In [1]:

```
import pandas as pd

stocks = pd.read_csv('9.stocks.csv',header='infer')
stocks.index = stocks['Date']
stocks = stocks .drop(['Date'],axis=1)
stocks.head()
```

Out[1]:

	MSFT	F	BAC
Date			
1/3/2007	29.860001	7.51	53.330002
1/4/2007	29.809999	7.70	53.669998
1/5/2007	29.639999	7.62	53.240002
1/8/2007	29.930000	7.73	53.450001
1/9/2007	29.959999	7.79	53.500000

In [2]:

```
import numpy as np

N,d = stocks.shape
delta = pd.DataFrame(100*np.divide(stocks.iloc[1:,:].values-stocks.iloc[:N-1,:].values,
                                   stocks.iloc[:N-1,:].values),columns=stocks.columns,index=stocks.iloc[1:].index)
delta.head()
```

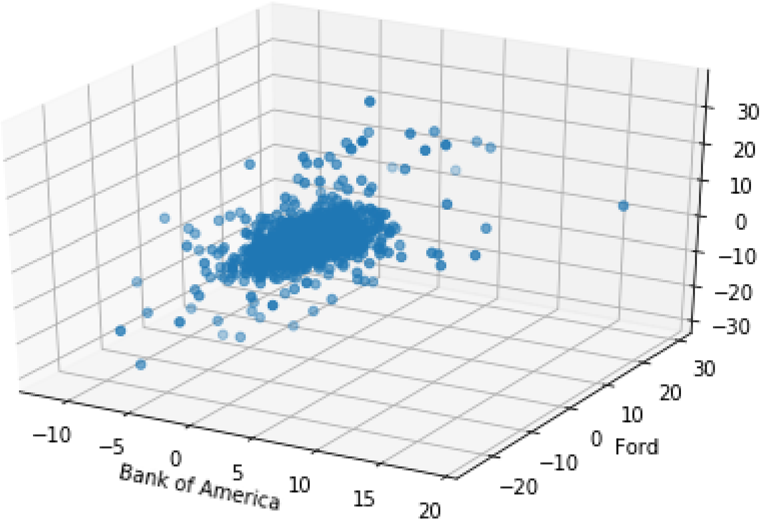
Out[2]:

	MSFT	F	BAC
Date			
1/4/2007	-0.167455	2.529960	0.637532
1/5/2007	-0.570278	-1.038961	-0.801185
1/8/2007	0.978411	1.443570	0.394438
1/9/2007	0.100231	0.776197	0.093543
1/10/2007	-1.001332	-0.770218	0.149536

In [3]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt
%matplotlib inline

fig = plt.figure(figsize=(8,5)).gca(projection='3d')
fig.scatter(delta.MSFT,delta.F,delta.BAC)
fig.set_xlabel('Microsoft')
fig.set_ylabel('Ford')
fig.set_xlabel('Bank of America')
plt.show()
```



In [4]:

```
meanValue = delta.mean()
covValue = delta.cov()
print(meanValue)
print(covValue)
```

```
MSFT    0.045003
F       0.061374
BAC     0.033351
dtype: float64
          MSFT         F        BAC
MSFT  3.191674  2.136351   2.788870
F     2.136351  8.524944   4.997405
BAC   2.788870  4.997405  13.770761
```

In [6]:

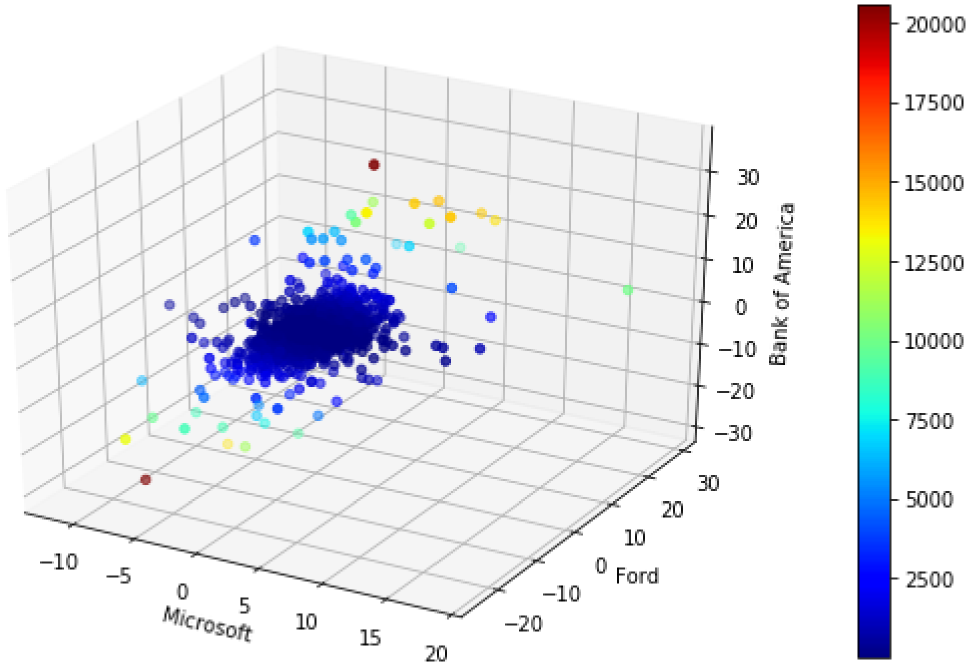
```
from numpy.linalg import inv

