BTC-Time-Series-Model-TechIndicators

September 29, 2021

1 Modeling BTC with Technical Indicators

1.1 Importing Necessary Libraries

[52]:
```
import pandas as pd
import numpy as np
import itertools
from statsmodels.tsa.stattools import adfuller
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.statespace.sarimax import SARIMAX
import statsmodels.api as sm
import matplotlib.pyplot as plt
from matplotlib.pylab import rcParams
from tqdm import tqdm_notebook as tqdm
import _pickle as pickle
import datetime
plt.style.use('bmh')
```

1.2 Loading the Data

[53]:
```
with open("df_indicators.pkl",'rb') as fp:
    df = pickle.load(fp)

df
```

[53]:
```
                 Close    volume_adi   volume_obv  volume_cmf  \
Date
2014-09-17  457.334015 -7.924336e+06     21056800   -0.376331
2014-09-18  424.440002 -2.454020e+07    -13426400   -0.441847
2014-09-19  394.795990 -4.448391e+07    -51346100   -0.475969
2014-09-20  408.903992 -3.937687e+07    -14482500   -0.302148
2014-09-21  398.821014 -5.037763e+07    -41062600   -0.321074
2014-09-22  402.152008 -4.974146e+07    -16935000   -0.274768
2014-09-23  435.790985 -1.610777e+07     28164500   -0.071232
2014-09-24  423.204987 -3.825869e+07     -2463200   -0.149007
2014-09-25  411.574005 -5.703557e+07    -29277600   -0.201132
2014-09-26  404.424988 -6.580018e+07    -50738400   -0.215715
```

2014-09-27	399.519989	-7.385019e+07	-65767700	-0.230737
2014-09-28	377.181000	-9.242139e+07	-89381000	-0.268920
2014-09-29	375.467010	-1.087491e+08	-121878700	-0.289093
2014-09-30	386.944000	-9.000780e+07	-87171400	-0.219061
2014-10-01	383.614990	-1.022057e+08	-113400800	-0.233821
2014-10-02	375.071991	-1.166056e+08	-135178500	-0.254105
2014-10-03	359.511993	-1.423567e+08	-166079700	-0.290649
2014-10-04	328.865997	-1.822998e+08	-213316200	-0.339462
2014-10-05	320.510010	-1.665553e+08	-296624296	-0.268493
2014-10-06	330.079010	-1.434237e+08	-217612496	-0.205083
2014-10-07	336.187012	-1.102698e+08	-168412596	-0.140683
2014-10-08	352.940002	-6.126977e+07	-113676296	-0.049121
2014-10-09	365.026001	-6.213157e+07	-30035192	-0.022241
2014-10-10	361.562012	-7.182317e+07	-73700892	-0.040544
2014-10-11	362.299011	-7.009444e+07	-60355692	-0.025052
2014-10-12	378.549011	-5.387418e+07	-42802892	-0.005295
2014-10-13	390.414001	-3.559150e+07	-7581492	-0.025285
2014-10-14	400.869995	-3.801354e+07	30910008	0.000315
2014-10-15	394.773010	-4.072957e+07	5642908	0.020989
2014-10-16	382.556000	-4.782394e+07	-21347092	0.022975
…	…	…	…	…
2020-02-13	10214.379883	8.775369e+11	625896693165	0.255428
2020-02-14	10312.116211	9.165162e+11	669234957326	0.306716
2020-02-15	9889.424805	8.754678e+11	625369902495	0.209350
2020-02-16	9934.433594	8.875694e+11	668744682800	0.196351
2020-02-17	9690.142578	8.805105e+11	622746384388	0.136835
2020-02-18	10141.996094	9.242217e+11	670017408341	0.204697
2020-02-19	9633.386719	8.808182e+11	623025388632	0.113443
2020-02-20	9608.475586	9.026752e+11	578100128396	0.145818
2020-02-21	9686.441406	9.211409e+11	619030675908	0.157686
2020-02-22	9663.181641	9.312132e+11	583192650754	0.168945
2020-02-23	9924.515625	9.686016e+11	624377836515	0.239247
2020-02-24	9650.174805	9.481172e+11	579297339867	0.223677
2020-02-25	9341.705078	9.145725e+11	536782080738	0.153098
2020-02-26	8820.522461	8.821537e+11	486362029977	0.097671
2020-02-27	8784.494141	8.896827e+11	440891834282	0.093664
2020-02-28	8672.455078	8.853651e+11	396286383840	0.051889
2020-02-29	8599.508789	8.495727e+11	360493991296	-0.026877
2020-03-01	8562.454102	8.394622e+11	325144826996	-0.010338
2020-03-02	8869.669922	8.709320e+11	368002501404	-0.017061
2020-03-03	8787.786133	8.642452e+11	325615785584	-0.039484
2020-03-04	8755.246094	8.522222e+11	290869079216	-0.029679
2020-03-05	9078.762695	8.788612e+11	330567133813	-0.044336
2020-03-06	9122.545898	8.925038e+11	371394019463	0.020131
2020-03-07	8909.954102	8.613936e+11	335177089094	-0.031195
2020-03-08	8108.116211	8.217034e+11	295203986974	-0.070590
2020-03-09	7923.644531	8.197206e+11	248266991166	-0.125490

