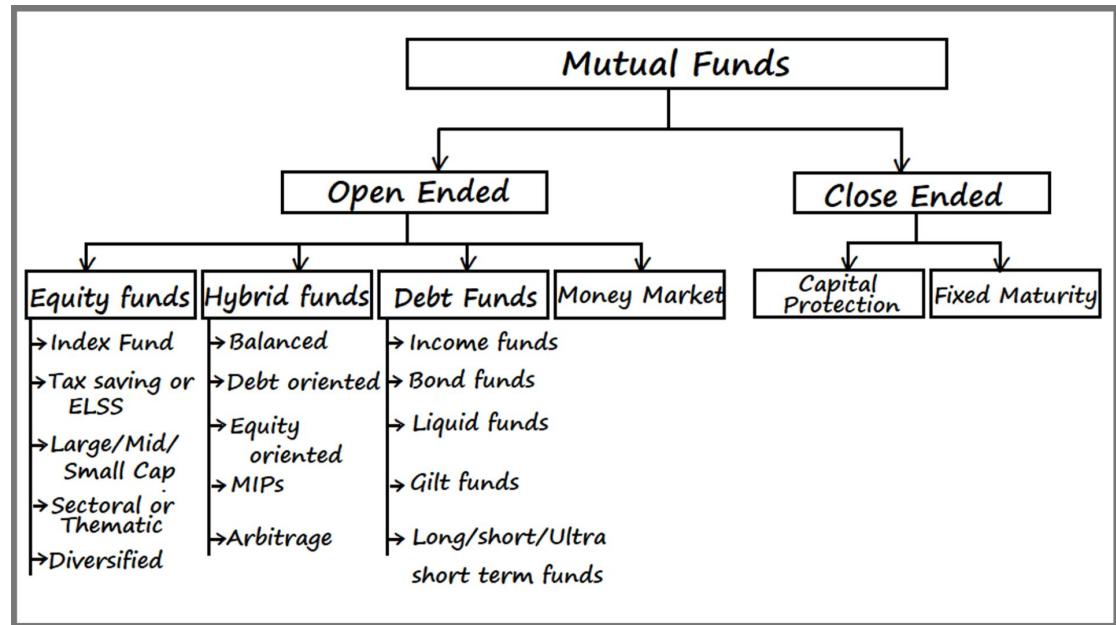
Mortgage Bond (Mortgage Backed Security)

- This is a form of a bond that is backed by-as-the-name-suggests a bunch of mortgages that are bundled into a portfolio that is then sold to an investor.
- This is where MOODY can come in hand and can assist the investor with pricing out this particular bond.
- Lets imagine the portfolio is an empty pot and you want to create this soup that can either turn out very tasty or not so tasty. Now the ingredients we will be adding into the pot are going to be a bunch of mortgages (a loan you would take on a home) and these mortgages will be weighted with AAA(not so risky), BBB, and even CCC (very high risk).
- Refer to the chart on the next slide



Mutual Fund

- ▶ A Portfolio of Securities (Stocks) that comes in different structures.



Mutual Fund

- ▶ Mutual Funds are different than a ETF.

	Mutual Funds	Exchange Traded Funds (ETFs)
Buy and Sell	Directly through mutual fund companies or brokerage firms	On an exchange throughout the day
Pricing	Priced on a daily basis at market close	Priced like an individual stock – constantly while the market is open
Minimum Investment	Minimum investment depends on the fund	Typically one share
Transparency of internal holdings	Holdings are generally reported once each quarter	Holdings are generally reported on a daily basis
Internal Cash Position	Most mutual funds maintain some cash in order to satisfy potential investor redemptions	Generally, there is no cash needed
Tax Implications (see below for further explanation)	Capital gains are triggered by the fund manager as gains are realized through sell transactions inside the fund	Capital gains are generally triggered by the individual investor when they sell their shares of the ETF

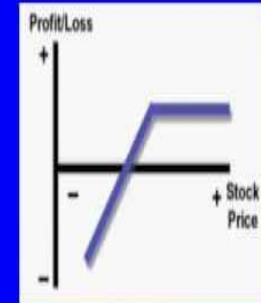
Mutual Fund

- ▶ The 7 Main Categories of Mutual Funds
 - ▷ **Money Market Funds** - Funds are used for low yield but very low risk investments
 - ▷ **Fixed Income Funds** - Funds are used for Corporate and Government Bonds
 - ▷ **Equity Funds** - Funds are used to invest in Companies on the Stock Exchange
 - ▷ **Balanced Funds** - Funds are created with a diversified balance of Stocks, Bonds, and etc.
 - ▷ **Index Funds** - This is a Fund created usually based on the S&P 500, NASDAQ, DOW, and etc.
 - ▷ **Specialty Funds** - Funds are used for a specific purpose (Real Estate Fund and etc.)
 - ▷ **Funds of Funds** - Funds are used to invest in other types of Funds

Naked Put Options

- # When an investor put selling options for his investment to take the advantage of premium benefits using his understanding of market that is considered as naked put options.
- # While it involves risk of losing money throughout the time but if the analysis goes right this particular investor gains more than other investors.
- # We can assume it as a calculated risk that an investor willing to take on the basis of his predictions.

What is a Naked Put?



NASDAQ

- ▶ National Association of Securities Dealers Automated Quotations (NASDAQ)
- ▶ Founded in 1971
- ▶ The Nasdaq is an Index that is made up of 3300 Stocks (mostly technology)
 - ▷ Microsoft
 - ▷ Apple

NASDAQ

- ▶ The NASDAQ has branches that people can invest in:

Index Name	Total Return	Change
NASDAQ-100 Index	13297.79	+ 382.26 ▲
NASDAQ Biotechnology Index	4241.06	+ 79.11 ▲
NASDAQ Composite Index	13172.36	+ 347.68 ▲
ABA Community Bank NASDAQ Index	342.54	- 3.11 ▼

Net Asset Value - NAV

- Net asset value is the net value of an entity (how much is a specific company worth)
- This is calculated by adding up all the entities assets and subtracting that from the liabilities
-



Net Asset Value
Formula

=



Fund Assets - Fund Liabilities
Number of Units Outstanding

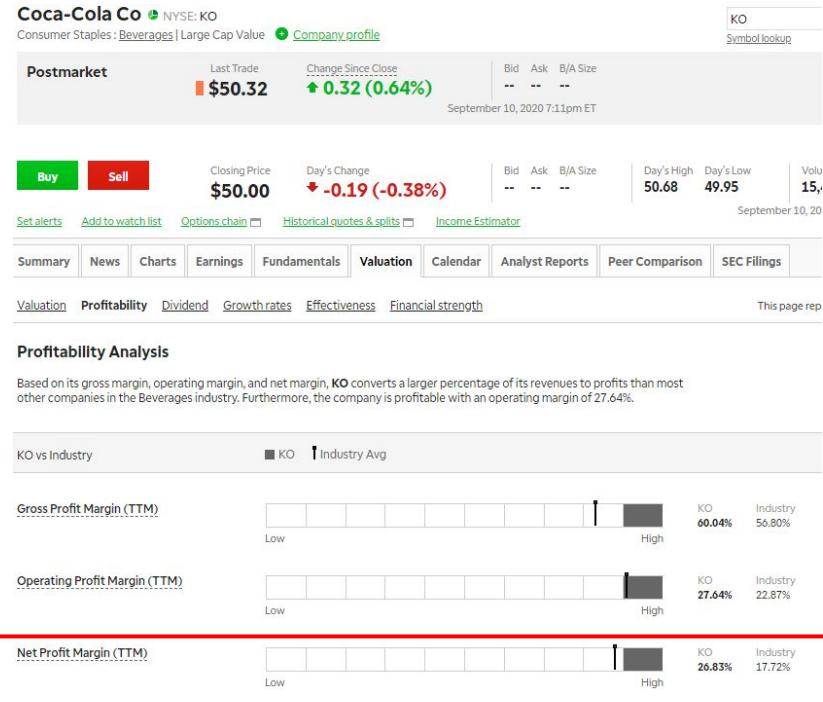


Net Profit Margin

- ▶ This refers to the money that a company can free use or is saved in a fiscal year or sometimes monthly.
- ▶ A Good Net profit margin assures us the company we have invested in is actually making money.
 - ▷ For example:
 - ▷ A Company profits .50 cents for every dollar spent monthly or yearly they have a 50% Net profit margin (after All Expenses)

