

## PYTHON NOTES

### READING AND PLOTING DATA

```
import pandas as pd
import matplotlib.pyplot

df = pd.read_csv("data/IBM.csv",index_col = 'Date',parse_dates = "True",na_values = ['nan'])
##Parse_dates parameter converts date and time into objects
#na_values = ['nan'] helps noting that invalid values are given by 'nan'

df = df.dropna()#Removes all 'nan' values
plt.plot(df['High'])
# or df['High'].plot

plt.show() # must be called to show plots
```

For ploting multiple columns in one plot use df[['col1','col2']].plot

Joining two dataframes -> df1.

For eg, a = a.join(b,how = 'inner') where a,b are dataframes and b is joined to a. All rows of 'a' are maintained and only those rows from 'b' whose indices are present in 'a'.

'how' parameter chooses rows with indices common to both dataframes and removes 'nan' values

pd.DataFrame(parameters) -> To create a dataframe

### Row slicing

```
df.ix[start index :end index]
##When using date as index use YY-MM-DD
```

### Column slicing

```
df[['GOOG','IBM']]
#To print columns
```

### Both

##Use the name of the column for printing a particular coumn within a particular date range or particular index range

```
df.ix[row range , column range]
df.ix[start index :end index , ['GOOG','IBM']]
```

## Data plotting

```
def plot_data(df, title="stock prices"):  
    """Plot stock prices with a custom title and meaningful axis  
    labels."""  
    ax = df.plot(title=title, fontsize=12)  
    ax.set_xlabel("Date")  
    ax.set_ylabel("Price")  
    plt.show()
```

## Normalizing

```
return df / df.ix[0:]
```

Let `nd1 = df.values` which gives values of dataframe except indices and labels.  
Elements in an N-D array of a dataframe can be accessed using `nd1[row,col]`

## Array creation in numpy

```
np.array([(1,2,3),(2,3,4)])
```

Here each tuple is a row

## Empty array creation

```
np.empty((5,4)) #Has 5 rows and 4 cols
```

## Array of ones

```
np.ones((5,4), dtype=np.int)
```

Use `np.zeros` to generate zero array

## Generate array of random values

```
numpy.random.random((5,4))
```

or

```
numpy.random.rand(5,4)
```

It generates an array of random values of 5 rows and 4 cols

**numpy.random.normal**: Normal or Gaussian distribution

**numpy.random.randint**: Integers from Uniform distribution

array.shape -> This return the dimensions of the array as a tuple

array.size -> No of elements present in the array

array.type -> Returns type of array

## Operations on N-D arrays

array.sum()

array.sum(axis=0)

# axis=0 , Returns sum of each column in an array

array.sum(axis=1)

# axis=1, Returns sum of each row in an array

array.min(axis =0)

#Returns min in each column

array.max(), array.mean()

## Masking in numpy

array[array < mean] = mean

#This replaces all elements of array < mean with mean value

### Arithmetic operations using

array

a+b , a-b is normal

a\*b returns element wise result

Similarly for division

Original array a:

```
[[ 1  2  3  4  5]
 [10 20 30 40 50]]
```

Original array b:

```
[[100 200 300 400 500]
 [ 1  2  3  4  5]]
```

Multiply a and b:

```
[[ 100  400  900 1600 2500]
 [ 10   40   90  160  250]]
```

## Statistical Analysis

### Global statistics

mean  
median  
std  
sum  
prod  
mode

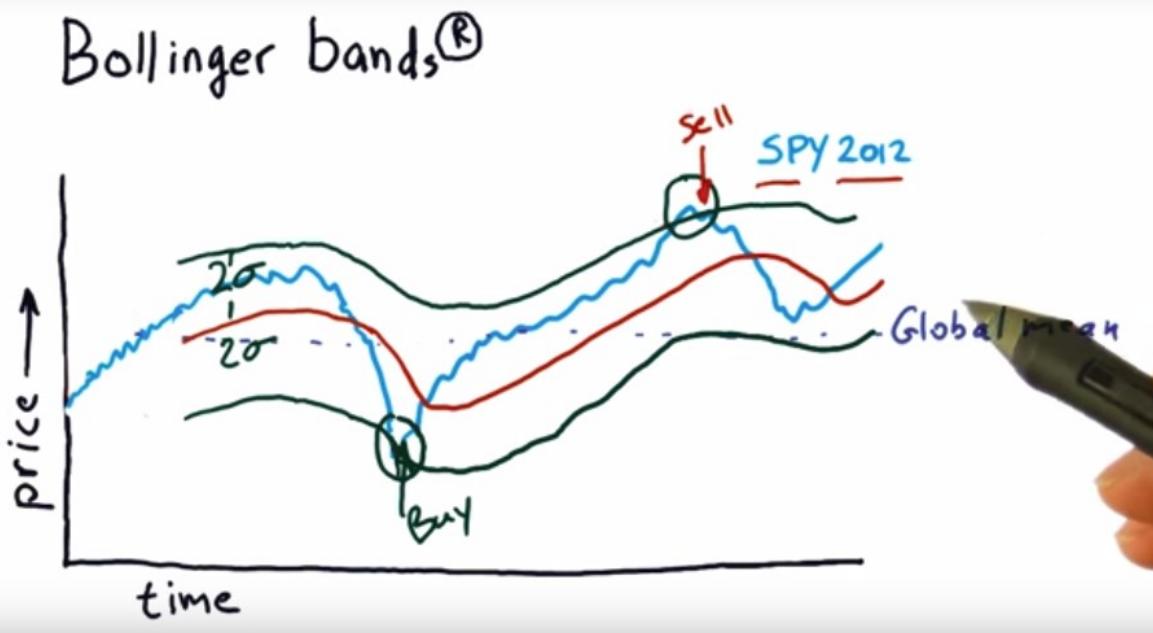
stat = df1.mean()

