EF_No_Short_Sell

December 7, 2023

[1]:
```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import scipy.optimize as sco
```

[2]:
```
import yfinance as yf
import pandas_datareader as pdr
import requests_cache
session = requests_cache.CachedSession()
```

[3]:
```
%config InlineBackend.figure_format = 'retina'
%precision 4
pd.options.display.float_format = '{:.4f}'.format
```

[4]:
```
# Download real-time stock data from Yahoo! Finance

rf = 0.0422
tickers = 'AMZN NVDA TSLA UNH LLY'
stocks = (
    yf.download(tickers=tickers, start='2018-12-01', end='2023-12-01',␣
 ↪progress=False)
    .resample('M')
    .last()
    .assign(Date=lambda x: x.index.tz_localize(None))
    .set_index('Date')
    .rename_axis(columns=['Variable', 'Ticker'])
)
monthly_prices = stocks['Adj Close']
monthly_prices;
```

[5]:
```
# Calculate monthly log returns

returns = np.log(monthly_prices / monthly_prices.shift(1)).
 ↪sort_values(by='Date', ascending=False).rename_axis(columns='Tickers').
 ↪dropna()
returns.head()
```

[5]:
```
Tickers       AMZN     LLY    NVDA    TSLA     UNH
Date
2023-11-30  0.0932  0.0667  0.1371  0.1785  0.0320
2023-10-31  0.0459  0.0308 -0.0645 -0.2198  0.0604
2023-09-30 -0.0822 -0.0313 -0.1262 -0.0309  0.0602
2023-08-31  0.0319  0.2004  0.0547 -0.0356 -0.0606
2023-07-31  0.0251 -0.0313  0.0995  0.0214  0.0521
```

[6]:
```python
def port_vol(weights, returns):
    return np.sqrt(np.dot(weights.T, np.dot(returns.cov() * 252, weights)))
```

[7]:
```python
def port_mean(weights, returns):
    return np.dot(weights, returns.mean()) * 252
```

[8]:
```python
def neg_sharpe_ratio(weights, returns, rf):
    return -(port_mean(weights, returns) - rf) / port_vol(weights, returns)
```

[9]:
```python
# Find the Global Minimum Variance Portfolio with minimize() function from␣
 ↪SciPy's optimize module

res_mv = sco.minimize(
    fun=port_vol,
    x0=np.ones(len(returns.columns)) / len(returns.columns),
    args=(returns),
    method='SLSQP',
    bounds=[(0,1) for _ in range(len(returns.columns))],
    constraints=({'type': 'eq', 'fun': lambda x: np.sum(x) - 1})
)

gmvp_weights = res_mv.x
gmvp_ret = port_mean(gmvp_weights, returns)
gmvp_vol = port_vol(gmvp_weights, returns)

res_mv;
```

[10]:
```python
# The Global Minimum Variance Portfolio Statistics

def print_port_res(w, r, title, ppy=252, tgt=None, rf=rf):
    width = len(title)
    rp = r.dot(w)
    mu = ppy * rp.mean()
    sigma = np.sqrt(ppy) * rp.std()
    if tgt is not None:
        er = rp.sub(tgt)
        sr = np.sqrt(ppy) * er.mean() / er.std()
    elif rf is not None:
        sr = (mu - rf) / sigma
```

```
    else:
        sr = None
    return print(
        title,
        '=' * width,
        '',
        'Performance',
        '-' * width,
        'Return:'.ljust(width - 6) + f'{mu:0.4f}',
        'Volatility:'.ljust(width - 6) + f'{sigma:0.4f}',
        'Sharpe Ratio:'.ljust(width - 6) + f'{sr:0.4f}\n' if sr is not None␣
 ↪else '',
        'Weights',
        '-' * width,
        '\n'.join([f'{_r}:'.ljust(width - 6) + f'{_w:0.4f}' for _r, _w in zip(r.
 ↪columns, w)]),
        sep='\n',
    )

print_port_res(w=res_mv['x'], r=returns, title='Global Minimum Variance␣
 ↪Portfolio', rf=rf)
```

```
Global Minimum Variance Portfolio
==================================

Performance
---------------------------------
Return:                     4.6811
Volatility:                 0.8185
Sharpe Ratio:               5.6673

Weights
---------------------------------
AMZN:                       0.1720
LLY:                        0.2783
NVDA:                       0.0156
TSLA:                       0.0000
UNH:                        0.5341
```

