hull_mini_project

December 18, 2023

[ ]:
```
import yfinance as yf
import math
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

[ ]:
```
# Ticker symbol for S&P 500 index
ticker_symbol = '^GSPC'

# Fetch historical data
sp500_data = yf.download(ticker_symbol, start='1900-01-01', end='2023-12-31')

# Display the fetched data
print(sp500_data)
```

```
[*********************100%%**********************]  1 of 1 completed
                  Open         High          Low        Close    Adj Close  \
Date
1927-12-30    17.660000    17.660000    17.660000    17.660000    17.660000
1928-01-03    17.760000    17.760000    17.760000    17.760000    17.760000
1928-01-04    17.719999    17.719999    17.719999    17.719999    17.719999
1928-01-05    17.549999    17.549999    17.549999    17.549999    17.549999
1928-01-06    17.660000    17.660000    17.660000    17.660000    17.660000
…                   …            …            …            …            …
2023-12-12  4618.299805  4643.930176  4608.089844  4643.700195  4643.700195
2023-12-13  4646.200195  4709.689941  4643.229980  4707.089844  4707.089844
2023-12-14  4721.040039  4738.569824  4694.339844  4719.549805  4719.549805
2023-12-15  4714.229980  4725.529785  4704.689941  4719.189941  4719.189941
2023-12-18  4725.580078  4741.970215  4725.580078  4740.740234  4740.740234

                Volume
Date
1927-12-30           0
1928-01-03           0
1928-01-04           0
1928-01-05           0
1928-01-06           0
…                  …
```

```
2023-12-12  3808380000
2023-12-13  5063650000
2023-12-14  6314040000
2023-12-15  8218980000
2023-12-18   775319409

[24107 rows x 6 columns]
```

```
                  Open         High          Low        Close    Adj Close  \
Date
1927-12-30    17.660000    17.660000    17.660000    17.660000    17.660000
1928-01-03    17.760000    17.760000    17.760000    17.760000    17.760000
1928-01-04    17.719999    17.719999    17.719999    17.719999    17.719999
1928-01-05    17.549999    17.549999    17.549999    17.549999    17.549999
1928-01-06    17.660000    17.660000    17.660000    17.660000    17.660000
…                   …            …            …            …            …
2023-12-12  4618.299805  4643.930176  4608.089844  4643.700195  4643.700195
2023-12-13  4646.200195  4709.689941  4643.229980  4707.089844  4707.089844
2023-12-14  4721.040039  4738.569824  4694.339844  4719.549805  4719.549805
2023-12-15  4714.229980  4725.529785  4704.689941  4719.189941  4719.189941
2023-12-18  4725.580078  4741.970215  4725.580078  4740.740234  4740.740234

                Volume
Date
1927-12-30           0
1928-01-03           0
1928-01-04           0
1928-01-05           0
1928-01-06           0
…                  …
2023-12-12  3808380000
2023-12-13  5063650000
2023-12-14  6314040000
2023-12-15  8218980000
2023-12-18   775319409

[24107 rows x 6 columns]
```

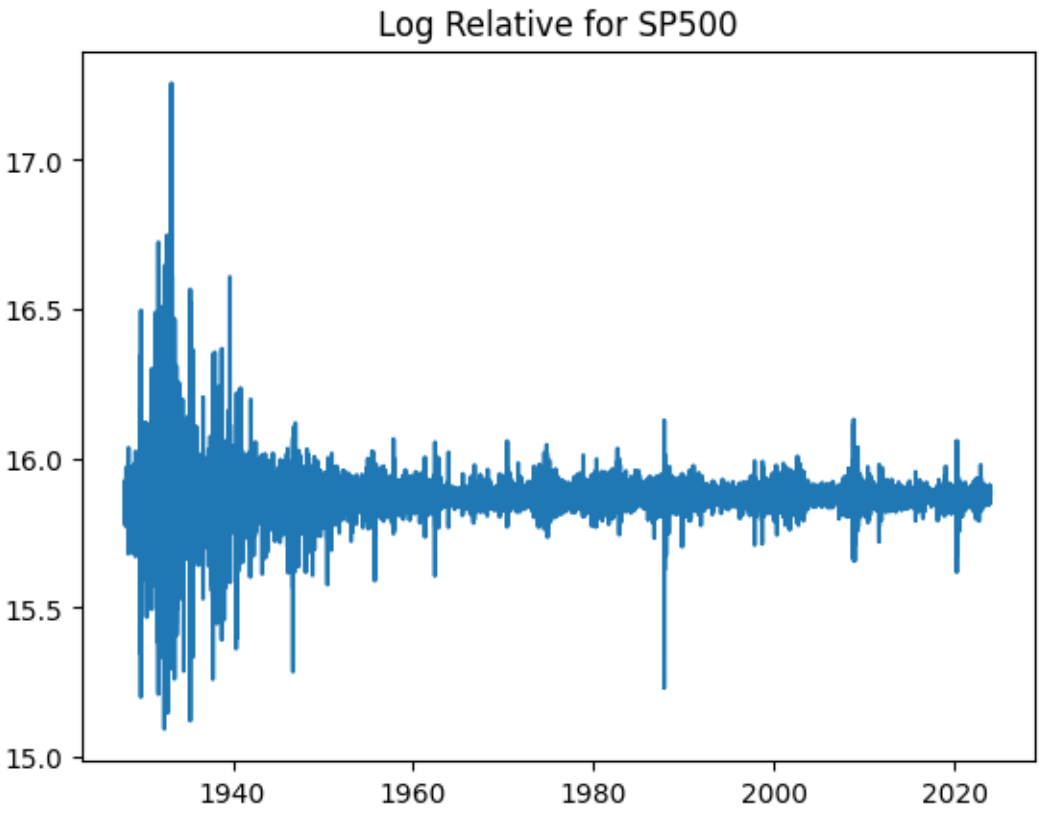
[ ]:
```
#LOG RELATIVE - currently not used
log_today = np.log(sp500_data['Close'])
log_yesterday =np.log(sp500_data['Close'].shift(1))
sqrt_252 = np.sqrt(252)
log_data = (log_today/log_yesterday)*sqrt_252
log_data
```

[ ]:
```
Date
1927-12-30          NaN
```