2020-03-10	7909.729492	8.023926e+11	206053050173	-0.094721
2020-03-11	7911.430176	8.311826e+11	244735812777	-0.087003
2020-03-12	4970.788086	7.810874e+11	190755455534	-0.167774
2020-03-13	5095.102539	7.906391e+11	261530690094	-0.161633

	volume_fi	volume_em	volume_sma_em	volume_vpt \
Date				
2014-09-17	0.000000e+00	0.000000	0.000000	-1.422178e+07
2014-09-18	-1.134291e+09	-3212.366691	-3212.366691	-2.109752e+07
2014-09-19	-1.132834e+09	-3288.687640	-3250.527166	-5.128636e+06
2014-09-20	-8.967045e+08	36.798834	-2154.751832	-1.331094e+06
2014-09-21	-8.068905e+08	-274.120355	-1684.593963	6.618911e+05
2014-09-22	-6.801392e+08	-31.656617	-1354.006494	-4.539104e+05
2014-09-23	-3.662477e+08	1695.136068	-845.816067	3.973973e+06
2014-09-24	-3.689952e+08	476.627823	-656.895511	2.887904e+06
2014-09-25	-3.608356e+08	-635.564367	-654.229118	-1.621496e+06
2014-09-26	-3.312053e+08	-627.501292	-651.259360	-1.109716e+06
2014-09-27	-2.944215e+08	-337.063812	-619.839805	-5.550532e+05
2014-09-28	-3.277180e+08	-1618.618146	-710.637836	-1.502608e+06
2014-09-29	-2.888584e+08	-357.187199	-681.183616	-1.468004e+06
2014-09-30	-1.906879e+08	176.035474	-615.243686	9.132299e+05
2014-10-01	-1.759207e+08	156.362329	-560.128971	8.352460e+05
2014-10-02	-1.773673e+08	-395.241741	-358.905760	-7.106437e+05
2014-10-03	-2.207181e+08	-734.641854	-176.473918	-1.766931e+06
2014-10-04	-3.959883e+08	-1846.065618	-310.964236	-5.308544e+06
2014-10-05	-4.388645e+08	-1867.937739	-424.808335	-6.143329e+06
2014-10-06	-2.681604e+08	447.149313	-390.607911	2.422075e+05
2014-10-07	-1.869213e+08	229.509613	-495.295515	3.269368e+06
2014-10-08	-2.921876e+07	541.745022	-490.644287	3.638066e+06
2014-10-09	1.193677e+08	1023.445024	-372.143616	5.591826e+06
2014-10-10	8.070694e+07	-60.315468	-331.630343	2.449813e+06
2014-10-11	7.058243e+07	-205.846382	-322.257669	-3.871721e+05
2014-10-12	1.012468e+08	824.937812	-147.717958	8.144887e+05
2014-10-13	1.464832e+08	1228.425980	-34.459874	1.891242e+06
2014-10-14	1.830523e+08	976.552879	22.719941	2.134828e+06
2014-10-15	1.348944e+08	-320.421918	-11.336077	6.465751e+05
2014-10-16	6.851845e+07	-911.425792	-48.206366	-1.219554e+06
…	…	…	…	…
2020-02-13	2.270028e+12	-7.683225	50.028022	-3.236642e+07
2020-02-14	2.550842e+12	-28.617726	49.097370	-1.190965e+08
2020-02-15	-4.623330e+11	-123.289499	40.289586	-1.383337e+09
2020-02-16	-1.173931e+11	-168.038571	30.203590	-1.600612e+09
2020-02-17	-1.705904e+12	-154.621530	15.710703	-9.337059e+08
2020-02-18	1.589165e+12	194.847679	38.630816	1.073145e+09
2020-02-19	-2.052228e+12	5.299720	16.064290	-1.523370e+08
2020-02-20	-1.918929e+12	-98.159507	-4.447305	-2.472768e+09
2020-02-21	-1.188913e+12	26.315414	-4.775144	2.159488e+08

