1. Risk to Return Ratio.

In any investment, we expect to make a return more than our intial investment. But in any investment, there is always risk involved, so how do we compare different investment with similar returns on average, but with different risk?

To do that, we can compares the average difference divided by standard deviation. a higher value of this means higher return for given amount of risk.

The description/concept above are called Sharpe ratio, i recommend you to find out the detailed version of Sharpe Ratio is.

Lets get started.

In [1]:
```
# Importing required modules
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

# Settings to produce nice plots in a Jupyter notebook
plt.style.use('fivethirtyeight')
%matplotlib inline

# Reading in the data
stock_data = pd.read_csv('datasets/stock_data.csv', parse_dates=['Date'], index_col=
benchmark_data = pd.read_csv('datasets/benchmark_data.csv',  parse_dates=['Date'], i
```

2. The Data

Take a look at the datasets we just loaded, how many columns and row does it have.

In [2]:
```
# Display summary for stock_data
print('Stocks\n')
stock_data.info()

# Display summary for benchmark_data
print('\nBenchmarks\n')
benchmark_data.info()
```

```
Stocks

<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 252 entries, 2016-01-04 to 2016-12-30
Data columns (total 2 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   Amazon    252 non-null    float64
 1   Facebook  252 non-null    float64
dtypes: float64(2)
memory usage: 5.9 KB

Benchmarks

<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 252 entries, 2016-01-04 to 2016-12-30
Data columns (total 1 columns):
 #   Column   Non-Null Count  Dtype  
---  ------   --------------  -----  
 0   S&P 500  252 non-null    float64
```

```
dtypes: float64(1)
memory usage: 3.9 KB
```

3. Summary and Plot of FB and AMZN

Before we compare it to our benchmark (SPY500), lets plot the the each company individualy so we understand better.

In [3]:
```
# visualize the stock_data
stock_data.plot(subplots=True, title='Stock Data')


# summarize the stock_data
stock_data.describe()
```

Out[3]:

	Amazon	Facebook
count	252.000000	252.000000
mean	699.523135	117.035873
std	92.362312	8.899858
min	482.070007	94.160004
25%	606.929993	112.202499
50%	727.875000	117.765000
75%	767.882492	123.902503
max	844.359985	133.279999

4. Summary and Plot of SPY500

Also take a look at the S&P 500 data, our benchmark.

In [4]:
```
# plot the benchmark_data
benchmark_data.plot(subplots=True, title='N&P 500')


# summarize the benchmark_data
benchmark_data.describe()
```

Out[4]:

	S&P 500
count	252.000000
mean	2094.651310
std	101.427615
min	1829.080000
25%	2047.060000
50%	2104.105000
75%	2169.075000
max	2271.720000

5. The inputs for the Sharpe Ratio: Starting with Daily Stock Returns

Let's calculate the difference in returns between the two companies.

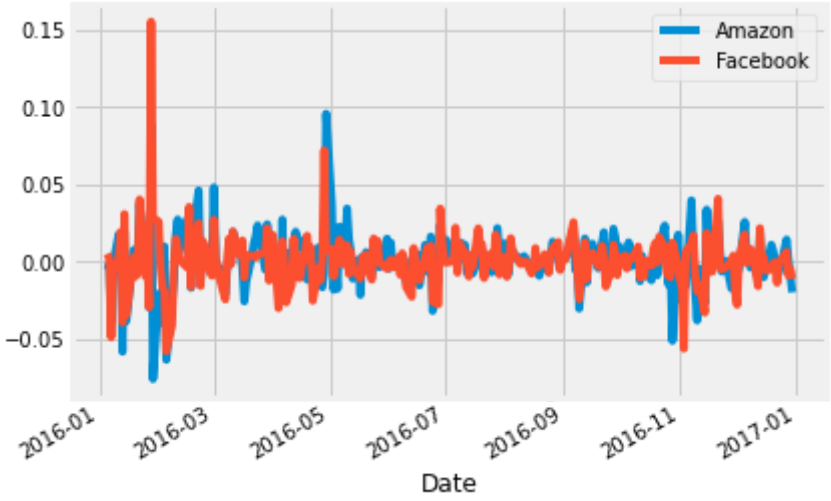
The values in our data is historical vlue of investment not return, to calculate return we need to calculate the percent change in certain date to the next day, also take a look at summary statistics because we need the mean of the difference to caculate the risk ratio.

