Portfolio Optimization

김태영

1. Input Data EDA

Return & Risk for Input Data

	Returns	Risk	Sharpe Ratio	Max Returns	Min Returns	Median Returns	Total Return
USYC2Y10 Index	0.080298	4.021143	0.017482	230.000000	-84.875000	0.000000	-0.455644

1. Input Data EDA

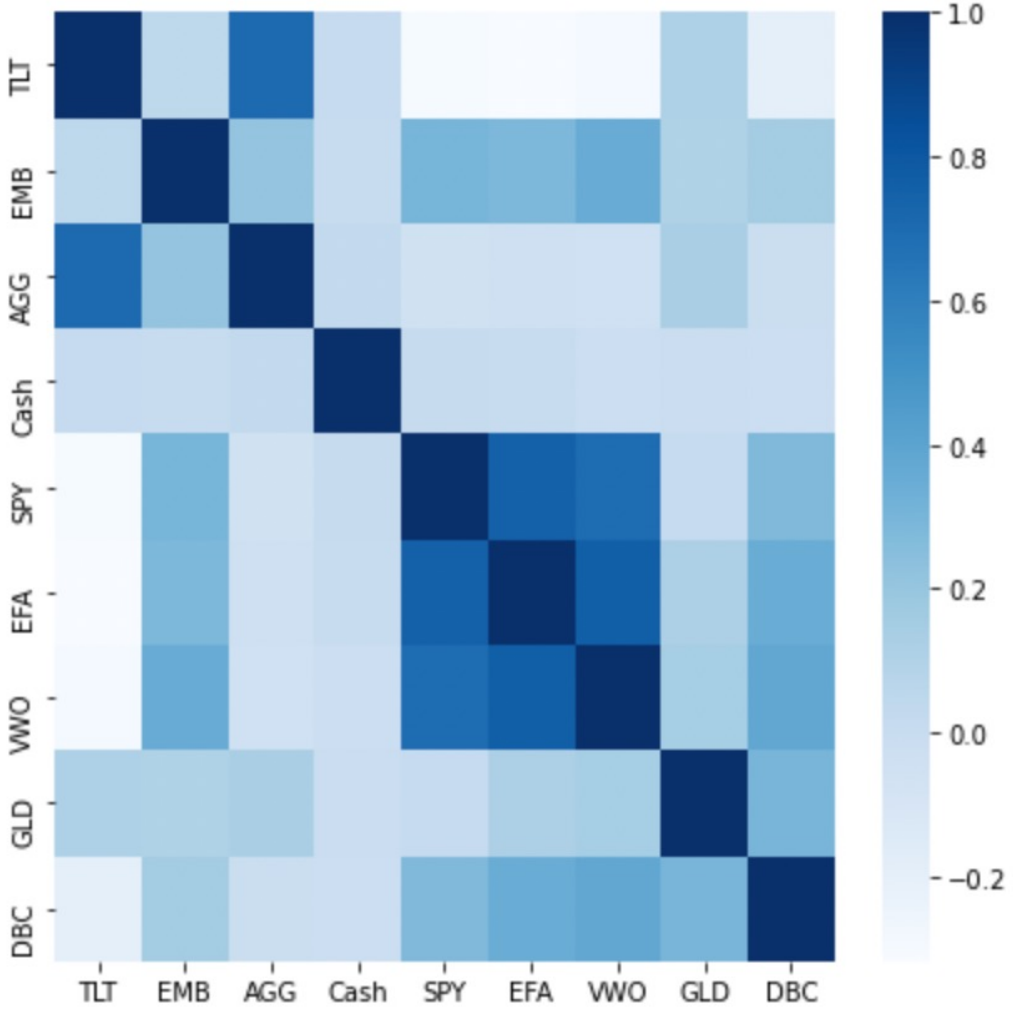
Return & Risk for Input Data

2. Target Data EDA

Return & Risk for Target Data

2. Target Data EDA

Target Data Correlation



2. Target Data EDA

Target Data Detail

	Returns	Risk	Sharpe Ratio	Max Returns	Min Returns	Median Returns	Total Return
TLT	0.000310	0.007899	-1.226716	0.075196	-0.066683	0.000246	0.231300
EMB	0.000365	0.006937	-1.388965	0.100498	-0.101104	0.000088	0.288800
AGG	0.000205	0.002862	-3.422357	0.038688	-0.068395	0.000156	0.104900
Cash	0.000177	0.000237	-41.454003	0.004194	-0.000105	0.000108	0.002429
SPY	0.000466	0.011981	-0.795774	0.145197	-0.109424	0.000485	-0.657000
EFA	0.000282	0.012521	-0.776152	0.158875	-0.123889	0.000000	-1.251600
VWO	0.000298	0.015119	-0.641707	0.202822	-0.153423	0.000672	-1.469200
GLD	0.000269	0.010164	-0.957426	0.112905	-0.087808	0.000000	-0.336900
DBC	0.000226	0.011282	-0.866286	0.068745	-0.077844	0.000036	-0.830600

