In [18]:
```
import pandas as pd
import matplotlib.pyplot as plt
from numpy import *
from scipy import stats
from numpy.linalg import multi_dot
#pip install cufflinks
#import cufflinks as cf
#cf.set_config_file(offline=True, dimensions=((1000,600)))
```

In [19]:
```
# Nasdaq-listed stocklist
symbols = ['NVDA', 'AAPL', 'JPM','AMZN', 'CAT', 'WMT', 'BA', 'JNJ', 'MCD', 'UNH', '

# Number of assets
numofasset = len(symbols)

# Number of portfolio for optimization
numofportfolio = 5000

#Retrieve Data
df = pd.read_excel('D:\\Derivatives Trading\\US_equity_data.xlsx', sheet_name='Pric
df
```

Out[19]:

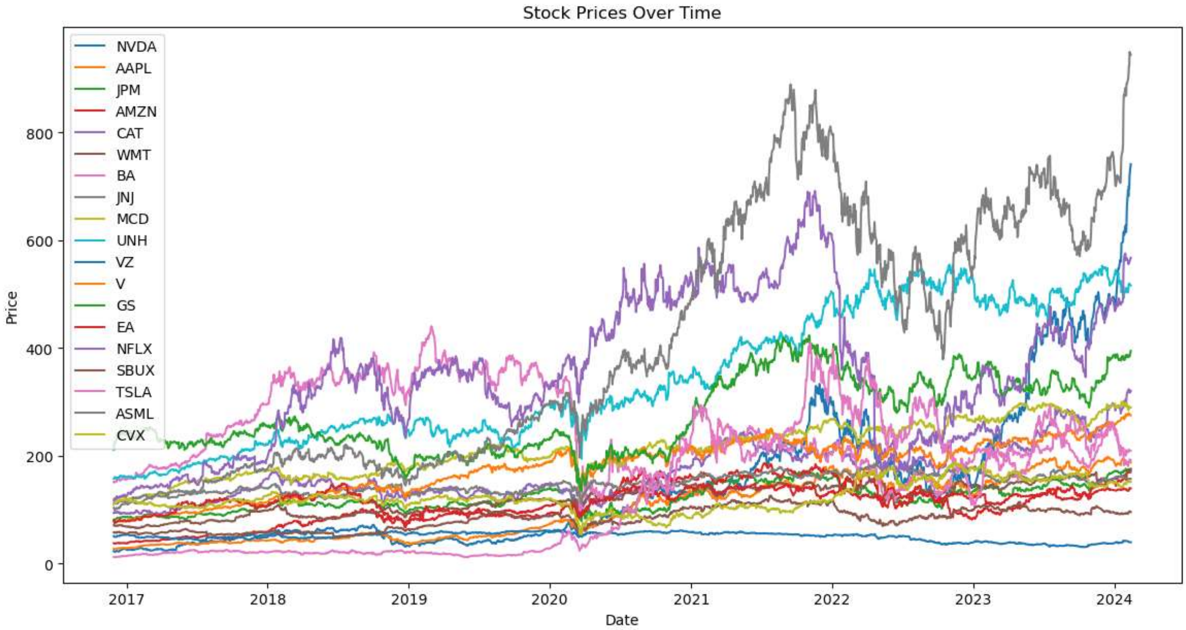
	NVDA	AAPL	JPM	AMZN	CAT	WMT	BA	JNJ	MCD	UNH	VZ
Date											
2016-11-29	23.3125	27.8650	78.92	38.1260	94.04	71.37	151.64	112.48	120.68	157.59	50.960
2016-11-30	23.0500	27.6300	80.17	37.5285	95.56	70.43	150.56	111.30	119.27	158.32	49.900
2016-12-01	21.9100	27.3725	81.79	37.1825	96.24	70.67	152.39	111.38	118.47	160.94	49.870
2016-12-02	22.1125	27.4750	81.60	37.0170	95.14	70.88	152.25	111.96	118.24	160.73	49.810
2016-12-05	22.9700	27.2775	83.26	37.9680	94.45	69.94	152.16	111.94	119.29	157.63	49.750
...	...	...	...	...	...	...	...	...	...	...	...
2024-02-06	682.2300	189.3000	175.10	169.1500	322.72	169.81	208.58	158.06	284.65	510.67	41.100
2024-02-07	700.9900	189.4100	175.43	170.5300	323.59	169.38	211.92	157.98	287.33	519.39	40.420
2024-02-08	696.4100	188.3200	174.80	169.8400	322.00	169.37	209.22	156.40	291.93	520.09	39.910
2024-02-09	721.3300	188.8500	175.01	174.4500	317.16	169.28	209.20	156.76	289.47	518.22	39.720
2024-02-12	741.2500	187.7500	176.26	173.3150	320.80	169.90	209.71	157.67	290.01	516.47	39.975