[11]:
```
# Find the Maximum Sharpe Ratio Portfolio with minimize() function from SciPy's␣
 ↪optimize module

res_max_sharpe = sco.minimize(
    fun=neg_sharpe_ratio,
    x0=np.ones(len(returns.columns)) / len(returns.columns),
    args=(returns, rf),
    method='SLSQP',
```

```
    bounds=[(0,1) for _ in range(len(returns.columns))],
    constraints=({'type': 'eq', 'fun': lambda x: np.sum(x) - 1})
)

max_sharpe_weights = res_max_sharpe.x
max_sharpe_ret = port_mean(max_sharpe_weights, returns)
max_sharpe_vol = port_vol(max_sharpe_weights, returns)

res_max_sharpe;
```

[12]:
```
# The Maximum Sharpe Ratio Portfolio Statistics

def print_port_res(w, r, title, ppy=252, tgt=None, rf=rf):
    width = len(title)
    rp = r.dot(w)
    mu = ppy * rp.mean()
    sigma = np.sqrt(ppy) * rp.std()
    if tgt is not None:
        er = rp.sub(tgt)
        sr = np.sqrt(ppy) * er.mean() / er.std()
    elif rf is not None:
        sr = (mu - rf) / sigma
    else:
        sr = None
    return print(
        title,
        '=' * width,
        '',
        'Performance',
        '-' * width,
        'Return:'.ljust(width - 6) + f'{mu:0.4f}',
        'Volatility:'.ljust(width - 6) + f'{sigma:0.4f}',
        'Sharpe Ratio:'.ljust(width - 6) + f'{sr:0.4f}\n' if sr is not None␣
 ↪else '',
        'Weights',
        '-' * width,
        '\n'.join([f'{_r}:'.ljust(width - 6) + f'{_w:0.4f}' for _r, _w in zip(r.
 ↪columns, w)]),
        sep='\n',
    )

print_port_res(w=res_max_sharpe['x'], r=returns, title='Maximum Sharpe Ratio␣
 ↪Portfolio', rf=rf)
```

```
Maximum Sharpe Ratio Portfolio
==============================
```

```
Performance
------------------------------
Return:                 7.2502
Volatility:             0.9655
Sharpe Ratio:           7.4652

Weights
------------------------------
AMZN:                   0.0000
LLY:                    0.4717
NVDA:                   0.2425
TSLA:                   0.0000
UNH:                    0.2859
```

[13]:
```
# Define target return

tret = 252 * np.linspace(returns.mean().min(), returns.mean().max(), 100)
tret;
```

[14]:
```
# Find the Efficient Frontier with minimize() function from SciPy's optimize␣
 ↪module

res_ef = []
for t in tret:
    _ = sco.minimize(
        fun=port_vol,
        x0=np.ones(len(returns.columns)) / len(returns.columns),
        args=(returns,),
        bounds=[(0,1) for _ in range(len(returns.columns))],
        constraints=(
            {'type': 'eq', 'fun': lambda x: np.sum(x) - 1},
            {'type': 'eq', 'fun': lambda x: port_mean(x, returns) - t}
        )
    )
    res_ef.append(_)
```

[15]:
```
# Create the Efficient Frontier Dataframe

ef = pd.DataFrame(
    {
        'tret': tret,
        'tvol': np.array([r['fun'] if r['success'] else np.nan for r in res_ef])
    }
)

ef.head();
```