df1

33



Bollinger bands(Buy/Sell determining)



Code for Bollinger bands

```
def get_bollinger_bands(rm, rstd):  
    """Return upper and lower Bollinger Bands."""  
    # TODO: Compute upper_band and lower_band  
    upper_band = rm + rstd * 2  
    lower_band = rm - rstd * 2  
    return upper_band, lower_band
```

## Daily return



$$\text{daily\_ret}[t] = (\text{price}[t]/\text{price}[t-1]) - 1$$
$$(110/100) - 1$$
$$1.1 - 1 = .1 = 10\%$$

## Cumulative returns (For eg , Increase over a year)



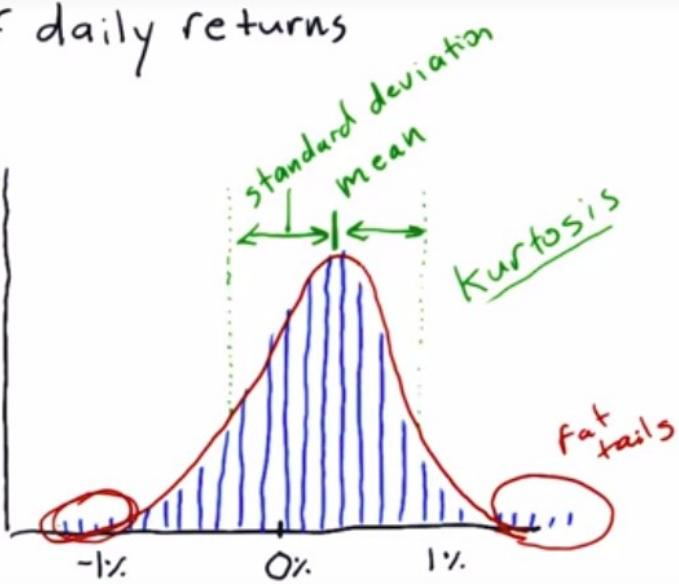
$$\text{cumret}[t] = (\text{price}[t]/\text{price}[0]) - 1$$
$$(142/125) - 1$$
$$1.136 - 1 = .136$$
$$= 13.6\%$$

So our cumulative return for

## Histogram

### Histogram of daily returns

- Standard deviation
- mean
- kurtosis
  - + fat tails
  - skinny tails



Mute

## Important terms

### Computing Sharpe ratio

what is the risk free rate?  $S = \frac{E[R_p - R_f]}{\text{std}[R_p - R_f]}$

- LIBOR
- 3mo T-bill
- 0%

*ex ante*

$$S = \frac{\text{mean}(\text{daily-rets} - \text{daily-}rf)}{\text{std}(\text{daily-rets} - \text{daily-}rf)}$$

traditional shortcut

$$\text{daily-}rf = \sqrt[252]{1.0 + 0.1} - 1$$

$$S = \frac{\text{mean}(\text{daily-rets} - \text{daily-}rf)}{\text{std}(\text{daily-rets})}$$

### Sharpe ratio

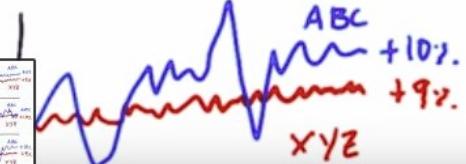
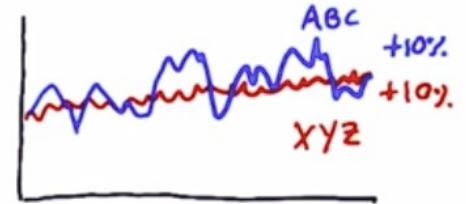
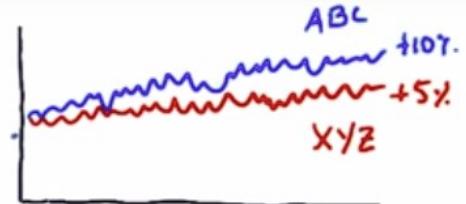
risk adjusted return

all else being equal

- lower risk is better
- higher return is better

SR also considers  
risk free rate of return

**0%**



Portfolio : Allocation of funds to a set of stocks

## But wait, there's more!

- SR can vary widely depending on how frequently you sample
- SR is an annual measure
- $SR_{annualized} = K * SR$
- $K = \sqrt{\# \text{samples per year}}$

$$\text{daily } K = \sqrt{252}$$

$$\text{weekly } K = \sqrt{52}$$

$$\text{monthly } K = \sqrt{12}$$

$$SR = \sqrt{252} * \frac{\text{mean(daily-rets - daily-rf)}}{\text{std(daily-rets)}}$$