X = delta.values
S = covValue.values
for i in range(3):
    X[:,i] = X[:,i] - meanValue[i]

def mahalanobis(row):
    return np.matmul(row,S).dot(row)

anomaly_score = np.apply_along_axis(mahalanobis,axis=1,arr=X)

fig = plt.figure(figsize=(10,6))
ax = fig.add_subplot(111,projection='3d')
p = ax.scatter(delta.MSFT,delta.F,delta.BAC,c=anomaly_score,cmap='jet')
ax.set_xlabel('Microsoft')
ax.set_ylabel('Ford')
ax.set_zlabel('Bank of America')
fig.colorbar(p)
plt.show()
```



In [7]:

```
anom = pd.DataFrame(anomaly_score,index=delta.index,columns=['Anomaly score'])
result = pd.concat((delta,anom),axis=1)
result.nlargest(2,'Anomaly score')
```

Out[7]:

	MSFT	F	BAC	Anomaly score
Date				
4/9/2009	2.411292	7.219024	35.20242	20615.483586
10/7/2008	-6.834285	-20.989957	-26.29265	20555.903465

In [8]:

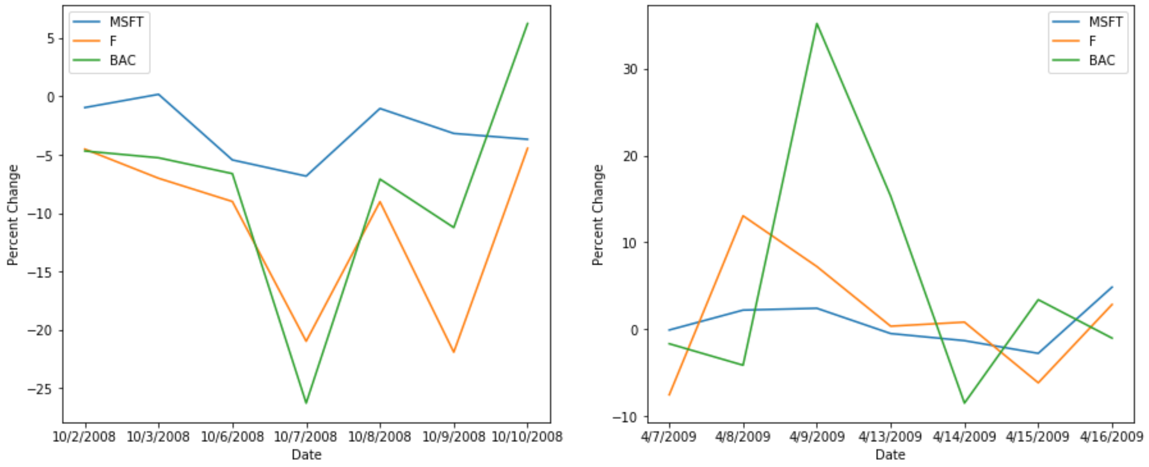
```
fig, (ax1,ax2) = plt.subplots(nrows=1,ncols=2,figsize=(15,6))

ts = delta[440:447]
ts.plot.line(ax=ax1)
ax1.set_xticks(range(7))
ax1.set_xticklabels(ts.index)
ax1.set_ylabel('Percent Change')

ts = delta[568:575]
ts.plot.line(ax=ax2)
ax2.set_xticks(range(7))
ax2.set_xticklabels(ts.index)
ax2.set_ylabel('Percent Change')
```

Out[8]:

```
Text(0, 0.5, 'Percent Change')
```



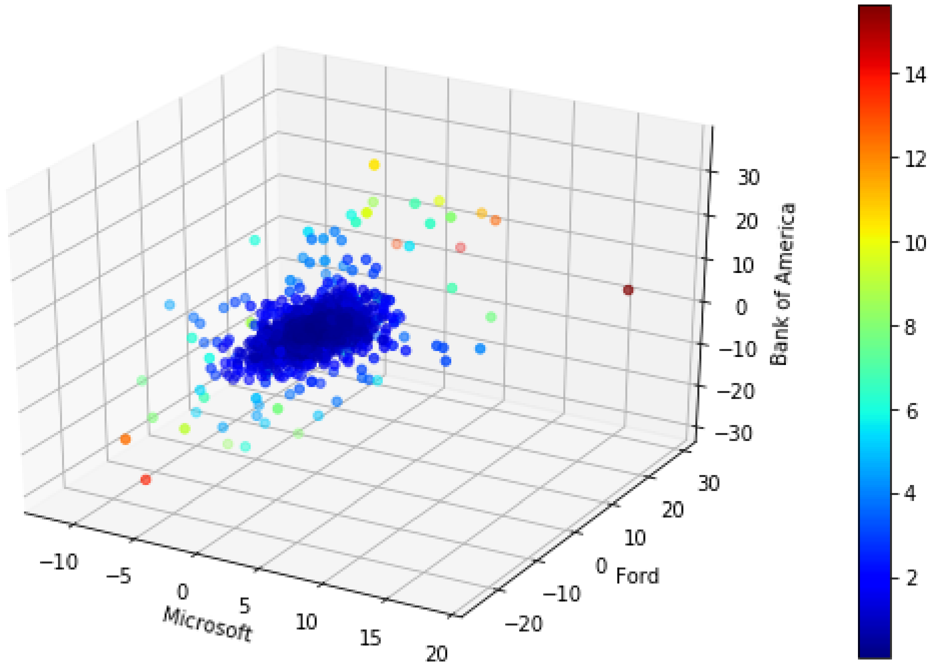
In [10]:

```
from sklearn.neighbors import NearestNeighbors
import numpy as np
from scipy.spatial import distance

knn = 4
nbrs = NearestNeighbors(n_neighbors=knn,metric=distance.euclidean).fit(delta.values)
distances, indices = nbrs.kneighbors(delta.values)

anomaly_score = distances[:,knn-1]

fig = plt.figure(figsize=(10,6))
ax = fig.add_subplot(111,projection='3d')
p = ax.scatter(delta.MSFT,delta.F,delta.BAC,c=anomaly_score,cmap='jet')
ax.set_xlabel('Microsoft')
ax.set_ylabel('Ford')
ax.set_zlabel('Bank of America')
fig.colorbar(p)
plt.show()
```



In [11]:

```
anom = pd.DataFrame(anomaly_score,index=delta.index,columns=['Anomaly score'])
result = pd.concat((delta,anom),axis=1)
result.nlargest(5,'Anomaly score')
```

Out[11]:

	MSFT	F	BAC	Anomaly score
Date				
10/13/2008	18.514646	19.977754	9.133106	15.642827
11/26/2008	2.411245	29.395324	4.190055	14.212749
10/7/2008	-6.834285	-20.989957	-26.292650	13.751302
11/28/2008	-1.407726	24.993531	5.247621	13.139586
9/30/2008	6.627312	24.577491	15.635778	12.599739

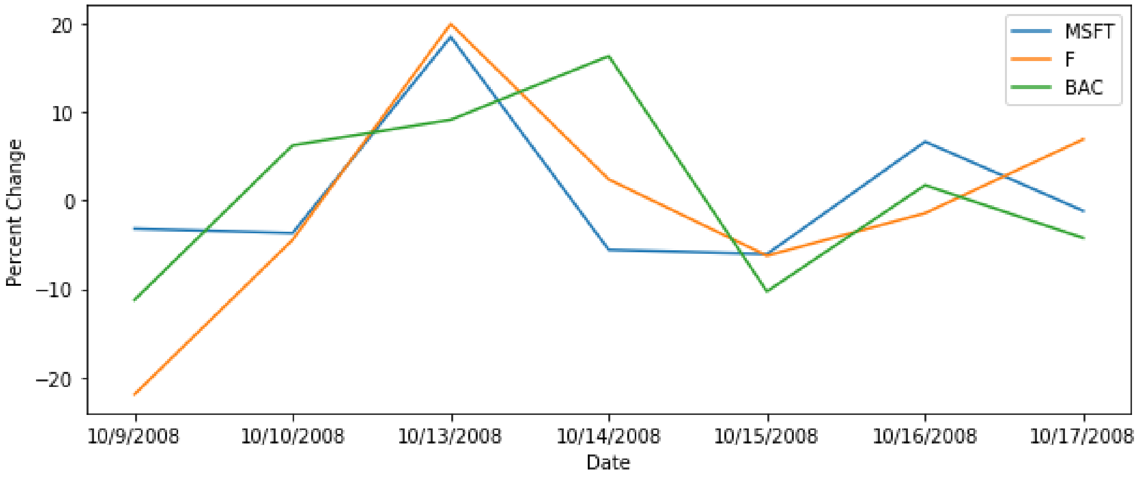
In [12]:

```
fig = plt.figure(figsize=(10,4))

ax = fig.add_subplot(111)
ts = delta[445:452]
ts.plot.line(ax=ax)
ax.set_xticks(range(7))
ax.set_xticklabels(ts.index)
ax.set_ylabel('Percent Change')
```

Out[12]:

```
Text(0, 0.5, 'Percent Change')
```



In [ ]: