In [78]:

```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import calendar


import seaborn as sns
import matplotlib.pyplot as plt
from matplotlib.pyplot import pie
from matplotlib import gridspec
import matplotlib.ticker as mtick

import warnings
warnings.filterwarnings('ignore')

import scipy.stats
from scipy.stats import norm, chi2
import os
```

In [79]:

```
pip install yfinance
```

```
Requirement already satisfied: yfinance in /opt/conda/lib/python3.7/site-packages (0.1.66
)
Requirement already satisfied: numpy>=1.15 in /opt/conda/lib/python3.7/site-packages (fro
m yfinance) (1.19.5)
Requirement already satisfied: multitasking>=0.0.7 in /opt/conda/lib/python3.7/site-packa
ges (from yfinance) (0.0.10)
Requirement already satisfied: lxml>=4.5.1 in /opt/conda/lib/python3.7/site-packages (fro
m yfinance) (4.6.3)
Requirement already satisfied: requests>=2.20 in /opt/conda/lib/python3.7/site-packages (
from yfinance) (2.25.1)
Requirement already satisfied: pandas>=0.24 in /opt/conda/lib/python3.7/site-packages (fr
om yfinance) (1.3.4)
Requirement already satisfied: pytz>=2017.3 in /opt/conda/lib/python3.7/site-packages (fr
om pandas>=0.24->yfinance) (2021.1)
Requirement already satisfied: python-dateutil>=2.7.3 in /opt/conda/lib/python3.7/site-pa
ckages (from pandas>=0.24->yfinance) (2.8.0)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.7/site-packages (from p
ython-dateutil>=2.7.3->pandas>=0.24->yfinance) (1.16.0)
Requirement already satisfied: idna<3,>=2.5 in /opt/conda/lib/python3.7/site-packages (fr
om requests>=2.20->yfinance) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/lib/python3.7/site-packag
es (from requests>=2.20->yfinance) (2021.10.8)
Requirement already satisfied: chardet<5,>=3.0.2 in /opt/conda/lib/python3.7/site-package
s (from requests>=2.20->yfinance) (4.0.0)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.7/site-pac
kages (from requests>=2.20->yfinance) (1.26.6)
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting
behaviour with the system package manager. It is recommended to use a virtual environment
instead: https://pip.pypa.io/warnings/venv
Note: you may need to restart the kernel to use updated packages.
```

In [80]:

```
import yfinance as yf
```

In [81]:

```
#define the ticker symbol
tickerSymbol = 'ETH-USD'
```

In [82]:

```
#get data on this ticker
tickerData = yf.Ticker(tickerSymbol)
```

In [83]:

```
#get the historical prices for this ticker
tickerDf = tickerData.history(period='1d', start='2015-9-1', end='2021-10-1')
```

In [84]:

```
tickerDf = tickerDf[['Close']]
```

In [85]:

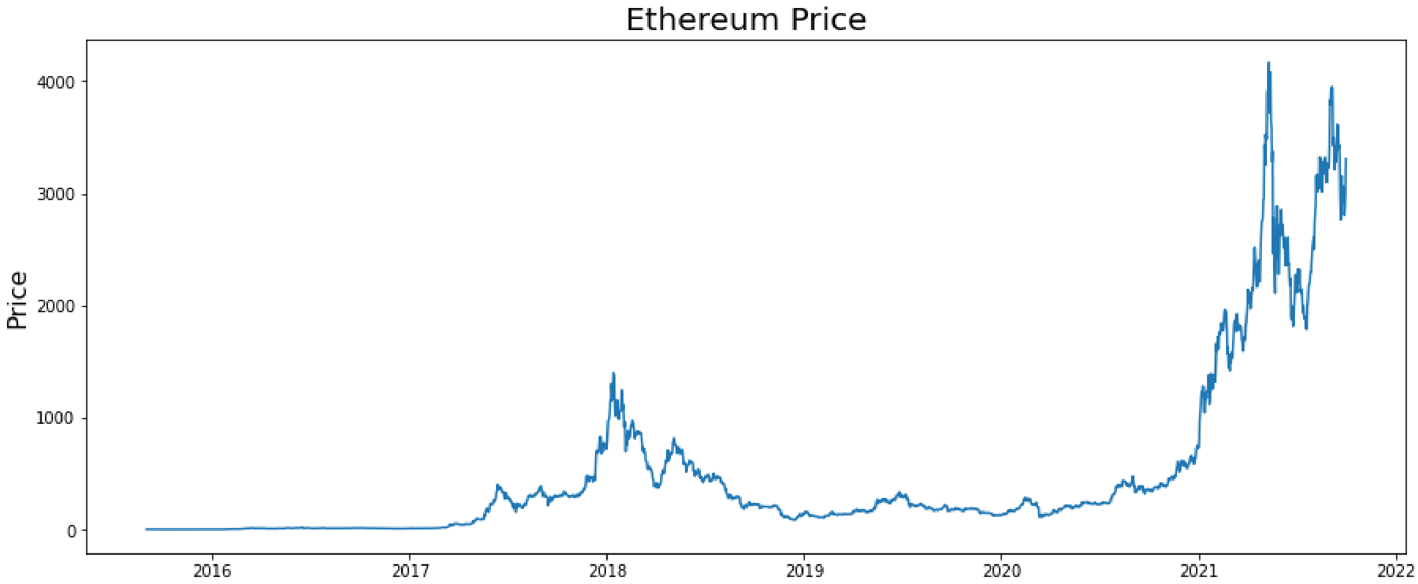
```
tickerDf.tail()
```

Out[85]:

	Close
Date	
2021-09-27	2934.138916
2021-09-28	2807.296631
2021-09-29	2853.143311
2021-09-30	3001.678955
2021-10-01	3307.516113

In [86]:

```
plt.figure(figsize=(15,6))
plt.plot(tickerDf['Close'], label='Ethereum')
plt.title('Ethereum Price', fontsize=20)
plt.ylabel('Price', fontsize=16)
plt.show()
```



In [87]:

```
tickerDf['logged'] = np.log(tickerDf['Close'])
```

In [88]:

```
tickerDf.tail()
```

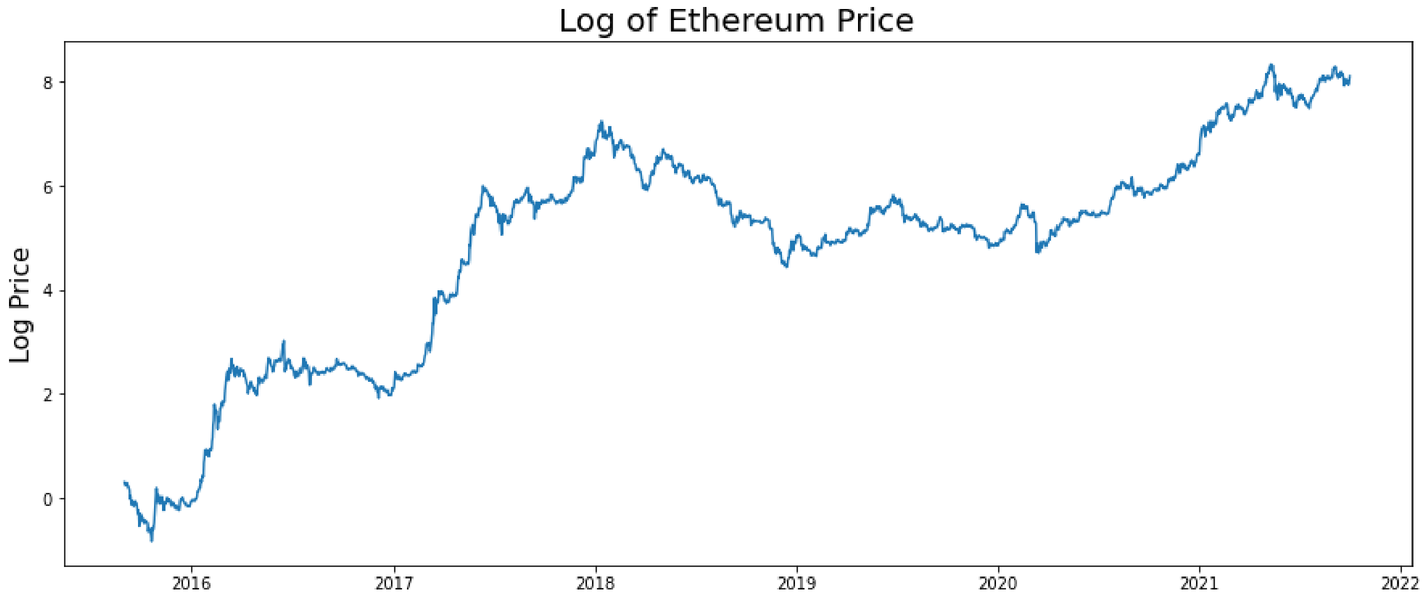
Out[88]:

	Close	logged
Date		
2021-09-27	2934.138916	7.984169

	Close	logged
Date		
2021-09-28	2807.2[illegible]	7.[illegible]
2021-09-29	2853.143311	7.956177
2021-09-30	3001.678955	8.006927
2021-10-01	3307.516113	8.103953

In [89]:

```
plt.figure(figsize=(15,6))
plt.plot(tickerDf['logged'], label='Ethereum')
plt.title('Log of Ethereum Price', fontsize=20)
plt.ylabel('Log Price', fontsize=16)
plt.show()
```