Net Profit Margin

- We consider a good Profit Margin at least 15% (Although it depends on industry)



Net Profit Margin

- A simple metric that is looking to answer: How much net income is generated as a percentage of revenue.
- Think of this as an indicator that tells you how healthy a company's financials are
- For example if the Net profit margin is 15% - that means for every dollar the business makes 15% of it will be its profits.
-

Net Profit Margin Ratio

Net Profit Margin Ratio =

Net Profit
Revenue

Non-Probabilistic Volatility model

- When trying to identify how volatile an asset is via time series data for example, as previewed in the stochastic graph below. The measurement of the “ups” and “downs”(a ratio) of the asset is an example of how volatile the asset is.
- This measurement is usually capturing a probability aspect in order to determine
- The ups and downs in an asset.
- Though a lot more difficult to capture without this probabilistic aspect, there were
- Models that were designed to not take into consideration this “probability” aspect.
- One model is the David Epstein & Paul Wilmott - Non-Linear Non-Probabilistic Interest rate model which is represented by the blue line on the next slide

Operating Profit margin

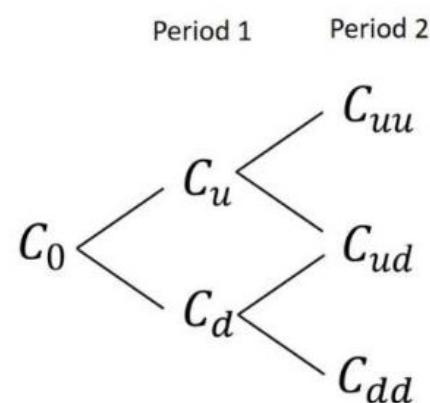
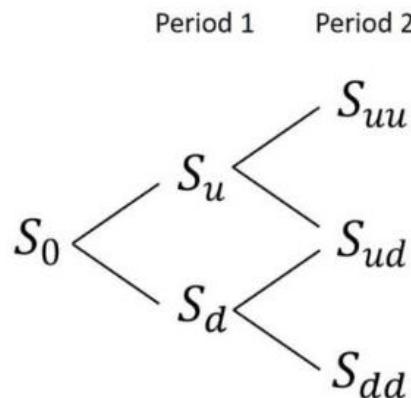
- Operating profit margin is the amount of profit a company makes per dollar made given it had paid all expenses such as, wages, materials, but before it pays the interest on the tax.
- This metric is just a ratio that shows a person how much profits a company makes from its primary operations.
- This can be calculated using:

$$\text{Operating Margin} = \frac{\text{Operating Earnings}}{\text{Revenue}}$$

Options pricing Models -1

Binomial Option Pricing Model

- One of the more simplistic ways to price an option given the assumption that the underlying asset will either go up or down given some specific period of time.



Options pricing Models -2

Black-Scholes Model

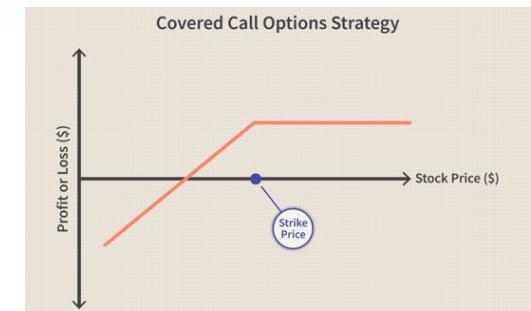
- Mainly used in europe to price options on a stock and takes into consideration all variables identified in here :
-



Option Strategies ~ 1

Covered Call

- This first strategy is widely used and all its doing is, say for example an investor is buying a call on a stock which represents 200 shares per call. For every call, that investor will sell 2 calls against that stock in order to have some form of protection because if the
- Price of the stock increases suddenly then the longer
- Position that it is holding ~200 shares is “covered” by the
- Long call.



Option Strategies ~ 2

Bull Call Spread

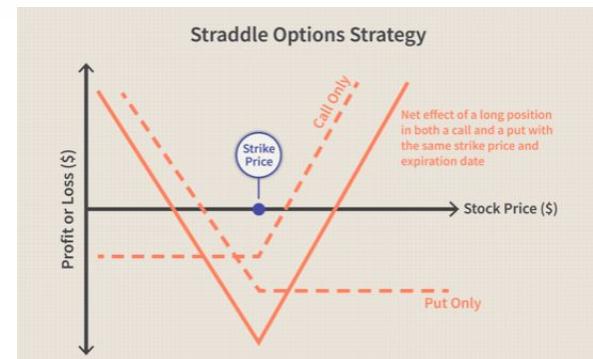
- A bull call spread is just how it sounds - a very bullish move that takes ahold of two sides of the trade, buying at a strike price and selling at a strike price .
- This usually happens when the investor is particularly
- Confident of the upside potential of the stock while
- Still mitigating their risk on the amount of net premiums
- They are about to spend.
- As shown on the graph, the upside potential is limited
- But at the same time the net amount spent on the
- Premium is reduced.



Option Strategies ~ 3

Long Straddle

- This strategy unlike the other strategies because it enables the investor to have unlimited upside potential while having a limited downside. As show on the graph, it is constructed in the form of a net for downside outcomes.
- What is happening is that the investor is buying a call and
- A put for the same asset at the same at a specific strike
- Price but the investor is unsure how much upside
- Potential the stock will have, so it offers them unlimited
- Upside potential.



Partial Differential Equations

- Partial Differential equations is taking several partial derivatives and is trying to draw a relationship based off those partial derivatives.
- So say for example you want the partial derivative of: $f(x,y) = x^2 + y^3$
- To find the partial derivative with respect to x : $f'_x = 2x + 0 = 2x$
- Now when taking the partial derivative of a function, what you are really looking at is how fast the entire function changes when changing a single variable thus holding all else equal.
- When it comes to partial differential equations, it is an equation that is relating these partial derivatives of some unknown function.

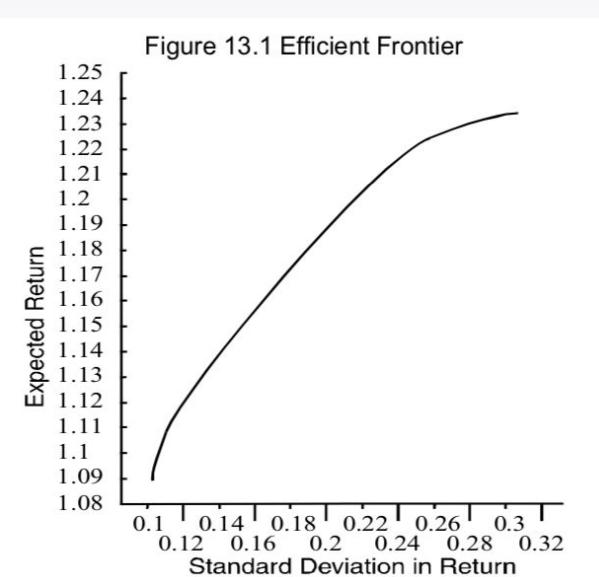
Portfolio Optimization Model for Portfolio Selection