```
1928-01-03    15.905726
1928-01-04    15.862066
1928-01-05    15.821274
1928-01-06    15.909128
                 …
2023-12-12    15.883140
2023-12-13    15.899999
2023-12-14    15.879470
2023-12-15    15.874365
2023-12-18    15.883058
Name: Close, Length: 24107, dtype: float64
```

[ ]:
```
plt.plot(log_data)
plt.title('Log Relative for SP500')
```

[ ]:
```
Text(0.5, 1.0, 'Log Relative for SP500')
```



[ ]:
```
#CALCULATE GARMAN KLASS FOR EACH DAY

# Download S&P 500 data from Yahoo Finance
sp500 = yf.download('^GSPC', start='1983-01-01', end='2023-12-31')
```

```python
# Calculate Garman-Klass estimator for each day
def calculate_gk_estimator(high, low, open_price, close):
    log_hl = np.log(high / low)
    log_co = np.log(close / open_price)
    log_co_square = log_co ** 2
    return np.sqrt((1 / (2)) * np.sum(log_hl ** 2 - (2 * np.log(2) - 1) *␣
 ↪log_co_square))

# Create an empty list to store daily estimators
gk_estimators = []

# Iterate through the dataset day by day
for i in range(len(sp500)):
    high = sp500['High'].iloc[i]
    low = sp500['Low'].iloc[i]
    open_price = sp500['Open'].iloc[i]
    close = sp500['Close'].iloc[i]

    # Calculate the Garman-Klass estimator for the current day
    gk_est = calculate_gk_estimator(high, low, open_price, close)
    gk_estimators.append(gk_est)