In [90]:

```
def turningpoints(x):
    N=0
    for i in range(1, len(x)-1):
        if ((x[i-1] < x[i] and x[i+1] < x[i]) or (x[i-1] > x[i] and x[i+1] > x[i])):
            N += 1
    return N


t = turningpoints(tickerDf['logged'])
expectatoion = ((2*tickerDf.shape[0]) - 4) / 3
variance = ((16*tickerDf.shape[0]) - 29) / 90
z_score = (t - expectatoion) / (variance**0.5)
print("z-score = ",z_score)
p_value = scipy.stats.norm.sf(abs(z_score))*2
print("p-value = ",p_value)# p<0.05 so null hypothesis is rejected at 5% level of signifi
cance. i.e. the the time series is not random.
```

```
z-score =  -15.16095463533037
p-value =  6.413038368338921e-52
```

In [91]:

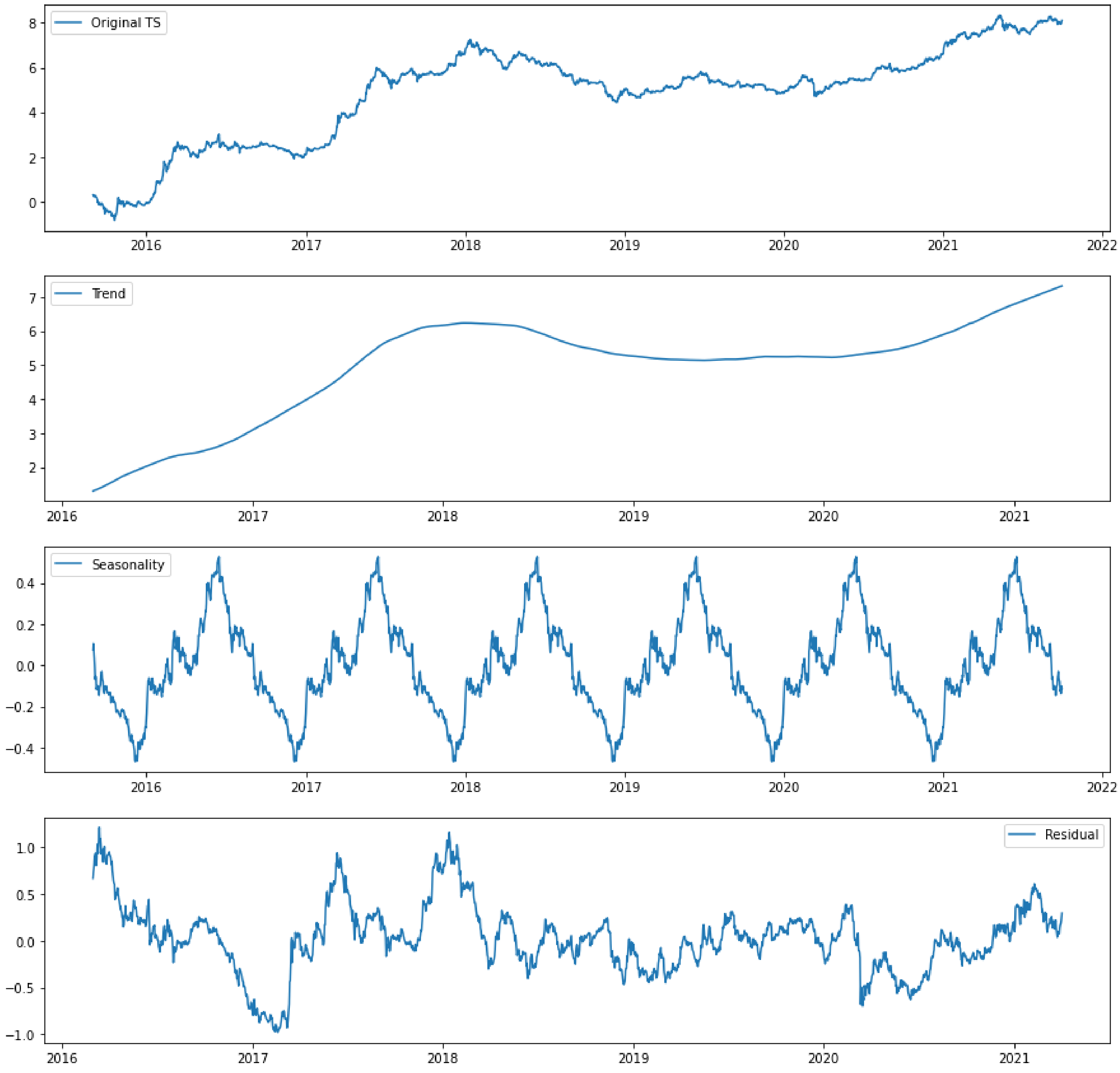
```
from statsmodels.tsa.seasonal import seasonal_decompose
```

In [92]:

```
decompose_add=seasonal_decompose(tickerDf['logged'], model='additive', period=365)
plt.figure(figsize=(15,15))
plt.subplot(411)
plt.plot(tickerDf['logged'], label='Original TS')
plt.legend(loc='best')
plt.subplot(412)
plt.plot(decompose_add.trend, label='Trend')
plt.legend(loc='best')
plt.subplot(413)
plt.plot(decompose_add.seasonal,label='Seasonality')
plt.legend(loc='best')
plt.subplot(414)
plt.plot(decompose_add.resid, label='Residual')
plt.legend(loc='best')
```

