Machine Learning for Trading
Financial Investing

The Fundamental Law
of active portfolio management

Efficient Markets Hypothesis
(does not support our assumption)
Assumption: *We can gain advantage in the market from exploiting different sources of ‘information’*

Technical Analysis:
• Historical Price (movements – are not random).
• Volume

Fundamental Analysis:
• Features of the intrinsic value of a stock, e.g., earning.

General Investment Intuition
News (Information) of a Company

**Good news**
• Stock price goes up!
• Good investment

**Bad news**
• Stock price goes down!
• Poor investment

Intuition to Earning Money on the Stock Market
Possible Scenario
1. Eric learns good news
2. Eric tells his grandmother Berta
3. Berta buys stock in advance
4. Announcement to public
Berta has an advantage
Efficient Market Hypothesis

- Instant Information Flow
  - Eric, Grandmother, and Public Learn about the news at the same time.

Efficient Markets Hypothesis

- All relevant information flows instantly - or super quickly – no one can take advantage of slow flowing information to gain an advantage.
- Any information is available instantly in a [perfectly] efficient market.
- Reflect: Both Fundamental & Technical Analysis are based on information so they are useless in a [perfectly] efficient market.

Information:
From public to less public

- Price volume (most public)
- Fundamental (intrinsic value)
- Exogenous
  - other or related information affecting price that is not intrinsic information
    - Example price of oil may affect a company making cars.
- Insider Information.

https://en.wikipedia.org/wiki/Efficient-market_hypothesis
Efficient Market Hypothesis
Forms

• Weak
  – Future price cannot be predicted by analyzing historical prices
  ⇒ Technical Analysis cannot work

• Semi-Strong
  – Prices adjust rapidly to new public information
  ⇒ Fundamental Analysis cannot work

• Strong:
  – Prices reflect all information, public an private.
  ⇒ No analysis relying on ANY information (including insider information) cannot work
### Case Study
*(Estimating Value of a Stock)*

- **Look at Price Earning Ratio**
  - 33% of investment managers considers this ratio before buying stock.
  - 15-20 PE Ratio (AVG 15.54), typical on average
  - Question: What type of information is the PE Ratio? (Technical, Fundamental or Insider?)
- **Lower PE Ratio is better**
  - Intuition: Low PE Ratio means lower expectation

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### Historical PE Ratios

https://jbmarwood.com/historical-pe-ratios/
Low PE Ratio is better

- A clear correlation
  - Lower PE ratio is equal to better investment returns
  - Holds through each twenty year period.

• Challenges:
  - Stock market will adjust
  - Historical PE ratio not easy to come by.

Fundamental Law of Active Portfolio Management

• Warrant Buffet:
  - Wide diversification is only necessary when the investors do not know what they are doing.

• Skill & Breath
  - Skill – Selecting the right stocks.
  - Breath – number of investment opportunities

Grinold’s Fundamental Law:
  - Performance = Skill \times \sqrt{Breath}

Casino
Coin flip: Which is better?

• 1 bias coin
  - .51 heads \rightarrow Win.
  - .49 tails \rightarrow Lose.

• 1,000 tokens that you can bet:
  - Which is better?
    - 1,000 tokens that you can bet:
      • Bet 1: 1 bet of 1,000 tokens
      • Bet 2: 1000 separate bets, one at a time.
      • Bet 3: Both are equivalent?
**Expected Return**

- **Single Bet:**
  - $0.51 \times 1000 + 0.49 \times -1000$
  - $510 - 490 = $20.00 Profit.

- **Multi Bet:**
  - $(0.51 \times 1.00) - (0.49 \times -1) = 0.51 - 0.49 = 0.02$ c.
  - Make the bet 1,000 times: $0.02 \times 1,000 = $20.00

Expected Return is the SAME

**Risk: Take 1 – Lose it all.**

- **Lose it All**
  - Bias Coin $\rightarrow 0.49$ Losing.

- **Single Bet**
  - $0.49$.

- **Multi Bet**
  - $0.49 \times 0.49 \times ... \times [0.49]^{1000} = $ really small chance you lose it all.

**Risk: Take 2 – Standard Deviation.**

- Allocating bets differently across tables.
  - 1 Extreme bet it all at one table
    - AT One table:
      - Win 1,000, or Lose 1,000
      - Outcome is 0.
    - AT Other tables (we did not bet on these)
      - Stdev($1000,0,0,0,...$) = 31.62
  - 1 Extreme evenly distribute the bets 1 bet at each table.
    - 1 win, -1 lose
    - Stdev(-1,1,-1,1,...) = 1.
    - $\rightarrow$ standard deviation is 1.
    - Then there are the in-betweens.

- **Summary:**
  - Risk / Standard Deviation is much larger if we do 1 single Bet.

**Coin flip: Reward/Risk**

- Combine
  - Expected Return & Risk
- Similar to the Sharpe Ratio
- Reward/Risk $\rightarrow$ Expected Return / StDev()

- **Single Bet:**
  - $20/31.62 = 0.63$

- **Multi Bet:**
  - $20/1 = 20.$
Towards a Model.

- **Single Bet:**
  - $20/31.62 = 0.63 \text{ (SR}_{\text{single}})\)

- **Multi Bet:**
  - $20 / 1 = 20.

- **Combine Single bet with Multi Bet**
  - $\text{SR}_{\text{multi}} = \text{SR}_{\text{single}} \times \sqrt{1,000}$

- **Performance improves with Breath.**
  - 1 single bet no improvement
  - 1000 spread maximum improvement.

- **Same relationship in active portfolio management.**
  - $\text{SR}_{\text{multi}} = \text{SR}_{\text{single}} \times \sqrt{1,000}$

- **Performance = Skill \times \sqrt{\text{Breath}}**

- **Lessons:**
  - Higher Alpha (skill) $\rightarrow$ Higher SR
  - More Opportunities $\rightarrow$ Higher SR
  - SR grows with the $\sqrt{\text{Breath}}$.

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**Fundamental Law**

- IR = IC $\times$ SQRT (BR)
- IR – information Ratio
- IC – Information Coefficient
- BR – number of trading opportunities

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- **Renaissance Technology**
  - 100K/day

- **Warren Buffet**
  - 120 Stocks

- **Information Ratio/Reward.**
  - Alpha encapsulate skill
  - **Recall:** $R_p(t) = \text{Beta} \ R_m(t) + \alpha$
  - IR = mean(alpha)/stdev(alpha)
Q: Simons vs Buffet

- Both have same IR
- Simons’ algo is \( \frac{1}{1000} \) as smart as Buffet
- Buffet trades 120/year

How many trades must Simons execute?

\[ IC_B \cdot \sqrt{120} = IC_S \cdot \sqrt{x} \]
\[ IC_B \cdot \sqrt{120} = IC_S / 1000 \cdot \sqrt{x} \]
\[ 100 \cdot \sqrt{120} = \sqrt{x} \]
\[ 100^2 \cdot 120 = x \]
\[ 120,000,000 \]

Efficient Frontier.

- Constraint in optimizer is a particular expected return (recall in our optimizer the constrain was that allocations summed to 1)
- Markovitz Bullet
- Maximum Sharpe Ratio