The Markowitz mean/variance portfolio Model

- What an optimized portfolio model is trying to capture is say we have a portfolio with ten investments such that $\{\text{Inv1}, \text{Inv2}, \text{Inv3}, \dots, \text{Inv10}\}$
- And say we introduce another group of ten investments $\{\text{Ninv1}, \text{Ninv2}, \text{Ninv3}, \dots, \text{Ninv10}\}$
- What we are trying to capture with the Markowitz model is, holding all else equal, which set of 10 investments work the best together such that they yield the greatest return over time (T).
- The Markowitz model requires two calculatable sets of information and that is 1) The estimated expected return for each candidate investment and 2) the covariance matrix of the expected returns

Portfolio Optimization Model for Portfolio Selection

- The graph is charting a group of 3 companies in which the investor was unsure what is yielding the most profit .
- After running a markowitz model and plotting the standard deviations, very small discrepancies are noticed.
- One is the knee shape of the graph as its expected returns passes $1.21894 \sim$ that knee shaped jolt.
- That knee obstruction is showing us where a single investment, in this case was ATT has proven to not work so well with this portfolio and will therefore drop ATT and test another company's performance with this portfolio.



Portfolio Management

- When helping a client with a large amount of investments and assets, portfolio management comes in handy in order to make sure the overall portfolio is reaching its long-term objective.
- Usually the person overseeing the portfolio is running constant analyses over a group of investments for a specific client and making sure that it is performing in a healthy manner -- this is called active portfolio management.
- Some clients prefer a passive portfolio manager -- and what that aims to do is to make sure the investments are going to producing healthy returns in the long run rather than the short run.
- The main takeaway from portfolio management is to make sure the clients asset allocation is where they should be and if not, to advise the client on what to do next in order to achieve their desired goal.

Probabilistic method for interest rates

- A probabilistic method for interest rates absorbs a lot of factors into consideration but tries to answer a single question, usually.
- The main question it is trying to answer is how it sets the interest rate for a particular type of borrower or investor.
- The measurement that is taken into consideration the greatest (has the highest weight) is the probability or likelihood that the borrower will default, classified as (PD) ~ probability of default
- The general rule of thumb is that creditors will typically charge a higher interest rate for those borrowers that are more likely to default and a lower interest rate for those who aren't.
- Capturing this “credit risk” mathematically can be previewed

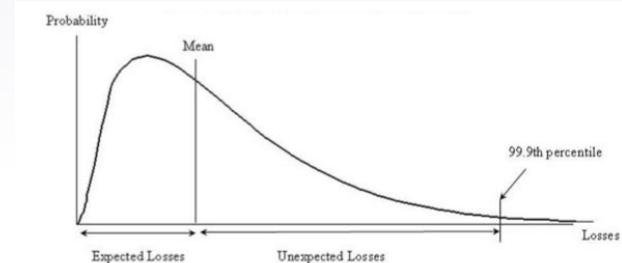


Figure 5.1: Distribution of credit losses.

To sum up, the expected loss is calculated as follows:

$$EL = PD \times LGD \times EAD = PD \times (1 - RR) \times EAD,$$

where :

PD = probability of default

LGD = loss given default

EAD = exposure at default

RR = recovery rate ($RR = 1 - LGD$).

Expected loss is covered by revenues (interest rate, fees) and by loan loss provisions (based on the level of expected impairment).

Put Options

- ▶ A Buy Put signifies the right to sell a Stock at a Specific Price
- ▶ A Sell Put signifies the Obligation to Buy a Stock at a Specific Price

Buying and Selling Options Primer			
ACTION	STATUS	CALL OPTION	PUT OPTION
Buy	Long	Holder has the right but not the obligation to buy 100 shares	Holder has the right but not the obligation to sell 100 shares
Sell	Short	Seller has the obligation to sell 100 shares if calls are exercised	Seller has the obligation to buy 100 shares if puts are exercised

Put Options

What is a Put Option?

- ★ **Buying** a put means you are looking for the **stock to go down (bearish)**
- ★ **Selling** a put means you looking for the **stock to go up (bullish)**

Put Options

- ▶ An option (a contract) in general gives the buyer or seller the right or option to buy an asset and/or security (shares) at a specific price before or on a date.
- ▶ **A Put Option** is a contract bought by the Holder (you) the right to Buy/Sell a security (stock) at a specific **Strike price (also called the Exercise Price)** to a Buyer/Seller.
 - ▶ The strike price is the price at which the Holder of the option can make a profit

Put Options

- ▶ An option (a contract) in general gives the buyer or seller the right or option to buy an asset and/or security (shares) at a specific price before or on a date.
- ▶ A Put Option can be bought and sold
- ▶ A **Buy Put signifies the right to sell a Stock at a Specific Price**
 - ▷ Specific price is also known as a Strike Price and/or Exercise Price
- ▶ A **Sell Put signifies the Obligation to Buy a Stock at a Specific Price**

Quantitative Risk and Return

First, we have to understand that there is no measurement that can completely predict exact amount of losses. The marketplace is a complex environment where various factors like social, economic, political things can happen.

So, predicting quantitative risk is a tough job and an analyst has to be very conscious about the market.

We measure quantitative risk by evaluating Standard deviation, Variance, Regression equation.

As an investor to understand and measure risk and return is one of the key factors of investment process.

Quick Ratio

- # By observing quick ratio, we can get an overview of a company's liquid assets and current liabilities.
- # If a company's quick ratio is more than 1 that means it can pay off its current liabilities instantly.
- # If a company's quick ratio is less than 1 that means it can't pay off fully all its debt depending on the amount of debt it took in the past.

$$\text{Quick Ratio} = \frac{\text{(Cash + Accounts Receivable} \\ \quad \quad \quad + \text{Short-term investments)}}{\text{Current Liabilities}}$$

Random Behavior of Assets

- ▶ "Quantitative analysis is about treating financial quantities such as stock prices or interest rates as random, [and] choosing the best models for that randomness." (Guidolin)
- ▶ The price of a stock differs from its mean by a **random** quantity ϵ .

$$S = \bar{S} + \epsilon$$

- ▶ Thus, we need good models for ϵ since it is crucial to find the pricing of securities.

Ray Dalio

- ▶ Billionaire Hedge Fund Manager and Legendary Investor
- ▶ Reported Net worth around \$18 Billion
- ▶ Founder of Bridgewater Associates (manages over \$140 Billion)
- ▶ Mentor of P Diddy
- ▶ Investing Trading Strategies are heavily focused on Risk Management, Quantitative Finance, and Data Analysis.

Reduced form model -1

- A simplistic definition for this economic model is that it is a mapping model for which the exogenous variable (an independent variable) as well as the unobservable variables are inputs in which yield an output of endogenous variables (variables that rely on the exogenous variable / think “dependent on”; refer to the formula to the right).
$$Y = f(X, Z, U)$$
- The reduced form model was formally obtained by solving for a structural model for each of the endogenous variables such that it is a function of the exogenous variable.

