ml-gwp01

June 20, 2024

[1]:
```python
# load libraries
import matplotlib.pyplot as plt
import numpy as np
import math
import pandas as pd
from scipy.optimize import brute, fmin
from scipy.integrate import quad
import yfinance as yf
from sklearn.linear_model import Lasso, LassoCV
```

1 STEP 2 - Computations

Category 1

[2]:
```python
# Create Training Dataset and Testing Dataset

# Define the ticker symbols and corresponding names
tickers = {
    'DXY': 'DX-Y.NYB',
    'GOLD': 'GLD',  # Gold ETF
    'SILVER': 'SLV',  # Silver ETF
    'US_STK': '^GSPC',
    'X13W_TB': '^IRX',
    'X10Y_TBY': '^TNX',
    'EURUSD': 'EURUSD=X'
}

# Define the start and end dates
start_date = '2022-01-01'
end_date = '2023-12-31'

# Fetch the data from Yahoo Finance
data = {}
for key, ticker in tickers.items():
    data[key] = yf.download(ticker, start=start_date, end=end_date)['Adj Close']

# Create a DataFrame with the fetched data
```

```
df = pd.DataFrame(data)

# Calculate daily returns
daily_returns = df.pct_change().dropna()

# Split the data into training and testing sets
train_data = daily_returns.loc['2022-01-01':'2022-12-31']
test_data = daily_returns.loc['2023-01-01':'2023-12-31']
```

```
[*********************100%%**********************]  1 of 1 completed
[*********************100%%**********************]  1 of 1 completed
[*********************100%%**********************]  1 of 1 completed
[*********************100%%**********************]  1 of 1 completed
[*********************100%%**********************]  1 of 1 completed
[*********************100%%**********************]  1 of 1 completed
[*********************100%%**********************]  1 of 1 completed
```

[3]:
```
# Separate training data into dependent (y) and independent (x) variables
train_data_y = train_data[['DXY']]
train_data_x = train_data.drop(columns=['DXY'])

# Separate testing data into dependent (y) and independent (x) variables
test_data_y = test_data[['DXY']]
test_data_x = test_data.drop(columns=['DXY'])
```

[4]:
```
# generate a sequence of lambdas to try
lambdas = [np.power(10, i) for i in np.arange(6, -6, -0.1)]

# Compile model
lasso_cv = LassoCV(cv=10, alphas=lambdas)
lasso_cv.fit(train_data_x,train_data_y)  # Fit Model

# Build final LASSO regression model
lasso_final = Lasso(alpha=lasso_cv.alpha_, fit_intercept=True)
lasso_final.fit(train_data_x,train_data_y)

print(
    "\n",
    pd.DataFrame(
        (lasso_final.coef_),
        index=['GOLD', 'SILVER', 'US_STK','X13W_TB', 'X10Y_TBY','EURUSD'],
        columns=["Coef."],
    ),
)
```

```
/usr/local/lib/python3.10/dist-
packages/sklearn/linear_model/_coordinate_descent.py:1568:
```

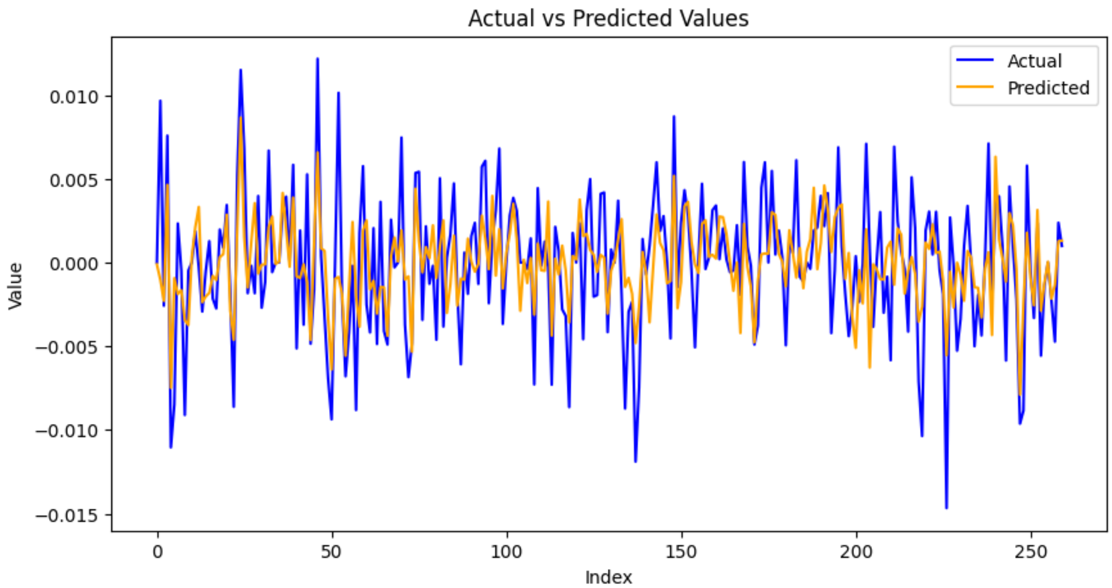
```
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples, ), for example using
ravel().
  y = column_or_1d(y, warn=True)
```

	Coef.
GOLD	-0.214884
SILVER	-0.015571
US_STK	-0.150072
X13W_TB	0.000691
X10Y_TBY	0.006786
EURUSD	-0.058955

[5]:
```python
# R squared formula and mean squared error
lasso_pred = lasso_final.predict(test_data_x)
#lasso_actual = test_data_y

# Ensure both predicted and actual values are in the same shape
lasso_actual = np.array(test_data_y).flatten()
lasso_pred = lasso_pred.flatten()

lasso_rss = np.sum(np.power(lasso_pred - lasso_actual, 2))
lasso_tss = np.sum(np.power(lasso_actual - np.mean(lasso_actual), 2))
lasso_rsq = 1 - lasso_rss / lasso_tss
print("\n LASSO_R^2: ", lasso_rsq)
```

```
 LASSO_R^2:  0.3963971289816126
```

[6]:
```python
# Predicting values using the Lasso model on test data
lasso_pred = lasso_final.predict(test_data_x)

# Assuming test_data_y is a pandas Series, reset the index
test_data_y_reset = test_data_y.reset_index(drop=True)
lasso_pred_reset = pd.Series(lasso_pred).reset_index(drop=True)

# Plotting the actual vs predicted values
plt.figure(figsize=(10, 5))
plt.plot(test_data_y_reset, label='Actual', color='blue')
plt.plot(lasso_pred_reset, label='Predicted', color='orange')
plt.legend()
plt.xlabel('Index')
plt.ylabel('Value')
plt.title('Actual vs Predicted Values')
plt.show()
```