Out[92]:

```
<matplotlib.legend.Legend at 0x7f9836d1a9d0>
```



In [93]:

```
def relative_ordering(temp,alpha):
    Q = 0
    n = len(temp)
    for i in range(n):
        for j in range(i+1,n):
            if(temp[i] - temp[j] > 0):
                Q+=1
    print('Q = ',Q)
    T=1-4*Q/(n*(n-1))
    VT=2*(2*n+5)/(9*n*(n-1))
    Z=T/(VT**0.5)
    t=norm.ppf(1-alpha/2)
    print('Z = ',Z)
    print('t_alpha/2 = ',t)
    if(abs(Z) <= t):
        print('So, Trend is not present')
    else:
        print('Trend is present')
```

In [94]:

```
temp=[float(i) for i in tickerDf['logged']]
relative_ordering(temp, 0.05)
```

```
Q =  534532
Z =  39.931689946114595
t_alpha/2 =  1.959963984540054
Trend is present
```

In [95]:

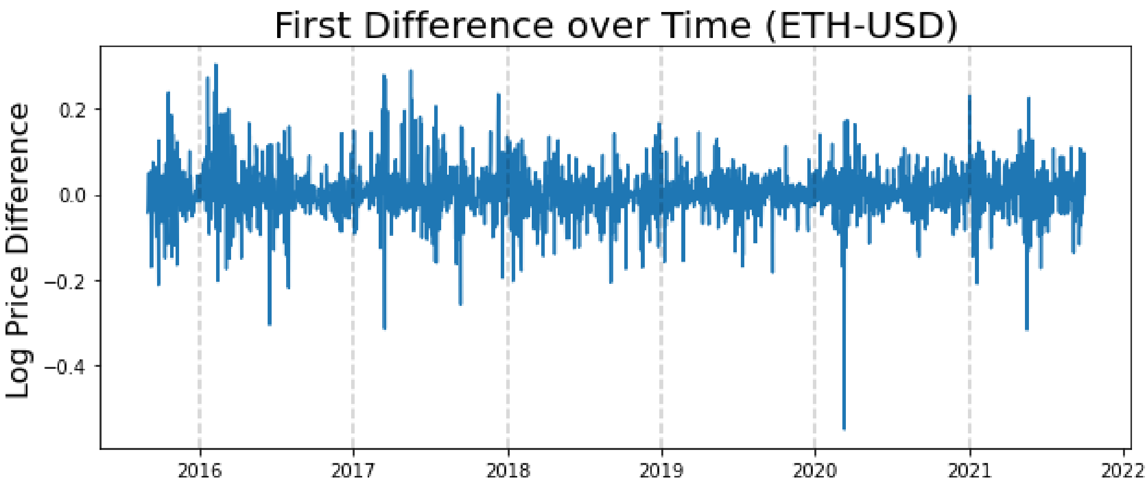
```
#take first difference
first_diffs = tickerDf.logged.values[1:] - tickerDf.logged.values[:-1]
first_diffs = np.concatenate([first_diffs, [0]])
```

In [96]:

```
#set first difference as variable in dataframe
tickerDf['FirstDifference'] = first_diffs
```

In [97]:

```
plt.figure(figsize=(10,4))
plt.plot(tickerDf.FirstDifference)
plt.title('First Difference over Time (%s)'%tickerSymbol, fontsize=20)
plt.ylabel('Log Price Difference', fontsize=16)
for year in range(2016,2022):
    plt.axvline(pd.to_datetime(str(year)+'-01-01'), color='k', linestyle='--', alpha=0.2
)
```



In [98]:

```
#Augmented Dicky-fuller test
from statsmodels.tsa.stattools import adfuller
from numpy import log
result = adfuller(tickerDf['FirstDifference'])
print('ADF Statistic: %f' % result[0])
print('p-value: %f' % result[1])
for key, value in result[4].items():
    print('\t%s: %.3f' % (key, value))

## Data is stationary
```

```
ADF Statistic: -8.666656
p-value: 0.000000
 1%: -3.433
 5%: -2.863
 10%: -2.567
```

```
    10%:  2.567
```

In [99]:

```
temp=[float(i) for i in tickerDf['FirstDifference']]
relative_ordering(temp, 0.05)
```