Reduced form model - 2

- An example of how the reduced form model can be applied to a perfectly competitive supply and demand:

$$Q = D(P, X, U_d) \quad (\text{demand})$$

$$P = MC(Q, Z, U_s) \quad (\text{supply})$$

- Reduced form relations:

$$P = p(Z, X, U_s, U_d)$$

$$Q = q(Z, X, U_s, U_d)$$

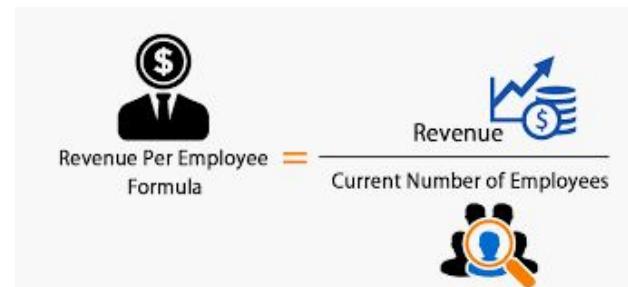
Reduced Form Credit Model

- Similar to the general reduced form model except is applied to credit analysis.
- Taken all endogenous and exogenous variables into consideration, this model tries to model the credit worthiness or in other words, the risk an investor/client will take on given there credit history.
- When it comes to credit models, it is assuming some exogenous or random cause that will yield a risk of default.
- Taking the previous formula into consideration, a general idea of what is being modeling can be captured with this formula:

minimum capital requirement = 8% × \sum risk weighted assets

Revenue per Employee

- Revenue per employee is calculated by obtaining the total revenue the business has made and divide it by the number of employees.
- This metric is important because it calculates how much money each employee is generating for the business or the amount of revenue an employee is responsible for holding all else constant.
- Usually the higher the ratio indicates a higher productivity level per employee .

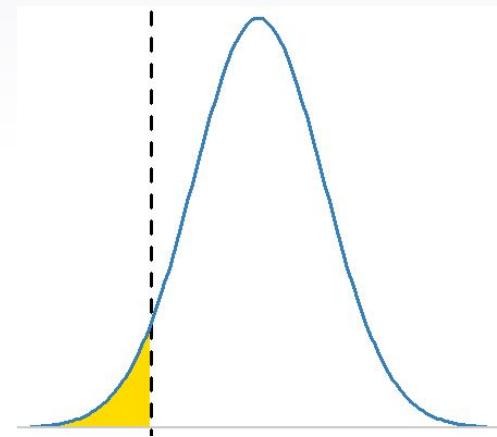


Risk Management

- Alongside with portfolio management is Risk management - and this is where a person is assigned the task of making sure each and every investment the client is about to get into is vetted or measured to an extent where the amount of risk is known and taken into consideration.
- With every investment in this world comes a degree of risk and this is measured as a beta value (the measurement of the volatility of some specific asset).
- When measuring the beta value - what the risk manager is looking for is seeing if the value is greater than or less than 1 (1 being the market in most cases)
- When the beta value is greater than 1, say for example 1.4 - this means that the stock or asset you are looking at is 40% more volatile than the market and this number is very important to the investor, especially if they are not so risk neutral.

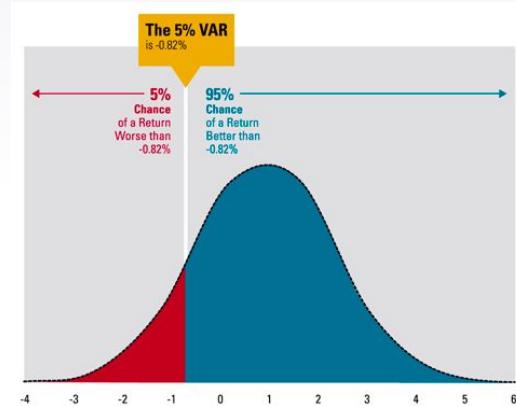
Risk Management Metrics

- Metrics for risk management (as previously discussed about the beta value of a specific asset) come in a handful because there is only so much a person from the outside can know about a stock (or else they would be considered an insider trader).
- Well known metrics such as ETL and VaR are widely used in the finance field and they are quite simple to understand.
- ETL (Estimated tail loss) which aims to capture extreme losses and provide some form of quantification measurement of what the expected losses can be in a tail event.



Risk Management Metric - VaR

- VaR (Value at risk) is a risk management metric that address the potential losses of a portfolio given how the market is moving.
- It aims to capture the maximum expected losses on a portfolio given “assumed” market conditions.
- This “assumed” portion of this metric is a drawback because it is assigning a specific condition of the market based off an assumption and therefore gives it a chance that it will not be a very good predictor of actual market conditions.

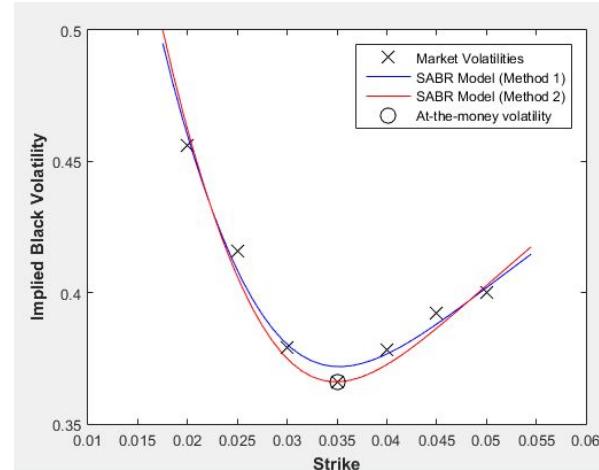


Risk of Default

- The risk of default is the amount of risk a lender takes when lending to a barrow.
- Usually lenders will asses the borrower before lending out money with metrics like FICO score and once they have an idea of the financial health of the borrower, they then can figure out how much money this person can borrow and whether there financials sufficient enough to pay it back.
- Usually the number the borrower is looking for is a non-zero or a non near zero number so the risk they are taking on is low.

SABR (stochastic alpha beta rho) Model

- ▶ Alpha, beta, and rho are the main parameters of the model
- ▶ The SABR model is a model of stochastic volatility developed to model market smiles (right) as the underlying asset's price changes
- ▶ The model was developed due to other local volatility models not accurately capturing dynamics of the market from asset price changes
- ▶ The formulas used in the SABR model yield the market price and market risks such as vanna and volga
 - ▷ Vanna is how much vega changes in response to changes in the spot FX (foreign exchange) rate
 - ▷ Volga is how much vega changes in response to changes in implied volatility



$$\text{Vanna} = \frac{\partial \mathcal{V}}{\partial S}$$

$$\text{Volga} = \frac{\partial \mathcal{V}}{\partial \sigma}$$

SEC

- ▶ Securities and Exchange Commission owned by the Government.
- ▶ The SEC is managed by a 5 Member Commission.
- ▶ The Commissioners and Chairman of the SEC are appointed by the President and Senate.
- ▶ The SEC governs public and private investment activities within the United States.
- ▶ The SEC is the intermediary between Businesses, Funds, Investment Opportunities, Stock Market, Banks, Exchanges, and Investors.

Sharpe Ratio (Market Price of Risk)

- ▶ The Sharpe ratio, also known as the market price of risk, is the risk-adjusted return of a portfolio
- ▶ The higher the Sharpe ratio, the better. A rule of thumb is that a Sharpe ratio above 1 is ideal, but it is more useful for comparing portfolios rather than as a standalone measure, or for deciding on what to change in a portfolio
- ▶ A Sharpe ratio of around 2-3 (or higher) is indicative of a portfolio that is performing quite well, as either the adjusted return is very high or the standard deviation is very low

$$\text{Sharpe Ratio} = \frac{R_p - R_f}{\sigma_p}$$

where:

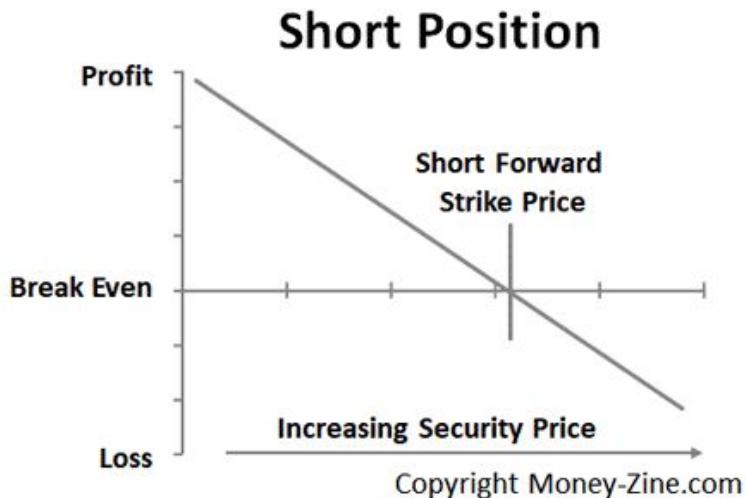
R_p = return of portfolio

R_f = risk-free rate

σ_p = standard deviation of the portfolio's excess return

Short Position

- ▶ A short position is an investment technique used when investors believe a stock's price will drop
- ▶ A set amount of shares are borrowed, usually through an investment firm, at the current price and are actually bought after a period of time
- ▶ The goal is to borrow and sell at the current (higher) price, then actually purchase them once the price drops in the future
- ▶ However, if the price increases, this results in a net loss for the investor



Simple Stochastic Differential Equations

- ▶ Stochastic differential equations are used throughout finance, as they allow analysts to capture and model the inherent randomness of most assets in finance
- ▶ They are particularly useful for modeling stock prices and foreign exchange rates as normal DEs do not take into account that the price of these assets cannot be less than zero
- ▶ Because the market is so complex, these models can only provide a simplified version of how an asset's price behaves

$$dX_t = \mu(X_t) dt + \sigma(X_t) dB_t.$$

Equation for geometric Brownian motion, used to model price change in a stock

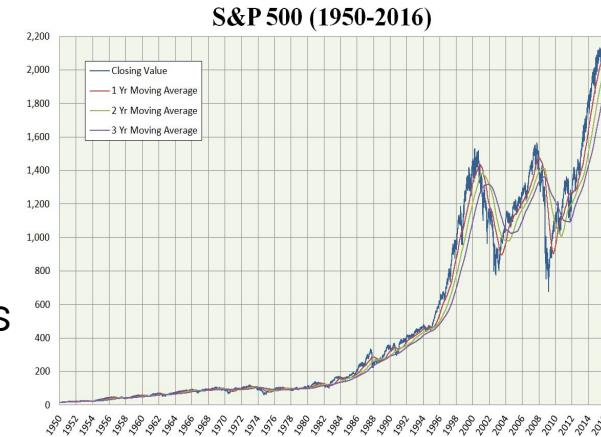
σ is the volatility, μ is the drift (movement from the average), X_t is the stock price, dX_t is the change in price

SRI Investments

- ▶ SRI (socially responsible investing) involves investing money into causes/areas that yield some sort of positive impact on society, such as clean energy, medicine, social justice causes and the like
- ▶ Investors actively avoid other areas that may have more cons than pros for society, such as alcohol/tobacco companies, fossil fuels, and others the investor may deem a moral gray area
- ▶ These areas deemed positive typically shift overtime, following the direction of the political and social climate
- ▶ Investors may also choose to invest in community improvement programs or schools/universities

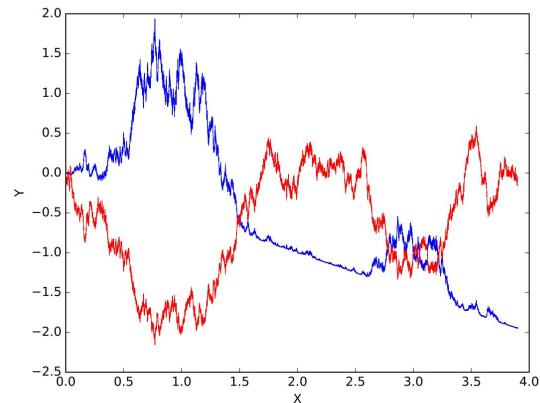
Standard & Poor 500

- ▶ The S&P 500 is a market index of 500 large-cap (for S&P, >\$8.2bn market cap) companies, providing an indicator of the overall “health” of the market
- ▶ The S&P is adjusted to include only shares available to the public, not ones owned by other companies or the government. As such, at least 50% of a company’s shares must be publicly owned to be listed
- ▶ With technology making up over 25% of the index’s weight, fluctuations in tech stock prices often cause significant price swings in the S&P 500 as well



Stochastic Calculus in Finance

- ▶ Stochastic calculus is very useful in mathematical finance, as it allows analysts to model the random movement of asset prices
- ▶ Stochastic differential equations are often used to create these models, as they can capture both the average drift (shift from average price) and volatility of the underlying asset
- ▶ They represent these assets as Brownian motion, which model the asset's underlying features, primarily that the price at one time is dependent on the price at the previous time



Stochastic Interest Rate Models

- ▶ Stochastic interest rate models are used to model fluctuations in interest rates in response to changes in market risk overtime
- ▶ There are two main types of models: single-factor models and multi-factor models
- ▶ Single-factor models typically only consider the short rate for determining/modeling the interest rate
- ▶ Multi-factor models also consider more factors and are often more realistic when it comes to creating interest rate simulations

Stochastic Volatility

- ▶ Models of assets with stochastic volatility have an underlying volatility are those with a variance (volatility) that is randomly distributed
- ▶ That is, the volatility of the asset is random and consistently changes overtime
- ▶ Since most assets do not have a constant volatility, accounting for stochastic volatility allows analysts to model assets, such as derivatives, more accurately
- ▶ Examples include the Heston model, SABR model, and GARCH (generalized autoregressive conditional heteroskedasticity) model

Structural Models of Credit Risk

- ▶ Credit risk modeling is carried out for assessing the risk of companies or people going into debt and their ability to meet financial obligations
- ▶ The Merton model is used to assess a company's structural credit risk by modeling the company's equity as a call option, which can help determine the probability of the company defaulting on any finances it may owe
- ▶ Merton's model laid the foundation for financial modeling formulas, most notably the Black-Scholes model

The Formula for the Merton Model Is

$$E = V_t N(d_1) - K e^{-r\Delta T} N(d_2)$$

where:

$$d_1 = \frac{\ln \frac{V_t}{K} + \left(r + \frac{\sigma_v^2}{2} \right) \Delta T}{\sigma_v \sqrt{\Delta T}}$$

and

$$d_2 = d_1 - \sigma_v \sqrt{\Delta t}$$

E = Theoretical value of a company's equity

V_t = Value of the company's assets in period t

K = Value of the company's debt

t = Current time period

T = Future time period

r = Risk-free interest rate

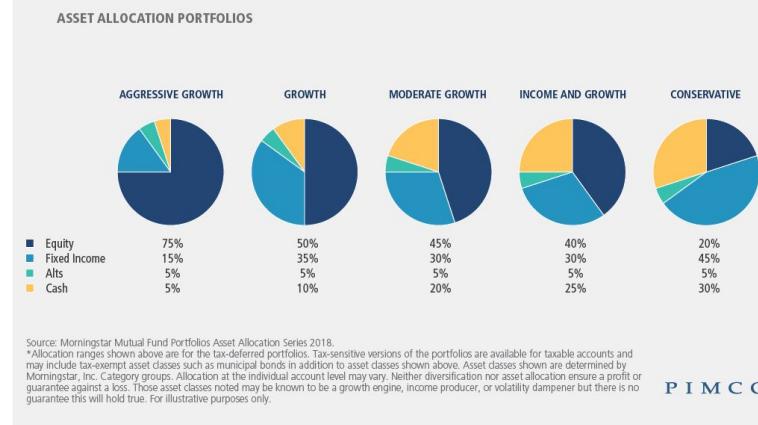
N = Cumulative standard normal distribution

e = Exponential term (*i.e.* 2.7183...)