In [5]:
```
# calculate daily stock_data returns
stock_returns = stock_data.pct_change()

# plot the daily returns
stock_returns.plot()

# summarize the daily returns
stock_returns.describe()
```

Out[5]:

	Amazon	Facebook
count	251.000000	251.000000
mean	0.000818	0.000626
std	0.018383	0.017840
min	-0.076100	-0.058105

	Amazon	Facebook
25%	-0.007211	-0.007220
50%	0.000857	0.000879
75%	0.009224	0.008108
max	0.095664	0.155214



In [6]:
```
stock_returns.tail()
```

Out[6]:

Date	Amazon	Facebook
2016-12-23	-0.007503	-0.001107
2016-12-27	0.014213	0.006310
2016-12-28	0.000946	-0.009237
2016-12-29	-0.009040	-0.004875
2016-12-30	-0.019970	-0.011173

6. Daily S&P 500 returns

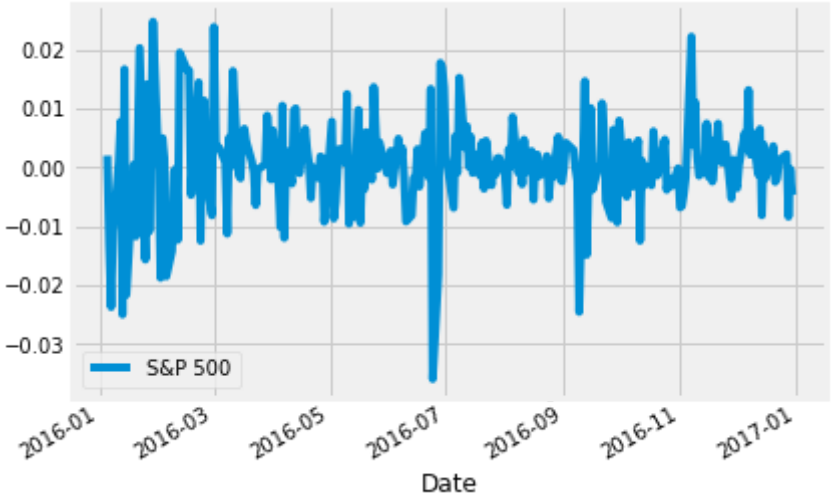
Repeat previous process for SPY500 data.

In [7]:
```
# calculate daily benchmark_data returns
sp_returns = benchmark_data.pct_change()

# plot the daily returns
sp_returns.plot()


# summarize the daily returns
sp_returns.describe()
```

Out[7]:

	S&P 500
count	251.000000
mean	0.000458
std	0.008205

	S&P 500
min	-0.035920
25%	-0.002949
50%	0.000205
75%	0.004497
max	0.024760



In [8]:
```
sp_returns.tail()
```

Out[8]:

Date	S&P 500
2016-12-23	0.001252
2016-12-27	0.002248
2016-12-28	-0.008357
2016-12-29	-0.000293
2016-12-30	-0.004637

7. Calculating Excess Returns for Amazon and Facebook vs. S&P 500

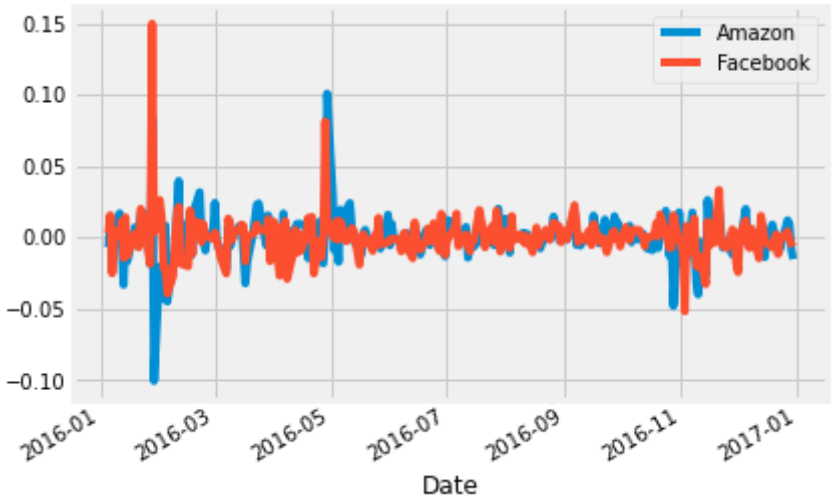
Calculate the relative performance of FB & AMZN vs SPY500. to do this, we will substract the value of difference in our benchmark from the FB and AMZN differences.

