GROUP WORK PROJECT # ___
GROUP NUMBER: _____

MScFE 560: FINANCIAL MARKETS

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Remember: Any group members who did **not contribute to the project should be given all zero (0) points for the collaboration grade on the GWP submission page.*

Statement of integrity: By typing the names of all group members in the text boxes below, you confirm that the assignment submitted is original work produced by the group (excluding any non-contributing members identified with an "X" above).	
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Team member 3	

Use the box below to explain any attempts to reach out to a non-contributing member. Type (N/A) if all members contributed. **Note:** You may be required to provide proof of your outreach to non-contributing members upon request.
N/A

Summary and Interpretation of Key Results

- Long/short positions can be used to reduce portfolio risk beyond what can be achieved with single security portfolios and with long-only portfolio construction algorithms. Specifically, short positions can be used to reduce ex ante volatility, and to improve portfolio skew and kurtosis.
- Multi-asset long only portfolios help to improve the return/risk trade-off via diversification; however, when tradable assets are highly correlated (same sector and asset class) then the diversification benefits are reduced.
- Portfolio construction algorithms, such as mean-volatility optimization, can help to highlight trade-offs and can help inform the portfolio management process.

Recommended Course of Action

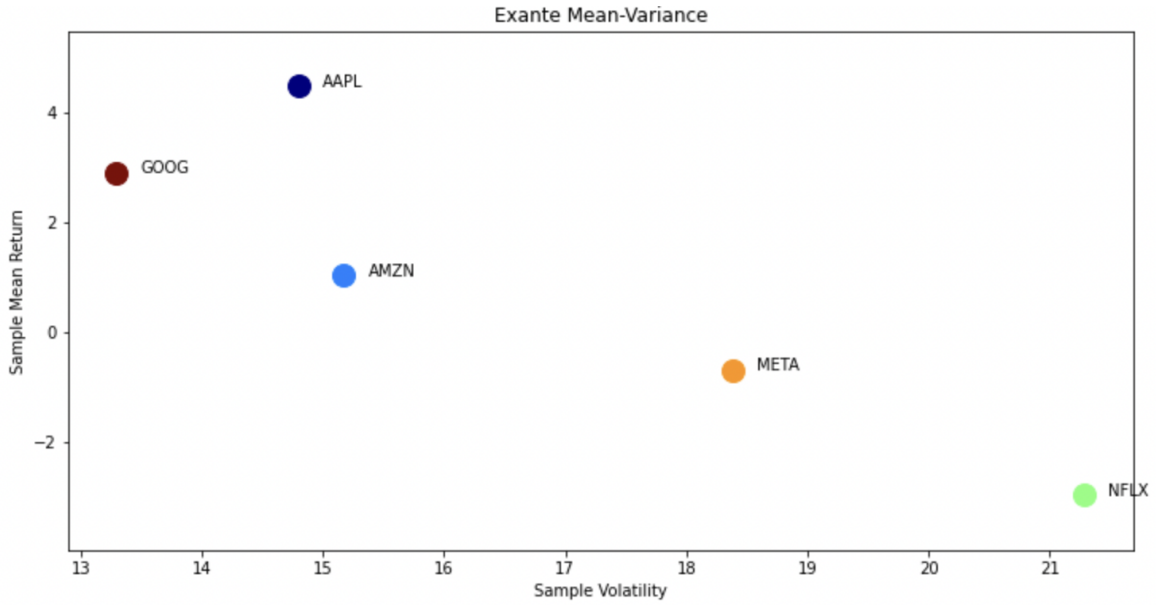
- Portfolio C (below) uses all five securities in the tradable universe to diversify and directly hedge risk exposures. It makes use of both longs and shorts in practical proportions to improve returns and diminish risks. While the allocation resulted from a portfolio optimization that maximizes the mean/volatility trade off, it also improves portfolio measures of skew and kurtosis. However, the optimization depends critically on the estimates of mean, volatility, and correlation used as inputs and should be subjected to additional sensitivity analysis before implementation.

