IE517_HWK5

September 24, 2021

[1]:
```
#Import libraries needed
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings('ignore')

#Check if any null values we need to change
def num_missing(x):
    return sum(x.isnull())
```

[2]:
```
#Read in Data
df = pd.read_csv('hw5_treasury yield curve data.csv', header=0)
#Reminder: ATT1-13 is noise, MEDV is target variable
df.head()
```

[2]:
```
        Date  SVENF01  SVENF02  SVENF03  ...  SVENF28  SVENF29  SVENF30
Adj_Close
0  5/17/2019   2.1224   2.0266   2.1023  ...   3.6471   3.6970   3.7458
10.130177
1  5/16/2019   2.1239   2.0317   2.1096  ...   3.6660   3.7153   3.7636
10.130177
2  5/15/2019   2.0874   1.9956   2.0844  ...   3.6421   3.6847   3.7257
10.150118
3  5/14/2019   2.1319   2.0559   2.1451  ...   3.7132   3.7630   3.8113
10.130177
4  5/13/2019   2.1051   2.0234   2.1180  ...   3.6655   3.7098   3.7525
10.130177

[5 rows x 32 columns]
```

[3]:
```
df = df.drop(columns = ['Date'])
print(df.apply(num_missing, axis = 0))
```

```
SVENF01      0
SVENF02      0
SVENF03      0
```

```
SVENF04      0
SVENF05      0
SVENF06      0
SVENF07      0
SVENF08      0
SVENF09      0
SVENF10      0
SVENF11      0
SVENF12      0
SVENF13      0
SVENF14      0
SVENF15      0
SVENF16      0
SVENF17      0
SVENF18      0
SVENF19      0
SVENF20      0
SVENF21      0
SVENF22      0
SVENF23      0
SVENF24      0
SVENF25      0
SVENF26      0
SVENF27      0
SVENF28      0
SVENF29      0
SVENF30      0
Adj_Close    0
dtype: int64
```

