# Quantopian CAPM Model

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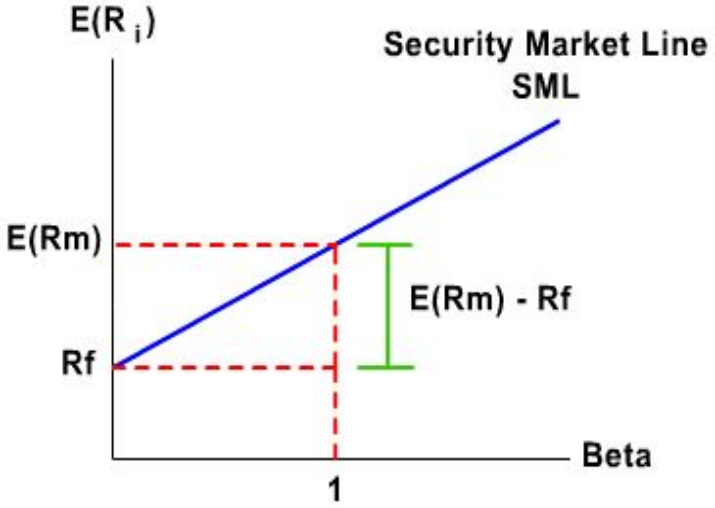
# Agenda

- Theory: Overview of CAPM and Security Market Line
- Assumptions and Set of Possible Stocks
- Stock Selection
- Calculating Expected Prices
- Beta Hedge
- Returns

# Capital Asset Pricing Model (CAPM)

- $R_a = R_f + \beta(R_m - R_f)$
  - $R_a$ = Return of asset
  - $R_f$ = Risk-free rate
  - $\beta$ = Beta of the security
  - $R_m$ = Expected return of the market