Single Asset Portfolios

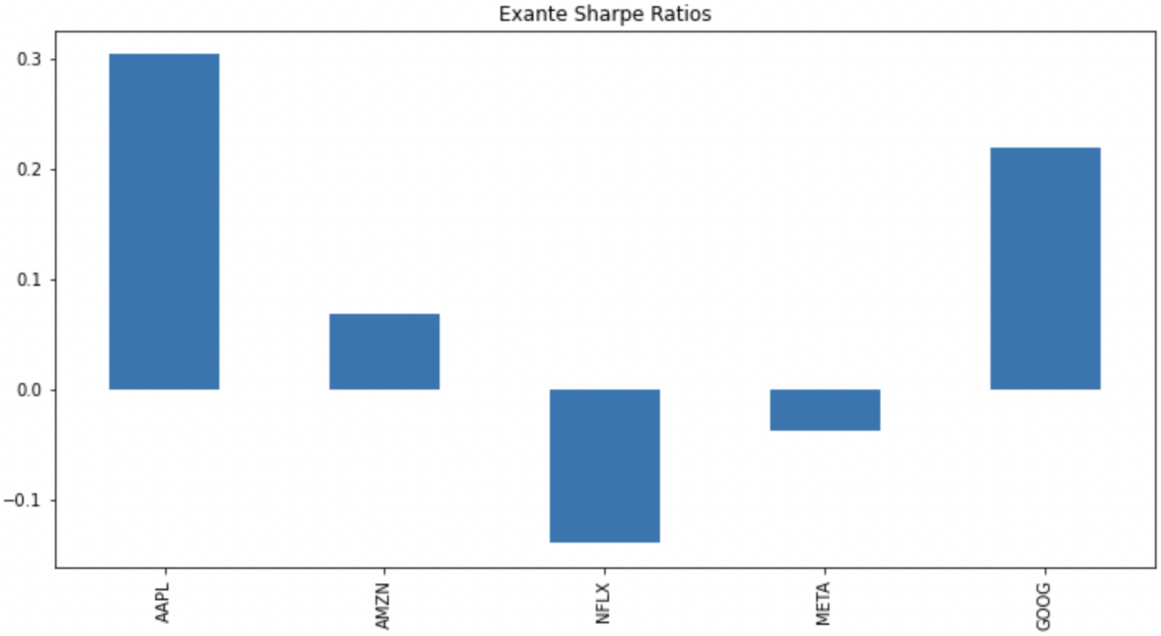
The single asset means (Mean) appear to be annualized in natural units and the volatilities (Vol) appear to be measured at daily frequency.

	Mean	Vol	Skew	Kurt
AAPL	0.044858	0.009320	-0.335173	5.034093
AMZN	0.010362	0.009557	-0.312865	4.729806
NFLX	-0.029675	0.013409	-3.101654	41.968015
META	-0.006934	0.011582	-1.936506	23.289236
GOOG	0.029035	0.008376	-0.197700	4.310171

If we annualize the volatilities we can plot means versus volatilities to get a better sense of the reward/risk trade-off for each security.



We can also plot the mean/volatility (Sharpe) ratios for another perspective.



From both the Sharpe ratios and the mean-variance plots we can see that AAPL and GOOG standout as good risk reward from the sample statistics provided.

Portfolio A: Long 1 / Short 1

Step 1

- We choose to go long GOOG because it has the second best Sharpe ratio and the least negative skew, and kurtosis. GOOG also has the lowest volatility.
- We choose to short NFLX because it has a significant sample correlation with GOOG (49%), and has the most negative skew, kurtosis, and highest volatility.
- We select the portfolio weights to minimize overall portfolio volatility, i.e., we choose the weight of NFLX using ordinary least squares regression