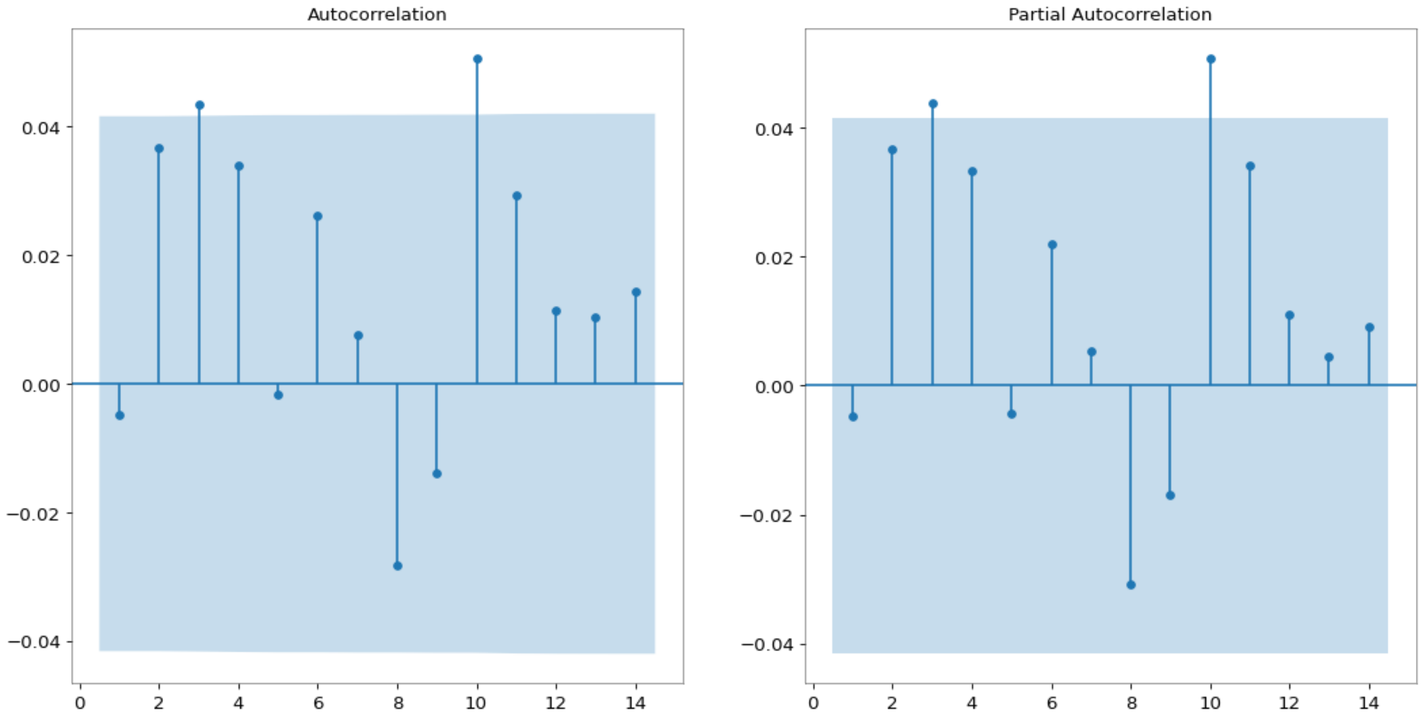
```
Q =  1203633
Z =  1.5379562249374217
t_alpha/2 =  1.959963984540054
So, Trend is not present
```

In [100]:

```
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
```

In [101]:

```
fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(16,8), dpi= 80)
acf_plot_diff = plot_acf(tickerDf.FirstDifference, ax=ax1, lags=np.arange(1,15))
pacf_plot_diff = plot_pacf(tickerDf.FirstDifference, ax=ax2, lags = np.arange(1,15), met
hod='ols')
ax1.spines["top"].set_alpha(.3); ax2.spines["top"].set_alpha(.3)
ax1.spines["bottom"].set_alpha(.3); ax2.spines["bottom"].set_alpha(.3)
ax1.spines["right"].set_alpha(.3); ax2.spines["right"].set_alpha(.3)
ax1.spines["left"].set_alpha(.3); ax2.spines["left"].set_alpha(.3)
# font size of tick labels
ax1.tick_params(axis='both', labelsize=12)
ax2.tick_params(axis='both', labelsize=12)
plt.show()
```

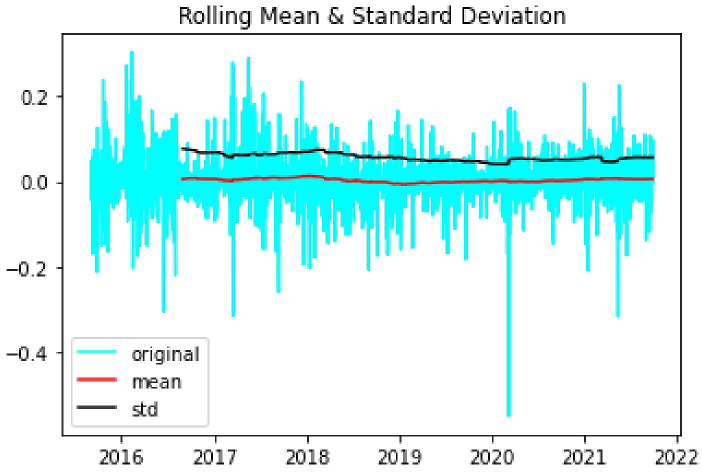


In [102]:

```
def test_stationary(timeseries):
    movingAvg=timeseries.rolling(window=365).mean()
    movingSTD=timeseries.rolling(window=365).std()
    #plotting rolling statistics
    orig=plt.plot(timeseries, color='aqua', label='original')
    mean=plt.plot(movingAvg, color='red', label='mean')
    std=plt.plot(movingSTD, color='black', label='std')
    plt.legend(loc='best')
    plt.title('Rolling Mean & Standard Deviation')
    plt.show(block=False)
```