Category 2: Hierarchical Clustering

[7]:
```
import pandas as pd
import yfinance as yf
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.cluster.hierarchy import dendrogram, linkage, fcluster
from sklearn.preprocessing import StandardScaler
from scipy.spatial.distance import pdist
from sklearn.cluster import AgglomerativeClustering


plt.style.use("seaborn-darkgrid")
sns.set_theme()
%matplotlib inline
```

```
<ipython-input-7-31bce5a85774>:11: MatplotlibDeprecationWarning: The seaborn
styles shipped by Matplotlib are deprecated since 3.6, as they no longer
correspond to the styles shipped by seaborn. However, they will remain available
as 'seaborn-v0_8-<style>'. Alternatively, directly use the seaborn API instead.
  plt.style.use("seaborn-darkgrid")
```

[8]:
```
#downloading forex data
def download_forex_data(tickers, start_date, end_date):
    data = {}
    for ticker in tickers:
        forex_data = yf.download(ticker, start=start_date, end=end_date)
        forex_data = forex_data.reset_index()
```

```
        data[ticker] = forex_data[['Date', 'Adj Close']]
        data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
    return data

tickers = ["USDEUR=X", "USDRUB=X", "USDGBP=X", "USDJPY=X", "USDKES=X",␣
 ↪"USDCNY=X",
           "USDKRW=X", "USDSGD=X", "USDTWD=X", "USDNGN=X", "USDZAR=X",␣
 ↪"USDMYR=X",
           "USDIDR=X", "USDTHB=X", "USDAUD=X", "USDNZD=X", "USDCAD=X",␣
 ↪"USDCHF=X",
           "USDNOK=X", "USDSEK=X", "USDARS=X", "USDPLN=X", "USDPHP=X",␣
 ↪"USDRON=X",
           "USDHUF=X", "USDBRL=X", "USDCLP=X", "USDMXN=X", "USDCOP=X",␣
 ↪"USDILS=X",
           "USDTRY=X", "USDINR=X"]
```

[9]:
```
start_date = "2019-01-02"
end_date = "2022-06-30"
forex_data = download_forex_data(tickers, start_date, end_date)
```

```
[*********************100%***********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%***********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%***********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%***********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
```

```
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
[*********************100%%**********************]  1 of 1 completed
<ipython-input-8-c9bdd524baff>:8: SettingWithCopyWarning:
```

```
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  data[ticker].rename(columns={'Adj Close': ticker}, inplace=True)
```

[10]:
```python
df_currencies = pd.concat([data.set_index('Date') for data in forex_data.
 ↪values()], axis=1)
df_currencies.fillna(method="ffill", inplace=True)
print(df_currencies.isna().sum().sum())
```

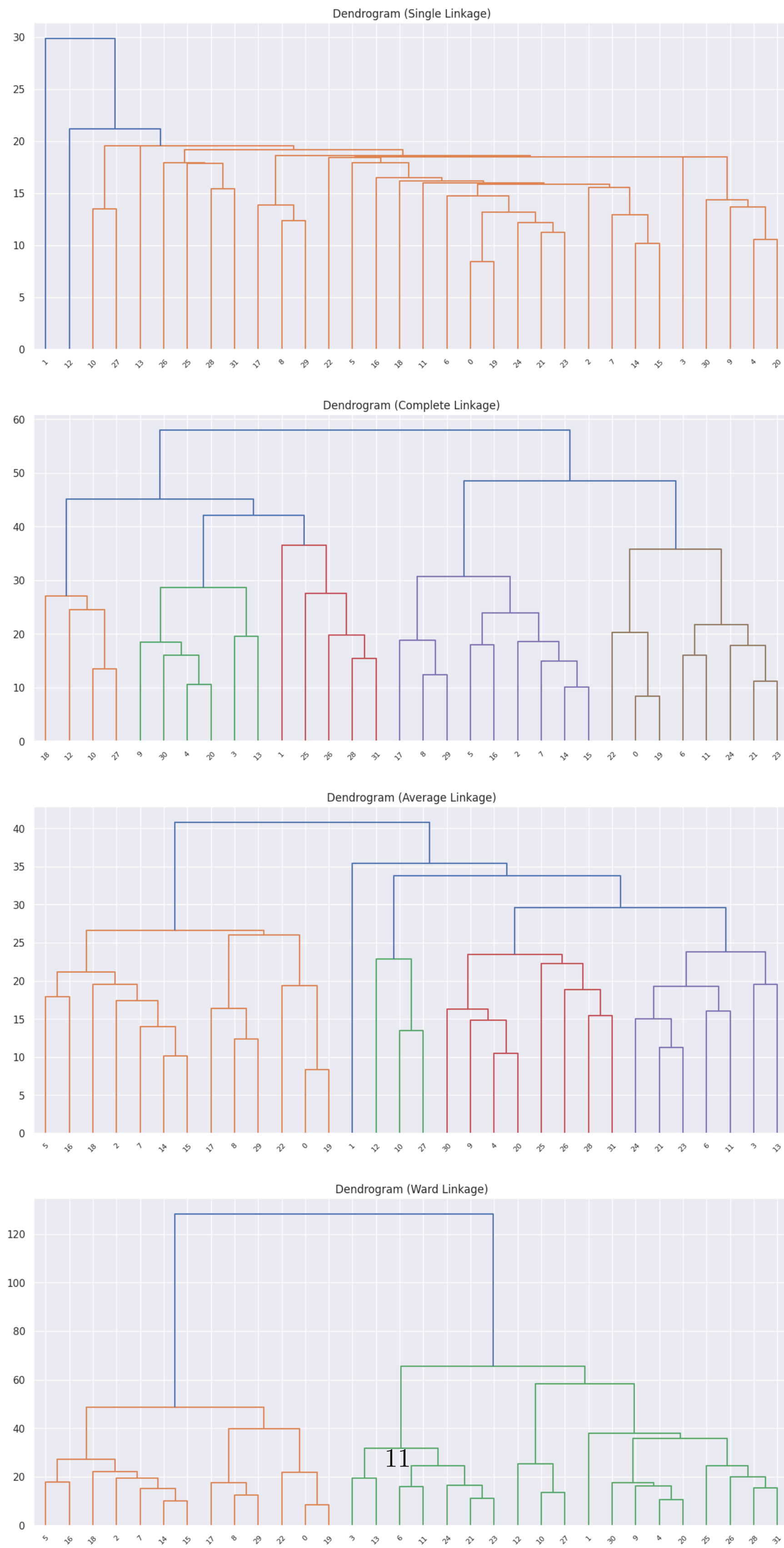
```
0
```

[11]:
```python
#Normalizng the data
sc = StandardScaler()
subset_scaled_df = pd.DataFrame(sc.fit_transform(df_currencies),␣
 ↪columns=df_currencies.columns)
```

[12]:
```python
#percentage returns
df_returns = (df_currencies / df_currencies.shift(-1)) - 1
subset_scaled_df.drop(subset_scaled_df.tail(1).index, inplace=True)

#hierarchical clustering using different linkage methods
linkage_methods = ["single", "complete", "average", "ward"]
```