σ = Standard deviation of stock returns

Tactical Asset Allocation Models

- ▶ The primary goal of tactical asset allocation (TAA) is to maximize profits while minimizing risk by actively adjusting the allocation of a portfolio's funds
- ▶ Investors pick and choose their assets and industries based on their allocation preferences and risk tolerance, then adjust accordingly based on the portfolio's performance



Taylor Series

- ▶ Any asset price movement, such as the movement of a bond, can be approximated by the Taylor series expansion.
- ▶ It is a simple expansion series of any function $f(y)$ around a small increment Δy .
Regarding bond prices, this expansion represents a non-linear relationship between the yield and price of a bond around its initial value:

$$P_1 = P_0 + f'(y_0)\Delta y + \frac{1}{2} f''(y_0)(\Delta y)^2 + \dots$$

- ▶ According to Taylor expansion and with $\Delta y \rightarrow 0$, we'd have
 $dP = (df/dy)dy + 0.5(d^2f/dy^2)dy^2$ as an approximation.

Trade on a Margin

- ▶ Margin trading involves borrowing money from a broker through a margin account to purchase stock or other tradable assets
- ▶ Margin accounts typically require a minimum balance to open and maintain
- ▶ Margin trading can be thought of as a loan, as borrowing this money also comes with interest. The broker does not directly share the profits; rather, you pay them back one way or another
- ▶ Short-term investments are preferred as the longer the money is borrowed, the more is owed back to the broker

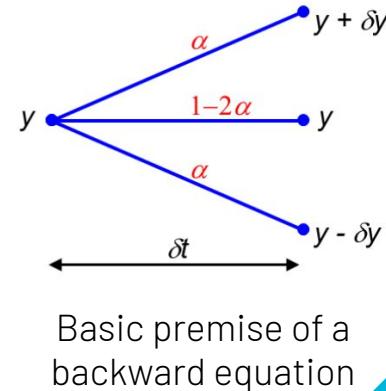
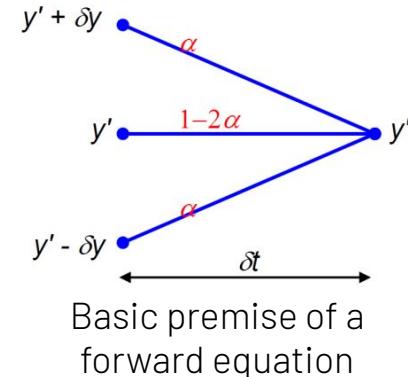
Trading and Pricing of Derivatives

- ▶ Derivatives are financial securities that derive their price from some other asset
- ▶ Common examples include stocks, options, bonds, interest rates, and market indexes, as they are not directly priced. For instance, stocks derive their prices from the overall market, supply/demand of shares, and a company's performance
- ▶ Most of these derivatives can be traded either over-the-counter (unregulated) or on exchanges, such as stocks on the NYSE, but exchange-traded derivatives can **only** be traded on regulated and standardized exchanges



Transition Density Functions

- ▶ Transition density functions provide a way to find the probability of an asset being a certain price after some time, given its current price at the current time
- ▶ Calculations can be done by starting at the present time, t , and present value, y , and finding the probability we end up at time and value t' and y' , (backward) or by starting at t' , y' and finding the probability we started at t , y (forward)
- ▶ They are often written as partial differential equations to help us focus on these two steps; any steps between y and y' are typically not important



Treasury Bills

- ▶ T-Bills are considered Short Term Investments

How T-Bills Work

Treasury bills are short-term securities, which means they come with shorter maturity dates than bonds and notes. Certain types of T-bills have a maturity period of just a few days, but they're typically issued in terms of four, 13, 26 or 52 weeks.

T-bills are assigned a specific face value, such as \$1,000, \$5,000 or \$10,000, but you can usually purchase them for less than that. The amount you pay is called the [discount rate](#). Once the securities mature, the government hands over the full amount of the bill.

Here's an example of how the process works. Let's say you purchase a \$10,000 T-bill with a discount rate of 3% that matures after 52 weeks. That means you pay \$9,700 for the T-bill up front. Once the year is up, you get back your initial investment plus another \$300.

Treasury Bills

- ▶ The Minimum Purchase is \$100
- ▶ The process is buy a T-Bill at a price and you will be paid the amount designated by Government at a specific payment date
- ▶ Direct website to purchase Treasury Bills

https://www.treasurydirect.gov/indiv/products/prod_tbills_glance.htm

T-**bills** are issued by the U.S. government and are considered among the safest **investments** in the world, so risk should never be a significant deterrent. However, the return on T-**bills** is typically quite low when compared to other types of **securities**, such as stocks, **bonds**, and mutual funds.

Treasury Bills

- ▶ The Minimum Purchase is \$100
- ▶ The process is buy a T-Bill at a price and you will be paid the amount designated by Government at a specific payment date broken down by:
 - ▷ 4 Weeks
 - ▷ 8 Weeks
 - ▷ 13 Weeks
 - ▷ 26 Weeks
 - ▷ 52 Weeks

Treasury Bills

- ▶ The Payments given by Government are determined by a Bid Process
 - ▷ Competitive Bidding vs NonCompetitive Bidding

The Auction Process for T-bills

- Individual competitive bidders
 - limited to 35% total issue size,
 - can submit more than one bid,
 - allocations made beginning with highest bidder
- Noncompetitive bidders
 - indicate quantity desired and agree to pay a weighted-average of the rate on winning competitive bids;
 - get preferential allocation

Treasury Bills

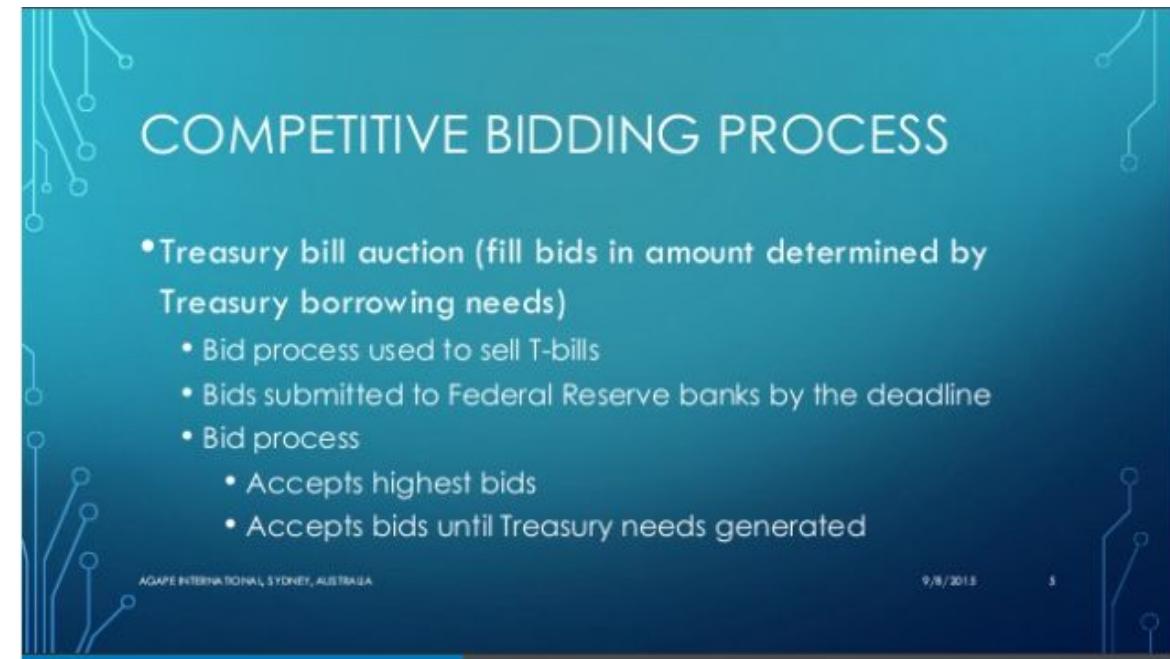
► Competitive Bidding vs NonCompetitive Bidding