In [103]:

```
test_stationary(tickerDf['FirstDifference'])
```



In [104]:

```
from statsmodels.tsa.arima.model import ARIMA
AIC=[]
BIC=[]
for p in range(1,12):
    for q in range(1,12):
        model=ARIMA(tickerDf['FirstDifference'],order=(p,0,q))
        model_fit=model.fit()
        AIC.append(model_fit.aic)
        BIC.append(model_fit.bic)
```

In [122]:

```
np.reshape(AIC,(11,11))
```

Out[122]:

```
array([[-6178.84528552, -6188.89917047, -6183.93427292, -6182.30009313,
        -6180.36535621, -6179.35783608, -6178.00292116, -6175.87456098,
        -6176.87962181, -6182.08269755, -6180.02146027],
       [-6188.94891142, -6183.78046509, -6181.95126777, -6180.36897549,
        -6178.35900787, -6182.11283176, -6183.83380727, -6179.31634688,
        -6174.90791315, -6184.16601873, -6183.5795504 ],
       [-6182.11959424, -6181.63200581, -6179.95728771, -6182.44306713,
        -6180.51085493, -6178.65395723, -6181.59325382, -6177.79827773,
        -6170.64946589, -6181.54302553, -6182.0936314 ],
       [-6182.54122733, -6180.7435382 , -6182.84959296, -6178.76108913,
        -6182.18608252, -6176.35701332, -6174.55397996, -6178.13531345,
        -6173.05727344, -6178.66750224, -6180.00394311],
       [-6180.5857696 , -6182.75371658, -6179.89090186, -6177.64734598,
        -6174.93742931, -6175.14447458, -6172.44479848, -6176.48561281,
        -6176.1243217 , -6182.33856413, -6181.95450153],
       [-6179.64587816, -6177.7004392 , -6183.12110181, -6178.13942339,
        -6178.86751654, -6175.88438514, -6170.3170915 , -6173.59478014,
        -6171.03266538, -6178.19106062, -6175.04595981],
       [-6177.70219546, -6175.7608257 , -6177.59567652, -6174.99316528,
        -6178.28515591, -6170.45269687, -6176.41076871, -6176.12379249,
        -6174.21281905, -6179.11894951, -6173.46586009],
       [-6177.8286461 , -6182.06360458, -6175.01057191, -6177.9810026 ,
        -6178.92972695, -6175.67813086, -6173.24318879, -6174.09193544,
        -6171.00616944, -6182.56097385, -6190.68775814],
       [-6177.79432616, -6177.88465376, -6177.17553016, -6173.8387316 ,
        -6172.0545382 , -6171.02033501, -6170.46494604, -6170.68859578,
        -6170.51427606, -6177.80122774, -6178.883846  ],
       [-6185.01955175, -6185.38855413, -6177.76075907, -6175.94497584,
        -6174.88903139, -6173.64478679, -6175.53571216, -6171.45448873,
        -6178.39582684, -6175.02865197, -6176.69241144],
       [-6180.74280773, -6183.43248678, -6182.27796853, -6173.8767776 ,
        -6177.72402909, -6174.90770609, -6173.30256026, -6171.22789149,
        -6175.6823492 , -6173.36816073, -6174.82142581]])
```

In [106]:

```
print(np.where(x == x.min()))
```

```
(array([7]), array([10]))
```