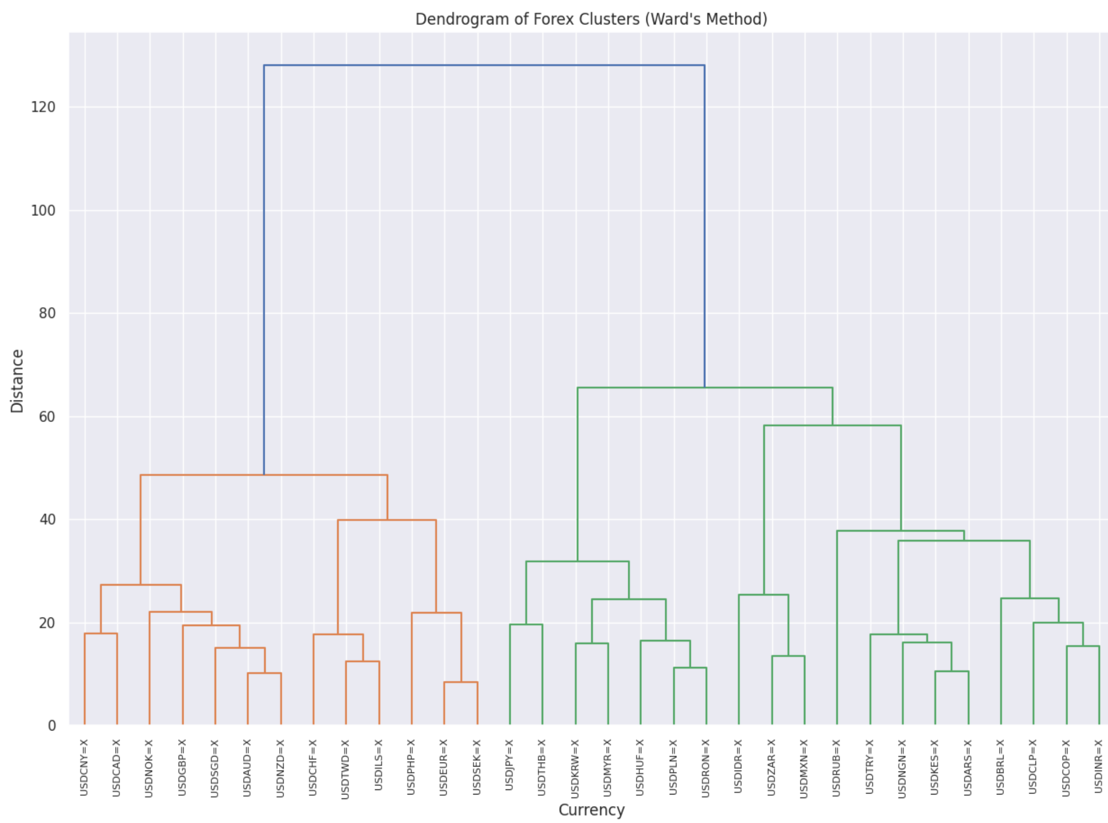
[13]:
```python
fig, axs = plt.subplots(len(linkage_methods), 1, figsize=(15, 30))
for i, method in enumerate(linkage_methods):
    Z = linkage(subset_scaled_df.T, method=method, metric="euclidean")
    dendrogram(Z, ax=axs[i])
    axs[i].set_title(f"Dendrogram ({method.capitalize()} Linkage)")
fig.suptitle("Dendrograms with Different Linkage Methods", fontweight="bold")
plt.show()
```

Dendrograms with Different Linkage Methods



[14]:
```
#Ward's method for clustering
Z = linkage(subset_scaled_df.T, method="ward", metric="euclidean")
```

[15]:
```
plt.figure(figsize=(15, 10))
plt.title("Dendrogram of Forex Clusters (Ward's Method)")
plt.xlabel("Currency")
plt.ylabel("Distance")
dendrogram(Z, labels=subset_scaled_df.columns, leaf_rotation=90)
plt.show()
```



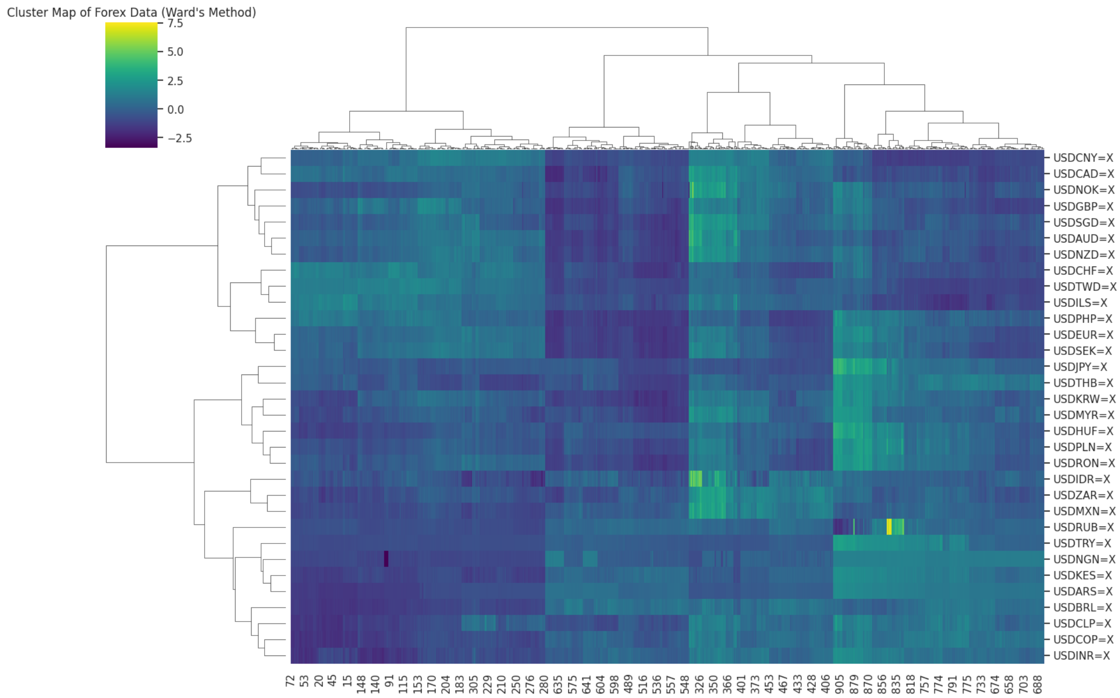
[16]:
```
num_clusters = 3
cluster_labels = fcluster(Z, num_clusters, criterion='maxclust')

#Adding cluster labels to the dataframe
df_currencies_t = df_currencies.T
df_currencies_t["Cluster"] = cluster_labels
```

[17]:
```
#Displaying cluster's composition
for cluster in df_currencies_t["Cluster"].unique():
    print(f"Cluster {cluster}:")
    print(df_currencies_t[df_currencies_t["Cluster"] == cluster].index.values)
    print("-" * 100)
```

```
Cluster 1:
['USDEUR=X' 'USDGBP=X' 'USDCNY=X' 'USDSGD=X' 'USDTWD=X' 'USDAUD=X'
 'USDNZD=X' 'USDCAD=X' 'USDCHF=X' 'USDNOK=X' 'USDSEK=X' 'USDPHP=X'
 'USDILS=X']
--------------------------------------------------------------------------------
--------------------
Cluster 3:
['USDRUB=X' 'USDKES=X' 'USDNGN=X' 'USDZAR=X' 'USDIDR=X' 'USDARS=X'
 'USDBRL=X' 'USDCLP=X' 'USDMXN=X' 'USDCOP=X' 'USDTRY=X' 'USDINR=X']
--------------------------------------------------------------------------------
--------------------
Cluster 2:
['USDJPY=X' 'USDKRW=X' 'USDMYR=X' 'USDTHB=X' 'USDPLN=X' 'USDRON=X'
 'USDHUF=X']
--------------------------------------------------------------------------------
--------------------
```