0.1 Part 1: EDA

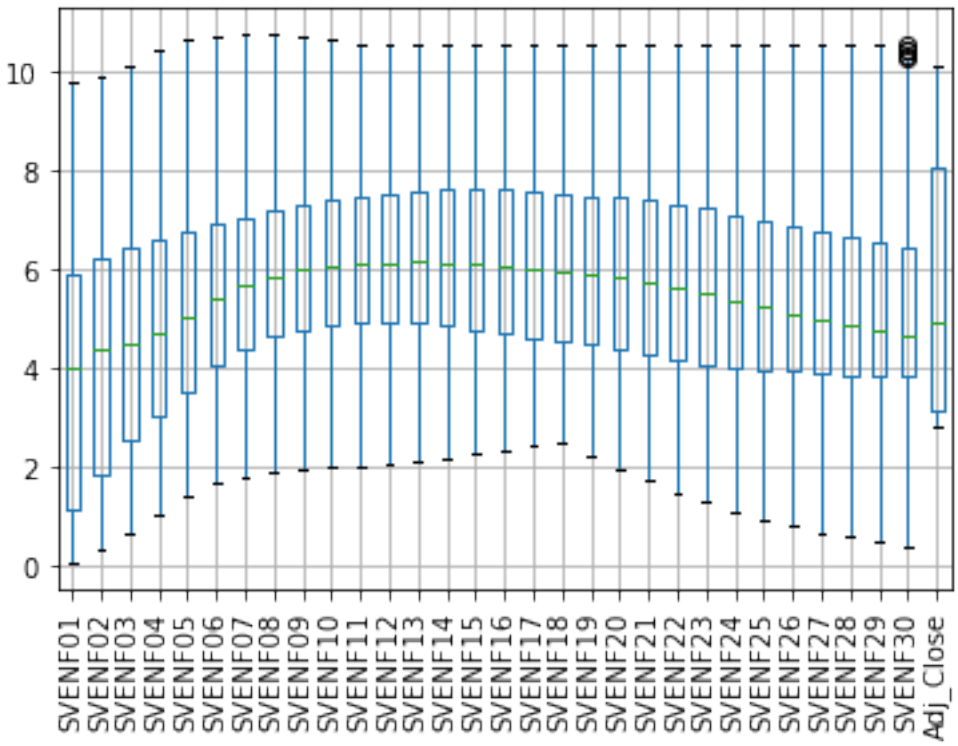
Before Standardizing

[4]:
```
df.describe()
```

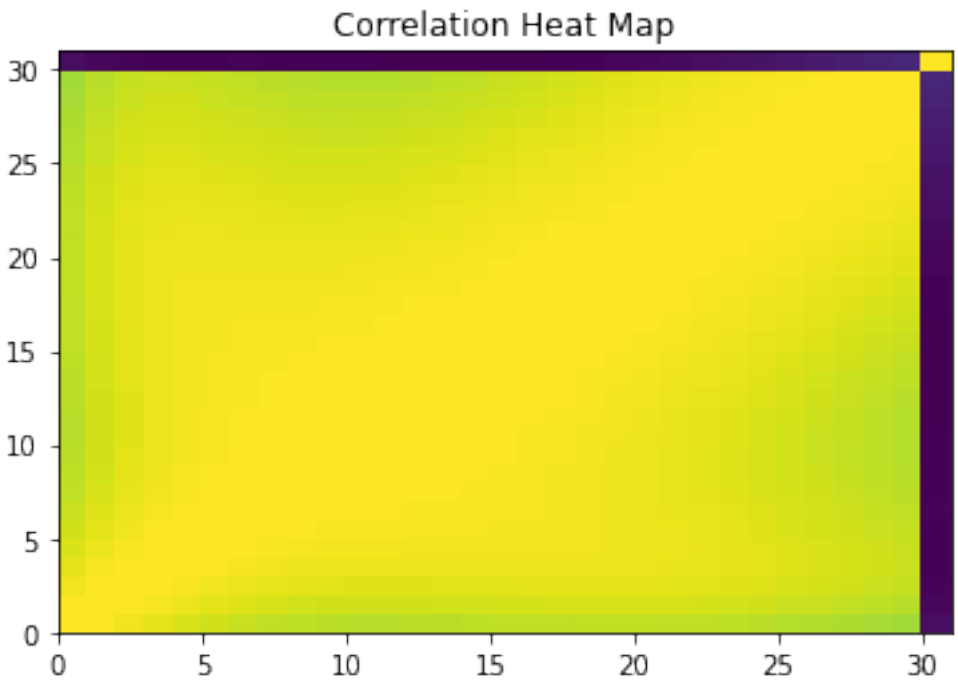
[4]:
```
           SVENF01      SVENF02  ...      SVENF30    Adj_Close
count  8071.000000  8071.000000  ...  8071.000000  8071.000000
mean      3.785311     4.258972  ...     5.167371     5.509793
std       2.648060     2.498137  ...     1.847834     2.491110
min       0.072700     0.327300  ...     0.411100     2.801050
25%       1.144050     1.865600  ...     3.831350     3.130587
50%       3.986500     4.393300  ...     4.669000     4.956219
75%       5.901500     6.221250  ...     6.421850     8.051437
max       9.813800     9.887800  ...    10.535100    10.150118

[8 rows x 31 columns]
```