# Add the daily estimators to the DataFrame
sp500['Garman_Klass_Estimator'] = gk_estimators

# Displaying the DataFrame with the Garman-Klass estimator for each day
print(sp500[['Open', 'High', 'Low', 'Close', 'Garman_Klass_Estimator']])
plt.plot(sp500['Garman_Klass_Estimator'])
plt.title('Garman_Klass_Estimator')
```

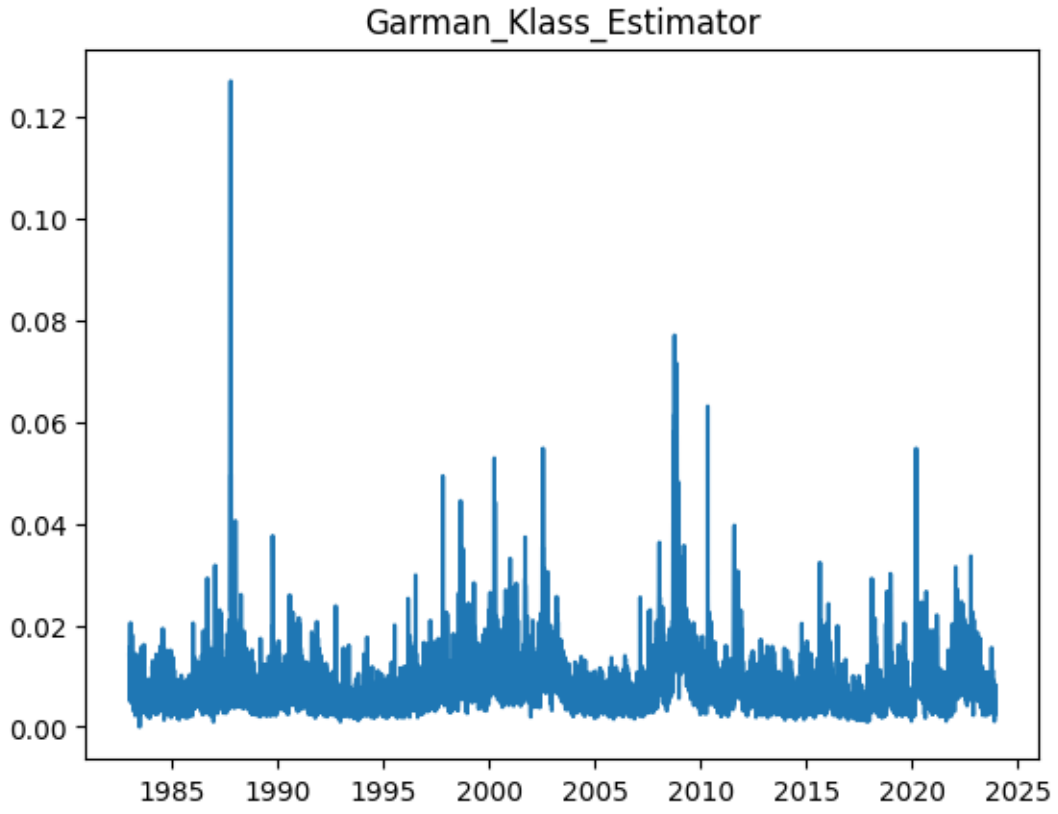
```
[**********************100%%**********************]  1 of 1 completed
                  Open         High          Low        Close  \
Date
1983-01-03   140.649994   141.330002   138.199997   138.339996
1983-01-04   138.330002   141.360001   138.080002   141.360001
1983-01-05   141.350006   142.600006   141.149994   141.960007
1983-01-06   142.009995   145.770004   142.009995   145.270004
1983-01-07   145.270004   146.460007   145.149994   145.179993
…                   …            …            …            …
2023-12-12  4618.299805  4643.930176  4608.089844  4643.700195
2023-12-13  4646.200195  4709.689941  4643.229980  4707.089844
2023-12-14  4721.040039  4738.569824  4694.339844  4719.549805
2023-12-15  4714.229980  4725.529785  4704.689941  4719.189941
2023-12-18  4725.580078  4746.629883  4725.580078  4742.859863

            Garman_Klass_Estimator
Date
```

```
1983-01-03                0.014065
1983-01-04                0.013598
1983-01-05                0.006975
1983-01-06                0.015555
1983-01-07                0.006347
…                              …
2023-12-12                0.004920
2023-12-13                0.008261
2023-12-14                0.006630
2023-12-15                0.003091
2023-12-18                0.002703

[10326 rows x 5 columns]
```

[ ]:
```
Text(0.5, 1.0, 'Garman_Klass_Estimator')
```



[ ]:
```
#HAR MODEL
import statsmodels.api as sm

# Assuming you have a pandas DataFrame 'data' with a column 'volatility'␣
 ↪representing daily volatility
```

```python
# Replace this with your actual dataset and column names

# Calculating different volatility measures
sp500['yesterday_volatility'] = sp500['Garman_Klass_Estimator'].shift(1)
sp500['avg_2_5_day_volatility'] = sp500['Garman_Klass_Estimator'].
 ↪rolling(window=5).mean()
sp500['avg_6_21_day_volatility'] = sp500['Garman_Klass_Estimator'].
 ↪rolling(window=16).mean()

# Dropping NaN values resulting from rolling means
data = sp500.dropna()

# Creating the HAR model
X = data[['yesterday_volatility', 'avg_2_5_day_volatility',␣
 ↪'avg_6_21_day_volatility']]
X = sm.add_constant(X)  # Adding a constant coefficient
y = data['Garman_Klass_Estimator']

# Fitting the model
model = sm.OLS(y, X).fit()

# Printing the model summary
print(model.summary())
```

```
                            OLS Regression Results
==============================================================================
==
Dep. Variable:     Garman_Klass_Estimator   R-squared:
0.674
Model:                               OLS   Adj. R-squared:
0.674
Method:                    Least Squares   F-statistic:
7106.
Date:                   Mon, 18 Dec 2023   Prob (F-statistic):
0.00
Time:                           10:59:30   Log-Likelihood:
44308.
No. Observations:                  10311   AIC:
-8.861e+04
Df Residuals:                      10307   BIC:
-8.858e+04
Df Model:                              3
Covariance Type:                nonrobust
==============================================================================
===========
                             coef    std err          t      P>|t|      [0.025
0.975]
```

```
------------------------------------------------------------------------------
-----------
const                         0.0003   6.74e-05      4.934      0.000       0.000
0.000
yesterday_volatility         -0.1303      0.010    -12.558      0.000      -0.151
-0.110
avg_2_5_day_volatility        1.2224      0.019     64.490      0.000       1.185
1.260
avg_6_21_day_volatility      -0.1340      0.017     -8.064      0.000      -0.167
-0.101
==============================================================================
Omnibus:                     7343.362   Durbin-Watson:                   1.560
Prob(Omnibus):                  0.000   Jarque-Bera (JB):          1473249.393
Skew:                           2.432   Prob(JB):                         0.00
Kurtosis:                      61.357   Cond. No.                         743.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```