

# Portfolio Management

## FN 4329

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American College of Greece

Spring Semester 2020

# Contents

- 1 Portfolio Construction
  - Asset Allocation
  - Security Selection
  - ??? (Q3)
- 2 Theory
  - Descriptive Statistics
  - Financial Metrics
- 3 Building the Portfolio
  - Naive allocation
  - Portfolio Optimization
- 4 Evaluation

## Todo

- fix contents (example: Intro, Theory, Results)
- better resolution on images

# Questionnaire

1/30/2020

Vanguard - Investor Questionnaire

PERSONAL INVESTORS



## Investor questionnaire

1. I plan to begin taking money from my investments in ...

- ☐ 1 year or less
- ☐ 1 - 2 years
- ☐ 3 - 5 years
- ☐ 6 - 10 years
- ☐ 11 - 15 years
- ☒ More than 15 years

2. As I withdraw money from these investments, I plan to spend it over a period of ...

- ☒ 2 years or less
- ☐ 3 - 5 years
- ☐ 6 - 10 years
- ☐ 11 - 15 years
- ☐ More than 15 years

3. When making a long-term investment, I plan to keep the money invested for ...

- ☐ 1 - 2 years
- ☐ 3 - 4 years
- ☐ 5 - 6 years
- ☐ 7 - 8 years
- ☒ More than 8 years

4. From September 2008 through November 2008, stocks lost more than 21%. If I owned a stock investment that lost about 21% in 3 months, I would ... (If you owned stocks or stock funds during this period, select the answer that corresponds to your actual behavior.)

- ☐ Sell all of the remaining investment.
- ☐ Sell a portion of the remaining investment.
- ☒ Hold onto the investment and sell nothing.
- ☐ Buy more of the investment.

5. Generally, I prefer investments with little or no fluctuation in value, and I'm willing to accept the lower return associated with these investments.

- ☐ Strongly disagree
- ☒ Disagree
- ☐ Somewhat agree
- ☐ Agree
- ☐ Strongly agree

6. During market declines, I tend to sell portions of my riskier assets and invest the money in safer assets.

- ☒ Strongly disagree
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- ☐ Somewhat agree
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- ☐ Strongly agree

7. I would invest in a mutual fund or ETF (exchange-traded fund) based solely on a brief conversation with a friend, co-worker, or relative.

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8. From September 2008 through October 2008, bonds lost nearly 4%. If I owned a bond investment that lost almost 4% in 2 months, I would ... (If you owned bonds or bond funds during this period, select the answer that corresponds to your actual behavior.)

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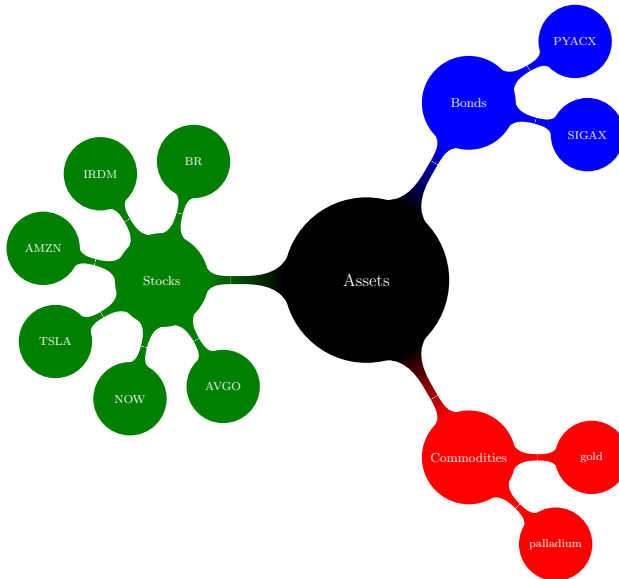
<https://personal.vanguard.com/us/FundInvQuestionnaire>