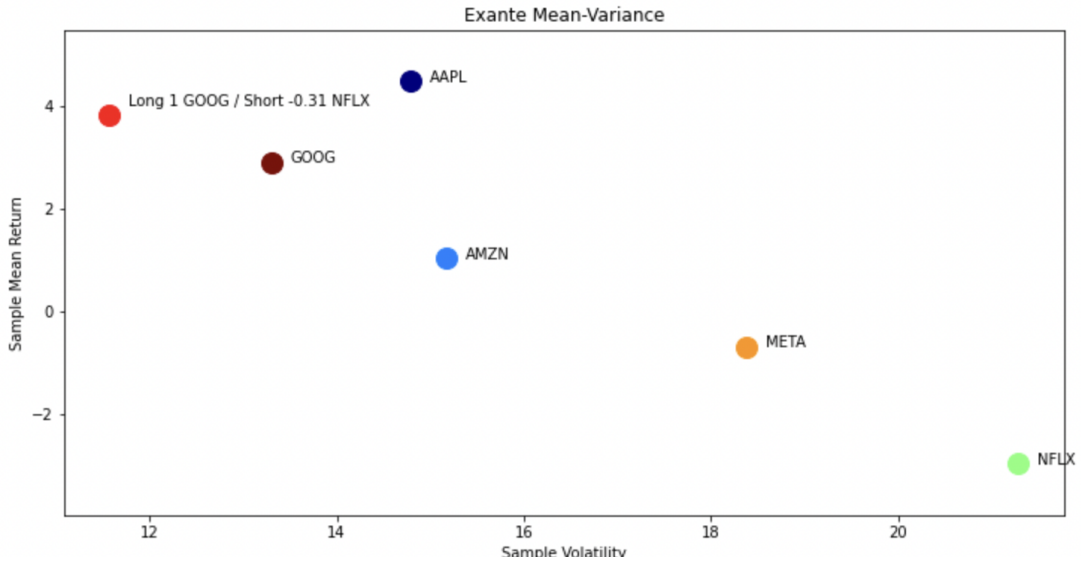
$$w^{\text{NFLX}} = -\frac{\sigma^2(R^{\text{NFLX}}, R^{\text{GOOG}})}{\sigma^2(R^{\text{NFLX}})}$$

where

- R^i is the return of instrument i, and
- $\sigma^2(R^i, R^j)$ is the covariance of instruments i and j and $\sigma^2(R^i) = \sigma^2(R^i, R^i)$.

- Applying the formula above results in **shorting .31 cents of NFLX for every 1 dollar of GOOG** bought.

We can add the Long/Short portfolio (red dot) to the mean-volatility scatter above.



- The location of the red dot (vol=11.87%, mean=3.82%) highlights the favorable mean-volatility trade-off that can be achieved by hedging out some of the volatility of GOOG by shorting NFLX.

Step 2

- Short Mechanics
    a. Yes
    b. Note that we should be able to short the NFLX position provided that the total capital allocated to the portfolio isn't too large. For example, if 1,000,000 USD is allocated to the portfolio then we would need to purchase 1 million USD in GOOG shares and borrow 310,000 USD in NFLX shares to go short. The short sale would raise 310,000 USD which could be invested at the risk free rate in order to mitigate the borrow fees.
- Credit Risk
    a. Yes
    b. This portfolio has no credit risk since our only long position is in equities.
- Portfolio Statistics
    a. We can see that the ex ante portfolio return is **3.82%**
    b. Portfolio volatility is **11.57%** (both annualized).
- Diversification
    a. The portfolio is not well diversified, since it is a very concentrated bet on the continued outperformance of GOOG vs NFLX.
    b. Too much focus on the Internet industry
- Comparing Portfolios
    a. Compared to the single asset portfolios the long/short GOOG/NFLX spread portfolio compares favorably. It has lower risk to AAPL. It has a higher Sharpe ratio than any of the single asset portfolios.
    b. Compared to the single asset portfolios the long/short GOOG/NFLX spread portfolio compares favorably. It has a similar return to AAPL. It has a higher Sharpe ratio than any of the single asset portfolios.
- Assessing Risk
    a. Since this portfolio is a long/short within the internet/tech sector, it represents very concentrated exposure to the idiosyncratic risk factors

associated with GOOG and NFLX. Thus, it is difficult to think of macroeconomic risk factors that would negatively affect the spread position; however, there are numerous idiosyncratic scenarios that could affect the spread.

b. Google's advertising revenue could be reduced by competition from alternative platforms that compete for consumer attention (Twitter, Meta, Instagram, Snapchat, TikTok), whereas Netflix could be hurt by increased competition in generating streaming content.

