1. Using Yahoo Finance (via yfinance)

Installation

In [2]:
```
pip install yfinance
```

```
Requirement already satisfied: yfinance in c:\users\ezeki\anaconda3\lib\site-package
s (0.2.55)
Requirement already satisfied: pandas>=1.3.0 in c:\users\ezeki\anaconda3\lib\site-pa
ckages (from yfinance) (2.1.4)
Requirement already satisfied: numpy>=1.16.5 in c:\users\ezeki\anaconda3\lib\site-pa
ckages (from yfinance) (1.26.4)
Requirement already satisfied: requests>=2.31 in c:\users\ezeki\anaconda3\lib\site-p
ackages (from yfinance) (2.32.3)
Requirement already satisfied: multitasking>=0.0.7 in c:\users\ezeki\anaconda3\lib\s
ite-packages (from yfinance) (0.0.11)
Requirement already satisfied: platformdirs>=2.0.0 in c:\users\ezeki\anaconda3\lib\s
ite-packages (from yfinance) (3.10.0)
Requirement already satisfied: pytz>=2022.5 in c:\users\ezeki\anaconda3\lib\site-pac
kages (from yfinance) (2023.3.post1)
Requirement already satisfied: frozendict>=2.3.4 in c:\users\ezeki\anaconda3\lib\sit
e-packages (from yfinance) (2.4.2)
Requirement already satisfied: peewee>=3.16.2 in c:\users\ezeki\anaconda3\lib\site-p
ackages (from yfinance) (3.17.9)
Requirement already satisfied: beautifulsoup4>=4.11.1 in c:\users\ezeki\anaconda3\li
b\site-packages (from yfinance) (4.12.2)
Requirement already satisfied: soupsieve>1.2 in c:\users\ezeki\anaconda3\lib\site-pa
ckages (from beautifulsoup4>=4.11.1->yfinance) (2.5)
Requirement already satisfied: python-dateutil>=2.8.2 in c:\users\ezeki\anaconda3\li
b\site-packages (from pandas>=1.3.0->yfinance) (2.8.2)
Requirement already satisfied: tzdata>=2022.1 in c:\users\ezeki\anaconda3\lib\site-p
ackages (from pandas>=1.3.0->yfinance) (2023.3)
Requirement already satisfied: charset-normalizer<4,>=2 in c:\users\ezeki\anaconda3
\lib\site-packages (from requests>=2.31->yfinance) (2.0.4)
Requirement already satisfied: idna<4,>=2.5 in c:\users\ezeki\anaconda3\lib\site-pac
kages (from requests>=2.31->yfinance) (3.4)
Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\ezeki\anaconda3\lib\si
te-packages (from requests>=2.31->yfinance) (2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\ezeki\anaconda3\lib\si
te-packages (from requests>=2.31->yfinance) (2025.1.31)
Requirement already satisfied: six>=1.5 in c:\users\ezeki\anaconda3\lib\site-package
s (from python-dateutil>=2.8.2->pandas>=1.3.0->yfinance) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

2. Obtaining the Historical Price Data

We'll use the yfinance library to fetch historical closing prices for the top 30 holdings over the past 6 months (approximately 120 trading days).

In [5]:
```
import yfinance as yf
import pandas as pd
from datetime import datetime, timedelta

# Define the list of top 30 tickers
tickers = ['PLD', 'WELL', 'EQIX', 'AMT', 'SPG', 'DLR', 'O', 'PSA', 'CBRE', 'CCI',
```

```
            'EXR', 'VTR', 'AVB', 'EQR', 'ESS', 'UDR', 'MAA', 'IRM', 'ARE', 'DOC',
            'HST', 'WY', 'BXP', 'SLG', 'VNO', 'HPP', 'HIW', 'KIM', 'FRT', 'REG']