[27]:
```
#Boxplots
df.boxplot()
plt.xticks(rotation = 90)
```

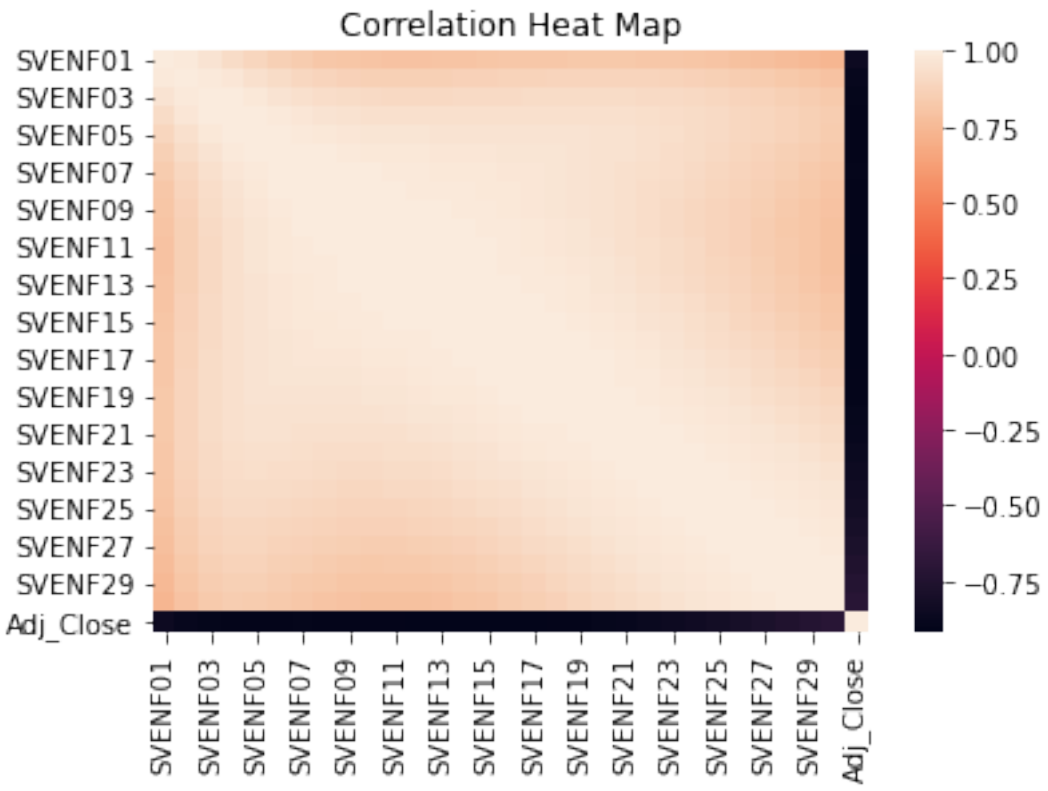
[27]:
```
(array([ 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16, 17,
        18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31]),
 <a list of 31 Text major ticklabel objects>)
```



[6]:
```
corMat = pd.DataFrame(df.corr())

plt.pcolor(corMat)
plt.title("Correlation Heat Map")
plt.show()
```



[7]:
```
correlation_mat = df.corr()

sns.heatmap(correlation_mat, annot = False)
plt.title("Correlation Heat Map")
plt.show()

#heavy correlation for most features
```



[8]:
```
#Split into training-test sets
from sklearn.model_selection import train_test_split

x = df.drop(columns = ['Adj_Close'])
x.head()

X_train, X_test, y_train, y_test = train_test_split(x, df['Adj_Close'],␣
↪test_size=0.15, random_state=42)
```

[9]:
```
#Standardize with standard scaler
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_train_std = sc.fit_transform(X_train)
X_test_std = sc.transform(X_test)
```

0.2 PCA on dataset

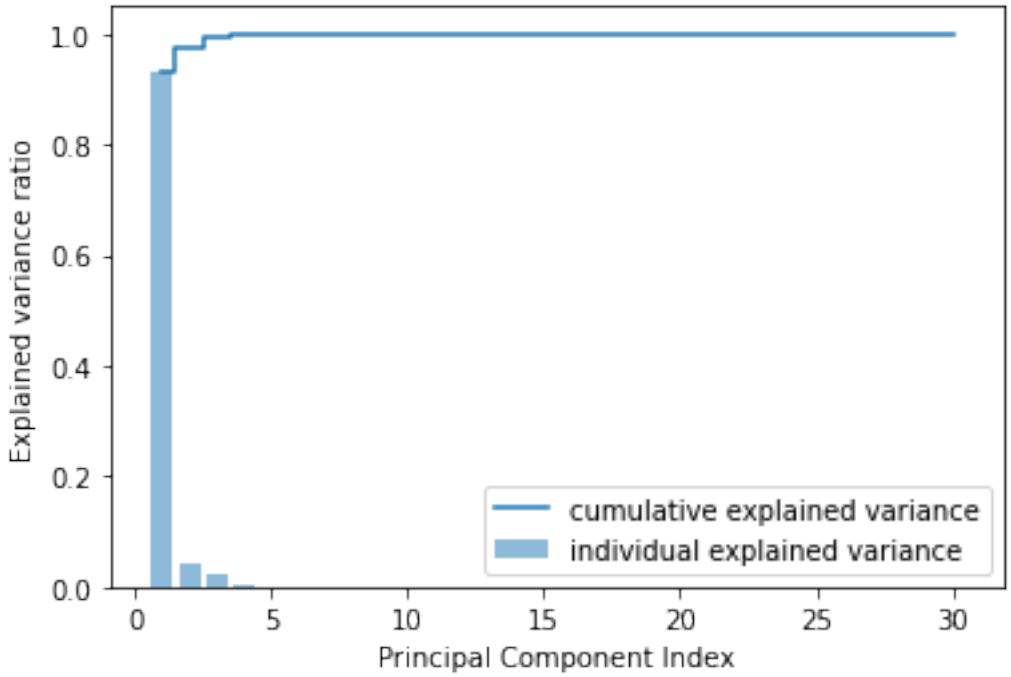
[10]:
```
#Cumulative explained variance
cov_mat = np.cov(X_train_std.T)
eigenvals, eigenvecs = np.linalg.eig(cov_mat)
print('\nEigenvalues \n%s' % eigenvals)
```

```
Eigenvalues
[2.79579848e+01 1.22313057e+00 6.55411544e-01 1.45561136e-01
 1.99031388e-02 2.06243818e-03 2.84492074e-04 3.29679042e-05
 2.55310505e-06 2.02358034e-07 1.41807223e-08 1.14065184e-09
 1.87834406e-10 2.79223564e-10 1.97434888e-10 2.08170843e-10
 2.16456135e-10 2.61581427e-10 2.21833140e-10 2.26975790e-10
 2.24866287e-10 2.31123423e-10 2.57846729e-10 2.56093138e-10
 2.35379808e-10 2.52582442e-10 2.49758675e-10 2.38344430e-10
 2.43769541e-10 2.44978760e-10]
```