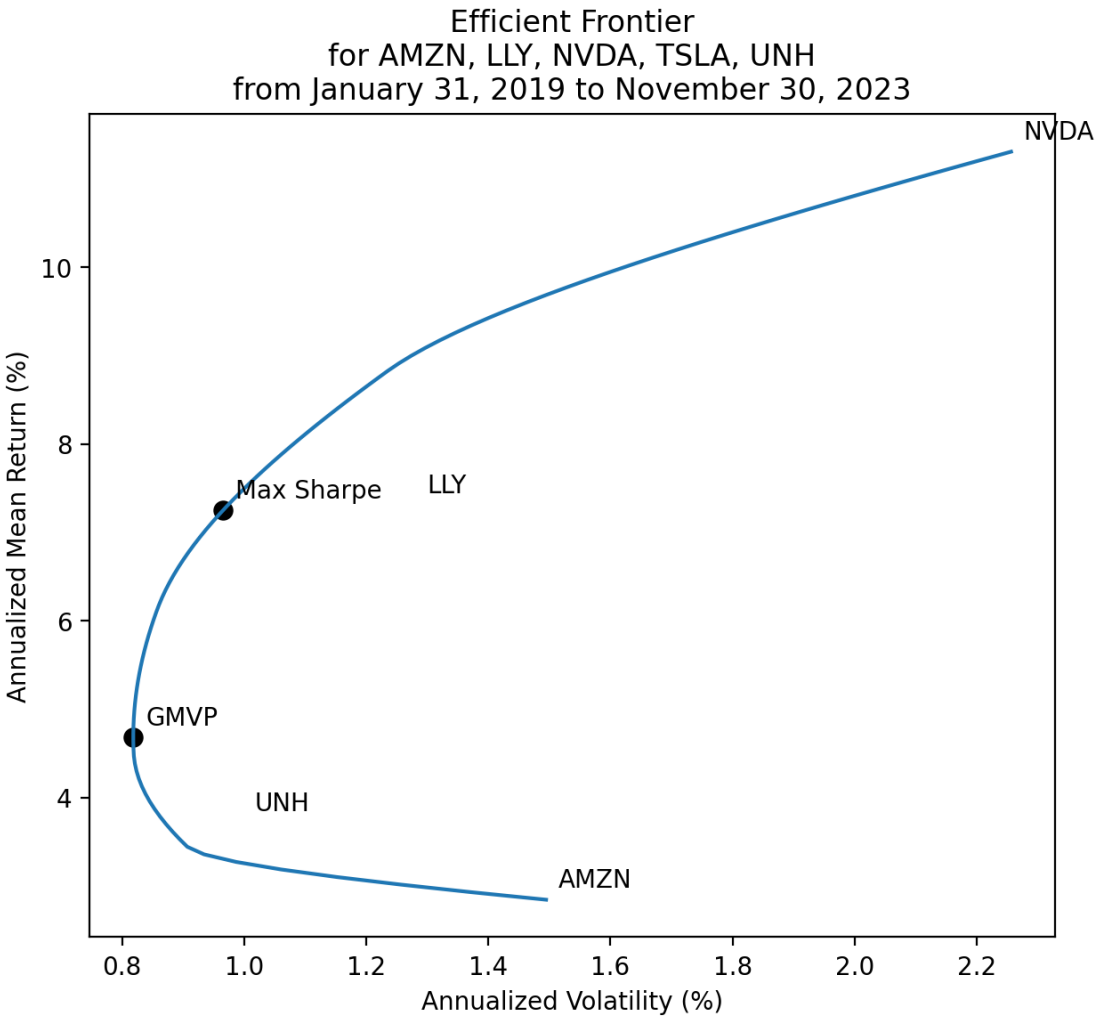
[16]:
```
# Plot the Efficient Frontier with target return

ef.plot(x='tvol', y='tret', legend=False, figsize=(7, 6))
plt.ylabel('Annualized Mean Return (%)')
plt.xlabel('Annualized Volatility (%)')
plt.title(
    f'Efficient Frontier' +
    f'\nfor {", ".join(returns.columns)}' +
    f'\nfrom {returns.index[-1]:%B %d, %Y} to {returns.index[0]:%B %d, %Y}'
)

for t, x, y in zip(
    returns.columns,
    returns.std().mul(np.sqrt(252)),
    returns.mean().mul(252)
):
    plt.annotate(text=t, xy=(x, y), xytext=(5, 5), textcoords='offset points')

# Plot the GMVP
plt.scatter(gmvp_vol, gmvp_ret, color='black', marker='o', s=50)
plt.annotate('GMVP', xy=(gmvp_vol, gmvp_ret), xytext=(5, 5), textcoords='offset␣
 ↪points', color='black')

# Plot the Maximum Sharpe Ratio Portfolio
plt.scatter(max_sharpe_vol, max_sharpe_ret, color='black', marker='o', s=50)
plt.annotate('Max Sharpe', xy=(max_sharpe_vol, max_sharpe_ret), xytext=(5, 5),␣
 ↪textcoords='offset points', color='black')
plt.show()
```


Efficient Frontier
for AMZN, LLY, NVDA, TSLA, UNH
from January 31, 2019 to November 30, 2023
NVDA
10
8
6
4
Annualized Mean Return (%)
Max Sharpe
LLY
GMVP
UNH
AMZN
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
Annualized Volatility (%)