# Define the date range
end_date = datetime.today()
start_date = end_date - timedelta(days=180)

# Fetch adjusted closing prices
data = yf.download(tickers, start=start_date, end=end_date)['Close']
```

```
YF.download() has changed argument auto_adjust default to True
[**********************100%**********************]  30 of 30 completed
```

In [7]:
```
data
```

Out[7]:

Ticker	AMT	ARE	AVB	BXP	CBRE	CCI	DLR
Date							
2024-10-17	220.373062	117.961929	221.892929	86.474564	124.930000	108.169281	161.263367
2024-10-18	222.476898	118.487289	223.536423	87.252571	125.680000	108.779099	162.928314
2024-10-21	217.728500	116.278839	220.593872	84.539299	123.519997	106.659271	162.750961
2024-10-22	217.718674	114.770874	221.154831	84.432320	122.730003	106.252724	162.800232
2024-10-23	222.447403	116.648537	225.898361	84.568474	123.120003	107.133575	163.342087
...	...	...	...	...	...	...	...
2025-04-08	202.989868	76.940002	187.229996	56.860001	113.940002	94.830002	136.110001
2025-04-09	205.786850	80.820000	200.389999	61.590000	121.269997	95.540001	145.770004
2025-04-10	206.620010	74.570000	193.589996	59.660000	116.650002	95.160004	142.289993
2025-04-11	213.220001	76.919998	193.000000	60.639999	115.949997	96.669998	145.089996
2025-04-14	217.789993	79.699997	200.919998	62.840000	119.010002	99.839996	146.309998

122 rows × 30 columns

3. Compute Daily Returns

Calculating the daily percentage change in closing prices.

In [10]:
```
# Compute daily returns
daily_returns = data.pct_change().dropna()
```

4. Calculate Covariance Matrix

Computing the covariance matrix of daily returns to understand how the assets move together.

In [15]:
```
# Calculate covariance matrix
cov_matrix = daily_returns.cov()
print(cov_matrix)
```

Ticker	AMT	ARE	AVB	BXP	CBRE	CCI	DLR
Ticker							
AMT	0.000362	0.000173	0.000129	0.000160	0.000127	0.000278	0.000058
ARE	0.000173	0.000403	0.000231	0.000315	0.000231	0.000178	0.000151
AVB	0.000129	0.000231	0.000268	0.000266	0.000241	0.000134	0.000146
BXP	0.000160	0.000315	0.000266	0.000496	0.000315	0.000152	0.000230
CBRE	0.000127	0.000231	0.000241	0.000315	0.000505	0.000118	0.000281
CCI	0.000278	0.000178	0.000134	0.000152	0.000118	0.000359	0.000035
DLR	0.000058	0.000151	0.000146	0.000230	0.000281	0.000035	0.000493
DOC	0.000163	0.000245	0.000202	0.000252	0.000192	0.000163	0.000117
EQIX	0.000088	0.000173	0.000169	0.000214	0.000283	0.000052	0.000318
EQR	0.000151	0.000251	0.000278	0.000286	0.000255	0.000151	0.000160
ESS	0.000143	0.000252	0.000275	0.000290	0.000248	0.000162	0.000148
EXR	0.000219	0.000242	0.000226	0.000275	0.000230	0.000193	0.000153
FRT	0.000113	0.000231	0.000231	0.000287	0.000243	0.000126	0.000170
HIW	0.000137	0.000256	0.000222	0.000342	0.000238	0.000138	0.000172
HPP	0.000259	0.000569	0.000423	0.000734	0.000638	0.000254	0.000338
HST	0.000033	0.000248	0.000216	0.000322	0.000275	0.000053	0.000225
IRM	0.000186	0.000251	0.000247	0.000312	0.000357	0.000131	0.000405
KIM	0.000120	0.000223	0.000210	0.000280	0.000234	0.000133	0.000166
MAA	0.000142	0.000194	0.000217	0.000208	0.000187	0.000145	0.000091
O	0.000164	0.000152	0.000140	0.000166	0.000115	0.000166	0.000063
PLD	0.000149	0.000295	0.000244	0.000328	0.000318	0.000132	0.000202
PSA	0.000218	0.000212	0.000201	0.000232	0.000202	0.000200	0.000152
REG	0.000111	0.000189	0.000192	0.000221	0.000192	0.000117	0.000125
SLG	0.000103	0.000319	0.000271	0.000449	0.000376	0.000117	0.000257
SPG	0.000069	0.000236	0.000243	0.000308	0.000301	0.000076	0.000237
UDR	0.000151	0.000239	0.000259	0.000273	0.000232	0.000160	0.000142
VNO	0.000115	0.000359	0.000294	0.000523	0.000447	0.000109	0.000320
VTR	0.000129	0.000150	0.000170	0.000171	0.000168	0.000120	0.000103
WELL	0.000111	0.000143	0.000170	0.000163	0.000170	0.000124	0.000115
WY	0.000170	0.000257	0.000213	0.000262	0.000259	0.000163	0.000143

Ticker	DOC	EQIX	EQR	...	PLD	PSA	REG
Ticker				...			
AMT	0.000163	0.000088	0.000151	...	0.000149	0.000218	0.000111
ARE	0.000245	0.000173	0.000251	...	0.000295	0.000212	0.000189
AVB	0.000202	0.000169	0.000278	...	0.000244	0.000201	0.000192
BXP	0.000252	0.000214	0.000286	...	0.000328	0.000232	0.000221
CBRE	0.000192	0.000283	0.000255	...	0.000318	0.000202	0.000192
CCI	0.000163	0.000052	0.000151	...	0.000132	0.000200	0.000117
DLR	0.000117	0.000318	0.000160	...	0.000202	0.000152	0.000125
DOC	0.000244	0.000138	0.000207	...	0.000212	0.000182	0.000153
EQIX	0.000138	0.000313	0.000187	...	0.000232	0.000164	0.000137
EQR	0.000207	0.000187	0.000312	...	0.000271	0.000221	0.000205
ESS	0.000209	0.000179	0.000300	...	0.000265	0.000212	0.000209
EXR	0.000201	0.000171	0.000243	...	0.000278	0.000268	0.000184
FRT	0.000185	0.000173	0.000249	...	0.000280	0.000196	0.000220
HIW	0.000212	0.000170	0.000241	...	0.000267	0.000200	0.000185
HPP	0.000389	0.000382	0.000452	...	0.000597	0.000390	0.000345
HST	0.000162	0.000195	0.000241	...	0.000314	0.000164	0.000184
IRM	0.000199	0.000333	0.000280	...	0.000280	0.000235	0.000191
KIM	0.000180	0.000165	0.000228	...	0.000262	0.000189	0.000194
MAA	0.000173	0.000126	0.000232	...	0.000192	0.000181	0.000157
O	0.000143	0.000080	0.000161	...	0.000165	0.000162	0.000117
PLD	0.000212	0.000232	0.000271	...	0.000470	0.000240	0.000219