3. The ways of setting weights

Maximize Sharpe-Ratio, Optimization (MVO)

```
Asset labels of Portfolio:
 ['TLT', 'EMB', 'AGG', 'Cash', 'SPY', 'EFA', 'VWO', 'GLD', 'DBC']

Mean Returns:
 [0.031 0.037 0.021 0.018 0.047 0.028 0.03  0.027 0.023]

Variance-Covariance Matrix of Returns:
 [[ 0.624  0.024  0.159  0.     -0.287 -0.314 -0.354  0.089 -0.168]
 [ 0.024  0.481  0.042  0.      0.25   0.245  0.37   0.072  0.122]
 [ 0.159  0.042  0.082  0.     -0.019 -0.014 -0.021  0.039 -0.005]
 [ 0.     0.     0.     0.001  0.     0.    -0.001 -0.    -0.001]
 [-0.287  0.25  -0.019  0.      1.435  1.124  1.255  0.018  0.378]
 [-0.314  0.245 -0.014  0.      1.124  1.568  1.441  0.15   0.495]
 [-0.354  0.37  -0.021 -0.001  1.255  1.441  2.286  0.222  0.648]
 [ 0.089  0.072  0.039 -0.      0.018  0.15   0.222  1.033  0.339]
 [-0.168  0.122 -0.005 -0.001  0.378  0.495  0.648  0.339  1.273]]

Risk free rate (daily %): 0.000
Maximal Sharpe Ratio:  [[11.713]]
Annualized Risk (%):   [[0.378]]
Annualized Expected Portfolio Return(%):   [4.455]

Optimal weights (%):
 [[ 0.366]
 [ 0.   ]
 [ 0.   ]
 [99.49 ]
 [ 0.   ]
 [ 0.   ]
 [ 0.   ]
 [ 0.144]
 [ 0.   ]]
```

3. The ways of setting weights

Maximize Sharpe-Ratio, Optimization (MVO)

```
# weight = Clusetered_Bond -> 6, Clustered_Stock -> 4
# TLT, AGG, GLD, CASH = 0.6
# EMB, SPY, EFA, VWD, DBC = 0.4


weights = np.array([0.15, 0.15, 0.15, 0.15, 0.06, 0.01,
                    0.14, 0.08, 0.11])
```

```
Daily Portfolio Risk: 0.17 %

Annualized Portfolio Risk: 6.62 %

Daily Portfolio Return: 0.03 %

Annualized Expected Portfolio Return: 6.97 %

PortfolioSharpe Ratio: 1.05 %
```

4. Rebalancing & Extracting Weight

Rebalancing Portfolio with Transaction

```
# extract the optimal solution (rebalanced weights)
OptimalRebalWeights = HOFIndividualW
print('Optimal Rebalanced Portfolio Weights', OptimalRebalWeights)

# compute  risk, return and Sharpe Ratio of the optimal rebalanced portfolio
DailyRebalancedPortfolioReturn = np.sum(np.multiply(MeanData, OptimalRebalWeights))

# number of trading days = 261
AnnualRebalancedPortfolioReturn =  261 * DailyRebalancedPortfolioReturn*100
print('Rebalanced portfolio annualized return ', AnnualRebalancedPortfolioReturn)

DailyRebalancedPortfolioRisk= np.sqrt(np.matmul( np.matmul(OptimalRebalWeights, CovData), OptimalRebalWeights.T))


AnnualRebalancedPortfolioRisk = np.sqrt(261)* DailyRebalancedPortfolioRisk*100
print('Rebalanced portfolio annualized risk ', AnnualRebalancedPortfolioRisk)

SharpeRatio  = (AnnualRebalancedPortfolioReturn-RiskFreeRate)/AnnualRebalancedPortfolioRisk
print('Rebalanced portfolio Sharpe Ratio', SharpeRatio)

# compare results with risk, return and Sharpe Ratio of the original portfolio
print('Original portfolio annualized return ', OriginalPortfolioAnnReturn)
print('Original portfolio annualized risk ', OriginalPortfolioAnnRisk)
print('Original portfolio Sharpe Ratio', OriginalPortfolioSharpeRatio)
```

```
['TLT', 'EMB', 'AGG', 'Cash', 'SPY', 'EFA', 'VWO', 'GLD', 'DBC']

Optimal Rebalanced Portfolio Weights [0.081 0.107 0.205 0.265 0.071 0.035 0.135 0.06  0.042]
Rebalanced portfolio annualized return  87024145.93077376
Rebalanced portfolio annualized risk  92906.87221109867
Rebalanced portfolio Sharpe Ratio 936.6814728521002
Original portfolio annualized return  6.58
Original portfolio annualized risk  5.53
Original portfolio Sharpe Ratio 1.19
```