How to use optimizer

## How to use an optimizer

1) Provide a function to minimize

$$f(x) = x^2 + 5$$

2) Provide an initial guess

3) Call the optimizer



## python minimizer/optimizer code

```
10     Y = (X - 1.5)**2 + 0.5
11     print "X = {}, Y = {}".format(X, Y) # for tracing
12     return Y
13
14 def test_run():
15     Xguess = 2.0
16     min_result = spo.minimize(f, Xguess, method='SLSQP', options={'disp': True})
17     print "Minima found at:"
18     print "X = {}, Y = {}".format(min_result.x, min_result.fun)
19
20     # Plot function values, mark minima
21     Xplot = np.linspace(0.5, 2.5, 21)
22     Yplot = f(Xplot)
23     plt.plot(Xplot, Yplot)
24     plt.plot(min_result.x, min_result.fun, 'ro')
25     plt.title("Minima of an objective function")
26     plt.show()
27
28 if __name__ == "__main__":
29     test_run()
```

## Important terms

Market capitalization = No of outstanding shares of the company \* price of the stock

Liquidity : Ease with which stock can be bought/sold.

**Outstanding shares** : This refers to a company's stock currently held by all its shareholders

## Types of funds

ETF

Mutual Fund

Hedge Fund

- Buy/Sell like stocks
  - Baskets of stocks
  - Transparent
- Buy/Sell at end of day
  - Quarterly disclosure
  - Less transparent
- Buy/sell by agreement
  - No disclosure
  - Not transparent

Liquid

Large Cap

How fund managers are compensated ?

## Incentives: How are they compensated?

- ETFs              Expense Ratio 0.01% - 1.00%
- Mutual Funds      Expense Ratio 0.5% - 3.00%
- Hedge Funds        "Two and Twenty"

For hedge funds two percent of AUM(assets under management) and 20 percent of profit for fund managers.

# Hedge fund goals and metrics

## Goals

- Beat a benchmark SP500
- Absolute return Long / short

## Metrics

- Cumulative return  $= (\text{Val}[-1]/\text{Val}[0]) - 1 = 0.2$
- Volatility  $= \text{daily-rets}.std()$
- Risk/Reward S.R.  $= \sqrt{252} \cdot \frac{\text{mean}(\text{daily-rets} - \text{RF})}{\text{daily-rets}.std}$

## Selling short

Taking negative position on a stock ie we sell a stock short if we believe that its price will go down. Note that here we are selling stocks that we do not own.

### Short selling : Entry

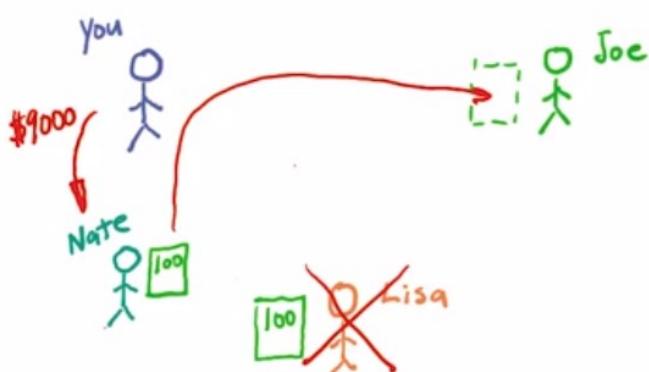
## Mechanics of short selling: Entry



IBM selling at \$100  
\$10,000 in account  
Owe Joe 100 shares

Short selling : Exit

## Mechanics of short selling: Exit



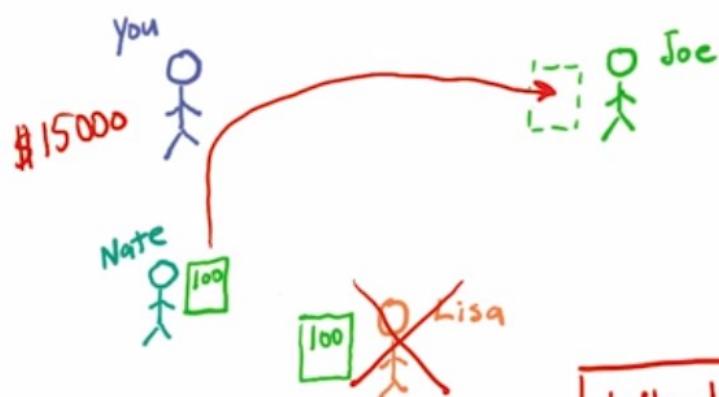
IBM selling at \$100  
\$10,000 in account  
Owe Joe 100 shares  
IBM selling at \$90  
\$1000 in account

## Q: What if you shorted IBM?



Problem of short selling

## Mechanics of shortselling: Exit



IBM selling at \$100  
\$10,000 in account  
owe Joe 100 shares  
IBM selling at \$150  
-\$5000

What can go wrong?