In [9]:
```
# calculate the difference in daily returns
excess_returns = excess_returns = stock_returns.sub(sp_returns['S&P 500'], axis=0)

# plot the excess_returns
excess_returns.plot()


# summarize the excess_returns
excess_returns.describe()
```

Out[9]:

	Amazon	Facebook

	Amazon	Facebook
count	251.000000	251.000000
mean	0.000360	0.000168
std	0.016126	0.015439
min	-0.100860	-0.051958
25%	-0.006229	-0.005663
50%	0.000698	-0.000454
75%	0.007351	0.005814
max	0.100728	0.149686



In [10]:
```
excess_returns.tail()
```

Out[10]:

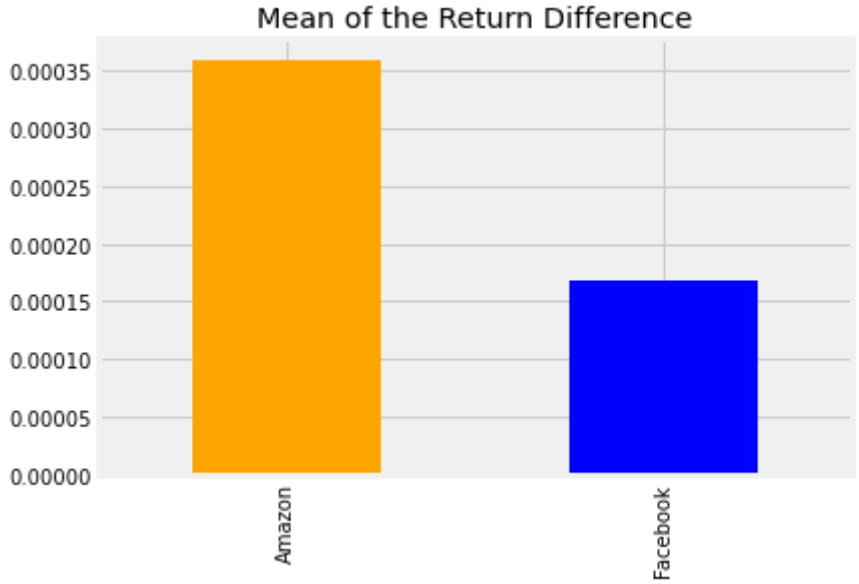
Date	Amazon	Facebook
2016-12-23	-0.008755	-0.002359
2016-12-27	0.011964	0.004062
2016-12-28	0.009303	-0.000880
2016-12-29	-0.008747	-0.004582
2016-12-30	-0.015333	-0.006536

8. The Risk/Return Ratio, Step 1: The Average Difference in Daily Returns Stocks vs S&P 500

Now we can calculate the risk/return ratio. First, get the mean of our calculated excess return over the year(all across the data). Then, plot it to see the return difference individualy compared to SPY500.

In [11]:
```
# calculate the mean of excess_returns
avg_excess_return = excess_returns.mean()

# plot avg_excess_returns
avg_excess_return.plot(title='Mean of the Return Difference', kind='bar', color=['or
```

Out[11]: <AxesSubplot:title={'center':'Mean of the Return Difference'}>



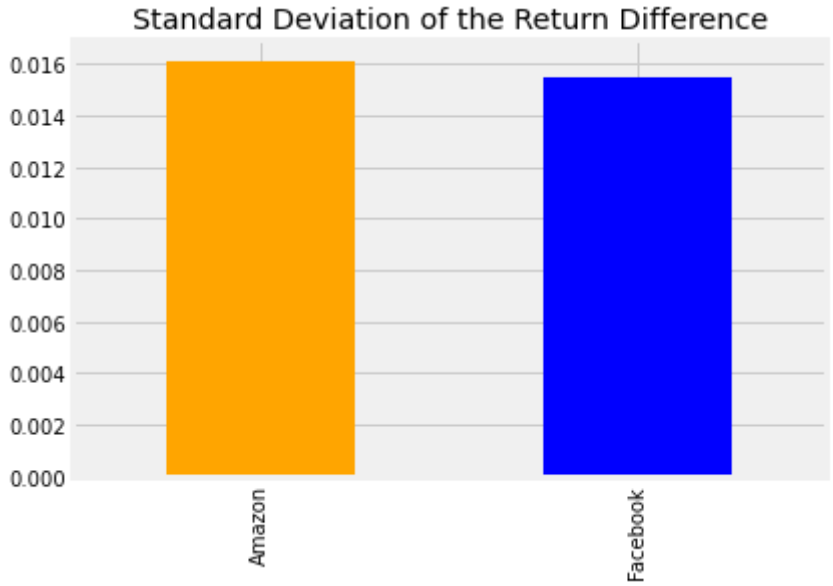
9. The Risk/Return Ratio, Step 2: Standard Deviation of the Return Difference

Theres some quite substantial amount difference of average daily returns between the two companies.