[18]:
```
#Visualization of clusters
sns.clustermap(subset_scaled_df.T, method="ward", metric="euclidean",␣
 ↪cmap="viridis", figsize=(15, 10))
plt.title("Cluster Map of Forex Data (Ward's Method)")
plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/seaborn/matrix.py:560: UserWarning:
Clustering large matrix with scipy. Installing `fastcluster` may give better
performance.
  warnings.warn(msg)
/usr/local/lib/python3.10/dist-packages/seaborn/matrix.py:560: UserWarning:
Clustering large matrix with scipy. Installing `fastcluster` may give better
performance.
  warnings.warn(msg)
```



[18]:

```

```

Category 3: Principal components

The method of PC analysis (PCA) is illustrated next. The application case is…

[19]:

```
# Load libraries
# Global Libraries
# Disable the warnings
import warnings
from datetime import datetime

import numpy as np
import pandas as pd
import pandas_datareader.data as web
import scipy as sp

# Plotting
import seaborn as sns
from matplotlib import pyplot
from sklearn.preprocessing import StandardScaler

warnings.filterwarnings("ignore")

from sklearn.decomposition import PCA
```

[20]:
```
# downloading the data: stock prices from S&P500
start = datetime(2012, 6, 19)
end = datetime(2022, 6, 19)

stocks = ['MSFT', 'NVDA', 'AAPL', 'AMZN', 'META', 'GOOGL', 'JPM', 'TSLA', 'XOM']

#for s in stocks:
data = web.DataReader(stocks, 'stooq', start=start, end=end).Close
df = data.copy()
```

[21]:
```
# calculate daily stock returns in terms of percentage changes
df = df.pct_change(1).dropna(axis=0)  #df.iloc[:-1]-df.iloc[1:]
#dd = dd.dropna(how="all").ffill()
print(df.head())
```

```
Symbols          MSFT      NVDA      AAPL      AMZN      META     GOOGL  \
Date
2022-06-16 -0.010823 -0.017569 -0.011398 -0.024101 -0.017528 -0.010351
2022-06-15  0.027719  0.059346  0.041283  0.038684  0.052713  0.035177
2022-06-14 -0.028880 -0.041800 -0.019716 -0.049782 -0.033186 -0.027778
2022-06-13 -0.009117 -0.011941 -0.006626  0.013293  0.003237 -0.003027
2022-06-10  0.044290  0.084807  0.039809  0.057683  0.068854  0.044834

Symbols           JPM      TSLA       XOM
Date
2022-06-16  0.003539 -0.016885  0.061194
2022-06-15  0.017463  0.093383  0.038297
2022-06-14 -0.011704 -0.051974  0.012752
2022-06-13  0.016920 -0.023328 -0.002601
2022-06-10  0.030697  0.076450  0.048096
```

[22]:
```
df.plot(figsize=(15, 8))
pyplot.ylabel("Return")
pyplot.legend(bbox_to_anchor=(1.01, 0.9), loc=2)
pyplot.suptitle(
    "Returns", fontweight="bold", horizontalalignment="right"
)
pyplot.show()
```

Let's now get principal components

[23]:
```python
# get principal components

# detrend data
df_std = (df - df.mean()) / df.std()
df_std.head()
```

[23]:
```
Symbols         MSFT      NVDA      AAPL      AMZN      META     GOOGL  \
Date
2022-06-16 -0.606816 -0.609575 -0.593081 -1.184953 -0.708300 -0.595895
2022-06-15  1.720559  2.256885  2.307826  1.994163  2.189672  2.204035
2022-06-14 -1.697216 -1.512615 -1.051088 -2.485299 -1.354306 -1.667646
2022-06-13 -0.503819 -0.399840 -0.330299  0.708481  0.148404 -0.145483
2022-06-10  2.721206  3.205771  2.226624  2.956169  2.855604  2.797919

Symbols          JPM      TSLA       XOM
Date
2022-06-16  0.236403 -0.442482  3.751031
2022-06-15  1.065606  2.669874  2.348533
2022-06-14 -0.671364 -1.432884  0.783799
2022-06-13  1.033288 -0.624346 -0.156628
2022-06-10  1.853761  2.191912  2.948771
```

[24]:
```python
# get covariance matrix
cov_matrix_array = np.array(np.cov(df_std, rowvar=False))

cov_df = pd.DataFrame(cov_matrix_array, columns=df.columns, index=df.columns)
```

```
cov_df
```

[24]:
```
Symbols      MSFT      NVDA      AAPL      AMZN      META     GOOGL       JPM  \
Symbols
MSFT     1.000000  0.592044  0.602031  0.571222  0.463380  0.675724  0.474186
NVDA     0.592044  1.000000  0.520977  0.495017  0.435469  0.544845  0.368798
AAPL     0.602031  0.520977  1.000000  0.481636  0.435784  0.551581  0.409802
AMZN     0.571222  0.495017  0.481636  1.000000  0.496748  0.613724  0.307693
META     0.463380  0.435469  0.435784  0.496748  1.000000  0.543076  0.303868
GOOGL    0.675724  0.544845  0.551581  0.613724  0.543076  1.000000  0.451644
JPM      0.474186  0.368798  0.409802  0.307693  0.303868  0.451644  1.000000
TSLA     0.379834  0.383449  0.363089  0.363691  0.304945  0.365202  0.259492
XOM      0.347618  0.268288  0.316177  0.229286  0.215389  0.358981  0.593158

Symbols      TSLA       XOM
Symbols
MSFT     0.379834  0.347618
NVDA     0.383449  0.268288
AAPL     0.363089  0.316177
AMZN     0.363691  0.229286
META     0.304945  0.215389
GOOGL    0.365202  0.358981
JPM      0.259492  0.593158
TSLA     1.000000  0.201615
XOM      0.201615  1.000000
```

[25]:
```
# Perform eigendecomposition

eigenvalues, eigenvectors = np.linalg.eig(cov_matrix_array)

# Put data into a DataFrame and save to excel
df_eigval = pd.DataFrame({"Eigenvalues": eigenvalues})


# calculate explained variance
explained_variance = [round(variance / sum(eigenvalues), 3) for variance in␣
 ↪eigenvalues]


# Save output to Excel
columns = [
    "PC1",
    "PC2",
    "PC3",
    "PC4",
    "PC5",
```

```
    "PC6",
    "PC7",
    "PC8",
    "PC9"
]
df_eigvec = pd.DataFrame(eigenvectors, columns=columns, index=df.columns)

df_eigvec
```

