Time Series Analysis of Litecoin Cryptocurrency in Python

Shpaner, Leonid - March 11, 2022

The following time series analysis is an update to the pre-existing analysis conducted in R, but this time done in Python. The data is sourced from Yahoo Finance.

[1]:
```
import pandas as pd
import numpy as np
import yfinance as yf
import scipy.stats as scs
import statsmodels.api as sm
import statsmodels.tsa.api as smt

import matplotlib.pyplot as plt
import seaborn as sns
```

[2]:
```
ltc = yf.download('LTC-USD', start ='2011-01-01',
                             end='2022-03-10',
                             progress=False)
```

[3]:
```
ltc.head()
```

[3]:

Date	Open	High	Low	Close	Adj Close	Volume
2014-09-17	5.08589	5.17077	4.96595	5.05855	5.05855	3071840
2014-09-18	5.06543	5.06543	4.57996	4.68523	4.68523	4569260
2014-09-19	4.68729	4.75582	4.25435	4.32777	4.32777	3917450
2014-09-20	4.32920	4.61608	4.20219	4.28644	4.28644	5490660
2014-09-21	4.26307	4.30013	4.15499	4.24592	4.24592	2931220

Simple Returns

Simple returns are aggregated over assets, which is a "weighted sum of the returns of the individual assests in the portfolio" (Lewinson, 2020).

$$R_t = \frac{(P_t - P_{t-1})}{P_{t-1}} = \frac{P_t}{P_{t-1}} - 1$$

Log Returns

Log returns are aggregated over time.

$$r_t = log\left(\frac{P_t}{P_{t-1}}\right) = log(P_t) - log(P_t - 1)$$

[4]:
```
ltc.rename(columns = {'Adj Close': 'adj_close'}, inplace=True)
ltc['simple_rtn'] = ltc.adj_close.pct_change()
ltc['log_rtn'] = np.log(ltc.adj_close/ltc.adj_close.shift(1))
```

[5]:
```
ltc.head()
```

[5]:
```
                Open     High      Low    Close  adj_close   Volume  \
Date
2014-09-17  5.08589  5.17077  4.96595  5.05855    5.05855  3071840
2014-09-18  5.06543  5.06543  4.57996  4.68523    4.68523  4569260
2014-09-19  4.68729  4.75582  4.25435  4.32777    4.32777  3917450
2014-09-20  4.32920  4.61608  4.20219  4.28644    4.28644  5490660
2014-09-21  4.26307  4.30013  4.15499  4.24592    4.24592  2931220

            simple_rtn   log_rtn
Date
2014-09-17         NaN       NaN
2014-09-18   -0.073800 -0.076665
2014-09-19   -0.076295 -0.079363
2014-09-20   -0.009550 -0.009596
2014-09-21   -0.009453 -0.009498
```

[6]:
```
ltc.head()
# ltc['Date'] = pd.to_datetime(ltc['Date'])
```

[6]:
```
                Open     High      Low    Close  adj_close   Volume  \
Date
2014-09-17  5.08589  5.17077  4.96595  5.05855    5.05855  3071840
2014-09-18  5.06543  5.06543  4.57996  4.68523    4.68523  4569260
2014-09-19  4.68729  4.75582  4.25435  4.32777    4.32777  3917450
2014-09-20  4.32920  4.61608  4.20219  4.28644    4.28644  5490660
2014-09-21  4.26307  4.30013  4.15499  4.24592    4.24592  2931220

            simple_rtn   log_rtn
Date
2014-09-17         NaN       NaN
2014-09-18   -0.073800 -0.076665
2014-09-19   -0.076295 -0.079363
2014-09-20   -0.009550 -0.009596
2014-09-21   -0.009453 -0.009498
```

[7]:
```
print('Number of Rows:', ltc.shape[0])
print('Number of Columns:', ltc.shape[1], '\n')

data_types = ltc.dtypes
data_types = pd.DataFrame(data_types)
data_types = data_types.assign(Null_Values =
                               ltc.isnull().sum())
data_types.reset_index(inplace = True)
data_types.rename(columns={0:'Data Type',
                           'index': 'Column/Variable',
                           'Null_Values': "# of Nulls"})
```