- Performance
    a. As we have seen during the Covid 19 pandemic, lockdown and work-from-home conditions were a benefit to both companies as consumers had more time and disposable income to allocate to home entertainment.
    b. Google (via YouTube) and Netflix are competing for consumer attention and a structural shift in consumer appetites from studio produced content (Netflix) to user produced content would benefit the spread position, while a shift in the opposite direction would negatively affect the spread portfolio.
- Disrupters
    a. Both companies are long duration technology plays, and thus a more hawkish central bank determined to raise real interest rates in response to high inflation is a major risk. Higher long duration real discount rates reduce the present value of future dividends that might be expected from both companies and this could affect the quality of the hedge ratio as volatilities would increase significantly and potentially differently for each security.
    b. Investment banks can affect the supply and demand of stocks by going long and short, and then affect the stock price
- Re-assessing Risk

a. The portfolio skew should be positive as allocations were chosen to take exposure to the less negatively skewed security (GOOG) and to short the most negatively skewed security (NFLX).
b. In the 5 stocks there is not, since they are all positive.

Portfolio B: Long Only

Step 1

- Portfolios on the mean-volatility optimal (MVO) frontier often finance large long positions with large short sales, however, we can impose both a budget and a long only constraint to inform our decision making process. Specifically, we solve the following convex optimization and analyze the resulting solutions on the frontier