[25]:

```
              PC1       PC2       PC3       PC4       PC5       PC6       PC7  \
Symbols
MSFT     0.391652  0.052807 -0.094991 -0.692580  0.297585 -0.346757 -0.354461
NVDA     0.350798  0.154299  0.045555  0.120785  0.411379  0.099108  0.220349
AAPL     0.356057  0.056458 -0.019538  0.135457  0.399939  0.144798  0.263886
AMZN     0.348470  0.278306 -0.152172 -0.085451 -0.138533  0.482206  0.304226
META     0.316499  0.243737 -0.284001 -0.162669 -0.690913 -0.002072  0.000960
GOOGL    0.391091  0.082706 -0.197613  0.656431 -0.054665 -0.485878 -0.251370
JPM      0.303798 -0.567165  0.000177  0.102302 -0.042127  0.532667 -0.533307
TSLA     0.261049  0.163822  0.918970  0.006098 -0.222810 -0.051745 -0.065828
XOM      0.248553 -0.691375  0.033905 -0.110578 -0.176916 -0.306520  0.558281

              PC8       PC9
Symbols
MSFT     0.136282  0.046005
NVDA    -0.245299 -0.740735
AAPL    -0.410769  0.657282
AMZN     0.649982  0.062543
META    -0.502246 -0.060711
GOOGL    0.257378  0.041950
JPM     -0.056289 -0.049709
TSLA     0.022006  0.057730
XOM      0.088882 -0.044878
```

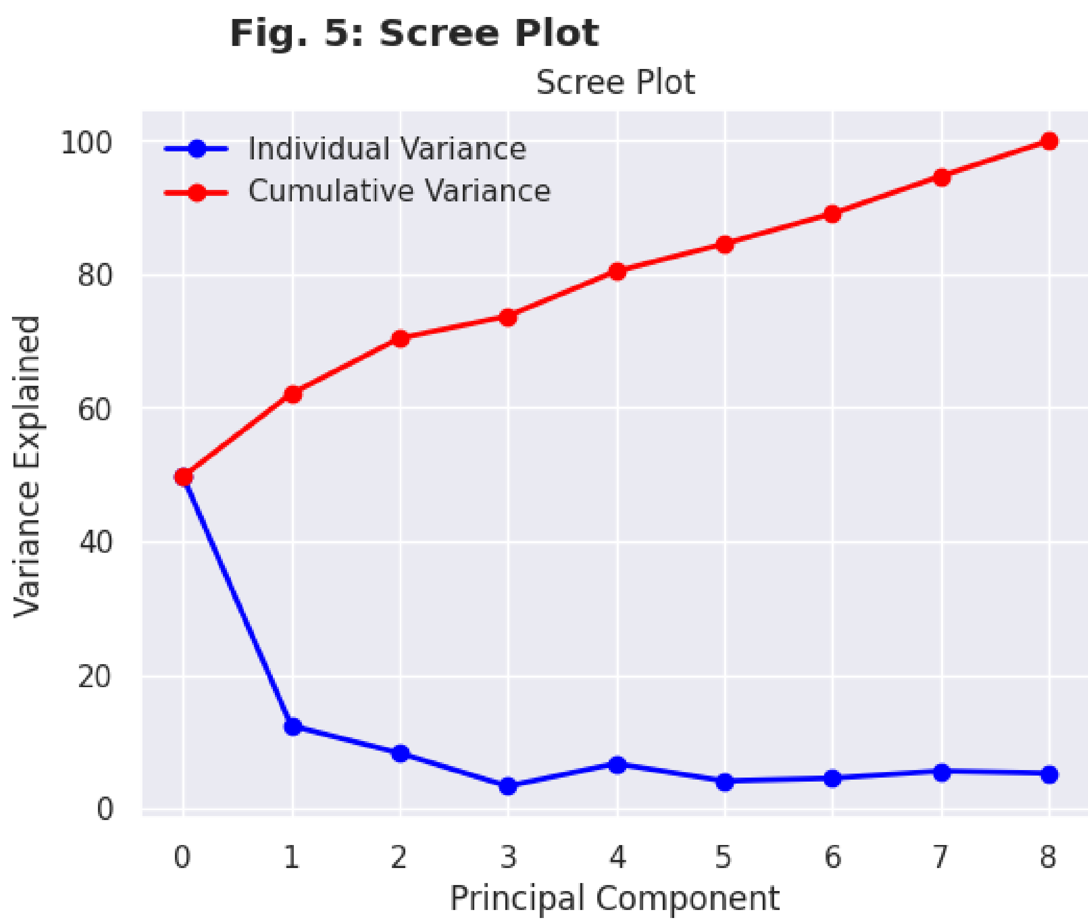
[26]:

```
from itertools import accumulate

df_eigval["Explained proportion"] = df_eigval["Eigenvalues"] / np.sum(
    df_eigval["Eigenvalues"]
)
df_eigval["Cumulative Explained Variance"] = list(
    accumulate(df_eigval["Explained proportion"])
)

# Format as percentage
df_eigval.style.format({"Explained proportion": "{:.2%}"})
df_eigval.style.format({"Cumulative Explained Variance": "{:.2%}"})
```

[26]:

```
<pandas.io.formats.style.Styler at 0x7c59fe9cafb0>
```

[27]:
```python
# plot scree plot
PC_values = np.arange(9)
pyplot.plot(
    PC_values, df_eigval["Explained proportion"] * 100, "o-", linewidth=2,␣
 ↪color="blue"
)
pyplot.plot(
    PC_values,
    df_eigval["Cumulative Explained Variance"] * 100,
    "o-",
    linewidth=2,
    color="red",
)
pyplot.suptitle("Fig. 5: Scree Plot", fontweight="bold",␣
 ↪horizontalalignment="right")
pyplot.title("Scree Plot")
pyplot.xlabel("Principal Component")
pyplot.ylabel("Variance Explained")
pyplot.legend(["Individual Variance", "Cumulative Variance"])
pyplot.show()
```



Note that in this case, the first PC explains 50 % of the variance, the second one around 10 %, and the resft of PCs explain similar variances (around 5 %). Therefore, to retrieve a large percentage of variances, we need a high number of PCs (6 PCs for close to 90 %). This indicates that most of the stocks chosen are uncorrelated, yet a low number of variables (the PCs) can represent a large amount of the index data. Future work could deepen into this analysis by considering a larger number of stocks from the SP500, and determine how many Pcs can retrieve a proper behaviour of the index.