## Company value

Intrinsic value : Value of company estimated by future dividends(Amount companies pay to their investors every year based on the number of shares they hold).

Book value : Based on the assets that the company owns ie *Total assets minus intangible assets and liabilities.*(intangible assets are value of patent , brand... and total assets = value of properties + patents+brand value)

Market cap : Based on value of stock on the market and how many shares are outstanding. (

### The value of a future dollar

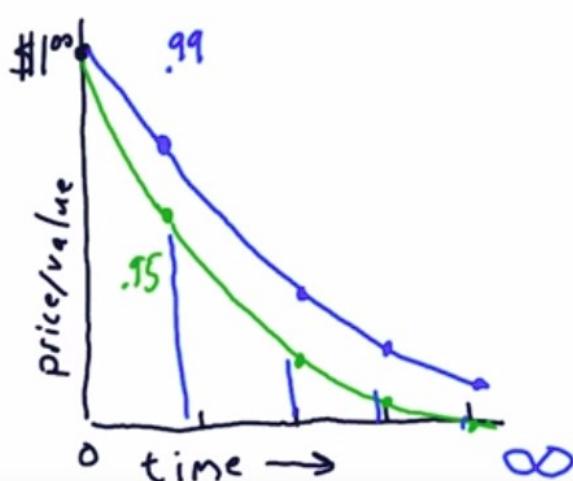
$$\underline{P.V} = F.V / (1 + I.R)^i$$

Where P.V is present value, F.V is future value(or dividend rate), IR is interest rate and i is no of years into the future.

$(1 + I.R)^i \rightarrow$  Discount rate

Discount rate should be higher for riskier companies

### The value of a future dollar



$$P.V = F.V / (1 + I.R)^i$$

Discount Rate =  $\frac{5\%}{DR}$

$$\sum_{i=1}^{\infty} \frac{F.V}{n^i} = \frac{F.V}{(n-1)} = \frac{F.V}{DR}$$
$$= \$1/.05 = \$20$$

**Intrinsic Value**

//Here \$20 means \$20 million

Book value : Total assets minus intangible assets and liabilities.(intangible assets are value of patent , brand... and total assets = value of properties + patents , )

## Book Value

"Total assets minus intangible assets and liabilities"

Factories					\$40M
patents				<del>\$15M</del>	Intangible
Liabilities				<u>\$ 10M</u>	<u>10aA</u>

Subtitles/closed captions

Here book value = total assets - (intangible assets + liabilities)

$$=(40 + 15) - (15 + 10) = 30$$

Market cap :

Market capitalization = No of outstanding shares of the company \* price of the stock

When intrinsic value is low and market cap is high --> short the stock

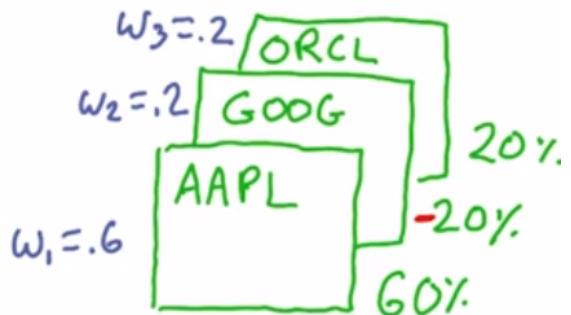
High intrinsic value and market cap is low --> Buy the stock

# CAP model

Portfolio :

## Definition of a portfolio

- $w_i$ : portion of funds in asset  $i$
- $\sum_i w_i = 1.0$
- $r_p(t) = \sum_i w_i r_i(t)$



where  $r_i$  is the return of that stock and  $r_p(t)$  is the total return of that day.

Market portfolio :

Here weight of stocks( $w_1, w_2, \dots$ ) are set according to market cap of that stock. To calculate weight of any particular stock

$w_i = \text{Market cap of that stock} / \text{sum of market caps of all stocks}$  where  
market cap = no of shares \* price of stock

Note : The term market just means an index that represents large number of stocks  
(US : S&P500, UK : FTA ...)

CAPM equation

## The CAPM equation

$$r_i(t) = \underbrace{\beta_i r_m(t)}_{\text{Market}} + \underbrace{\alpha_i(t)}_{\text{residual}} \xrightarrow{\text{CAPM says}} E = 0$$

Return on a particular stock on a particular day ' t '  $\rightarrow r_i$

Return on the market on day ' t '  $\rightarrow r_m$

Beta value is determined when market value goes up or down. Beta(i) represents the relation of a particular stock with market.