# Security Market Line



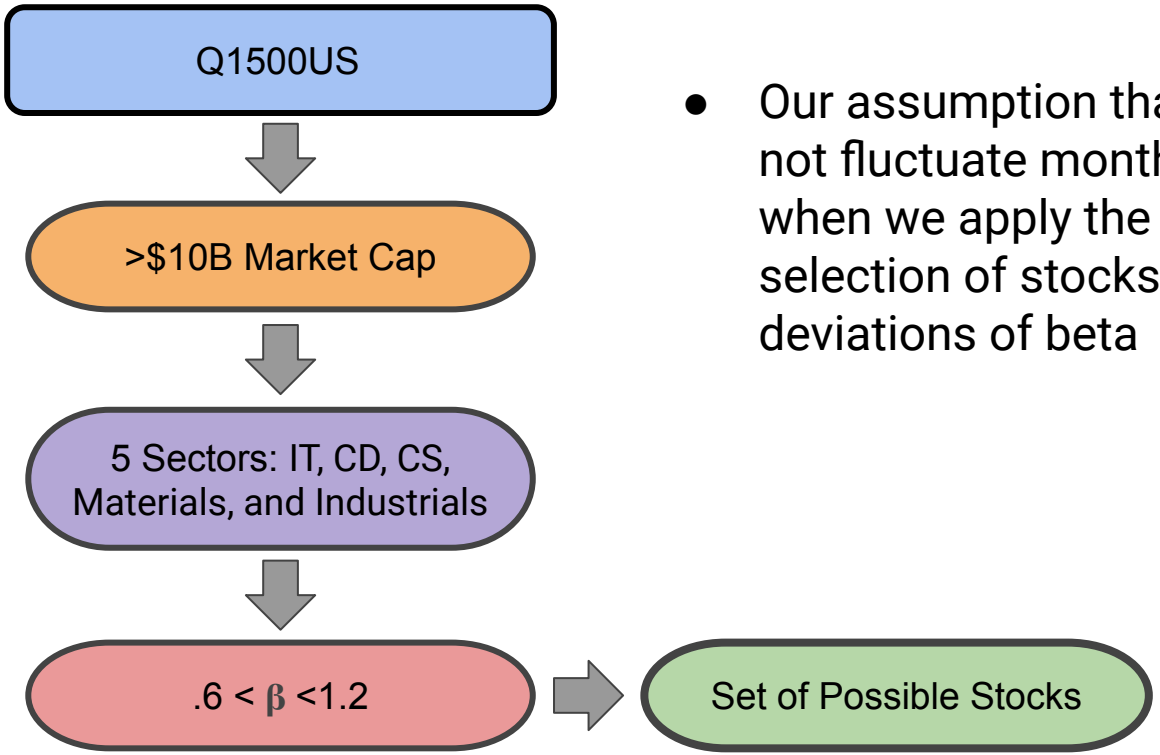

- Derive the Security Market Line
  - Slope is determined by the market risk premium
    - Higher the premium, higher the slope
  - All correctly priced assets fall along the SML
  - Assets **above** the SML are **undervalued**
    - Market price is lower than it should be
    - Thus, expected return in the market for the asset is too low
  - Assets **below** the SML are **overvalued**
    - Market price is higher than it should be
    - Thus, expected return in the market for the asset is too high

$$R_a = R_f + \beta(R_m - R_f)$$

# Assumptions

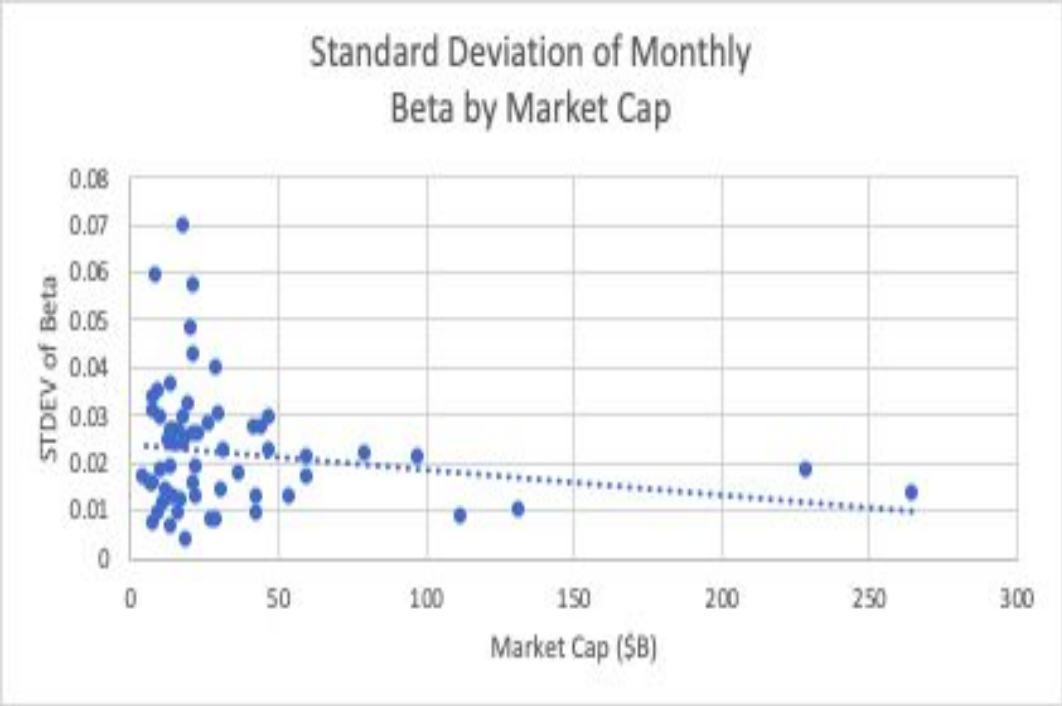
1. The beta of an equity will not fluctuate much month to month
2. Return of the S&P 500 in the previous month will be the same in the month to follow
3. The monthly risk-free rate is 0.15%

# Possible Stock Selection




- Our assumption that the beta of an equity will not fluctuate month to month is supported when we apply the following filters - giving us a selection of stocks with lower standard deviations of beta