```
PSA     0.000182  0.000164  0.000221  ...  0.000240  0.000274  0.000160
REG     0.000153  0.000137  0.000205  ...  0.000219  0.000160  0.000201
SLG     0.000250  0.000230  0.000295  ...  0.000343  0.000215  0.000227
SPG     0.000180  0.000232  0.000263  ...  0.000316  0.000190  0.000213
UDR     0.000204  0.000174  0.000285  ...  0.000257  0.000217  0.000203
VNO     0.000276  0.000301  0.000315  ...  0.000397  0.000226  0.000240
VTR     0.000173  0.000117  0.000174  ...  0.000156  0.000141  0.000136
WELL    0.000150  0.000127  0.000175  ...  0.000165  0.000145  0.000153
WY      0.000187  0.000182  0.000236  ...  0.000298  0.000222  0.000173

Ticker       SLG       SPG       UDR       VNO       VTR      WELL        WY
Ticker
AMT     0.000103  0.000069  0.000151  0.000115  0.000129  0.000111  0.000170
ARE     0.000319  0.000236  0.000239  0.000359  0.000150  0.000143  0.000257
AVB     0.000271  0.000243  0.000259  0.000294  0.000170  0.000170  0.000213
BXP     0.000449  0.000308  0.000273  0.000523  0.000171  0.000163  0.000262
CBRE    0.000376  0.000301  0.000232  0.000447  0.000168  0.000170  0.000259
CCI     0.000117  0.000076  0.000160  0.000109  0.000120  0.000124  0.000163
DLR     0.000257  0.000237  0.000142  0.000320  0.000103  0.000115  0.000143
DOC     0.000250  0.000180  0.000204  0.000276  0.000173  0.000150  0.000187
EQIX    0.000230  0.000232  0.000174  0.000301  0.000117  0.000127  0.000182
EQR     0.000295  0.000263  0.000285  0.000315  0.000174  0.000175  0.000236
ESS     0.000292  0.000259  0.000288  0.000307  0.000168  0.000179  0.000229
EXR     0.000259  0.000223  0.000237  0.000273  0.000158  0.000160  0.000237
FRT     0.000312  0.000273  0.000243  0.000334  0.000146  0.000165  0.000224
HIW     0.000365  0.000253  0.000236  0.000386  0.000152  0.000144  0.000232
HPP     0.000807  0.000496  0.000449  0.000922  0.000248  0.000225  0.000492
HST     0.000369  0.000294  0.000228  0.000434  0.000109  0.000095  0.000241
IRM     0.000328  0.000300  0.000246  0.000412  0.000135  0.000172  0.000232
KIM     0.000292  0.000261  0.000218  0.000328  0.000135  0.000140  0.000218
MAA     0.000205  0.000188  0.000226  0.000217  0.000149  0.000139  0.000184
O       0.000151  0.000133  0.000153  0.000148  0.000136  0.000121  0.000150
PLD     0.000343  0.000316  0.000257  0.000397  0.000156  0.000165  0.000298
PSA     0.000215  0.000190  0.000217  0.000226  0.000141  0.000145  0.000222
REG     0.000227  0.000213  0.000203  0.000240  0.000136  0.000153  0.000173
SLG     0.000602  0.000353  0.000281  0.000592  0.000168  0.000175  0.000290
SPG     0.000353  0.000374  0.000247  0.000399  0.000158  0.000177  0.000244
UDR     0.000281  0.000247  0.000289  0.000297  0.000175  0.000176  0.000225
VNO     0.000592  0.000399  0.000297  0.000762  0.000162  0.000159  0.000306
VTR     0.000168  0.000158  0.000175  0.000162  0.000263  0.000211  0.000133
WELL    0.000175  0.000177  0.000176  0.000159  0.000211  0.000249  0.000132
WY      0.000290  0.000244  0.000225  0.000306  0.000133  0.000132  0.000341