Alpha value expected is mostly 0.

Alpha and beta values are decided based on daily returns (It is decided based on how daily returns relate to daily returns of market)

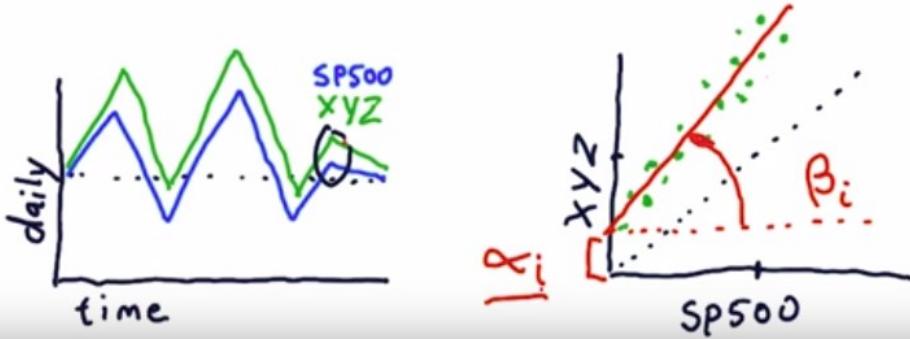
Beta is the slope and alpha is y-intercept

## The CAPM equation

$$r_i(t) = \underline{\beta_i} r_m(t) + \underline{\alpha_i(t)}$$

market                            residual

CAPM says  $E(\alpha) = 0$



Active Vs Passive investing

## CAPM vs Active Management

- passive : buy index and hold
- active : pick stocks overweight  
underweight

$$r_i(t) = \underline{\beta_i} r_m(t) + \underline{\alpha_i(t)}$$

[CAPM says random and  $E(\alpha) = 0$ ]

[Active managers believe they can predict  $\alpha$ ]