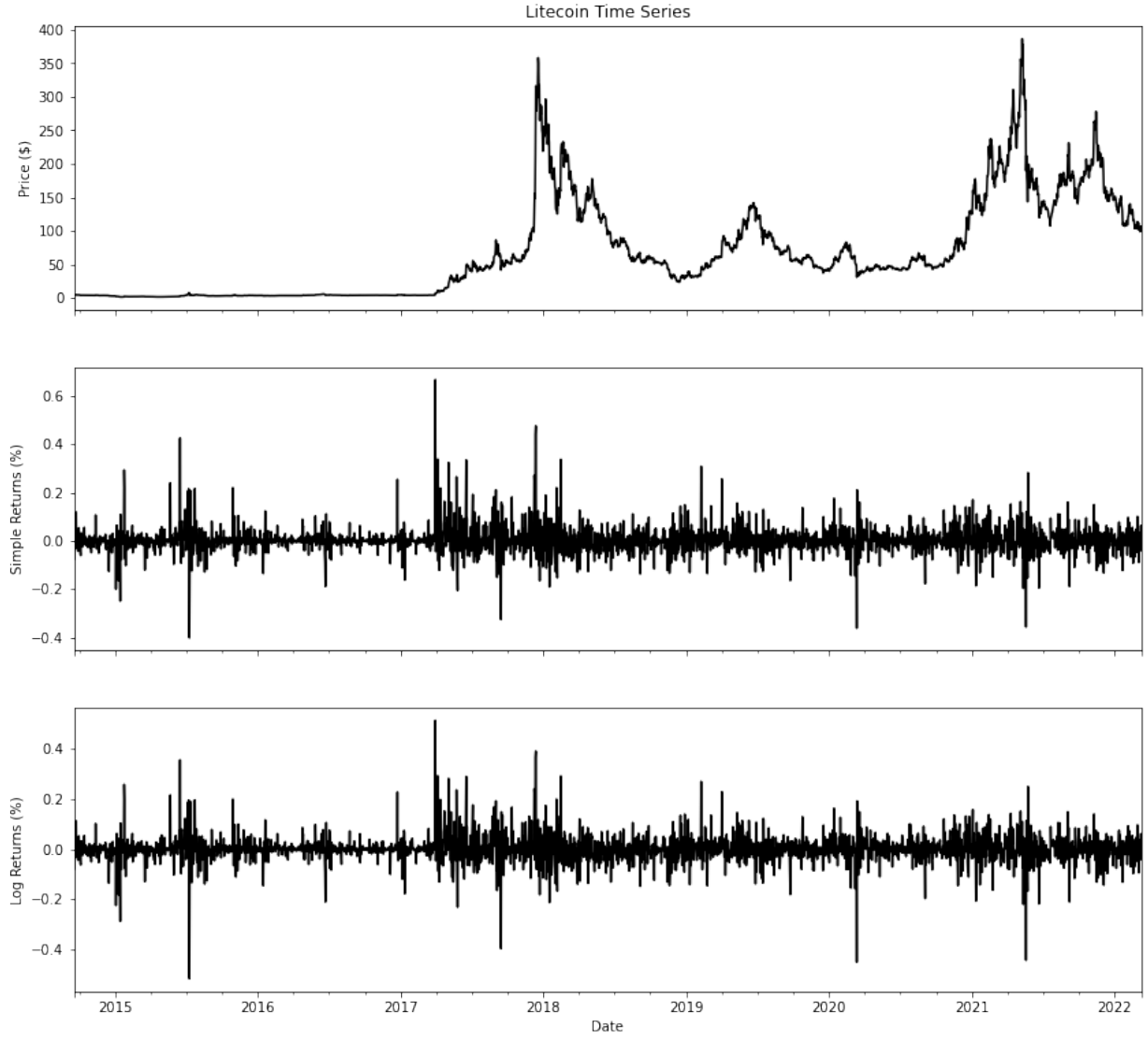
```
Number of Rows: 2732
Number of Columns: 8
```

[7]:

	Column/Variable	Data Type	# of Nulls
0	Open	float64	0
1	High	float64	0
2	Low	float64	0
3	Close	float64	0
4	adj_close	float64	0
5	Volume	int64	0
6	simple_rtn	float64	1
7	log_rtn	float64	1

Below, litecoin's historical prices (2015 - Present), simple returns, and log returns, respectively, are shown.