# Beta Standard Deviation by Market Cap



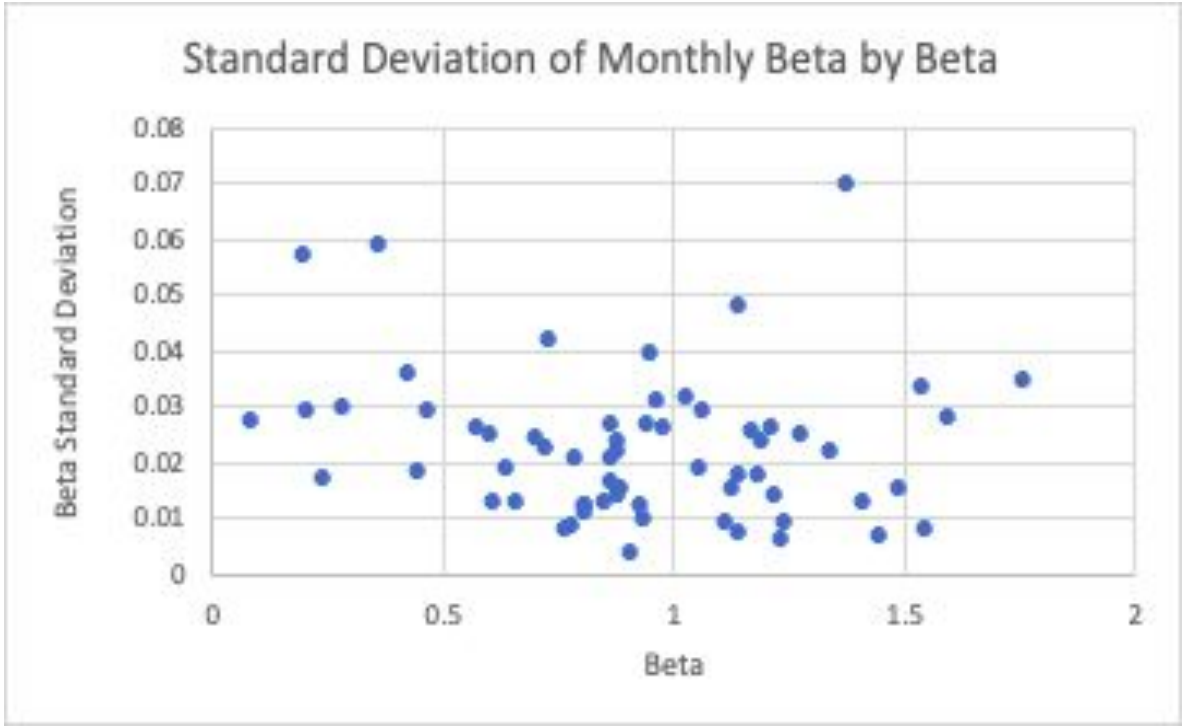

- Theory
  - Betas have lower standard deviations for companies with small and large market caps
- Our Action
  - Only include equities with market caps over $10B

# Beta Standard Deviation by Sector

| Average Standard Deviation | |
|---|---|
| Information Technology | 0.0146323 |
| Consumer Discretionary | 0.0171794 |
| Consumer Staples | 0.0174556 |
| Materials | 0.0176313 |
| Industrials | 0.0193521 |
| Financials | 0.0202005 |
| Utilities | 0.0234717 |
| Health Care | 0.0248539 |
| Communication Services | 0.025955 |
| Energy | 0.0327615 |
| Real Estate | 0.0363134 |