CAPM for all portfolios in a particular day

### CAPM for portfolios

$$r_p(t) = \sum_i w_i (\beta_i r_m(t) + \alpha_i(t))$$

$$\beta_p = \sum_i w_i \beta_i$$

$$r_p(t) = \underline{\beta_p r_m(t)} + \underline{\alpha_p(t)}$$

$$= \beta_p r_m(t) + \sum_i w_i \alpha_i(t)$$

CAPM

Active

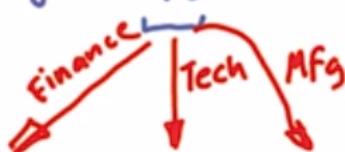
Arbitrage Pricing Theory

### Arbitrage Pricing Theory (APT)

• Stephen Ross 1976

$$r_i = \beta_i r_m + \alpha_i$$

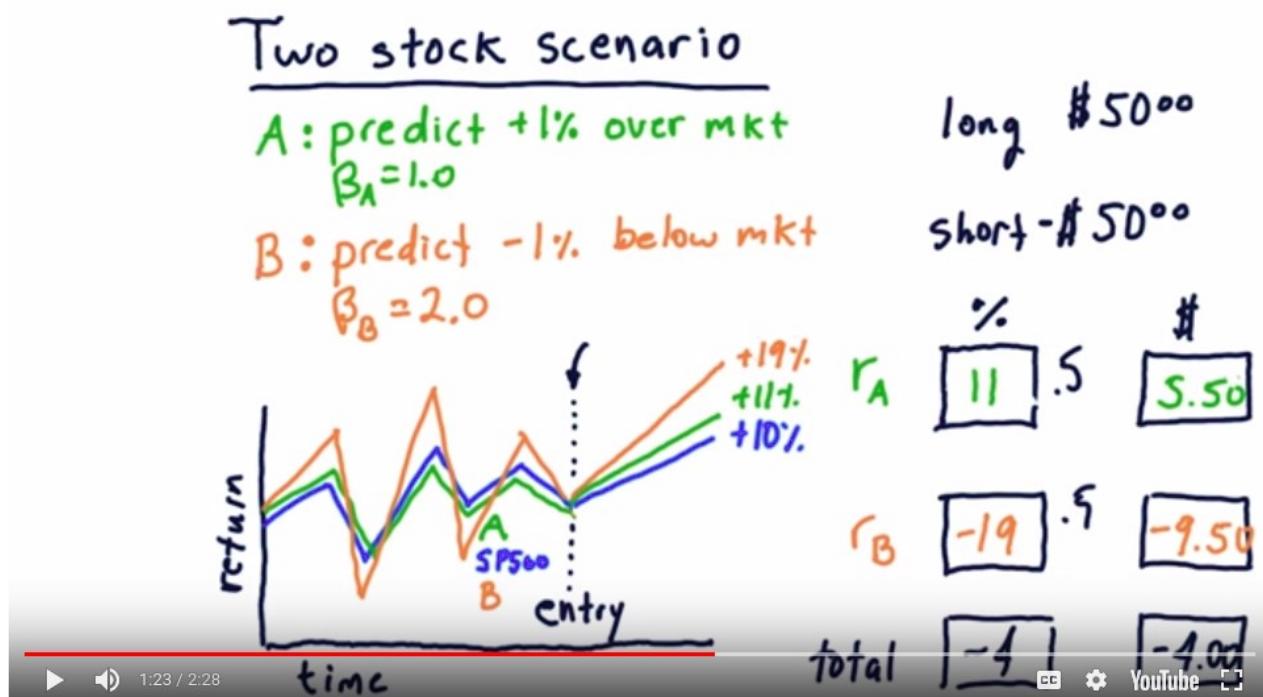
CAPM = Ocean



$$r_i = \beta_{iF} r_F + \beta_{iT} r_T + \beta_{im} r_m + \dots + \alpha_i$$

Here Beta(i) is the sum of betas of different sectors (ie sum of islands in the CAPM ocean).

Example on short and long on two stocks



Example on short and long of two stocks using capm method

### Two stock CAPM math

$$r_p = \sum_i w_i (\beta_i r_m + \alpha_i)$$

$$= (w_A \beta_A + w_B \beta_B) r_m + w_A \alpha_A + w_B \alpha_B$$

$$\begin{cases} w_A = .5 & \alpha_A = 1\% \\ w_B = -.5 & \alpha_B = -1\% \\ \beta_A = 1.0 \\ \beta_B = 2.0 \end{cases}$$

$$= (.5 \cdot 1 - .5 \cdot 2) r_m + 1\% + (-1\%)$$

$= \boxed{-0.5} \boxed{r_m} + \boxed{1\%} = 0 ?$

$$r_p = 0? = w_1 \beta_A + w_2 \beta_B = \boxed{0}$$

(same example )Removing market risk

Q: How to allocate to A and B?

- $\beta_A = 1.0 \quad \alpha_A = +1\%$
- $\beta_B = 2.0 \quad \alpha_B = -1\%$

→ Find  $w_A$  and  $w_B$  so that  
Market risk is minimized

$$\beta_p = w_A \cdot 1 + w_B \cdot 2 = 0$$
$$w_A = -2w_B$$
$$|w_A| + |w_B| = 1$$
$$|-2w_B| + |w_B| = 1$$
$$3|w_B| = 1$$
$$|w_B| = 1/3$$
$$w_B = -1/3$$
$$w_A = 2/3$$

$w_A = .66$      $w_B = -.33$

Fundamental Analysis Vs technical analysis

Fundamental Analysis : Here we consider aspects which determine value of company

Technical analysis : Here we consider trends or patterns in price of stock.

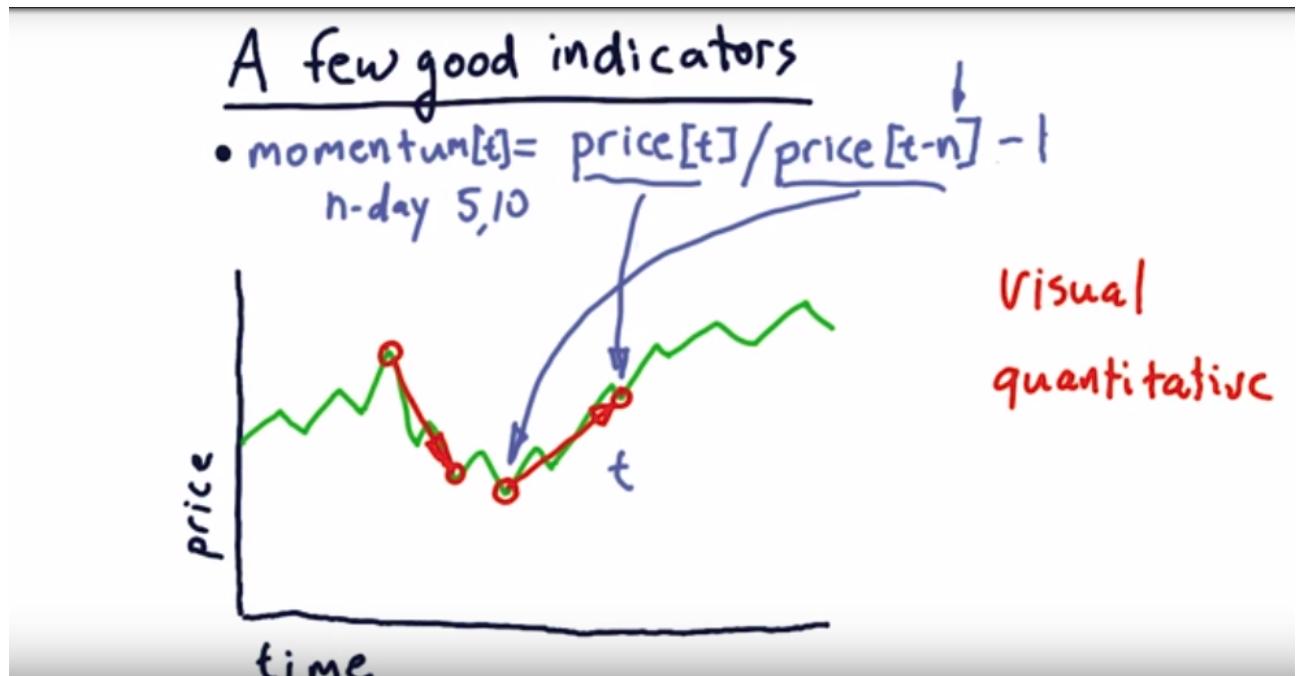
Technical analysis

Chars -

1. Only historical price and volume are considered.
2. Based on this we compute statistics called indicators which indicate a buy/sell opportunity.