5. LSTM

Rebalancing Portfolio with Transaction

```
for data in train_data.take(1):
    print(f'데이터셋(X) 구성(batch_size, window_size, feature갯수): {data[0].shape}')
    print(f'데이터셋(Y) 구성(batch_size, window_size, feature갯수): {data[1].shape}')
```

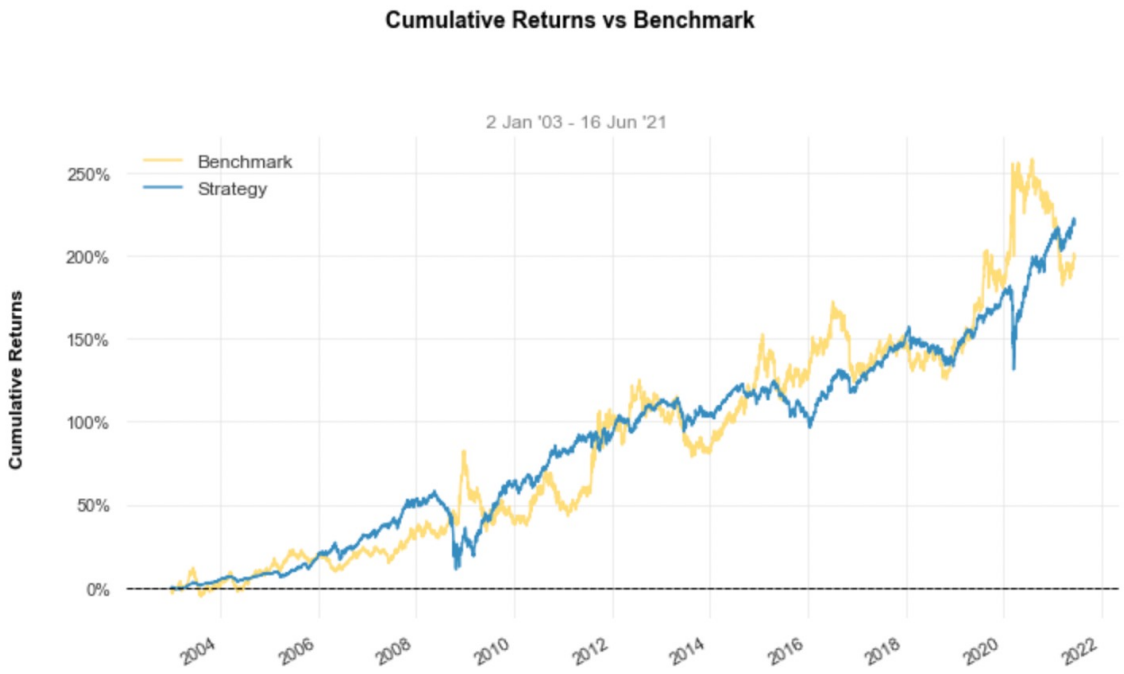
```
데이터셋(X) 구성(batch_size, window_size, feature갯수): (32, 20, 30)
데이터셋(Y) 구성(batch_size, window_size, feature갯수): (32,)
```