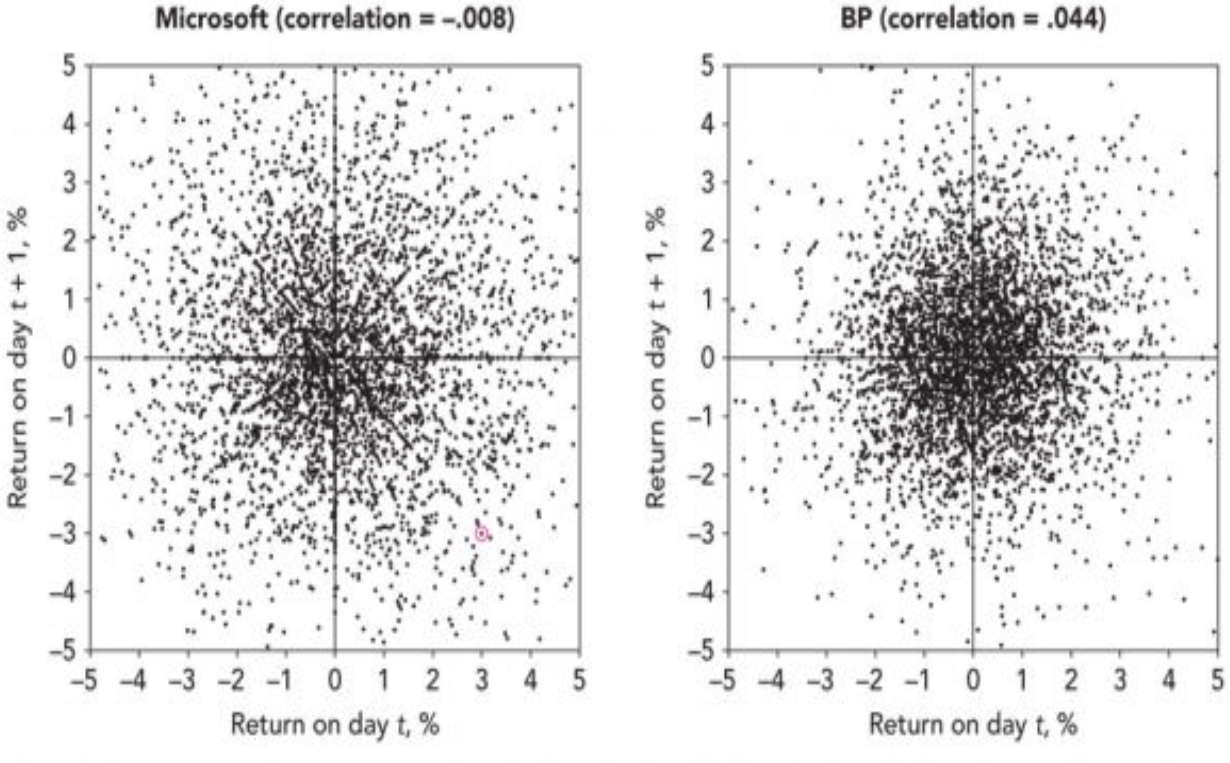
- Theory
  - Different Sectors have monthly betas that have lower standard deviation than other sectors
- Our Action
  - Choose the 5 sectors with the betas that have the lowest standard deviation