## Technical analysis indicators

### 1. Momentum



## Fundamental law of active portfolio management

### Grinolds fundamental Law

#### Grinold's Fundamental Law

- Performance
- Skill
- Breadth

$$\text{performance} = \text{skill} \cdot \sqrt{\text{breadth}}$$

$$IR = IC \sqrt{BR}$$

Adjusted risk/reward ratio or sharpe ratio = expected return / risk

## Coin Flip casino observation



$$20 = .63 \cdot \sqrt{1000}$$

$$\text{SR}_{\text{multi}} = \frac{\text{SR}_{\text{single}}}{\sqrt{\text{bets}}} \cdot \sqrt{\text{breadth}}$$

↓      ↓      ↓

$$\text{performance} = \text{skill} \cdot \sqrt{\text{breadth}}$$

Fundamental terms

Information ratio

## IR, IC, Breadth

- IR, Information Ratio

$$r_p(t) = \underbrace{\beta_p r_m(t)}_{\text{market}} + \underbrace{\alpha_p(t)}_{\text{skill}}$$

$$\text{IR} = \frac{\text{mean}(\alpha_p(t))}{\text{stdev}(\alpha_p(t))}$$

IR is like Sharpe of excess return

## Information coefficient and breadth

### IR, IC, Breadth

- IR, Information Ratio  $\frac{\text{mean}(\alpha_p(t))}{\text{stdev}(\alpha_p(t))}$
- IC, Information Coefficient  
correlation of forecasts to returns
- BR, Breadth  
number of trading opportunities per year

## Fundamental Law for performance

### The Fundamental Law

- IR, Information Ratio  $\frac{\text{mean}(\alpha_p(t))}{\text{stdev}(\alpha_p(t))}$
- IC, Information Coefficient  
correlation of forecasts to returns
- BR, Breadth  
number of trading opportunities per year

$$\frac{\text{IR}}{\text{perf}} = \frac{\text{IC} \cdot \sqrt{\text{BR}}}{\text{breadth}}$$

the fund, is due to the skill  
at making predictions.

Grinold and Kahn

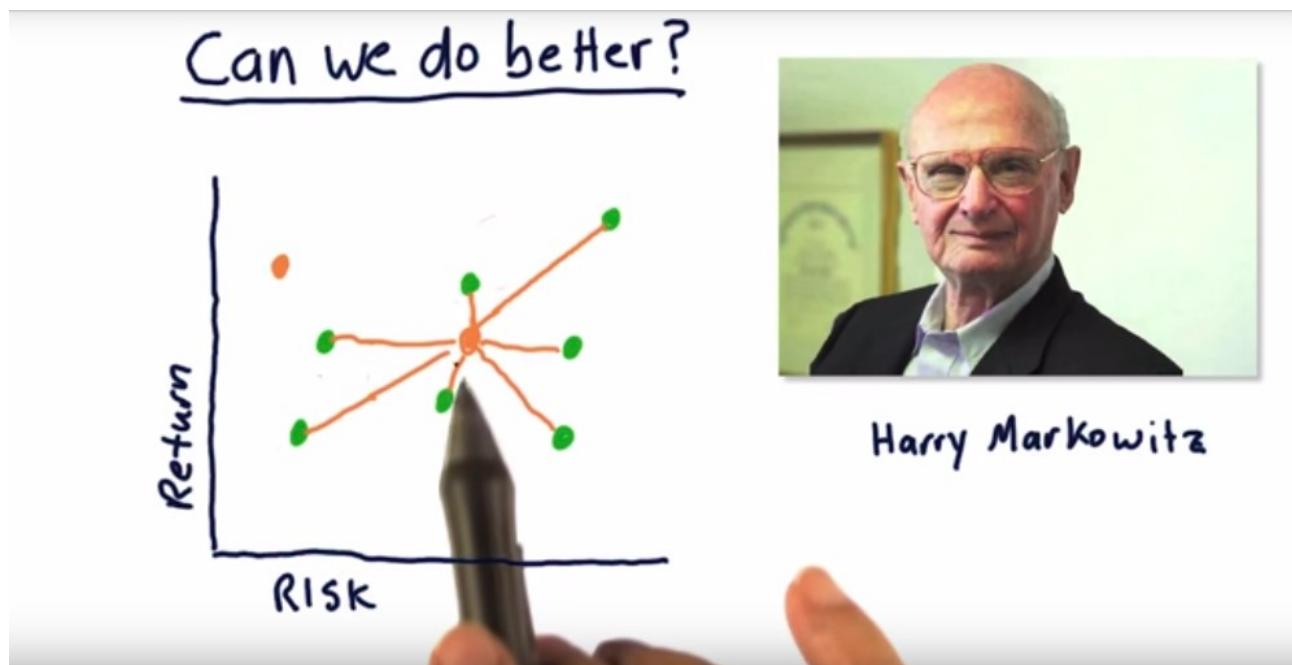
Risk :