$$\max_{w} \left\{ \mu' w - \frac{\gamma}{2} w' \Sigma w \right\}$$

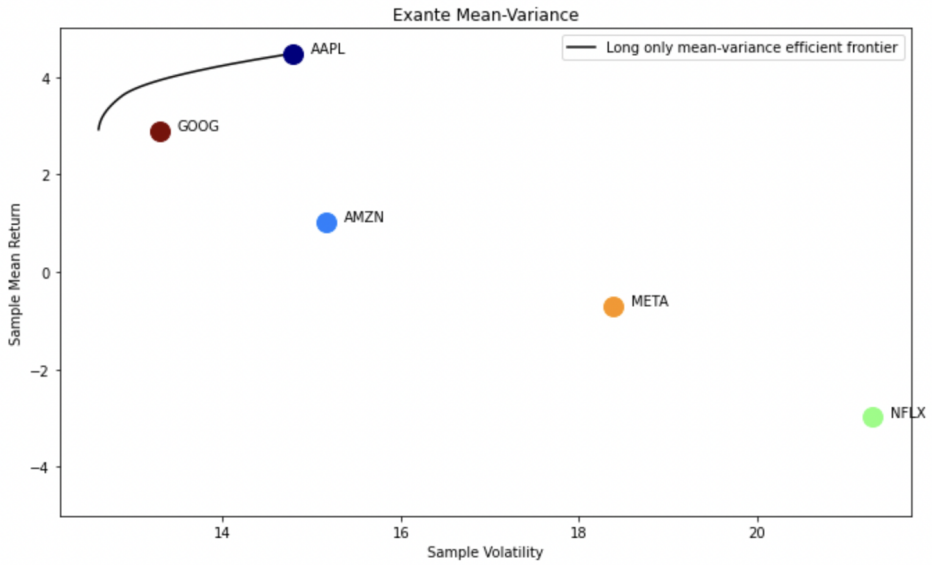
subject to

$$1' w = 1$$
$$w \geq 0$$

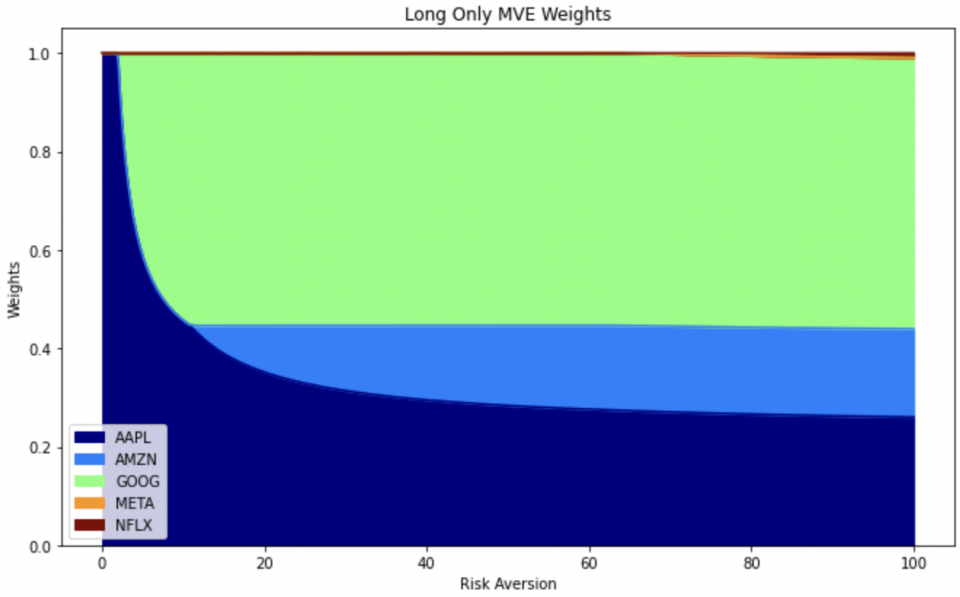
where

- μ is an $N \times 1$ vector of asset excess returns
- Σ is an $N \times N$ covariance matrix of asset excess returns and
- γ is the investor's coefficient of risk aversion.

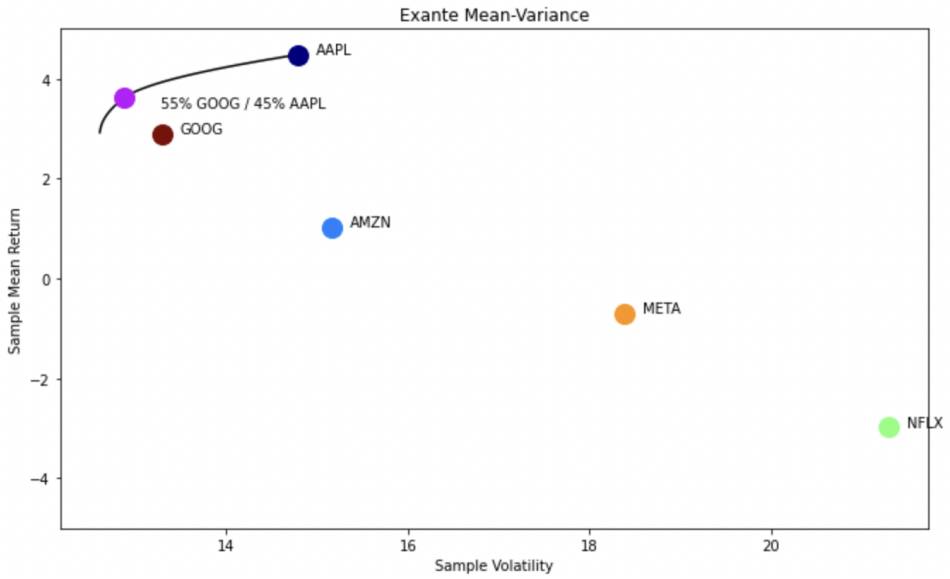
- The optimal long only portfolios lie on the curve (roughly connecting GOOG to AAPL)



- Portfolio weights can be visualized as a function of the risk aversion parameter (gamma)



- Since AAPL and GOOG are relatively efficient with respect to mean, volatility, skew, and kurtosis. **We choose a portfolio consisting of 55% GOOG and 45% AAPL.**
- This point (Purple dot) sits close to the frontier and should be easy to implement


Exante Mean-Variance
AAPL
55% GOOG / 45% AAPL
GOOG
AMZN
META
NFLX
Sample Mean Return
Sample Volatility
4
2
0
−2
−4
14
16
18
20