2 STEP 3

Lasso Regression

[28]:
```
import numpy as np
import pandas as pd
import yfinance as yf
from sklearn.linear_model import Lasso
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import mean_squared_error
import matplotlib.pyplot as plt

np.random.seed(42)
```

[29]:
```
#Downloading Data
ticker = 'NVDA'
start_date = '2020-01-01'
end_date = '2024-01-01'

stock_data = yf.download(ticker, start=start_date, end=end_date)
stock_data['Returns'] = stock_data['Adj Close'].pct_change().dropna()
```

```
[*********************100%%**********************]  1 of 1 completed
```

[30]:
```
# Define predictors (for simplicity, use lagged returns)
stock_data['Lagged_Returns'] = stock_data['Returns'].shift(1).dropna()

# Drop missing values
stock_data = stock_data.dropna()

# Define features and target variable
X = stock_data[['Lagged_Returns']]
y = stock_data['Returns']
```

[31]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42)
```

[32]:
```
#Defining model
lasso = Lasso()

#Defining hyperparameter grid
param_grid = {'alpha': np.logspace(-4, 0, 50)}

grid_search = GridSearchCV(lasso, param_grid, cv=5,␣
 ↪scoring='neg_mean_squared_error')

grid_search.fit(X_train, y_train)

best_alpha = grid_search.best_params_['alpha']
print(f'Best alpha: {best_alpha}')
```

```
Best alpha: 0.0001
```

[33]:
```
best_lasso = Lasso(alpha=best_alpha)
best_lasso.fit(X_train, y_train)

y_pred = best_lasso.predict(X_test)

mse = mean_squared_error(y_test, y_pred)
print(f'Mean Squared Error: {mse}')
```

```
Mean Squared Error: 0.0014837570650276092
```

[34]:
```
#Plotting Coefficients
plt.figure(figsize=(10, 6))
plt.plot(X_train.columns, best_lasso.coef_, marker='o')
plt.title('Lasso Coefficients')
plt.xlabel('Predictors')
plt.ylabel('Coefficient Value')
plt.show()
```

Hierarchical Clustering

[35]:
```
import numpy as np
import pandas as pd
import yfinance as yf
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.cluster.hierarchy import dendrogram, linkage, fcluster
from scipy.spatial.distance import pdist, squareform
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import silhouette_score

sns.set(style="whitegrid")
plt.style.use("seaborn-darkgrid")
%matplotlib inline
```

[36]:
```
tickers = ['AAPL', 'MSFT', 'GOOGL', 'AMZN', 'JPM', 'GS', 'BAC', 'WFC', 'C']
start_date = '2022-01-01'
end_date = '2023-01-01'

# Download daily closing prices
data = yf.download(tickers, start=start_date, end=end_date)['Adj Close']

returns = data.pct_change().dropna()
```

```
returns.head()
```

```
[*********************100%%**********************]  9 of 9 completed
```

[36]:

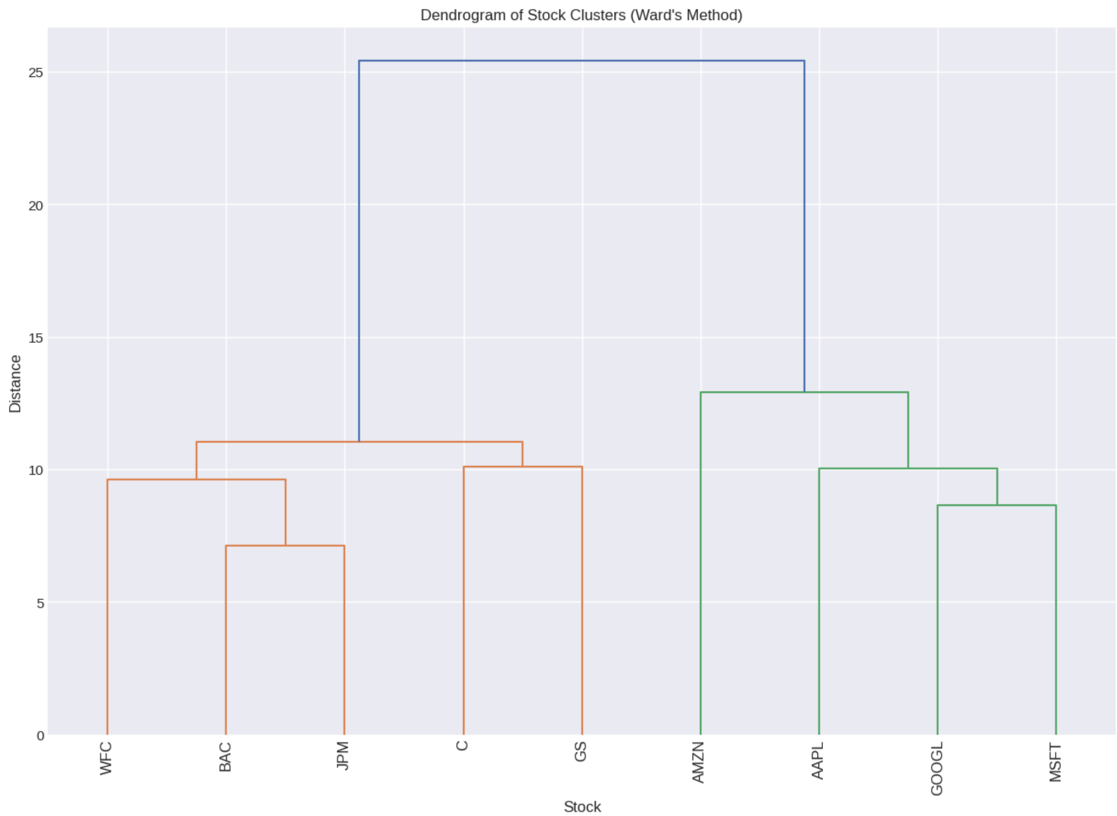
```
Ticker           AAPL      AMZN       BAC         C     GOOGL        GS  \
Date
2022-01-04 -0.012692 -0.016916  0.039195  0.007765 -0.004083  0.030734
2022-01-05 -0.026600 -0.018893 -0.016879 -0.011637 -0.045876 -0.021719
2022-01-06 -0.016693 -0.006711  0.020136  0.032776 -0.000200 -0.004265
2022-01-07  0.000988 -0.004288  0.021816  0.013403 -0.005303  0.001461
2022-01-10  0.000116 -0.006570 -0.005083  0.003800  0.012061  0.004176

Ticker            JPM      MSFT       WFC
Date
2022-01-04  0.037910 -0.017147  0.039819
2022-01-05 -0.018282 -0.038388 -0.008720
2022-01-06  0.010624 -0.007902  0.025626
2022-01-07  0.009908  0.000510  0.021257
2022-01-10  0.000957  0.000732  0.010590
```

[37]:

```
scaler = StandardScaler()
scaled_returns = scaler.fit_transform(returns)

scaled_returns_df = pd.DataFrame(scaled_returns, index=returns.index,
  ↪columns=returns.columns)