1812 rows × 19 columns

In [20]:
```
# Plot
# Assuming 'df' is a pandas DataFrame with datetime index and stock symbols as colu
# and you want to plot the prices over time
```

```
# Plot all columns in the DataFrame
plt.figure(figsize=(14, 7))  # Set the figure size
for column in df.columns:
    plt.plot(df.index, df[column], label=column)

plt.title('Stock Prices Over Time')
plt.xlabel('Date')
plt.ylabel('Price')
plt.legend()  # Add a legend to display the symbols
plt.show()
```



In [21]:
```
# Calculate returns
returns = df.pct_change().fillna(0)
returns
```

Out[21]:

Date	NVDA	AAPL	JPM	AMZN	CAT	WMT	BA	JNJ	N
2016-11-29	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000
2016-11-30	-0.011260	-0.008434	0.015839	-0.015672	0.016163	-0.013171	-0.007122	-0.010491	-0.01
2016-12-01	-0.049458	-0.009320	0.020207	-0.009220	0.007116	0.003408	0.012155	0.000719	-0.00
2016-12-02	0.009242	0.003745	-0.002323	-0.004451	-0.011430	0.002972	-0.000919	0.005207	-0.00
2016-12-05	0.038779	-0.007188	0.020343	0.025691	-0.007252	-0.013262	-0.000591	-0.000179	0.00
...	...	...	...	...	...	...	...	...	
2024-02-06	-0.015995	0.008632	0.003438	-0.006811	0.004107	0.006818	0.009437	0.014506	-0.00
2024-02-07	0.027498	0.000581	0.001885	0.008158	0.002696	-0.002532	0.016013	-0.000506	0.00
2024-02-08	-0.006534	-0.005755	-0.003591	-0.004046	-0.004914	-0.000059	-0.012741	-0.010001	0.01
2024-02-09	0.035784	0.002814	0.001201	0.027143	-0.015031	-0.000531	-0.000096	0.002302	-0.00
2024-02-12	0.027616	-0.005825	0.007142	-0.006506	0.011477	0.003663	0.002438	0.005805	0.00

1812 rows × 19 columns

In [22]:

```
#########################################################Efficient Frontier & Const
# Import optimization module from scipy
import scipy.optimize as sco

# Define portfolio stats function
def portfolio_stats(weights):

    weights = array(weights)[:,newaxis]
    port_rets = weights.T @ array(returns.mean() * 252)[:,newaxis]
    port_vols = sqrt(multi_dot([weights.T, returns.cov() * 252, weights]))

    return array([port_rets, port_vols, port_rets/port_vols]).flatten()

#Example 1 : Maximum sharpe ratio portfolio
# Maximizing sharpe ratio
def min_sharpe_ratio(weights):
    return -portfolio_stats(weights)[2]

# Define initial weights
initial_wts = numofasset * [1./numofasset]
initial_wts

# Each asset boundary ranges from 0 to 1 bounds
bnds = tuple((0,1) for x in range(numofasset))

# Specify constraints
cons = ({'type': 'eq', 'fun': lambda x: sum(x)-1})
```

```
cons

# Optimizing for maximum sharpe ratio
opt_sharpe = sco.minimize(min_sharpe_ratio, initial_wts, method='SLSQP', bounds=bnd
opt_sharpe
bnds
```

Out[22]:

```
((0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1),
 (0, 1))
```

In [23]:

```
# Portfolio weights
list(zip(symbols, opt_sharpe['x']))
```

Out[23]:

```
[('NVDA', 0.273053733372647),
 ('AAPL', 0.08671842689290042),
 ('JPM', 8.851964168858266e-17),
 ('AMZN', 7.061435335512556e-17),
 ('CAT', 0.06908207851383266),
 ('WMT', 0.22097735511694094),
 ('BA', 5.584220102641086e-17),
 ('JNJ', 1.7758401840368728e-17),
 ('MCD', 0.0325772972057475),
 ('UNH', 0.1523305674945298),
 ('VZ', 8.216394721800937e-17),
 ('V', 2.5704335403502673e-17),
 ('GS', 6.091325034838343e-17),
 ('EA', 1.323772414385636e-17),
 ('NFLX', 0.004014765956249008),
 ('SBUX', 0.0),
 ('TSLA', 0.12605456060649503),
 ('ASML', 0.03519121484065745),
 ('CVX', 1.2611413626254993e-16)]
```