[30 rows x 30 columns]
```

5. Perform Principal Component Analysis (PCA)

We apply PCA to reduce dimensionality and identify the principal components that explain the most variance in the data.

In [19]:
```python
from sklearn.decomposition import PCA

# Initialize PCA
pca = PCA()
pca.fit(daily_returns)
```

```
# Explained variance ratio
explained_variance = pca.explained_variance_ratio_
print("Explained Variance Ratio:", explained_variance)
```

```
Explained Variance Ratio: [6.02691768e-01 1.01757186e-01 7.03334710e-02 4.34443155e-
02
 2.64139844e-02 2.21292246e-02 1.79260943e-02 1.51903313e-02
 1.27386337e-02 1.05174602e-02 9.54581680e-03 8.61527902e-03
 7.99650373e-03 6.23564432e-03 6.07306096e-03 5.18738763e-03
 4.82970135e-03 4.39607324e-03 3.95959073e-03 3.51087617e-03
 3.04845992e-03 2.69791252e-03 2.01802063e-03 1.89964550e-03
 1.60317549e-03 1.49817643e-03 1.29583568e-03 1.19617747e-03
 8.12371691e-04 4.37821783e-04]
```

6. Perform Singular Value Decomposition (SVD)

Use SVD to decompose the daily returns matrix into its singular vectors and singular values.

In [24]:
```
import numpy as np

# Perform SVD
U, S, Vt = np.linalg.svd(daily_returns, full_matrices=False)
print("Singular Values (U):", U)
print("Singular Values (S):", S)
print("Singular Values (Vt):", Vt)
```