#Euclidean distance
distance_matrix = pdist(scaled_returns_df.T, metric='euclidean')
```

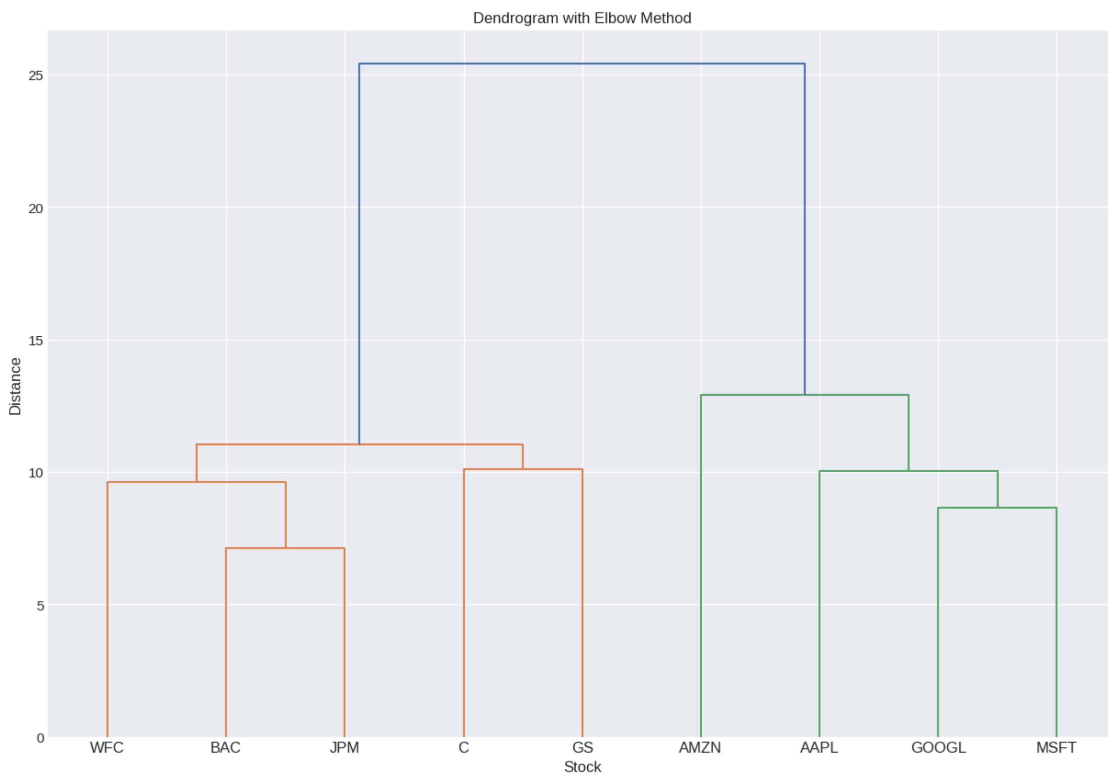
[38]:

```
Z = linkage(distance_matrix, method='ward')

#dendrogram
plt.figure(figsize=(15, 10))
dendrogram(Z, labels=scaled_returns_df.columns, leaf_rotation=90,
  ↪leaf_font_size=12)
plt.title('Dendrogram of Stock Clusters (Ward\'s Method)')
plt.xlabel('Stock')
plt.ylabel('Distance')
plt.show()
```



[39]:
```
#determining the optimal number of clusters
def plot_dendrogram(model, **kwargs):
    #crearing linkage matrix and then plot the dendrogram
    counts = np.zeros(model.children_.shape[0])
    n_samples = len(model.labels_)
    for i, merge in enumerate(model.children_):
        current_count = 0
        for child_idx in merge:
            if child_idx < n_samples:
                current_count += 1
            else:
                current_count += counts[child_idx - n_samples]
        counts[i] = current_count

    linkage_matrix = np.column_stack([model.children_, model.distances_,
                                      counts]).astype(float)

    dendrogram(linkage_matrix, **kwargs)

from sklearn.cluster import AgglomerativeClustering
```

```
model = AgglomerativeClustering(distance_threshold=0, n_clusters=None,␣
 ↪linkage='ward')

model = model.fit(scaled_returns_df.T)

plt.figure(figsize=(15, 10))
plot_dendrogram(model, labels=scaled_returns_df.columns)
plt.title('Dendrogram with Elbow Method')
plt.xlabel('Stock')
plt.ylabel('Distance')
plt.show()
```



[40]:

```
num_clusters = 3
cluster_labels = fcluster(Z, num_clusters, criterion='maxclust')

clustered_stocks = pd.DataFrame({'Stock': scaled_returns_df.columns, 'Cluster':␣
 ↪cluster_labels})

#Evaluation of the clusters using silhouette score
silhouette_avg = silhouette_score(squareform(distance_matrix), cluster_labels,␣
 ↪metric='precomputed')
print(f'Silhouette Score: {silhouette_avg}')
```

```
#Display the clustered stocks
print(clustered_stocks.sort_values(by='Cluster'))
```

```
Silhouette Score: 0.26977594015313294
   Stock  Cluster
2    BAC        1
3      C        1
5     GS        1
6    JPM        1
8    WFC        1
0   AAPL        2
4  GOOGL        2
7   MSFT        2
1   AMZN        3
```

[40]:

```
```

Principal Components

[41]:

```
import numpy as np
import pandas as pd
import yfinance as yf
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler
import matplotlib.pyplot as plt
import seaborn as sns

np.random.seed(42)
```

[42]:

```
#Downloading Data
tickers = ['AAPL', 'MSFT', 'GOOGL', 'AMZN', 'JPM', 'GS', 'BAC', 'WFC', 'C']
start_date = '2020-01-01'
end_date = '2024-01-01'

data = yf.download(tickers, start=start_date, end=end_date)['Adj Close']

returns = data.pct_change().dropna()

returns.head()
```

```
[*********************100%%**********************]  9 of 9 completed
```

[42]:

```
Ticker          AAPL      AMZN       BAC         C     GOOGL        GS  \
Date
2020-01-03 -0.009722 -0.012139 -0.020763 -0.018836 -0.005231 -0.011693
2020-01-06  0.007969  0.014886 -0.001433 -0.003137  0.026654  0.010234
2020-01-07 -0.004703  0.002092 -0.006600 -0.008685 -0.001932  0.006583
```

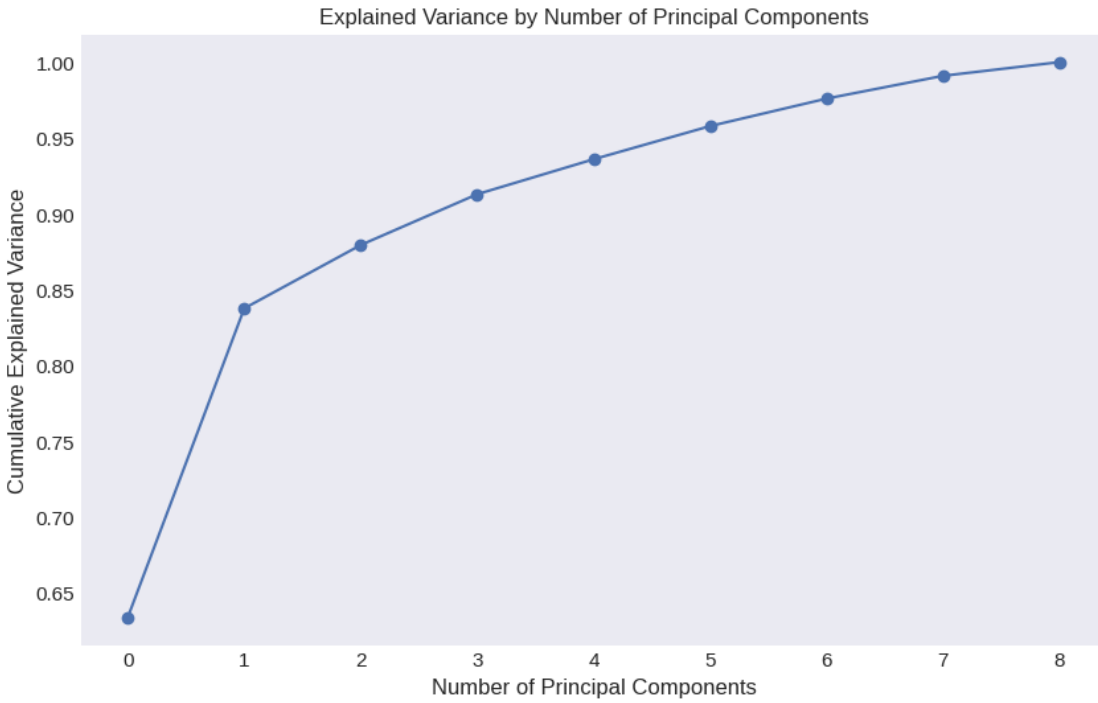
```
2020-01-08  0.016086 -0.007809  0.010110  0.007618  0.007118  0.009639
2020-01-09  0.021241  0.004799  0.001715  0.009073  0.010498  0.020357