2020-02-22	-1.138152e+12	-1.876960	-4.807551	2.460650e+08
2020-02-23	5.620254e+11	100.559627	-9.429918	1.027768e+09
2020-02-24	-1.285038e+12	-48.942456	-11.906144	-1.323240e+08
2020-02-25	-2.974986e+12	-217.154536	-26.918226	-2.605157e+09
2020-02-26	-6.303995e+12	-579.507359	-78.633495	-4.171991e+09
2020-02-27	-5.637455e+12	-214.773594	-93.425664	-2.998710e+09
2020-02-28	-5.546041e+12	-56.458865	-95.414317	-7.546338e+08
2020-02-29	-5.126738e+12	-2.029302	-86.752874	-8.699653e+08
2020-03-01	-4.581469e+12	-64.035192	-79.324062	-4.533763e+08
2020-03-02	-2.046037e+12	116.051760	-59.990255	1.385391e+09
2020-03-03	-2.249572e+12	35.402786	-71.379176	1.146399e+09
2020-03-04	-2.089727e+12	-9.569684	-72.441276	-5.199719e+08
2020-03-05	4.351646e+10	166.485743	-53.538044	1.338227e+09
2020-03-06	2.926615e+11	49.903434	-51.853186	1.663781e+09
2020-03-07	-8.490647e+11	-54.849611	-55.636946	-6.471077e+08
2020-03-08	-5.306619e+12	-1046.826168	-137.593074	-4.441318e+09
2020-03-09	-5.785466e+12	-598.335234	-176.835416	-4.665205e+09
2020-03-10	-5.042887e+12	31.985056	-159.039731	-1.142020e+09
2020-03-11	-4.313076e+12	-142.556797	-127.828976	-6.581640e+07
2020-03-12	-2.637362e+13	-7970.760717	-681.828056	-2.005593e+10
2020-03-13	-2.134905e+13	-3431.799535	-922.923818	-1.829423e+10

	volume_nvi	volatility_atr	…	momentum_uo	momentum_stoch	\
Date			…			
2014-09-17	1000.000000	0.000000	…	50.000000	31.183428	
2014-09-18	1000.000000	0.000000	…	50.000000	20.584704	
2014-09-19	1000.000000	0.000000	…	50.000000	12.271320	
2014-09-20	1035.734917	0.000000	…	50.000000	29.138447	
2014-09-21	1010.195200	0.000000	…	50.000000	17.083524	
2014-09-22	1018.632454	0.000000	…	50.000000	21.065966	
2014-09-23	1018.632454	0.000000	…	50.000000	61.283773	
2014-09-24	989.213520	0.000000	…	50.000000	46.236311	
2014-09-25	962.026873	0.000000	…	50.000000	32.330638	
2014-09-26	945.316521	25.504999	…	50.000000	23.783477	
2014-09-27	933.851412	23.879596	…	50.000000	17.919199	
2014-09-28	933.851412	24.160136	…	50.000000	3.035953	
2014-09-29	933.851412	23.041224	…	50.000000	3.363791	
2014-09-30	933.851412	22.490501	…	50.000000	15.327211	
2014-10-01	925.817173	21.301351	…	50.000000	13.442449	
2014-10-02	905.199482	20.426315	…	50.000000	4.085578	
2014-10-03	905.199482	20.367284	…	50.000000	1.974939	
2014-10-04	905.199482	22.190657	…	50.000000	2.576281	
2014-10-05	905.199482	25.222091	…	50.000000	20.500336	
2014-10-06	932.224703	26.957283	…	50.000000	26.784939	
2014-10-07	949.475210	26.138056	…	50.000000	31.938630	
2014-10-08	949.475210	26.241853	…	50.000000	47.416269	
2014-10-09	949.475210	27.121568	…	50.000000	60.274440	