```
Singular Values (U): [[-8.51809470e-02  9.78603949e-02  4.28670084e-02 ... -1.243103
38e-02
  -6.57846383e-02  6.79478441e-02]
 [ 1.13055856e-01  4.78157722e-02 -8.41210073e-02 ...  4.37554518e-02
   1.24417220e-01 -3.97007327e-02]
 [ 1.53280668e-04 -5.04533101e-02 -1.14099377e-02 ...  1.90169560e-01
   7.69481852e-02  3.95429033e-02]
 ...
 [ 1.96011876e-01 -8.08115900e-02  6.77615435e-02 ...  1.37374869e-01
   1.27388918e-01 -8.43767483e-03]
 [-5.72831229e-02 -4.06630767e-02  1.92078524e-02 ... -2.85775796e-02
   2.13270181e-02  3.15023304e-02]
 [-1.30431367e-01 -9.73138847e-02  8.78442104e-02 ... -4.67613489e-02
   1.06082132e-02 -1.85788171e-01]]
Singular Values (S): [0.97512108 0.40010711 0.33194741 0.26090544 0.20491072 0.18684
975
 0.1683717  0.15453967 0.14168237 0.12869969 0.12234249 0.11644309
 0.11242726 0.09927949 0.09766129 0.09057569 0.08710619 0.08357745
 0.07884254 0.07435474 0.06926055 0.06542129 0.05626488 0.05455431
 0.05011748 0.04928599 0.04520645 0.04336274 0.03568776 0.02644303]
Singular Values (Vt): [[-9.82224894e-02 -1.80769334e-01 -1.58455429e-01 -2.21223622e
-01
  -1.96474112e-01 -9.66528525e-02 -1.37168644e-01 -1.40028362e-01
  -1.39605691e-01 -1.71688868e-01 -1.69808378e-01 -1.62827439e-01
  -1.68692399e-01 -1.78780516e-01 -4.42676928e-01 -1.82506463e-01
  -1.96844233e-01 -1.58825992e-01 -1.30359667e-01 -9.97929950e-02
  -1.98345323e-01 -1.43898082e-01 -1.29894704e-01 -2.36908753e-01
  -1.81494398e-01 -1.64477672e-01 -2.64993950e-01 -1.04228293e-01
  -1.03796903e-01 -1.65621266e-01]
 [-1.84290157e-01 -5.00318480e-02 -1.36673498e-01  1.83658586e-02
  -1.56170547e-02 -1.75693620e-01 -8.31919395e-02 -1.09494704e-01
  -7.90469176e-02 -1.54389180e-01 -1.45519992e-01 -1.45826493e-01
  -8.02010607e-02 -5.24043996e-03  7.75438425e-01  5.01073295e-02
  -1.56119221e-01 -9.07300910e-02 -1.12302624e-01 -1.17408471e-01
  -6.79730760e-02 -1.53972448e-01 -1.13042633e-01  7.78003809e-02
  -8.45024455e-02 -1.42411134e-01  1.15996444e-01 -1.60207217e-01
  -1.79301077e-01 -8.27082797e-02]
 [ 3.35040861e-01  1.01071478e-01  4.06421058e-02 -3.39998603e-02
  -1.84756224e-01  3.66383030e-01 -4.36696256e-01  1.10688821e-01
  -2.51335899e-01  4.18080113e-02  6.47221322e-02  1.32470823e-01
  -8.58029234e-03  2.45030873e-02  2.78503552e-01 -1.89012437e-01
  -2.98683598e-01 -2.29618594e-02  1.26252565e-01  1.81292750e-01
  -2.76930318e-02  1.42606704e-01  2.68644081e-02 -1.45437400e-01
  -1.72000169e-01  7.76668903e-02 -2.56202185e-01  1.06395790e-01
   6.33035353e-02  6.83515167e-02]
 [-3.36171118e-01  6.72744574e-02  9.38442173e-02  1.35746151e-01
  -1.37545310e-01 -2.04397803e-01 -3.86738283e-01  3.62898550e-02
  -2.52530255e-01  8.57556718e-02  1.07479317e-01 -6.63681911e-02
   1.45869756e-01  1.35824217e-01 -2.38514443e-01  2.54771904e-01
  -4.74807103e-01  1.07192411e-01  3.68500235e-02 -1.13534293e-02
   1.04329887e-01 -1.33477479e-01  9.98946748e-02  2.33524153e-01
   1.51520580e-01  9.41973844e-02  1.72702743e-01  2.11847358e-02
   2.30441037e-04  3.61053237e-02]
 [ 2.96267706e-01  2.17263426e-01 -1.78795476e-01  2.73534916e-01
  -1.32977920e-01  2.67367552e-01 -7.74670028e-03  7.97088943e-02
  -1.24686012e-01 -1.55275578e-01 -1.78517036e-01  6.60447615e-02
```

```
 -8.42638597e-02  1.41799486e-01 -2.28954377e-01  6.86260087e-02
  5.92053142e-02  3.40390930e-02 -1.75858586e-01  2.53393628e-02
  5.15448796e-03  6.29964782e-02 -1.27014712e-01  2.35356083e-01
 -1.54201978e-01 -1.61503780e-01  3.49363005e-01 -3.09676141e-01
 -3.39516865e-01  8.71005106e-02]
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In [28]:
```
pip install pypandoc
```

```
Collecting pypandocNote: you may need to restart the kernel to use updated packages.

  Downloading pypandoc-1.15-py3-none-any.whl.metadata (16 kB)
Downloading pypandoc-1.15-py3-none-any.whl (21 kB)
Installing collected packages: pypandoc
Successfully installed pypandoc-1.15
```

In [ ]:
```

```