[8]:
```
fig, ax = plt.subplots(3,1,figsize=(14,13), sharex = True)
ltc.adj_close.plot(ax=ax[0], color = 'black')
ax[0].set(title = 'Litecoin Time Series', ylabel = 'Price ($)')
ltc.simple_rtn.plot(ax=ax[1], color = 'black')
ax[1].set(xlabel = 'Date', ylabel = 'Simple Returns (%)')
ltc.log_rtn.plot(ax=ax[2], color = 'black')
ax[2].set(xlabel = 'Date', ylabel = 'Log Returns (%)')
plt.show()
```



Outliers

Outliers are identifying within 3 standard deviations from the mean in order to avoid biased estimates/ingesting unecessary noise into the modeling framework.

The rolling mean and standard deviation are thus calculated.

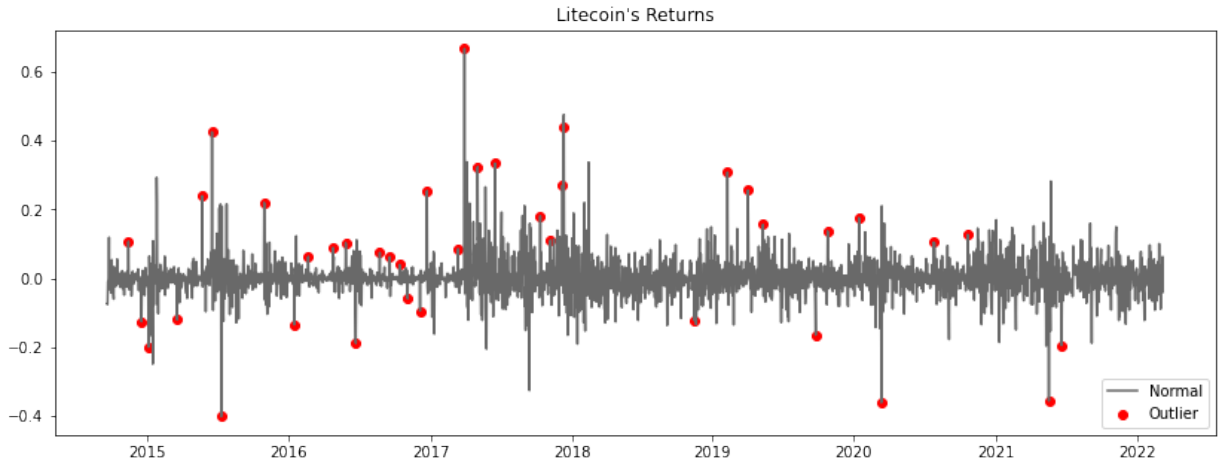
[9]:
```
ltc_rolling = ltc[['simple_rtn']].rolling(window=21).agg(['mean', 'std'])
ltc_rolling.columns = ltc_rolling.columns.droplevel()
ltc_outliers = ltc.join(ltc_rolling)

# detect outliers
def outliers_ltc (row, n_sigmas=3):
    x = row['simple_rtn']
    mu = row['mean']
    sigma = row['std']
    if (x > mu + 3 * sigma) | (x < mu - 3 * sigma):
        return 1
    else:
        return 0

ltc_outliers['outlier'] = ltc_outliers.apply(outliers_ltc,
axis=1)
outliers = ltc_outliers.loc[ltc_outliers['outlier'] == 1,['simple_rtn']]
```

Outlier Plot

[10]:
```
fig, ax = plt.subplots(figsize=(14,5))
ax.plot(ltc_outliers.index, ltc_outliers.simple_rtn,
color='dimgrey', label='Normal')
ax.scatter(outliers.index, outliers.simple_rtn,
color='red', label='Outlier')
ax.set_title("Litecoin's Returns")
ax.legend(loc='lower right')
plt.show()
```



Visualizing Returns Via Distributions

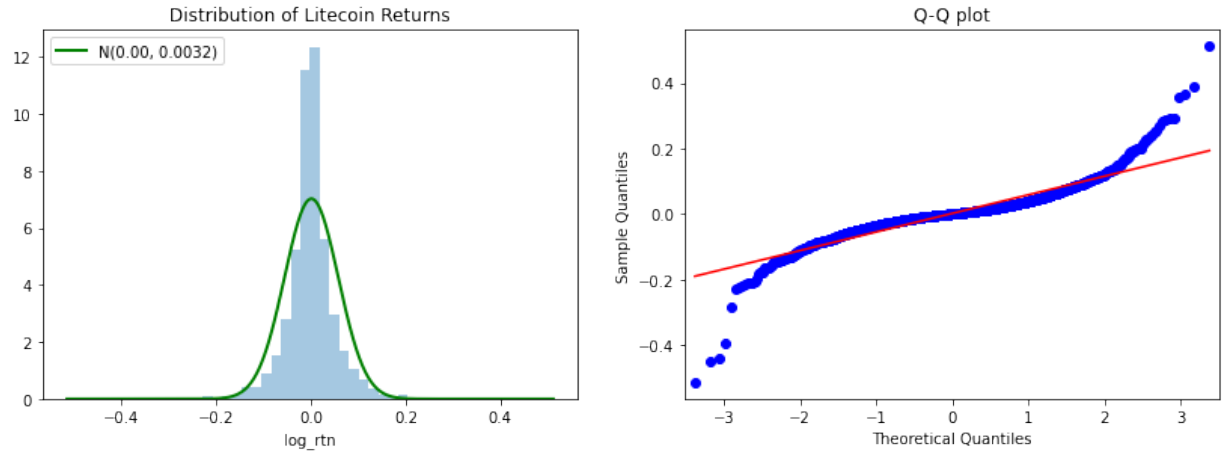
[11]:
```
ltc1 = ltc[['adj_close', 'log_rtn']].dropna(how = 'any')
```

[12]:
```
# probability density function
r_range = np.linspace(min(ltc1.log_rtn), max(ltc1.log_rtn), num=1000)
mu = ltc1.log_rtn.mean()
sigma = ltc1.log_rtn.std()
norm_pdf = scs.norm.pdf(r_range, loc=mu, scale=sigma)
```

[13]:
```
fig, ax = plt.subplots(1, 2, figsize=(14, 4.5))
# histogram
sns.distplot(ltc1.log_rtn, kde=False, norm_hist=True, ax=ax[0])
ax[0].set_title('Distribution of Litecoin Returns')
ax[0].plot(r_range, norm_pdf, 'g', lw=2,
label=f'N({mu:.2f}, {sigma**2:.4f})')
ax[0].legend(loc='upper left')

# Q-Q plot
qq = sm.qqplot(ltc1.log_rtn.values, line='s', ax=ax[1])
ax[1].set_title('Q-Q plot')
plt.show()

jb_test = scs.jarque_bera(ltc1.log_rtn.values)
print('---------- Descriptive Statistics ----------')
print('Range of dates:', min(ltc1.index.date), '-', max(ltc1.index.date))
print('Number of observations:', ltc1.shape[0])
print(f'Mean: {ltc1.log_rtn.mean():.4f}')
print(f'Median: {ltc1.log_rtn.median():.4f}')
print(f'Min: {ltc1.log_rtn.min():.4f}')
print(f'Max: {ltc1.log_rtn.max():.4f}')
print(f'Standard Deviation: {ltc1.log_rtn.std():.4f}')
print(f'Skewness: {ltc1.log_rtn.skew():.4f}')
print(f'Kurtosis: {ltc1.log_rtn.kurtosis():.4f}')
print(f'Jarque-Bera statistic: {jb_test[0]:.2f} with p-value: {jb_test[1]:.2f}')
```



```
---------- Descriptive Statistics ----------
Range of dates: 2014-09-18 - 2022-03-10
Number of observations: 2731
Mean: 0.0011
Median: -0.0003
Min: -0.5146
Max: 0.5114
Standard Deviation: 0.0568
Skewness: 0.1153
Kurtosis: 12.9461
Jarque-Bera statistic: 19001.57 with p-value: 0.00
```