1/2

## Asset Allocation

- 70% Stocks
- 20% Bonds
- 10% Commodities

# Security Selection



# Stocks

AVGO - Broadcom Inc

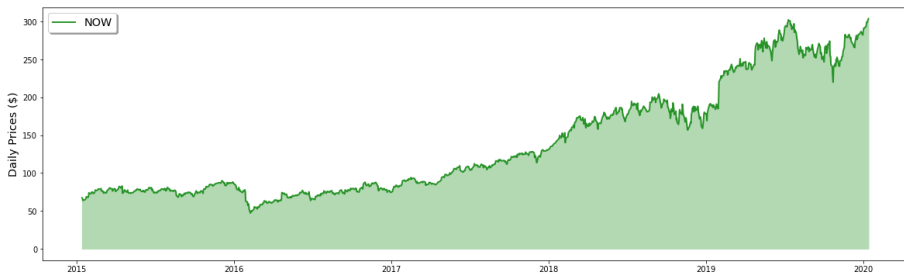
## add - DO THIS FOR EVERY SECURITY

- category
- few words
- price chart



# Stocks

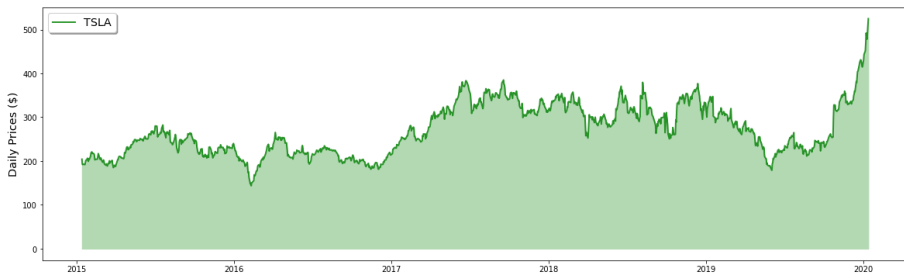
NOW - ServiceNow Inc.





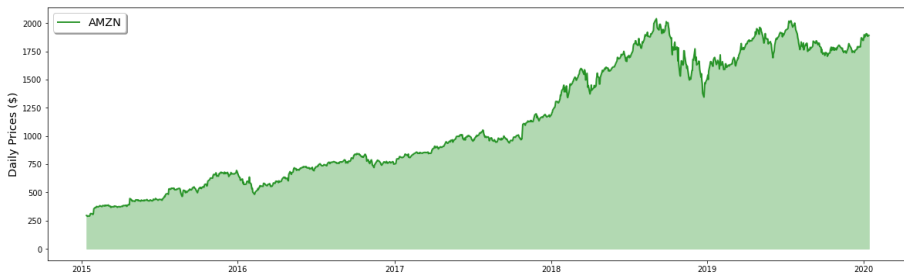
# Stocks

TSLA - Tesla Inc.



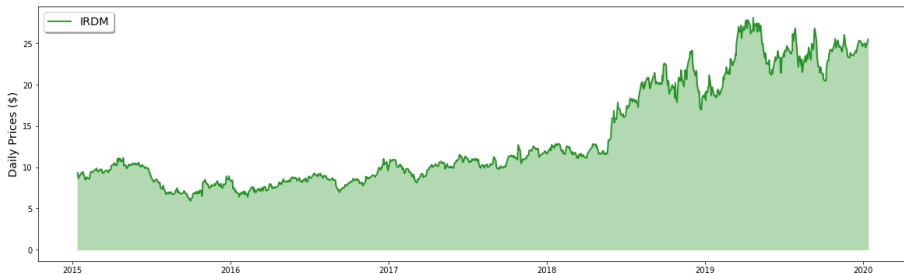
# Stocks

AMZN - Amazon Inc.