(Less volatile stocks have less risk)

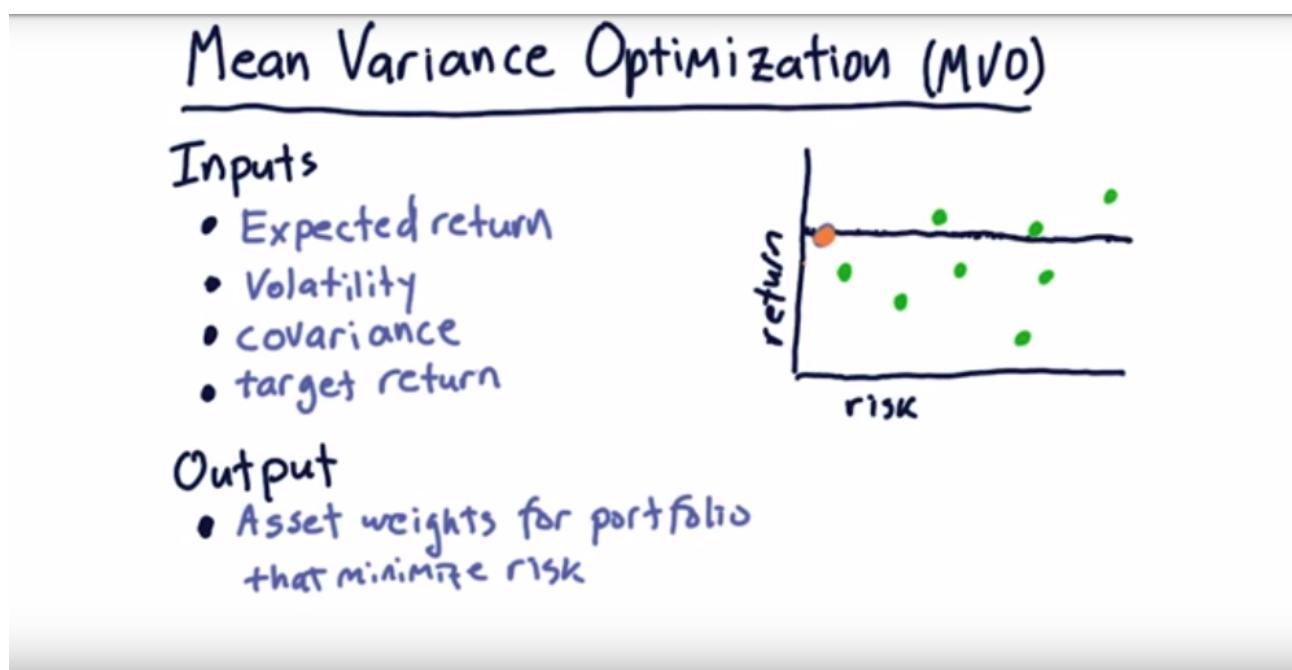
It is the standard deviation of historical daily returns

Can we reduce risk ?

Relationship of stocks in terms of covariance

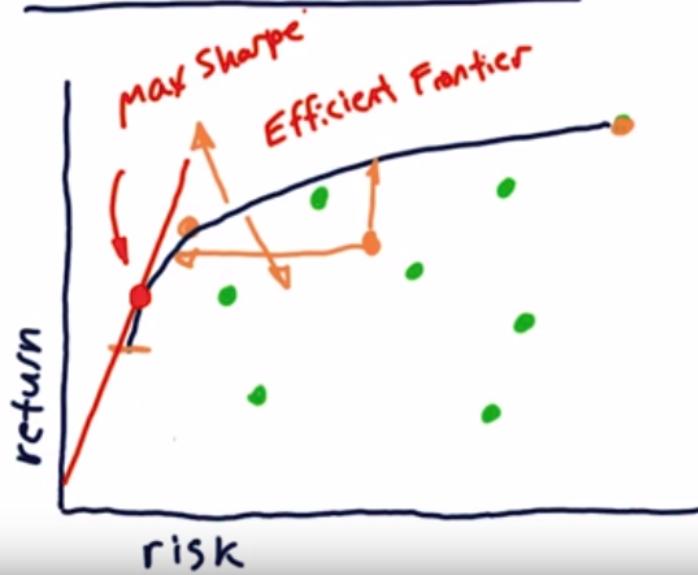


Mean variance optimization



## The efficient Frontier

### The Efficient Frontier



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