In [25]:

```
# Portfolio stats
stats = ['Returns', 'Volatility', 'Sharpe Ratio']
list(zip(stats, around(portfolio_stats(opt_sharpe['x']),4)))
```

Out[25]:

```
[('Returns', 0.3594), ('Volatility', 0.2614), ('Sharpe Ratio', 1.3747)]
```

In [26]:

```
#Example 2 : Minumum variance portfolio
# Minimize the variance
def min_variance(weights):
    return portfolio_stats(weights)[1]**2

# Optimizing for minimum variance
opt_var = sco.minimize(min_variance, initial_wts, method='SLSQP', bounds=bnds, cons
opt_var
```

Out[26]:
```
 message: Optimization terminated successfully
 success: True
  status: 0
     fun: 0.020815086532275064
       x: [ 0.000e+00  4.962e-18 ...  0.000e+00  2.231e-04]
     nit: 13
     jac: [ 5.735e-02  4.736e-02 ...  4.670e-02  4.193e-02]
    nfev: 261
    njev: 13
```

In [27]:
```
# Portfolio weights
list(zip(symbols, around(opt_var['x']*100,2)))
```

Out[27]:
```
[('NVDA', 0.0),
 ('AAPL', 0.0),
 ('JPM', 0.0),
 ('AMZN', 3.11),
 ('CAT', 0.95),
 ('WMT', 18.36),
 ('BA', 0.0),
 ('JNJ', 24.53),
 ('MCD', 18.41),
 ('UNH', 0.0),
 ('VZ', 24.63),
 ('V', 0.0),
 ('GS', 0.0),
 ('EA', 9.99),
 ('NFLX', 0.0),
 ('SBUX', 0.0),
 ('TSLA', 0.0),
 ('ASML', 0.0),
 ('CVX', 0.02)]
```

In [28]:
```
# Portfolio stats
stats = ['Returns', 'Volatility', 'Sharpe Ratio']
list(zip(stats, around(portfolio_stats(opt_var['x']),4)))
```

Out[28]:
```
[('Returns', 0.088), ('Volatility', 0.1443), ('Sharpe Ratio', 0.6102)]
```

In [29]:
```
#Example 3 : Efficient Frontier portfolio
def min_volatility(weights):
    return portfolio_stats(weights)[1]

# Efficient frontier params
targetrets = linspace(0.30,0.60,100)
tvols = []

for tr in targetrets:

    ef_cons = ({'type': 'eq', 'fun': lambda x: portfolio_stats(x)[0] - tr},
               {'type': 'eq', 'fun': lambda x: sum(x) - 1})

    opt_ef = sco.minimize(min_volatility, initial_wts, method='SLSQP', bounds=bnds,

    tvols.append(opt_ef['fun'])

targetvols = array(tvols)

# Dataframe for EF
efport = pd.DataFrame({
    'targetrets' : around(100*targetrets[14:],2),
    'targetvols': around(100*targetvols[14:],2),
    'targetsharpe': around(targetrets[14:]/targetvols[14:],2)
})
```

```
efport.head(5)
```

Out[29]:

	targetrets	targetvols	targetsharpe
0	34.24	24.93	1.37
1	34.55	25.14	1.37
2	34.85	25.36	1.37
3	35.15	25.57	1.37
4	35.45	25.79	1.37

In [30]:

```
# Plot efficient frontier portfolio
#pip install plotly
import plotly.express as px

# Plot starts
fig = px.scatter(
    efport, x='targetvols', y='targetrets', color='targetsharpe',
    labels={'targetrets': 'Expected Return', 'targetvols': 'Expected Volatility', '
    title="Efficient Frontier Portfolio"
).update_traces(mode='markers', marker=dict(symbol='cross'))

# Plot maximum sharpe portfolio
fig.add_scatter(
    mode='markers',
    x=[100*portfolio_stats(opt_sharpe['x'])[1]],
    y=[100*portfolio_stats(opt_sharpe['x'])[0]],
    marker=dict(color='red', size=20, symbol='star'),
    name='Max Sharpe'
).update(layout_showlegend=True)

# Plot minimum variance portfolio
fig.add_scatter(
    mode='markers',
    x=[100*portfolio_stats(opt_var['x'])[1]],
    y=[100*portfolio_stats(opt_var['x'])[0]],
    marker=dict(color='green', size=20, symbol='star'),
    name='Min Variance'
).update(layout_showlegend=True)

# Show spikes
fig.update_xaxes(showspikes=True)
fig.update_yaxes(showspikes=True)
fig.show()
```

In [ ]:

```

```

In [ ]:

```

```