Equity Asset Allocation Exploration using Monte Carlo Simulation

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- **Why**
- **How to Implement**
    - Time Series Analysis
    - Efficient Frontier and Sharpe ratio
    - Monte Carlo Simulation
- **What’s the output**

WorkFlow

Stocks Selection
(S&P 500)

Forcasting

Portfolio Structure

Monte Carlo Simulation

Portfolio Implementation

Asset Allocation

- Forecasting: To use Time Series Analysis to forecast the stock movement
- Monte Carlo Simulation: To simulate the optimal weights with highest Sharpe ratio within 10,000 iterations
- Asset Allocation: To constructure the portfolio with selected stocks using the weights aforementioned

Time Series Analysis - Long Short Term Memory

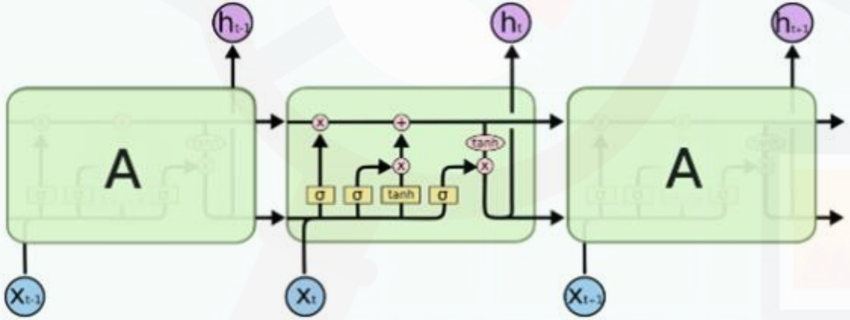
- Long term dependency
- Chain structure
- 3 gates

$$i_t = \sigma(w_i[h_{t-1}, x_t] + b_i)$$

$$f_t = \sigma(w_f[h_{t-1}, x_t] + b_f)$$

$$o_t = \sigma(w_o[h_{t-1}, x_t] + b_o)$$

Equation of Gates



The repeating module in an LSTM contains four interacting layers.

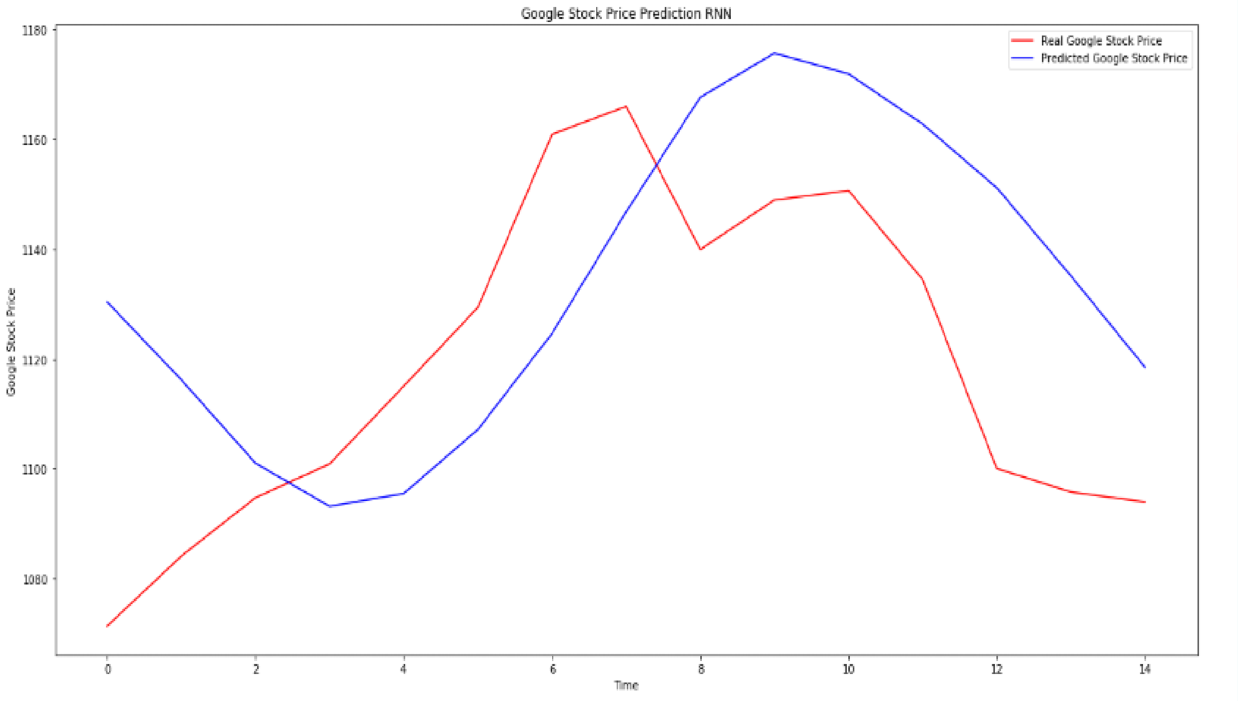
$$\tilde{c}_t = tanh(w_c[h_{t-1}, x_t] + b_c)$$

$$c_t = f_t * c_{t-1} + i_t * \tilde{c}_t$$

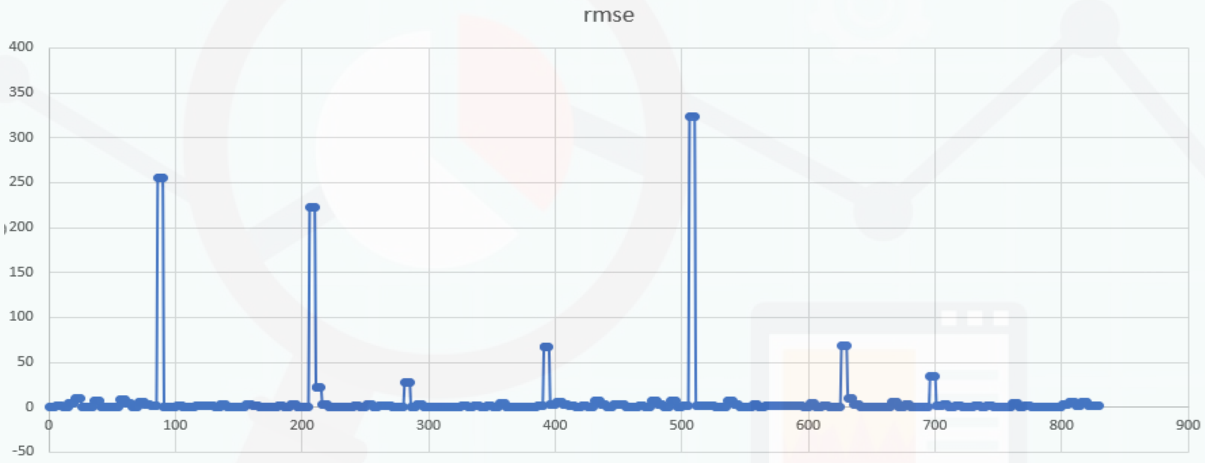
$$h_t = o_t * tanh(c^t)$$

Python Implementation and Resutls

```python
# Part 2 - Building the RNN

# Importing the Keras libraries and packages
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import LSTM
from keras.layers import Dropout

# Initialising the RNN
regressor = Sequential()

# Adding the first LSTM layer and some Dropout regularisation
regressor.add(LSTM(units = 50, return_sequences = True, input_shape = (X_train.shape[1], 1)
regressor.add(Dropout(0.2))

# Adding a second LSTM layer and some Dropout regularisation
regressor.add(LSTM(units = 50, return_sequences = True))
regressor.add(Dropout(0.2))

# Adding a third LSTM layer and some Dropout regularisation
regressor.add(LSTM(units = 50, return_sequences = True))
regressor.add(Dropout(0.2))

# Adding a fourth LSTM layer and some Dropout regularisation
regressor.add(LSTM(units = 50))
regressor.add(Dropout(0.2))

# Adding the output layer
regressor.add(Dense(units = 1))

# Compiling the RNN
regressor.compile(optimizer = 'adam', loss = 'mean_squared_error')
```