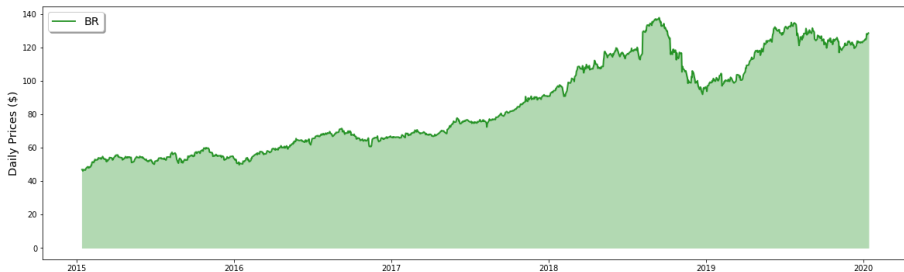
# Stocks

IRDM - Iridium Communications Inc.



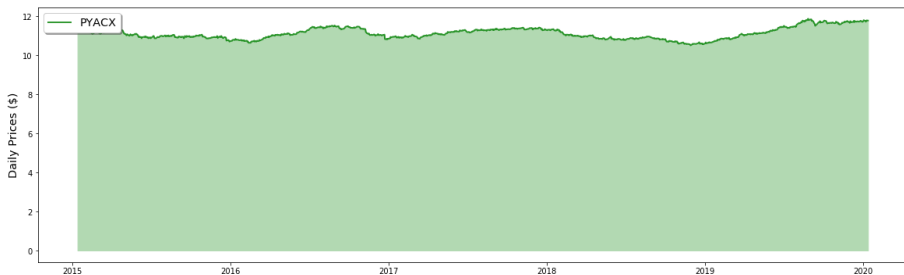
# Stocks

BR - Broadridge Financial Solutions Inc.