In [107]:

```
np.reshape(BIC,(11,11))
```

Out[107]:

```
array([[-6156.02603783, -6160.37511085, -6149.70540138, -6142.36640967,
        -6134.72686082, -6128.01452877, -6120.95480193, -6113.12162983,
        -6108.42187874, -6107.92014255, -6100.15409335],
       [-6160.42485181, -6149.55159355, -6142.01758431, -6134.7304801 ,
        -6127.01570056, -6125.06471253, -6121.08087612, -6110.85860381,
        -6100.74535815, -6104.29865181, -6098.00737156],
       [-6147.89072271, -6141.69832235, -6134.31879233, -6131.09975982,
        -6123.4627357 , -6115.90102608, -6113.13551074, -6103.63572273,
        -6090.78209897, -6095.97084669, -6090.81664063],
       [-6142.60754387, -6135.10504281, -6131.50628565, -6121.7129699 ,
        -6119.43315137, -6107.89927024, -6100.39142497, -6098.26794653,
        -6087.4850946 , -6087.39051147, -6083.02214042],
       [-6134.94727422, -6131.41040928, -6122.84278263, -6114.89441483,
        -6106.47968623, -6100.98191958, -6092.57743156, -6090.91343397,
        -6084.84733093, -6085.35676144, -6079.26788692],
       [-6128.30257085, -6120.65231997, -6120.36817066, -6109.68168031,
        -6104.70496155, -6096.01701822, -6084.74491265, -6082.31778937,
        -6074.05086269, -6075.50444601, -6066.65453327],
       [-6120.65407623, -6113.00789455, -6109.13793344, -6100.83061028,
        -6098.41778898, -6084.88051802, -6085.13377794, -6079.1419898 ,
        -6071.52620444, -6070.72752297, -6059.36962163],
       [-6115.07571494, -6113.6058615 , -6100.84801691, -6098.11363568,
        -6093.35754811, -6084.40114009, -6076.2613861 , -6071.40532082,
        -6062.61474291, -6068.46473539, -6070.88670776],
       [-6109.33658309, -6103.72209877, -6097.30816324, -6088.26655276,
        -6080.77754743, -6074.03853232, -6067.77833143, -6062.29716924,
        -6056.4180376 , -6058.00017736, -6053.37798369],
       [-6110.85699675, -6105.52118721, -6092.18858022, -6084.66798507,
        -6077.9072287 , -6070.95817217, -6067.14428563, -6057.35825028,
        -6058.59477646, -6049.52278967, -6045.48173721],
       [-6100.87544081, -6097.86030794, -6091.00097776, -6076.89497491,
        -6075.03741448, -6066.51627956, -6059.2063218 , -6051.42684111,
        -6050.1764869 , -6042.1574865 , -6037.90593966]])
```

In [124]:

```
final=ARIMA(tickerDf,order=(8,1,11))
final=final.fit()
```

In [125]:

```
final.summary()
```

Out[125]:

SARIMAX Results

Dep. Variable:	logged	**No. Observations:**	2219
Model:	ARIMA(8, 1, 11)	**Log Likelihood**	3112.687
Date:	Wed, 17 Nov 2021	**AIC**	-6185.374
Time:	02:16:28	**BIC**	-6071.287
Sample:	0	**HQIC**	-6143.703
	- 2219		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.3019	0.172	-1.754	0.080	-0.639	0.036
ar.L2	0.4448	0.147	3.031	0.002	0.157	0.732

ar.L3	0.3820	0.168	2.268	0.023	0.052	0.712
ar.L4	0.2759	0.182	1.517	0.129	-0.081	0.632
ar.L5	0.1886	0.179	1.052	0.293	-0.163	0.540
ar.L6	0.1981	0.163	1.214	0.225	-0.122	0.518
ar.L7	-0.0128	0.139	-0.092	0.927	-0.286	0.260
ar.L8	-0.4560	0.130	-3.506	0.000	-0.711	-0.201
ma.L1	0.2972	0.172	1.724	0.085	-0.041	0.635
ma.L2	-0.4112	0.149	-2.759	0.006	-0.703	-0.119
ma.L3	-0.3228	0.164	-1.963	0.050	-0.645	-0.001
ma.L4	-0.2564	0.181	-1.416	0.157	-0.611	0.098
ma.L5	-0.2211	0.175	-1.262	0.207	-0.565	0.122
ma.L6	-0.2052	0.159	-1.295	0.195	-0.516	0.105
ma.L7	-0.0148	0.135	-0.109	0.913	-0.280	0.251
ma.L8	0.4171	0.126	3.299	0.001	0.169	0.665
ma.L9	-0.0587	0.023	-2.532	0.011	-0.104	-0.013
ma.L10	0.0873	0.023	3.847	0.000	0.043	0.132
ma.L11	0.0932	0.027	3.467	0.001	0.041	0.146
sigma2	0.0035	5.91e-05	59.745	0.000	0.003	0.004

Ljung-Box (L1) (Q):	0.03	**Jarque-Bera (JB):**	3997.82
Prob(Q):	0.87	**Prob(JB):**	0.00
Heteroskedasticity (H):	0.58	**Skew:**	-0.28
Prob(H) (two-sided):	0.00	**Kurtosis:**	9.55