Python Implementation and Resutls



Date	Average RMSE	Median RMSE
1/4/2018	8.65	0.87
1/11/2018	6.84	1.00

- Time series analysis is a robust method to predict
- Only few outliers
- Suitable to analyze linear change stocks

Optimal Weights Decision - Monte Carlo Simulation

- Goal: to find out the optimal weights to be assigned to each selected stock to maximize the Sharpe ratio.

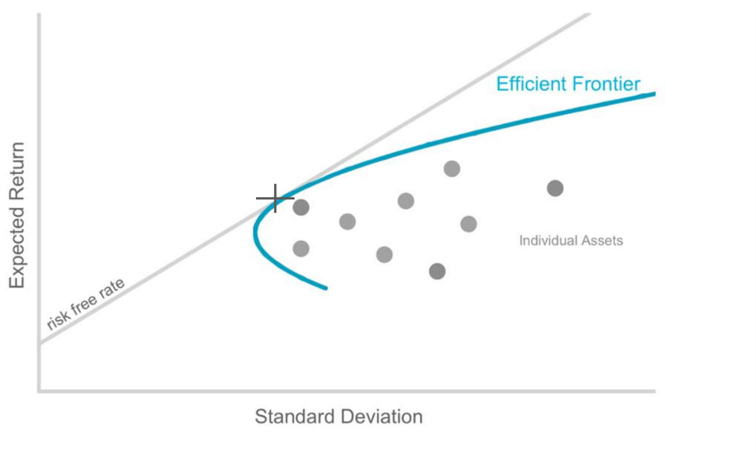
- Sharpe ratio: $S(x) = (r_x - R_f) / StdDev(x)$

r_x= return of portfolio
R_f = risk-free rate

- The greater a portfolio's Sharpe ratio, the better its risk-adjusted performance.

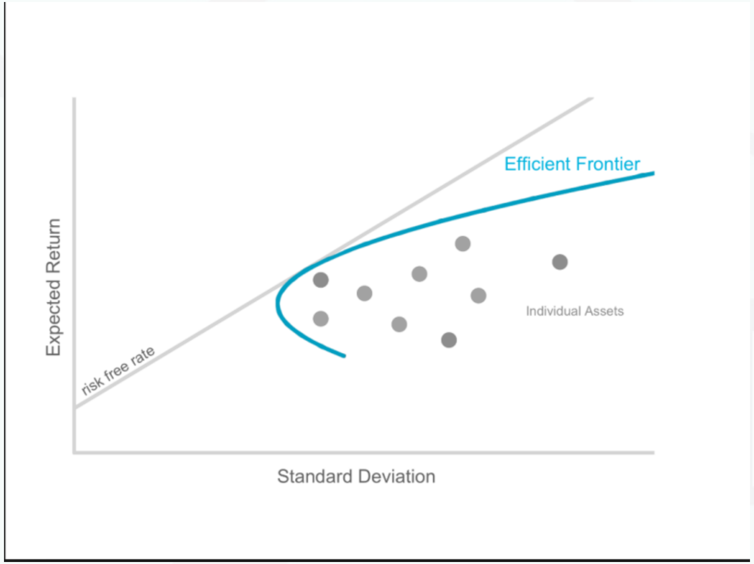
***Efficient Frontier* -** the curve consisting of optimal portfolios that offer the highest expected return for a defined level of risk

***x* -** the market portfolio resulting in the possible highest return per unit of risk taken, as measured by Sharpe ratio