6. Without Cash

Backtesting

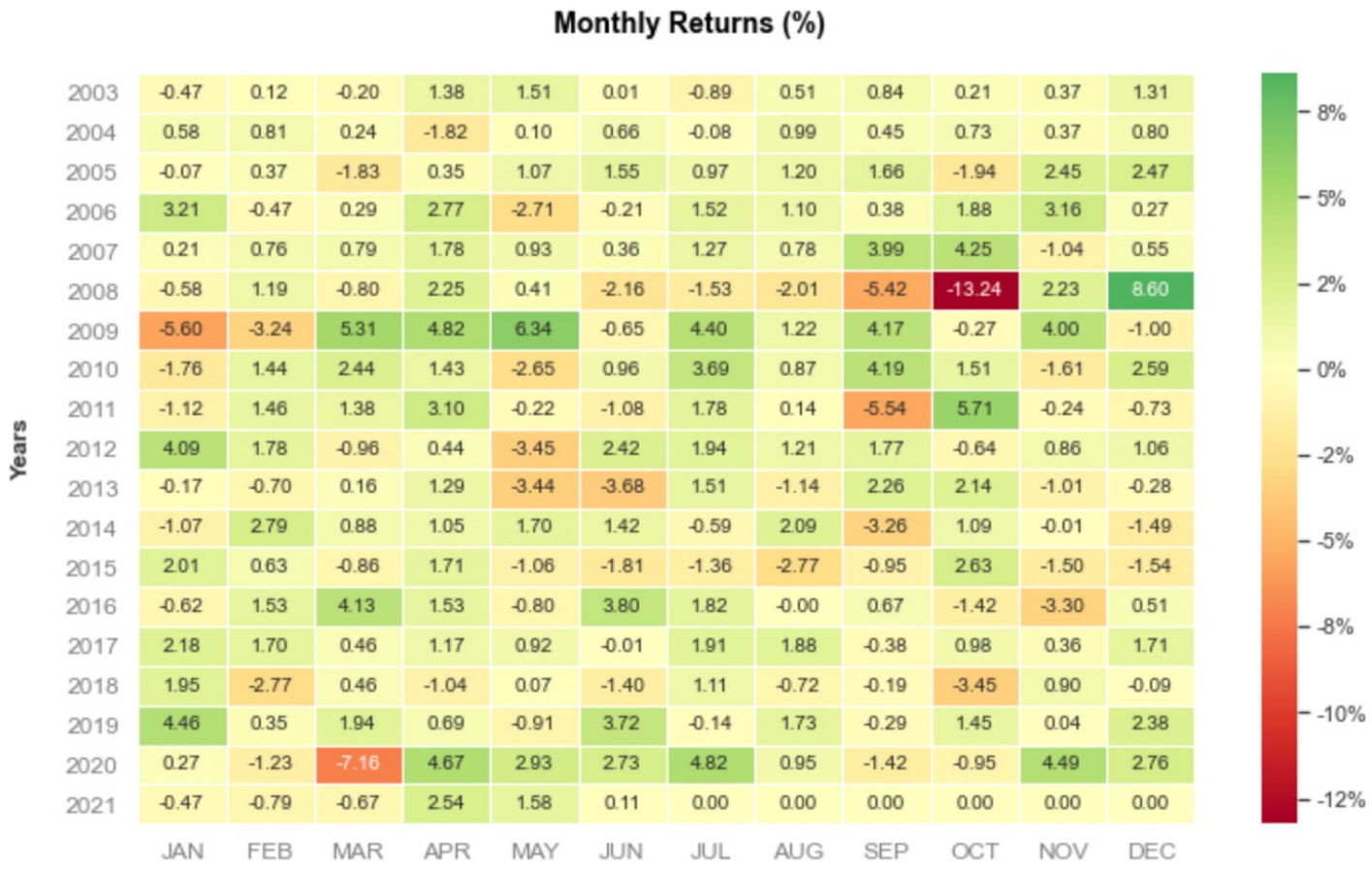
```
p = Engine(
start_date = '2003-01-01',
portfolio = ['TLT', 'EMB', 'AGG', 'SPY', 'EFA', 'VWO', 'GLD', 'DBC'],
weights = [0.11, 0.145, 0.28, 0.096, 0.047, 0.183, 0.081, 0.057],
benchmark = ['EFA'])
```

	Backtest
Annual return	6.0%
Cumulative return	218.53%
Annual volatility	8.8 %
Winning day ratio	54.8%
Sharpe ratio	0.76
Calmar ratio	0.22
Information ratio	-0.0
Stability	0.95
Max Drawdown	-0.3 %
Sortino ratio	1.08
Skew	-0.13
Kurtosis	19.57
Tail Ratio	0.99
Common sense ratio	1.14
Daily value at risk	-1.0 %
Alpha	0.03
Beta	0.34



6. Without Cash

Feature Correlation



6. Without Cash

Drawdown Point

6. Regression Analysis

Volatility

THANK YOU