# Standard Deviation of Beta by Beta



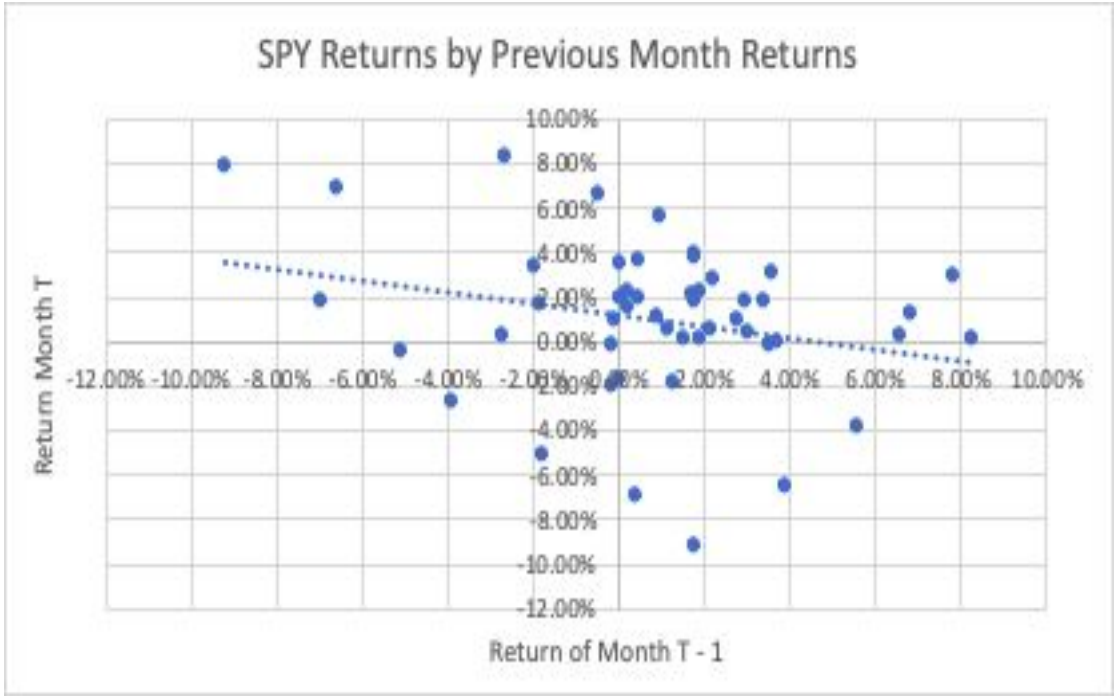

- Theory
  - Betas have higher standard deviations for companies with high betas
- Our Action
  - Only include equities with betas 0.6 ←→1.2

# Assumption - CAPM Return




- Today's return cannot be predicted by yesterday's return
- Let's try this by monthly return!

# Assumption - CAPM Return




- Several theories suggest that past returns can be used to predict future returns when looking at larger time intervals like months
- This graph does not support that theory, but we are going to do it anyway!

# Calculating Expected Prices

- Risk-free rate is 0.15%
- Step 1: Calculate Market Returns
  - Last Month Market Return $= (\text{Current SPY Price} - \text{Last Month SPY Price})/\text{Last Month SPY Price}$
- Step 2: Calculate CAPM Returns
  - $\text{CAPMR} = \text{Risk-free rate} + \text{beta}(\text{market return} - \text{risk-free rate})$
  - Based on assumptions, Predicted CAPMR = Last Month CAPMR
- Step 3: Calculate what the stock price should be in 1 month
  - $\text{Stock Price in 1 Month} = \text{Stock Price Last Month} \times (1 + \text{CAPMR})^2$

# Calculating Expected Prices

| Company Name | Sector | Beta | Market Cap | Price 1 Month Ago | Price Now | Return CAPM | What Price Should be in 1 Month |
|---|---|---|---|---|---|---|---|
| Apple | IT | 1.1 | $1 Trillion | $150 | $160 | 2% | $156 |
| Nike | CD | .84 | $140 Billion | $75 | $82 | 7% | $86 |

# Stock Selection

- Step 1: Calculate expected upside or expected downside
  - (Expected Price in 1 Month − Current Price)/Current Price
- Step 2: Filter out stocks with expected upside/downside more than 4%
  - Filter out the “winners” and “losers”
  - CAPM assumes the market efficiency so there likely won’t be amazing opportunities
- Step 3:  Choose stocks to long and stocks to short
  - For each of the 5 sectors, long the equity with the largest upside and short the equity with the largest downside

# Beta Hedge

- Step 1: Calculate appropriate hedge for each long/short position
  - Equity Position = 10%/(1+beta)
    - Ex. Long Equity ABC w/ beta 1.5 → 10%/(1+1.5) = 4%
  - SPY Position = 10% - Equity Position
    - Short SPY → 10% - 4% = 6%
- Step 2: Calculate Total Position for Equity and SPY
  - Total Equity Position = sum(abs(Equity Positions))
  - Net SPY Position = sum(SPY Positions)
- Step 3: Use multiplier to use all capital available
  - Multiplier = 100/(Equity Position + SPY Position)
  - Each equity position and net SPY position × multiplier
  - Ex: Total Equity position (45%) and Net SPY Position (5%)
    - Multiplier = 100/(45 + 5) = 2
    - Multiply each equity position by 2 (Total position is now 90%)
    - Net SPY position = 5% × 2 = 10%