Next, calculate the standard deviation of our excess returns. this will be the amount of risk an investment implies compared to SPY500.

In [12]:
```
# calculate the standard deviations
sd_excess_return = excess_returns.std()

# plot the standard deviations
sd_excess_return.plot(title='Standard Deviation of the Return Difference', kind='bar
```

Out[12]: <AxesSubplot:title={'center':'Standard Deviation of the Return Difference'}>

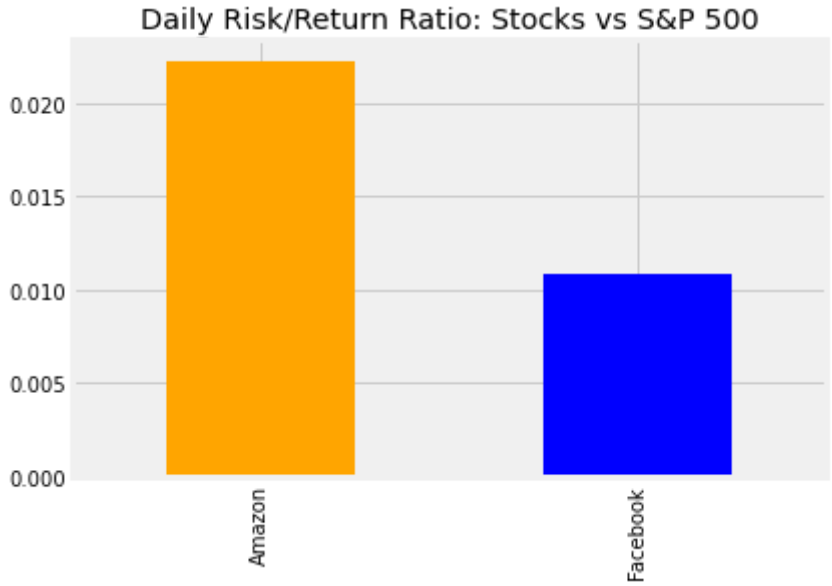


10. Putting it all together

Now we just need to calculate the ratio of our average returns and standard deviation returns, simply by dividing the average by standard deviation, we will have our dialy risk/return ratio.

In [13]:
```
# calculate the daily sharpe ratio
daily_ratio = avg_excess_return.div(sd_excess_return)
daily_ratio.plot(title='Daily Risk/Return Ratio: Stocks vs S&P 500', kind='bar', col
```

Out[13]:
```
<AxesSubplot:title={'center':'Daily Risk/Return Ratio: Stocks vs S&P 500'}>
```



In [14]:
```
print('Amazon Daily Risk/Return Ratio :'+str(daily_sharpe_ratio[0]))
print('Facebook Daily Risk/Return Ratio :'+str(daily_sharpe_ratio[1]))
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-14-190792e6270d> in <module>
----> 1 print('Amazon Daily Risk/Return Ratio :'+str(daily_sharpe_ratio[0]))
      2 print('Facebook Daily Risk/Return Ratio :'+str(daily_sharpe_ratio[1]))

NameError: name 'daily_sharpe_ratio' is not defined
```

To adjust the ratio, multiply the daily ratio by the squareroot of number of trading day (in this case 252 days), then we have annual ratio.

In [ ]:
```
# annualize the sharpe ratio
annual_factor = np.sqrt(252)
annual_ratio = daily_ratio.mul(annual_factor)

# plot the annualized sharpe ratio
annual_ratio.plot(title='Annualized Risk/Return Ratio: Stocks vs S&P 500', kind='bar

print('Amazon Annual Risk Ratio :'+str(daily_sharpe_ratio[0]))
print('Facebook Annual Risk Ratio :'+str(daily_sharpe_ratio[1]))
```

11. Conclusion

Which investment we should go for? Amazon had a Ratio twice as high as Facebook, this means investment in Amazon likely to return twice as much compare to the SPY500 for each unit of risk an investor would assume, in other words, investment in amazon is more attractive.

The difference was mostly driven by differences in return rather than risk between the two companies. The risk on amazon over FB(measured by standard deviation) was only slightly

higher that the higher Risk/Return ratio for amazon end up higher mainly due to higher average return for Amazon, in short both companies have almost the same risk but amazon return double the investment.