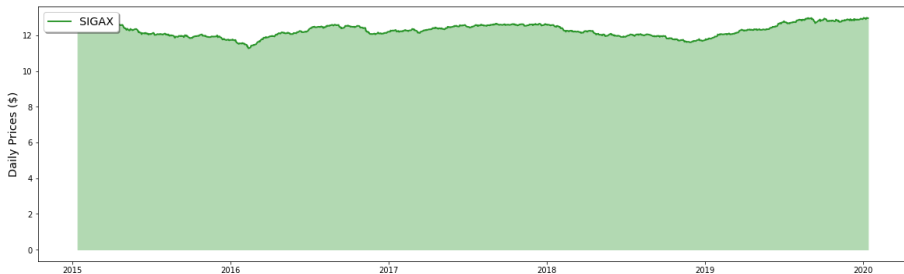
# Bonds

## PYACX - Payden Corporate Bond Mutual Fund



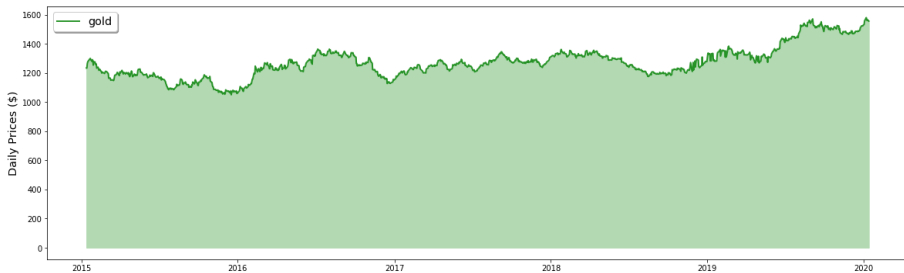
# Bonds

## SIGAX - Western Asset Corporate Bond Mutual Fund



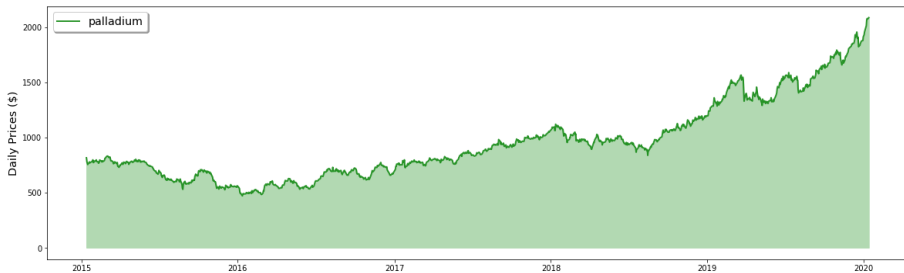
# Commodities

gold



# Commodities

## palladium

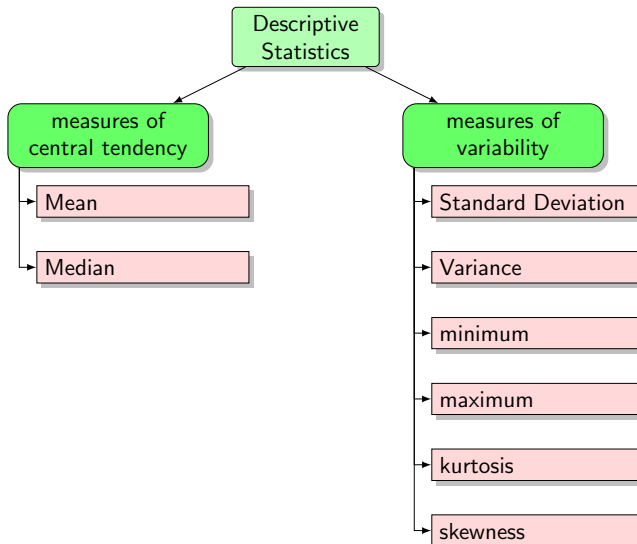




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# Descriptive statistics Taxonomy



# Measures of central tendency

## Mean

### Mean

$$\bar{x} = \frac{1}{n} \left( \sum_{i=1}^n x_i \right) = \frac{x_1 + x_2 + \cdots + x_n}{n}$$

# Measures of central tendency

## Median

- i.e. the middle value

# Measures of central tendency

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- i.e. the middle value
- Why?

# Measures of central tendency

## Median

- i.e. the middle value
- Why? robust w.r.t. outliers

# Measures of central tendency

## Median

- i.e. the middle value
- Why? robust w.r.t. outliers
- indicates whether returns are positive or negative on most time instances.

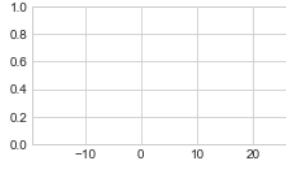
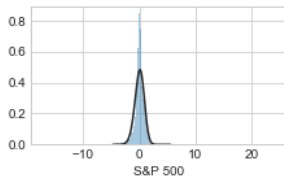
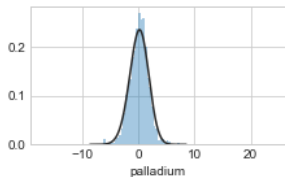
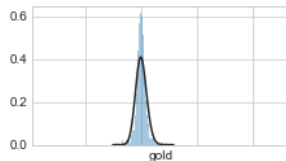
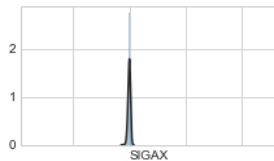
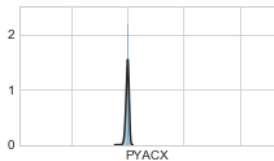
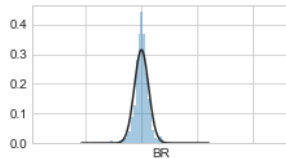
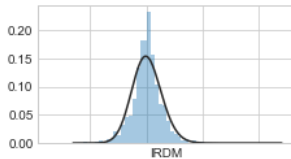
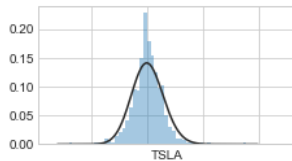
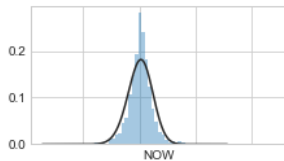
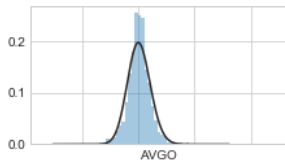
# Measures of Variability

## Standard Deviation

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^2}$$

- how "spread out" are the data around the mean
- measures confidence in statistics  $\implies$  risk in finance





# Measures of Variability

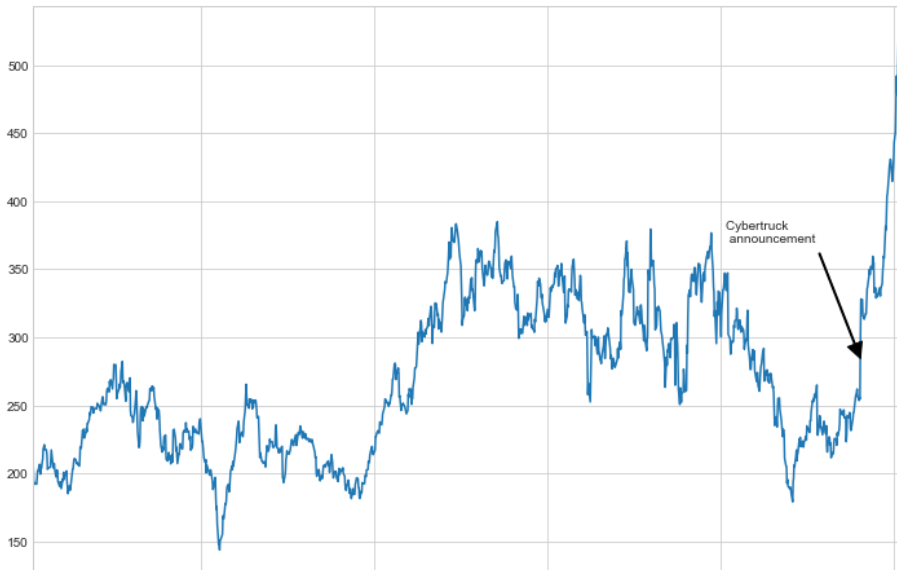
## Minimum & Maximum



**Figure:** The minimum of the S&P500 returns would occur on the day of the economic crisis for this period.

# Measures of Variability

## Minimum & Maximum



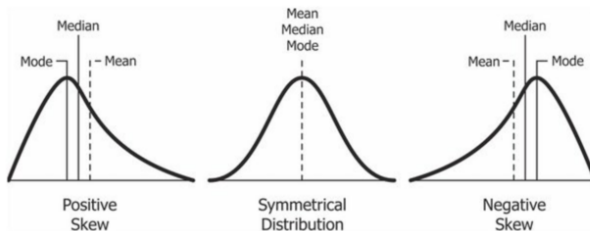
# Measures of Variability

## Skewness

### Definition

$$\tilde{\mu}_3 = \mathbb{E} \left[ \left( \frac{X - \bar{x}}{\sigma} \right)^3 \right]$$

Skewness is a measure of asymmetry that indicates if the tail of the distribution is on the left or the right.



# Measures of Variability

## Kurtosis

### Definition

$$\text{Kurt}(X) = \tilde{\mu}_4 = \mathbb{E} \left[ \left( \frac{X - \bar{x}}{\sigma} \right)^4 \right]$$

Kurtosis measures whether the distribution is heavy- or light-tailed relative to a normal distribution

- high kurtosis  $\rightarrow$  heavy tails (**outliers**)
- low kurtosis  $\rightarrow$  no outliers

# Measures of Variability

## An overview

### Moments from an investor's perspective

- $\tilde{\mu}_2$  standard deviation  $\sigma$
- $\tilde{\mu}_3$  skewness
- $\tilde{\mu}_4$  kurtosis

### TODO

add what each moments means to understanding security performance

## Covariance Definition

Let  $X$  and  $Y$  be two random variables. Then the covariance is a measure of the joint variability of these two random variables:

$$\text{cov}(X, Y) = \mathbb{E}[(X - \bar{x})(Y - \bar{y})]$$

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- not so helpful!  $\rightarrow$  correlation

# Correlation

## Definition

The correlation is the normalization of the covariance.

$$\rho_{X,Y} = \frac{\text{cov}(X,Y)}{\sigma_X \cdot \sigma_Y}$$

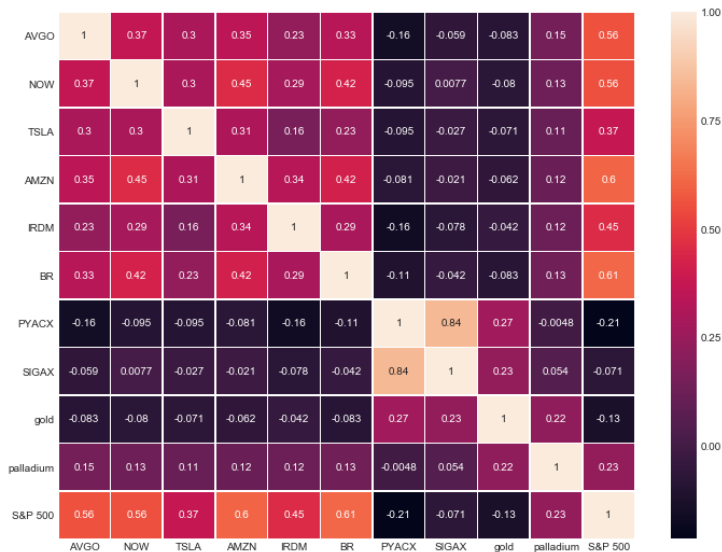
$$\rho_{X,Y} \begin{cases} = -1, & \text{perfect decreasing (inverse) linear relationship} \\ \in (-1, 1), & \text{indicating the degree of linear dependence} \\ = 1, & \text{perfect (increasing) linear relationship} \end{cases}$$

# A closer look at correlation

todo

add regression plots to show the difference

# Correlation Matrix



## Definition

The beta coefficient measures the systematic risk of an individual stock compared to the market risk, also called unsystematic risk.

$$\beta = \frac{\text{cov}(R_e, R_m)}{\text{var}(R_m)}$$

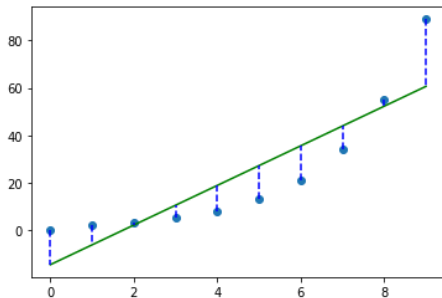
## Definition

Alpha is the difference between the realised returns and the expected returns:

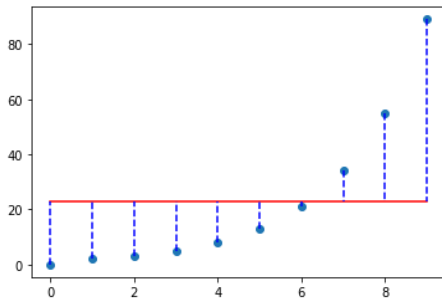
$$\alpha = \bar{R} - \mathbb{E}(R)$$
$$\stackrel{\text{CAPM}}{\implies} \alpha = \bar{R} - \left\{ R_f + \beta(\mathbb{E}(R_m) - R_f) \right\}$$

# R-squared

$$R^2 = 1 - \frac{\text{Explained Variation}}{\text{Total Variation}}$$



(a) Explained Variation



(b) Total Variation

# Sharpe Ratio

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

where

- $R_p$  = return of mutual fund
- $R_f$  = risk-free rate
- $\sigma_p$  = standard variation of the portfolio's excess return



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# Risk and return

## Return

$$R_p = \vec{w}^\top \cdot \mathbb{E}(\mathcal{R})$$

## Risk

$$\sigma_p = \sqrt{\vec{w}^\top K \vec{w}}$$

$$= \sqrt{\begin{bmatrix} w_1 & w_2 & \dots & w_n \end{bmatrix} \begin{bmatrix} \sigma_1^2 & \text{COV}_{1,2} & \dots & \text{COV}_{1,n} \\ \text{COV}_{2,1} & \sigma_2^2 & \dots & \text{COV}_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \text{COV}_{n,1} & \text{COV}_{n,2} & \dots & \sigma_n^2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}}$$

$$= \sqrt{\sum_{i=1}^n w_i^2 \sigma_i^2 + \sum_{i=1}^n \sum_{j=1}^n w_i w_j \text{COV}_{ij}}$$

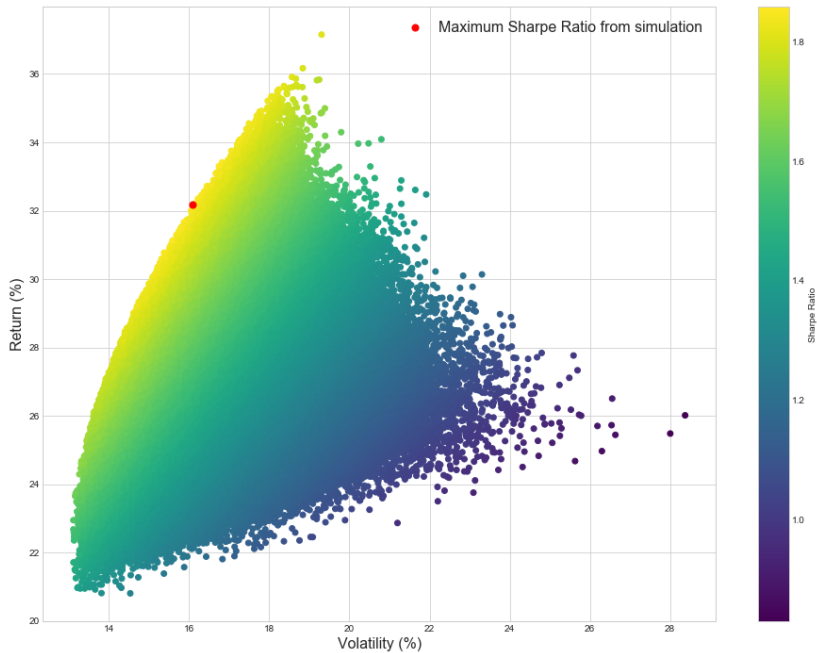
# Naive weight allocation

## Remember!

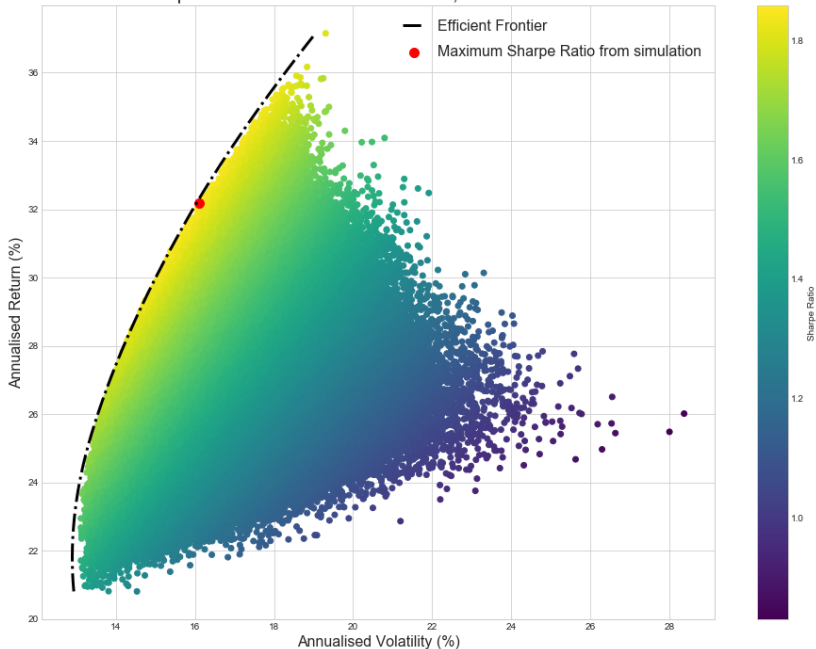
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- 10% Commodities