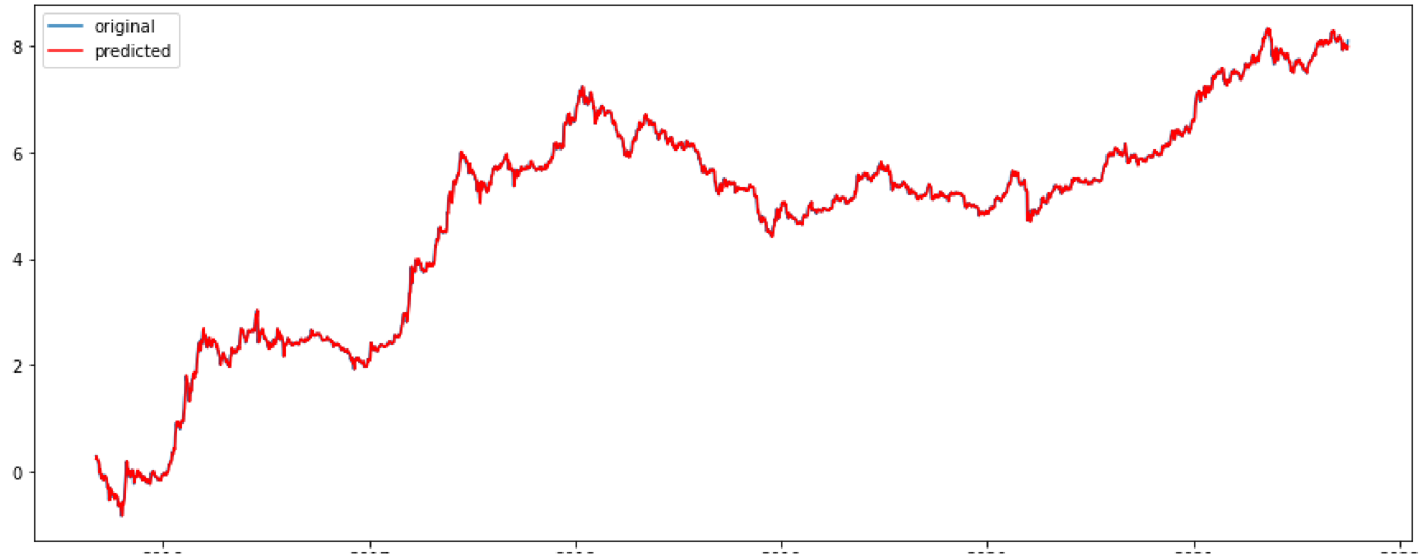
Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

In [126]:

```
pred=final.predict()
```

In [127]:

```
plt.figure(figsize=(15,6))
plt.plot(tickerDf[4:] , label='original')
plt.plot(pred[4:], color='red', label='predicted')
plt.legend(loc='best', prop={'size': 10})
plt.show()
```



In [128]:

```
forecast= final.forecast(steps=10)
forecast
```

Out[128]:

```
2219    8.105358
2220    8.115314
2221    8.112732
2222    8.108238
2223    8.107634
2224    8.106199
2225    8.100470
2226    8.094526
2227    8.091902
2228    8.097686
Name: predicted_mean, dtype: float64
```

In [129]:

```
import math
forecast_data = list(forecast)
forecast_data1 = []
for ele in forecast_data:
    forecast_data1.append(math.exp(ele))
```

In [130]:

```
for ele in forecast_data1:
    print(ele)
```

```
3312.1669098132747
3345.309455990676
3336.680254911625
3321.7200143952005
3319.713968019474
3314.9542023633553
3296.016329827274
3276.4829813090882
3267.8972047825905
3286.8524687978957
```

In [131]:

```
def mean_absolute_percentage_error(y_true, y_pred):
    y_true, y_pred = np.array(y_true), np.array(y_pred)
    return(np.mean(np.abs((y_true - y_pred) / y_true)) * 100)
```

In [132]:

```
org = tickerData.history(period='1d', start='2021-10-1', end='2021-10-10')
```

In [133]:

```
org_data = list(org['Close'])
```

In [134]:

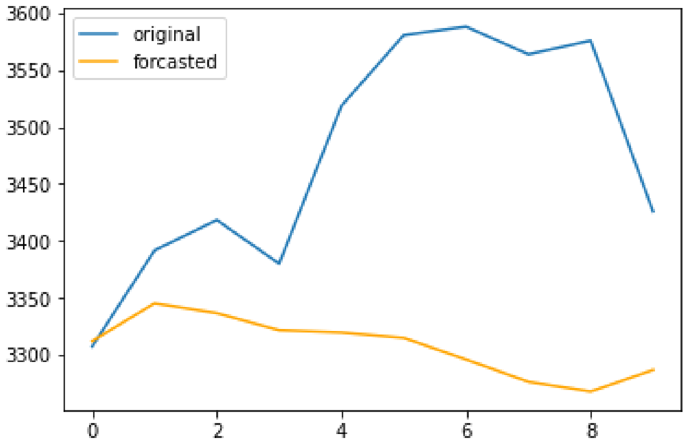
```
org_data
```

Out[134]:

```
[3307.51611328125,
 3391.6943359375,
 3418.358642578125,
 3380.089111328125,
 3518.5185546875,
 3580.56201171875,
 3587.974853515625,
 3563.75927734375,
 3575.716796875,
 3425.852783203125]
```

In [135]:

```
plt.plot(org_data , label='original')
plt.plot(forecast_data1, color='orange', label='forcasted')
plt.legend(loc='best', prop={'size': 10})
plt.show()
```



In [136]:

```
mean_absolute_percentage_error(org_data, forecast_data1)
```

Out[136]:

```
4.755694460288888
```