[11]:
```
tot = sum(eigenvals)
var_exp = [(i/tot) for i in sorted(eigenvals, reverse = True)]
cum_var_exp = np.cumsum(var_exp)

print(var_exp)
print(cum_var_exp)

print(len(var_exp))
```

```
[0.9317969749380347, 0.04076507559642957, 0.021843866774838572,
0.004851330579495056, 0.000663341249742568, 6.87379176250734e-05,
9.481686747978828e-06, 1.0987699468249641e-06, 8.509109602390575e-08,
6.744284524055292e-09, 4.726218380051956e-10, 3.8016185315353525e-11,
9.306095353676375e-12, 8.71810986919668e-12, 8.593638070386526e-12,
8.535193547628366e-12, 8.418187396993204e-12, 8.324075570815556e-12,
8.164768289399366e-12, 8.12446687552559e-12, 7.943656188689898e-12,
7.84484986872113e-12, 7.702991064291871e-12, 7.564756762006768e-12,
7.494450263299693e-12, 7.393360094241526e-12, 7.2141527135822344e-12,
6.9380165690743895e-12, 6.580203582839132e-12, 6.260234154352169e-12]
[0.93179697 0.97256205 0.99440592 0.99925725 0.99992059 0.99998933
 0.99999881 0.99999991 0.99999999 1.         1.         1.
 1.         1.         1.         1.         1.         1.
 1.         1.         1.         1.         1.         1.
 1.         1.         1.         1.         1.         1.        ]
30
```

[12]:
```
plt.bar(range(1,31), var_exp, alpha = 0.5, align = 'center', label =␣
 ↪'individual explained variance')
plt.step(range(1,31), cum_var_exp, where = 'mid', label = 'cumulative explained␣
 ↪variance')
plt.ylabel('Explained variance ratio')
plt.xlabel('Principal Component Index')
plt.legend(loc = 'best')
plt.show()
```



[13]:
```
print("Cumulative explained variance for 3 components: " + str(cum_var_exp[2]))
```

```
Cumulative explained variance for 3 components: 0.994405917309303
```

[14]:
```
from sklearn.decomposition import PCA
pca = PCA(n_components = 3)
X_train_pca = pca.fit_transform(X_train_std)
X_test_pca = pca.transform(X_test_std)
```

0.3 Lin Reg v. SVM Reg: Baseline

Linear Regression: Full set

[15]:
```
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error, r2_score

lr = LinearRegression()
lreg = lr.fit(X_train_std, y_train)
y_pred = lreg.predict(X_test_std)
y_train_pred = lreg.predict(X_train_std)
```

[16]:
```
print("Train Score: " + str(lreg.score(X_train_std, y_train)))
print("Test Score: " + str(lreg.score(X_test_std, y_test)))
print("Mean Squared Error (MSE): " + str(mean_squared_error(y_test, y_pred)))
print("RMSE: " + str(np.sqrt(mean_squared_error(y_test, y_pred))))
```

```
print("Train R^2: " + str(r2_score(y_train, y_train_pred)))
print("Test R^2: " + str(r2_score(y_test, y_pred)))
```

```
Train Score: 0.9022730353400435
Test Score: 0.9041309535337262
Mean Squared Error (MSE): 0.6121021683244493
RMSE: 0.7823695855057565
Train R^2: 0.9022730353400437
Test R^2: 0.9041309535337262
```