Step 2

- Short Mechanics
    a. Yes
    b. To go long one unit of this portfolio it isn't necessary to short any securities.
- Credit Risk
    a. Yes
    b. The credit risk from the company that the dividends and principal may lose.
- Portfolio Statistics
    a. The ex ante portfolio return is **3.62%**
    b. ex ante portfolio volatility is **12.88%** (both annualized).
- Diversification
    a. The portfolio is not well diversified. It is concentrated in two securities in the same sector that are both exposed to similar macroeconomic risk factors.
    b. Too much focus on the same sector.
- Comparing Portfolios
    a. Compared to the single asset portfolios the long GOOG/AAPL portfolio compares favorably. It has lower risk than all the single asset portfolios, It has a similar Sharpe ratio (.28) to the highest single asset portfolio (.30).
    b. But similar ex ante returns to AAPL.
- Assessing Risk
    a. Since this portfolio is concentrated long within the tech sector it will be very exposed to real discount rates. An unexpected rise in inflation would harm these portfolios as the Federal Reserve would attempt to raise real discount rates, thus reducing the present value of expected future dividends.

   b. Another risk, to AAPL specifically, is a disruption in international shipping (since many of Apple's devices are manufactured in Asia) or to the production of semiconductors used to assemble computer chips.

- Performance
   a. As we have seen during the Covid 19 pandemic, lockdown and work-from-home conditions were a benefit to both companies as consumers had more time and disposable income to allocate to home entertainment and they made upgrades to computer hardware.
   b. Increased sales will lead to increased business performance and higher stock prices, which will benefit our strategy.
- Disrupters
   a. Both companies are long duration technology plays, and thus a more hawkish central bank determined to raise real interest rates in response to high inflation is a major risk. Higher long duration real discount rates reduce the present value of future dividends that might be expected from both companies.
   b. Investment banks can affect the supply and demand of stocks by going long and short, and then affect the stock price
- Re-assessing Risk
   a. The portfolio skew and kurtosis should be relatively attractive because both GOOG and AAPL had relatively attractive skew and kurtosis individually.
   b. In the 5 stocks there is not, since they are all positive.

Portfolio C: Long/Short Three or More

Step 1

- We can simply relax the long only constraint in the mean-variance optimization for Portfolio B to generate an efficient frontier that allows for short sales. That is we solve the optimization problem below