Ticker           JPM      MSFT       WFC
Date
2020-01-03 -0.013197 -0.012452 -0.006139
2020-01-06 -0.000795  0.002585 -0.005990
2020-01-07 -0.017001 -0.009118 -0.008286
2020-01-08  0.007801  0.015928  0.003038
2020-01-09  0.003652  0.012493 -0.001704
```

[43]:

```
scaler = StandardScaler()
scaled_returns = scaler.fit_transform(returns)

pca = PCA()
pca.fit(scaled_returns)
explained_variance = np.cumsum(pca.explained_variance_ratio_)
```

[44]:

```
plt.figure(figsize=(10, 6))
plt.plot(explained_variance, marker='o')
plt.title('Explained Variance by Number of Principal Components')
plt.xlabel('Number of Principal Components')
plt.ylabel('Cumulative Explained Variance')
plt.grid()
plt.show()

#number of components
num_components = np.argmax(explained_variance >= 0.95) + 1
print(f'Number of components to retain: {num_components}')
```




```
Number of components to retain: 6
```

[45]:
```python
pca = PCA(n_components=num_components)
principal_components = pca.fit_transform(scaled_returns)

# Creating DataFrame with the principal components
pc_df = pd.DataFrame(data=principal_components, columns=[f'PC{i+1}' for i in␣
↪range(num_components)])
pc_df.head()
```

[45]:

	PC1	PC2	PC3	PC4	PC5	PC6
0	-1.696103	0.051460	0.058269	-0.222788	0.125109	-0.241872
1	0.608828	-0.952897	-0.216857	-0.541343	-0.517812	-0.535154
2	-0.809089	-0.099268	-0.317787	0.051350	-0.444100	-0.273544
3	1.000352	-0.113498	0.823868	0.036464	-0.112960	0.196693
4	1.136324	-0.540541	0.504995	0.273131	-0.627523	-0.127234

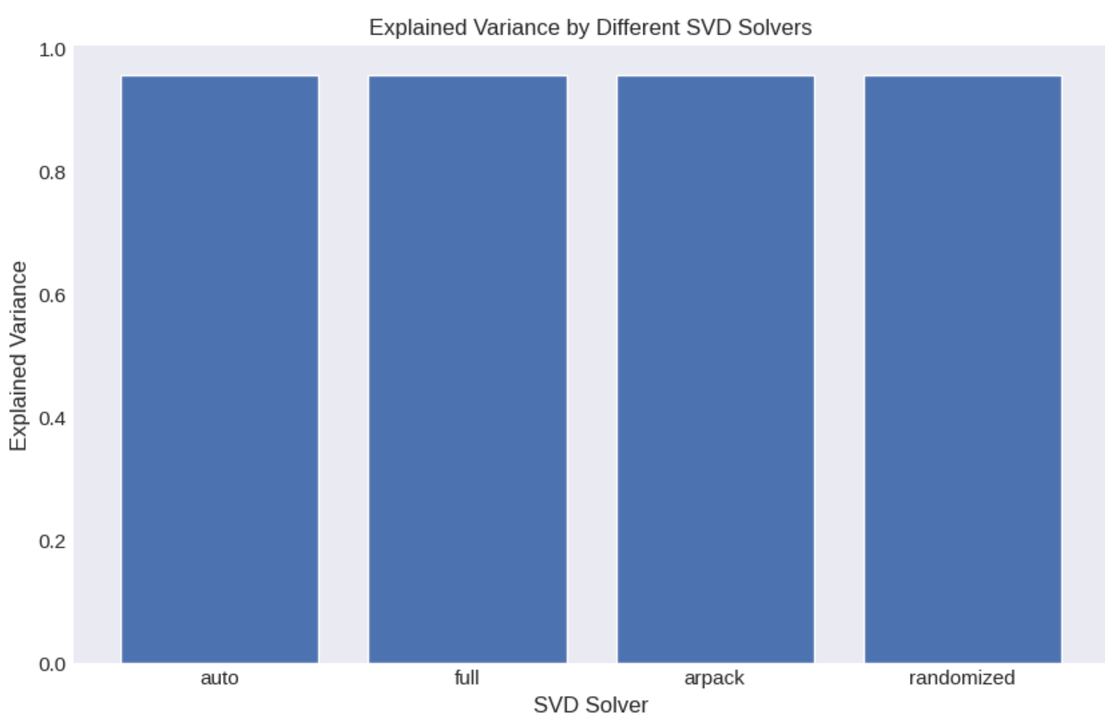
[46]:
```python
#SVD
svd_solvers = ['auto', 'full', 'arpack', 'randomized']
explained_variances = {}

for solver in svd_solvers:
    pca = PCA(n_components=num_components, svd_solver=solver)
    pca.fit(scaled_returns)
```

```
    explained_variances[solver] = np.sum(pca.explained_variance_ratio_)

    print(f'SVD Solver: {solver}')
    print(f'Explained Variance: {explained_variances[solver]}')
    print('-' * 50)
```

```
SVD Solver: auto
Explained Variance: 0.9577946337087656
--------------------------------------------------
SVD Solver: full
Explained Variance: 0.9577946337087667
--------------------------------------------------
SVD Solver: arpack
Explained Variance: 0.9577946337087675
--------------------------------------------------
SVD Solver: randomized
Explained Variance: 0.9577946337087653
--------------------------------------------------
```

[47]:

```
plt.figure(figsize=(10, 6))
plt.bar(explained_variances.keys(), explained_variances.values())
plt.title('Explained Variance by Different SVD Solvers')
plt.xlabel('SVD Solver')
plt.ylabel('Explained Variance')
plt.grid()
plt.show()
```



[47]:

```

```