Linear Regression: PCA

[17]:
```
lr_pca = LinearRegression()
lregpca = lr_pca.fit(X_train_pca, y_train)
y_pred = lregpca.predict(X_test_pca)
y_train_pred = lregpca.predict(X_train_pca)
```

[18]:
```
print("Train Score: " + str(lregpca.score(X_train_pca, y_train)))
print("Test Score: " + str(lregpca.score(X_test_pca, y_test)))
print("Mean Squared Error (MSE): " + str(mean_squared_error(y_test, y_pred)))
print("RMSE: " + str(np.sqrt(mean_squared_error(y_test, y_pred))))

print("Train R^2: " + str(r2_score(y_train, y_train_pred)))
print("Test R^2: " + str(r2_score(y_test, y_pred)))
```

```
Train Score: 0.8672181160186359
Test Score: 0.8662415053375473
Mean Squared Error (MSE): 0.8540177213873134
RMSE: 0.924130792359671
Train R^2: 0.8672181160186357
Test R^2: 0.8662415053375473
```

SVM Reg: Baseline

[19]:
```
from sklearn import svm
clf_svr = svm.SVR(kernel = 'linear')
clf_svr.fit(X_train_std, y_train)
y_pred = clf_svr.predict(X_test_std)
y_train_pred = clf_svr.predict(X_train_std)
```

[20]:
```
print("Train Score: " + str(clf_svr.score(X_train_std, y_train)))
print("Test Score: " + str(clf_svr.score(X_test_std, y_test)))
print("Mean Squared Error (MSE): " + str(mean_squared_error(y_test, y_pred)))
print("RMSE: " + str(np.sqrt(mean_squared_error(y_test, y_pred))))

print("Train R^2: " + str(r2_score(y_train, y_train_pred)))
print("Test R^2: " + str(r2_score(y_test, y_pred)))
```

```
Train Score: 0.8920208361922309
Test Score: 0.8924613825895129
```

```
Mean Squared Error (MSE): 0.686609738198755
RMSE: 0.8286191756161301
Train R^2: 0.8920208361922309
Test R^2: 0.8924613825895129
```

SVM Reg: PCA

[21]:
```
clf_svr = svm.SVR(kernel = 'linear')
clf_svr.fit(X_train_pca, y_train)
y_pred = clf_svr.predict(X_test_pca)
y_train_pred = clf_svr.predict(X_train_pca)
```

[22]:
```
print("Train Score: " + str(clf_svr.score(X_train_pca, y_train)))
print("Test Score: " + str(clf_svr.score(X_test_pca, y_test)))
print("Mean Squared Error (MSE): " + str(mean_squared_error(y_test, y_pred)))
print("RMSE: " + str(np.sqrt(mean_squared_error(y_test, y_pred))))

print("Train R^2: " + str(r2_score(y_train, y_train_pred)))
print("Test R^2: " + str(r2_score(y_test, y_pred)))
```

```
Train Score: 0.8624827979809777
Test Score: 0.8611702699819538
Mean Squared Error (MSE): 0.8863964116075648
RMSE: 0.9414862779709351
Train R^2: 0.8624827979809778
Test R^2: 0.8611702699819538
```

0.4 Statements & Print to PDF

[23]:
```
print("My name is Emma Mayes")
print("My NetID is: eemayes2")
print("I hereby certify that I have read the University policy on Academic␣
 ↪Integrity and that I am not in violation.")
```

```
My name is Emma Mayes
My NetID is: eemayes2
I hereby certify that I have read the University policy on Academic Integrity
and that I am not in violation.
```

[ ]:
```
!wget -nc https://raw.githubusercontent.com/brpy/colab-pdf/master/colab_pdf.py
from colab_pdf import colab_pdf
colab_pdf('IE517_HWK5.ipynb')
```

```
File colab_pdf.py already there; not retrieving.


WARNING: apt does not have a stable CLI interface. Use with caution in scripts.
```

```
WARNING: apt does not have a stable CLI interface. Use with caution in scripts.

Extracting templates from packages: 100%
```