NON-COMPETITIVE BIDDING

- Treasury bill auction—noncompetitive bids
(\$1 million limit)
 - May be used to make sure bid is accepted
 - Price is the weighted average of the accepted competitive bids
 - Investors do not know the price in advance so they submit cheque for full par value
 - After the auction, investor receives cheque from the Treasury covering the difference between par and the actual price

Treasury Bills

- ▶ Competitive Bidding vs **NonCompetitive Bidding**



COMPETITIVE BIDDING PROCESS

- Treasury bill auction (fill bids in amount determined by Treasury borrowing needs)
 - Bid process used to sell T-bills
 - Bids submitted to Federal Reserve banks by the deadline
 - Bid process
 - Accepts highest bids
 - Accepts bids until Treasury needs generated

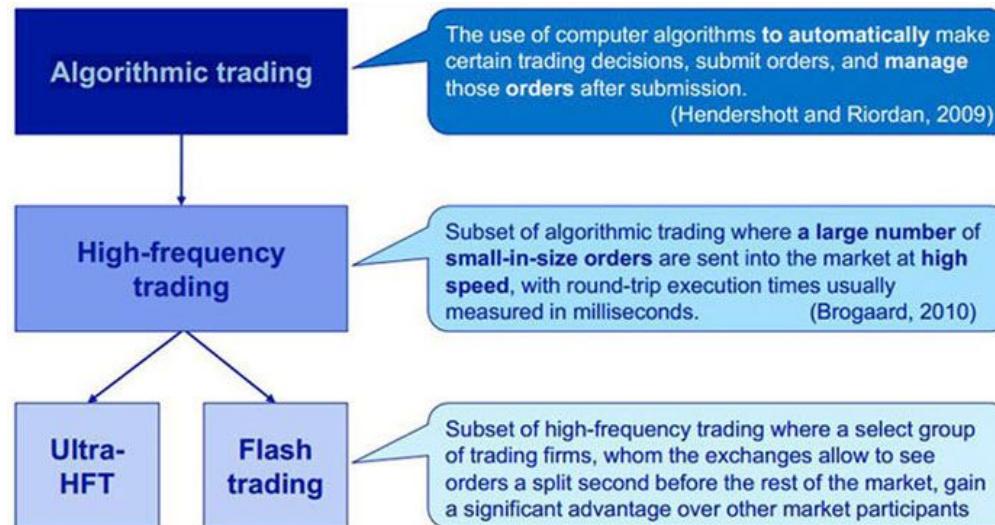
AGAPE INTERNATIONAL, SYDNEY, AUSTRALIA

9/8/2013

189

Ultra High Frequency Trading

- ▶ Strategies that hold assets in seconds and milliseconds



Ultra High Frequency Trading

- ▶ Strategies that hold assets in seconds and milliseconds

Pros and Cons of High Frequency Trading

Pros

Huge volume increases liquidity

Increases market efficiency

Reduces costs of trades

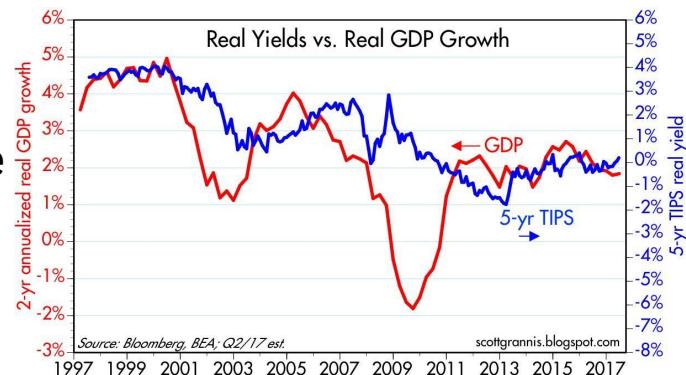
Cons

- Only a small circle of “traders” truly benefit
- Difficult to regulate
- Can lead to market manipulation (fraud)



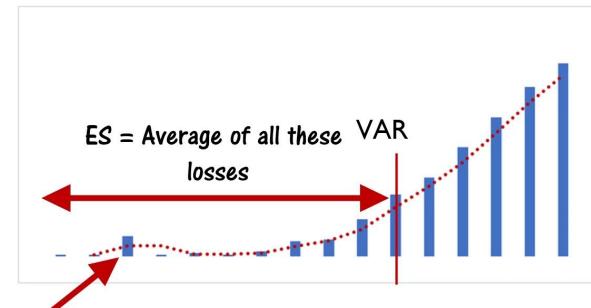
U.S. Treasury Inflation Protected Bonds

- ▶ A type of security, "TIPS", that adjusts its principal based on current inflation/deflation rates
- ▶ Interest is paid on the bond twice a year, with the amount also adjusting with the inflation/deflation rate
- ▶ These bonds have maturity dates of 5, 10, or 30 years and are backed by the government, so they are a very low risk investment
- ▶ Even with deflation, bondholders never get less than their initial principal back at bond maturity



Value at Risk and Expected Shortfall

- ▶ Value at risk (VaR) measures the level of risk on a portfolio or position over a specified period of time to determine possible losses
- ▶ For example, if a stock is found to have a 5% VaR of 10%, this means it has a 5% chance to decrease by 10% during the specified time frame
- ▶ Confidence intervals are typically used to quantify how confident we are in this risk calculation
- ▶ The larger the confidence interval, the more tolerant we are to extreme values (i.e. more risk tolerant)



Value at Risk and Expected Shortfall cont.

- ▶ Expected shortfall considers this confidence interval and looks at the worst values - that is, the ones outside of our confidence interval - and finds the averages of these losses
- ▶ For instance, after calculating VaR with a 95% confidence interval, we look at the 5% of values outside this confidence interval and calculate the average of these values to determine the expected shortfall

Volatility Arbitrage Strategies

- ▶ Volatility arbitrage strategies take advantage of the arbitrage, or difference, between the implied (historical) volatility and forecasted volatility of an asset's options to make a profit
- ▶ A common approach is using delta-neutral portfolios, which aim to offset the positive delta of calls with the negative delta of puts
- ▶ Suppose an investor buys a few shares and a put option. The goal is to offset any losses from whichever asset loses value
- ▶ The investor must be well-verses on the asset's volatility, when to hold their position, and be aware of possible "black swans" (sudden, unexpected events) to profit off of this strategy

Volatility Filtering (GARCH Family)

- ▶ The generalized autoregressive conditional heteroskedasticity (GARCH) process is an econometric term developed in 1982 by Robert F. Engle.
- ▶ There are several GARCH models (thus, the name GARCH Family.)
- ▶ Financial institutions use the model to **estimate the return volatility** of stocks, bonds, and other investment vehicles.
- ▶ The GARCH process provides a more real-world context than other models when predicting the prices and rates of financial instruments.

Volatility Filtering (GARCH Family)

Why is GARCH Family useful?

On a plot of returns, for example, stock returns may look relatively uniform for the years leading up to a financial crisis such as that of 2007.

In the period following the onset of a crisis, however, returns may swing wildly from negative to positive territory. Moreover, the increased volatility may be predictive of volatility going forward. A simple regression model does not account for this variation in volatility exhibited in financial markets. GARCH models help us take changing volatility into account.