## What about $\vec{w}$ ?

- 70% for 6 Stocks  $\rightarrow \frac{70\%}{6} = 11.67\%$  each
- 20% for 2 Bonds  $\rightarrow 10\%$  each
- 10% for 2 Commodities  $\rightarrow 5\%$  each



## Portfolio Optimization with Individual Stocks, Bonds and Commodities



# Optimal portfolio

## Optimization problem formulation

$$\begin{aligned} \max \quad & \frac{\vec{w}^\top \cdot \mathbb{E}(\mathcal{R}) - r_f}{\sqrt{\vec{w}^\top K \vec{w}}} \\ \text{s.t.} \quad & \mathbf{1}^\top \vec{w} = 1 \\ & \mathbf{1}^\top \vec{w}_S = w_s \\ & \mathbf{1}^\top \vec{w}_B = w_b \\ & \mathbf{1}^\top \vec{w}_C = w_c \\ & w_s + w_b + w_c = 1 \\ & w_i \geq 0 \quad i = 1, \dots, n \end{aligned}$$

# Optimal portfolio

## Optimization problem formulation

Sharpe Ratio

max

$$\frac{\vec{w}^\top \cdot \mathbb{E}(\mathcal{R}) - r_f}{\sqrt{\vec{w}^\top K \vec{w}}}$$

s.t.

$$\mathbf{1}^\top \vec{w} = 1$$

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# Capital Allocation Line

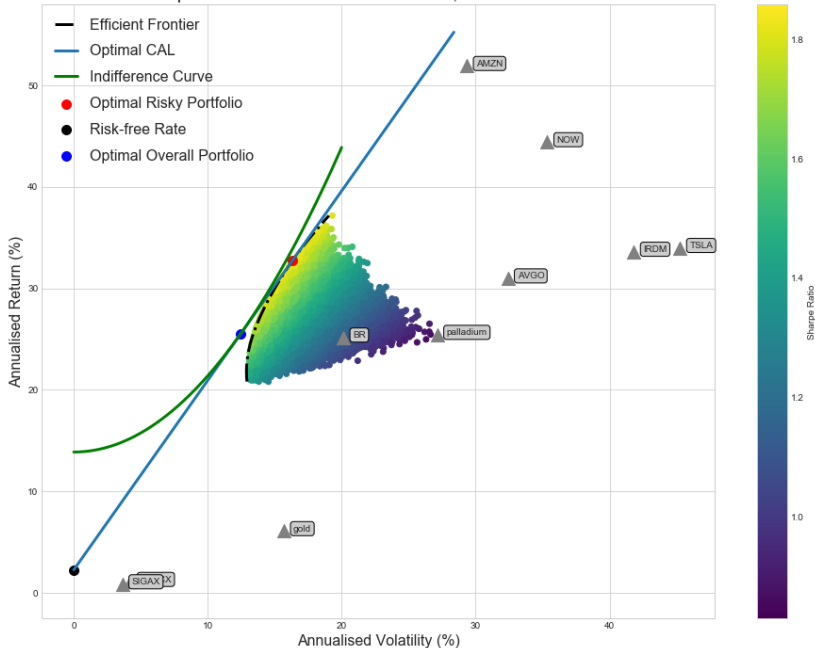
$$\left\{ \begin{array}{l} (0, r_f) \in \epsilon_{\text{CAL}} \\ (\sigma_{\text{OPT}}, r_{\text{OPT}}) \in \epsilon_{\text{CAL}} \end{array} \right\}$$



# Capital Allocation Line

$$\left\{ \begin{array}{l} (0, r_f) \in \epsilon_{\text{CAL}} \\ (\sigma_{\text{OPT}}, r_{\text{OPT}}) \in \epsilon_{\text{CAL}} \end{array} \right\} \Rightarrow \epsilon_{\text{CAL}} : y = \underbrace{\frac{r_{\text{OPT}} - r_f}{\sigma_{\text{OPT}}}}_{\text{max Sharpe ratio}} \cdot x + r_f$$

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