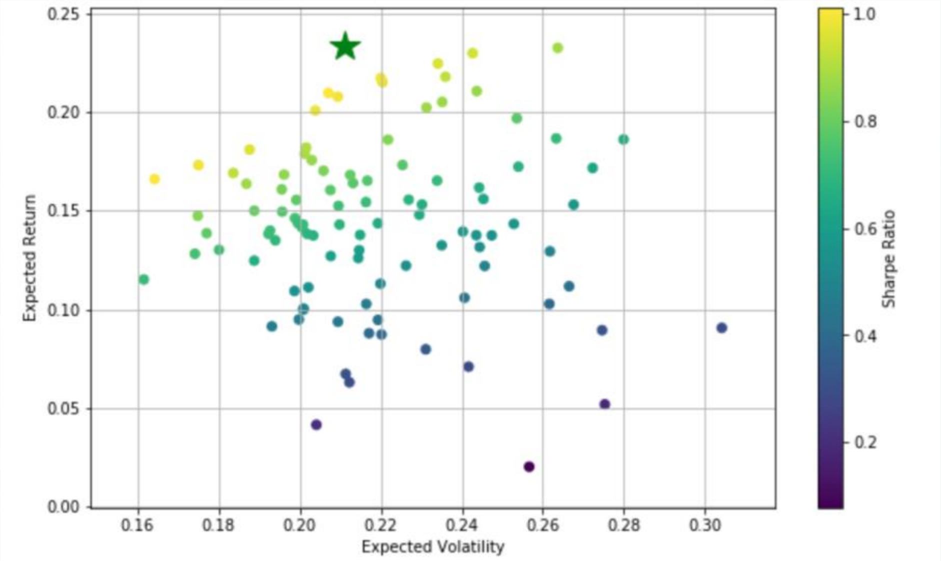


Python Code Implementation and Results

Theoretical output



Our run results:

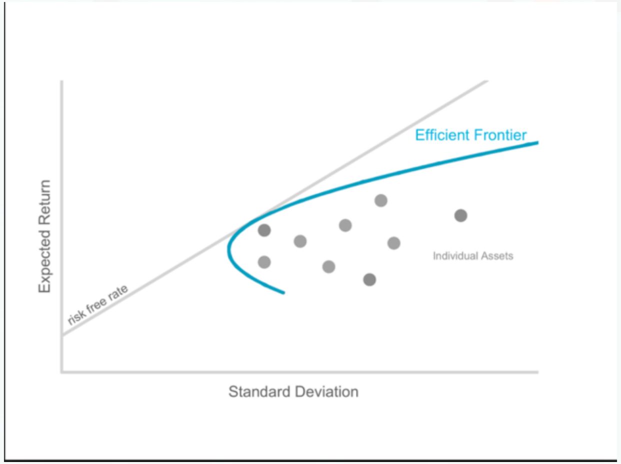


Model Output

annual_return	annual_vol	annual_sharpe_ratio	5days_return	source	DATE
835.93	3.87	216.28	3.32	Prediction	1/4/2018
509.39	22.68	22.46	2.02	real	1/4/2018
788.47	2.14	367.88	3.13	Prediction	1/11/2018
283.54	35.45	8.00	1.13	real	1/11/2018

- Sharpe Ratio
- Diversification

DATE	Ticker	Pred_Return	Real_Return	Weight
1/4/2018	AES	2.74	0.10	0.19999814
1/4/2018	BMY	4.15	0.50	0.19999804
1/4/2018	HSIC	3.15	2.17	0.20000146
1/4/2018	CCL	3.02	-0.17	0.20000113
1/4/2018	AGN	3.53	7.50	0.20000122
1/11/2018	CAH	3.65	7.89	0.20000867
1/11/2018	AIZ	3.07	-5.75	0.19999013
1/11/2018	ALXN	2.97	-0.09	0.19999823
1/11/2018	CCL	3.05	3.26	0.19999876
1/11/2018	ADM	2.90	0.31	0.20000421



Conclusion

- Time series analysis is a good method to perform prediction with linear changes.
- Modern portfolio theory tell us it’s important to have diversified assets in the portofolio
- Derivatives should be added in the portfolio to improve our strategy, i.e. to hedge the risk of unexpected sudden stock price drop.

Thank You