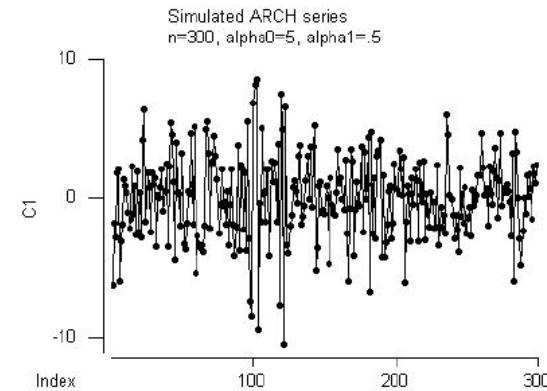
Volatility Models: The ARCH Framework

- ▶ ARCH (autoregressive conditional heteroscedasticity) models how the volatility of an asset changes over time
- ▶ The ARCH model is particularly useful for using the historical volatility to create forecasts for the future volatility
- ▶ The model assumes that the time series has a constant mean, usually zero, which can be attained by taking the first difference - subtracting today's price from yesterday's, yesterday's price from the day before, and so on
- ▶ The main goals are to model historic volatility, calculate the current volatility using the volatility at the previous time point, and extend this into forecasting future volatility using the current point

Volatility Models: The ARCH Framework: Example

- There are two main parameters in the model - α_0 and α_1
 - ▷ α_0 and α_1 both control how the model's volatility changes over time
 - ▷ Additionally, y_t represents the asset price at the current time and y_{t-1} the asset price at the previous time. Var is the variance (volatility)
- In the simulated series shown, $\alpha_0=5$ and $\alpha_1=0.5$
- With α_1 set to only 0.5, we can see the variance does not leave the range -10 to 10
- Additionally, most of the points are quite close to 0
- This is identical to modeling an asset's volatility, but we use the data to find α_0 and α_1

$$\text{Var}(y_t | y_{t-1}) = \sigma_t^2 = \alpha_0 + \alpha_1 y_{t-1}^2$$



Win Rate

- ▶ The win rate is a relatively simple metric that is calculated by dividing the number of winning trades (money made) by the total number of trades
- ▶ This provides a quick way to get an idea of a portfolio's performance to determine if current strategies are effective. Typically, a win rate of at least 50% is desirable
- ▶ However, it should not be the only metric used - if wins average \$10 and losses \$50, a 50% win rate means that we lose, on average, \$40 per trade
- ▶ In a pinch, it can still be useful when determining which trading strategies may be more effective

X-Valuation Adjustment (XVA)

- ▶ Umbrella term for adjustments made to derivative contracts
- ▶ XVA, unlike the Black-Scholes model, accounts for the risk rate
- ▶ Credit valuation adjustment
 - ▷ Adjustment made based on how likely it is for the other party in a transaction to default
- ▶ Funding valuation adjustment
 - ▷ Funding benefit adjustment
 - ▷ Funding cost adjustment
- ▶ Capital valuation adjustment

X-Valuation Adjustment (XVA)

- ▶ Credit valuation adjustment (CVA) is calculated with the following formula: $CVA = E^Q[L^* | t = \tau]$
 - ▷ L^* is the true amount of loss that can occur
 - ▷ Q is the risk-free probability of the other defaulting
 - ▷ t is the time when default may occur
- ▶ CVA increases the market value of the derivative by eliminating some of the costs associated with the other party's credit risk
- ▶ This can be done by using the other party's credit spread, a more advanced method using market data to estimate the replacement cost of the asset, or through simulations



X-Valuation Adjustment (XVA)

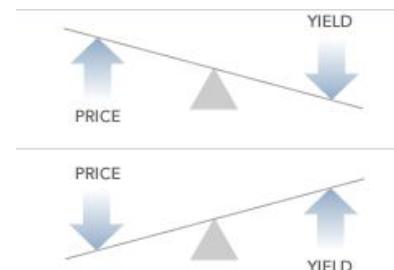
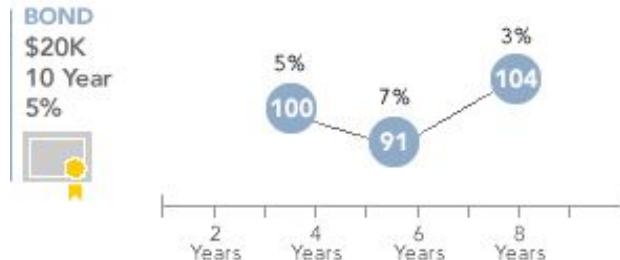
- ▶ Funding valuation adjustment (FVA) adjusts costs based on an uncollateralized derivative that is priced above the risk-free rate
- ▶ There are two main components to FVA
 - ▷ Funding benefit adjustment - an entity such as a bank buys/trades for a derivative that has a negative market value. The bank also accepts cash due to the negative value, which can be invested to raise funds
 - ▷ Funding cost adjustment - the derivative has a positive market value, so the bank has to pay cash for the derivative. The positive value the derivative holds makes up for the inability to use cash to fundraise/invest

X-Valuation Adjustment (XVA)

- ▶ Banks are required to always have some amount of cash on hand, usually 10% of the amount of deposits it has. The Federal Reserve controls this ratio
- ▶ Having a capital reserve is required in the event of a financial crisis or other unexpected expenses
- ▶ Capital Valuation Adjustment (KVA) increases this ratio for banks, or other financial institutions, that hold derivative contracts
 - ▷ This is likely due to the risk of the derivative losing money over time

Yield, Duration, and Convexity

- ▶ Yield is the return, usually annual, of a bond
- ▶ The yield depends on the bond's current selling price and coupon rate
 - ▷ Ex.: A \$5000 bond with a 5% coupon rate selling for \$4700 would have a yield of $\$250/\$4900=0.053=5.3\%$
 - ▷ Changes in the prevailing interest rate also cause the yield to change - they have an inverse relationship. Investors are willing to pay more for a high coupon rate when the interest rate drops

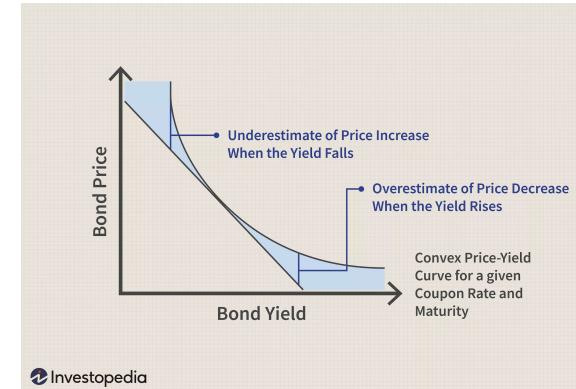


Yield, Duration, and Convexity

- ▶ Economist Frederick Macaulay proposed the formula for calculating duration in 1938
- ▶ Duration is used to describe how sensitive a bond's price is to interest rate changes, and measures how long it takes for an investor to get paid back on their bond
- ▶ The time to maturity and coupon rate both affect a bond's duration
 - ▷ Longer maturity → higher duration and interest rate risk
 - ▷ Higher coupon rate → lower duration and interest rate risk
- ▶ A similar measure, modified duration, provides the expected change in a bond's price per 1% change in the interest rate instead of a time

Yield, Duration, and Convexity

- Duration is useful, but it only provides an estimated linear relationship between price and yield. Convexity helps us model the true non-linear relationship for more extreme yield values
 - ▷ As yield increases, the bond price decrease is overestimated
 - ▷ As yield decreases, the bond price increase is underestimated
- The coupon rate and convexity have an inverse relationship, as lower coupon rates are more sensitive to interest rates
- That is, the convex curve would be closer to the linear duration line for bonds with higher coupon rates



Investopedia

$$C = \frac{d^2 (B (r))}{B * d * r^2}$$

where:

C = convexity

B = the bond price

r = the interest rate

d = duration

References

1. [wikipedia](#)
2. [Springer](#)
3. [Investopedia](#)
4. [Medium](#)
- 5.