$$\max_w \left\{ \mu' w - \frac{\gamma}{2} w' \Sigma w \right\}$$

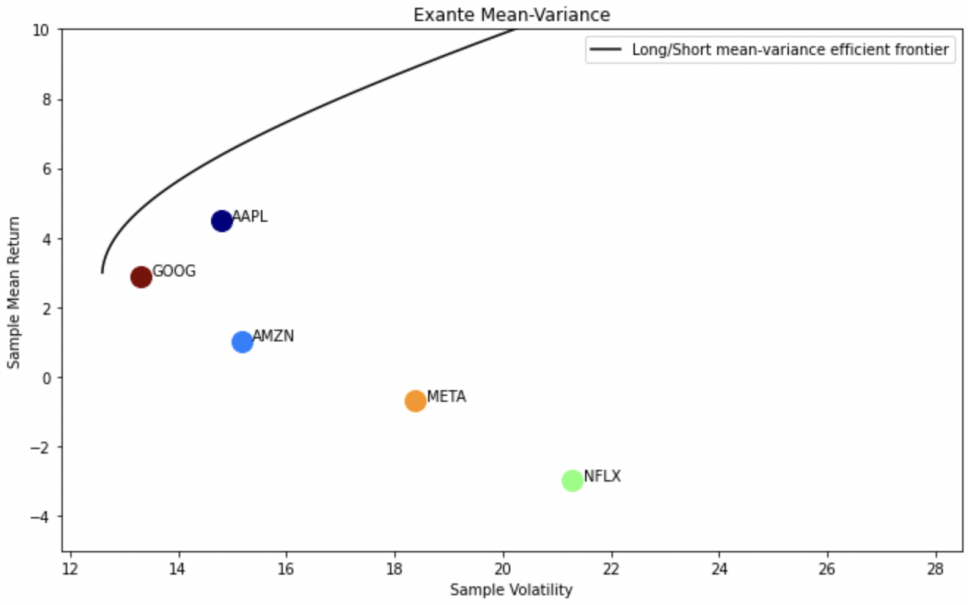
subject to

$$1' w = 1.$$

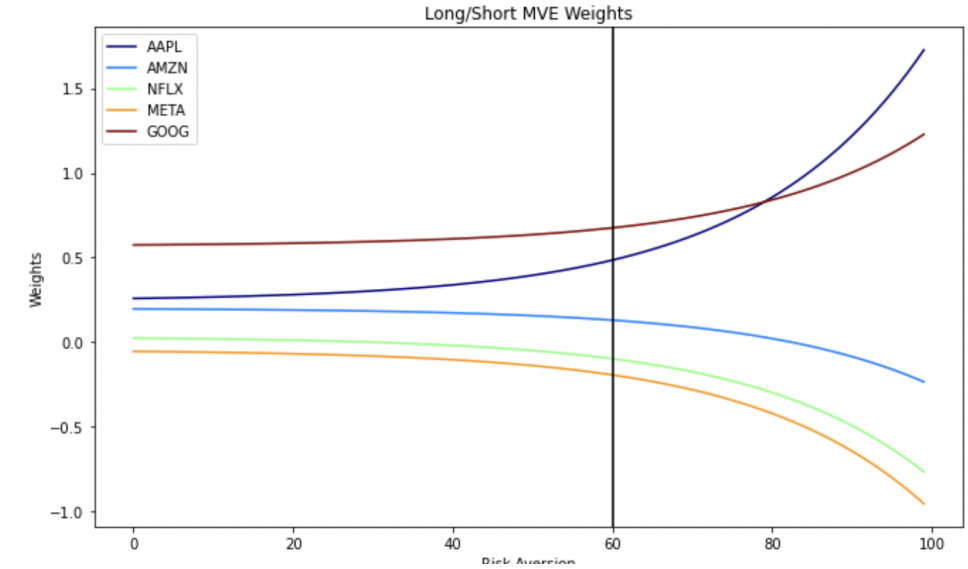
- All solutions to the problem above form an efficient frontier in mean-variance (or equivalently mean-volatility) space. It is an interesting fact that if you know the weights for any two (different) portfolios on the frontier, then you can sweep out the entire frontier of efficient portfolios. In particular, all weights on the frontier can be expressed as a linear combination of the maximum Sharpe portfolio and the the minimum-variance portfolio

$$w(\alpha) = \alpha \underbrace{\left(\frac{1}{1' \Sigma^{-1} \mu} \Sigma^{-1} \mu \right)}_{\text{Max Sharpe}} + (1 - \alpha) \underbrace{\left(\frac{1}{1' \Sigma 1} \Sigma^{-1} 1 \right)}_{\text{Min Vol}}, \qquad \text{for } \alpha \in [0, 1]$$

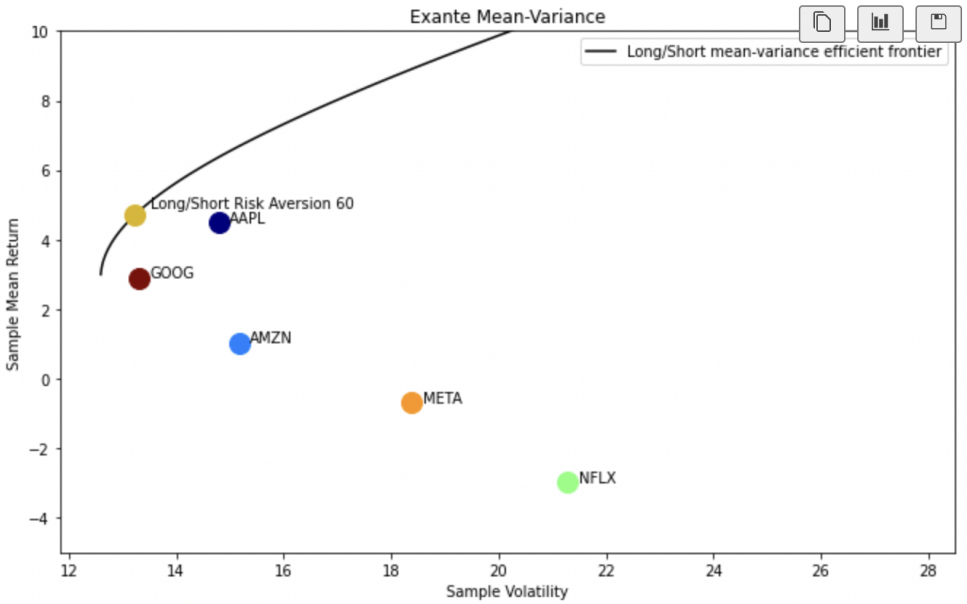
  However, since we generally have more confidence in ex ante estimates of variance/covariance than we do for mean return, we will choose a point near to the minimum variance portfolio, but which satisfies the requirement that we go long and short 3 or more securities, and which is reasonably easy to implement (e.g., low leverage and small shorts).
- The MVO frontier is a curve that sits above and to the left of the single security portfolio points


Exante Mean-Variance
Long/Short mean-variance efficient frontier
AAPL
GOOG
AMZN
META
NFLX
Sample Mean Return
Sample Volatility
10
8
6
4
2
0
−2
−4
12
14
16
18
20
22
24
26
28

- The weights are now both long and short and here again can be viewed as a function of risk aversion.



- The risk aversion coefficient (gamma) of 60 seems to provide a reasonably good trade off between risk, reward, and ease of implementation since the position sizes are all reasonable (as a proportion of total capital). Adding this point (gold dot) to the plot shows where it sits on the frontier



- The portfolio's weights are given numerically as

AAPL	0.49
AMZN	0.13
NFLX	−0.10
META	−0.19
GOOG	0.68

Step 2

- Short Mechanics
    a. Yes
    b. To go long one unit of this portfolio one must borrow and short a small amount of NFLX and META.
- Credit Risk
    a. Yes
    b. The credit risk from the company that the dividends and principal may lose.
- Portfolio Statistics
    a. The ex ante portfolio return is **4.70%**
    b. ex ante portfolio volatility is **13.72%** (both annualized).
- Diversification
    a. The portfolio is reasonably well diversified. However, it is still concentrated in FAANG securities which are exposed to similar macroeconomic risk factors.
    b. Not fully diversified.
- Comparing Portfolios

a. Compared to the single asset portfolios the long/short MVO portfolio compares favorably. It has lower risk than all the single asset portfolios. It has a higher Sharpe ratio (.35) than the highest single asset portfolio (AAPL has Sharpe = .30).
b. Compared to the single asset portfolios the long/short MVO portfolio compares favorably. It has a higher return. It has a higher Sharpe ratio (.35) than the highest single asset portfolio (AAPL has Sharpe = .30).

- Assessing Risk
    a. Since this portfolio is concentrated (net) long within the tech sector it will be very exposed to real discount rates. An unexpected rise in inflation would harm these portfolios as the Federal Reserve would attempt to raise real discount rates, thus reducing the present value of expected future dividends.
    b. Since Portfolio C is long GOOG, AAPL, AMZN and short META, NFLX it shares many of the same risk exposures to Portfolios A and B above.
- Performance
    a. As we have seen during the Covid 19 pandemic, lockdown and work-from-home conditions were a benefit to all of the FAANG stocks.
    b. However, the high inflation experienced globally as a result of extraordinary fiscal and monetary stimulus combined with a shock to energy production and global supply chains, has caused the sector to underperform most other asset sectors and classes in 2022.
- Disrupters
    a. This portfolio is a (net) long technology play, and thus a more hawkish central bank determined to raise real interest rates in response to high inflation is a major risk. Higher long duration real discount rates reduce the present value of future dividends that might be expected from both companies.
    b. Investment banks can affect the supply and demand of stocks by going long and short, and then affect the stock price

- Re-assessing Risk
    a. The portfolio skew and kurtosis should be relatively attractive because both GOOG and AAPL are the largest portfolio weights and the portfolio is short both META and NFLX which have the least attractive skew and kurtosis.
    b. In the 5 stocks there is not, since they are all positive.