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2014-10-10   940.464971      26.619808  …    50.000000       61.593686
2014-10-11   942.381991      25.081830  …    50.000000       65.344041
2014-10-12   942.381991      24.902547  …    50.000000       87.431809
2014-10-13   942.381991      25.245193  …    50.000000       93.688492
2014-10-14   942.381991      24.849073  …    50.000000       91.153737
2014-10-15   928.048943      23.710266  …    56.540246       86.172622
2014-10-16   928.048943      23.912939  …    55.805860       76.191569
…                  …             …  …       …                …
2020-02-13   395.164153     292.961014  …    63.219808       81.912234
2020-02-14   398.945282     283.311104  …    65.738248       89.179873
2020-02-15   398.945282     301.692787  …    54.687866       57.748689
2020-02-16   400.760963     304.681711  …    53.444037       61.095527
2020-02-17   400.760963     317.331314  …    55.707048       42.930133
2020-02-18   400.760963     338.553456  …    57.571597       75.606671
2020-02-19   380.663265     362.743325  …    48.267008       13.236889
2020-02-20   379.678901     340.000633  …    50.404628       10.614635
2020-02-21   382.759720     319.327718  …    49.132871       18.821656
2020-02-22   381.840611     297.145239  …    54.081452       16.373232
2020-02-23   381.840611     295.392043  …    56.219863       43.882384
2020-02-24   381.840611     307.323152  …    54.413135       15.004076
2020-02-25   369.635001     311.362418  …    40.672249        3.182667
2020-02-26   369.635001     345.261333  …    41.019850        6.621931
2020-02-27   368.125189     346.304535  …    42.023958       11.749039
2020-02-28   363.430052     351.426426  …    41.033552        9.711145
2020-02-29   360.373147     333.896088  …    39.461777        6.273825
2020-03-01   358.820324     326.064877  …    35.203111        5.303294
2020-03-02   358.820324     332.326163  …    41.761759       23.159874
2020-03-03   355.507736     318.754387  …    42.440774       18.400469
2020-03-04   354.191336     299.972405  …    47.867243       19.184521
2020-03-05   354.191336     308.656024  …    51.748405       41.035878
2020-03-06   354.191336     291.352043  …    53.564267       43.993137
2020-03-07   345.937262     289.464495  …    51.244736       29.634000
2020-03-08   345.937262     341.427127  …    37.800594        0.155066
2020-03-09   345.937262     356.053946  …    35.172298       11.899609
2020-03-10   345.329747     352.666764  …    34.430841       13.193606
2020-03-11   345.403997     348.200283  …    39.856198       17.615627
2020-03-12   345.403997     620.256475  …    20.638760        2.563857
2020-03-13   345.403997     729.830193  …    27.714073       19.296816

            momentum_stoch_signal  momentum_wr  momentum_ao  momentum_kama  \
Date
2014-09-17              31.183428   -68.816572     0.000000     457.334015
2014-09-18              25.884066   -79.415296     0.000000     424.440002
2014-09-19              21.346484   -87.728680     0.000000     394.795990
2014-09-20              20.664824   -70.861553     0.000000     408.903992
2014-09-21              19.497764   -82.916476     0.000000     398.821014
2014-09-22              22.429312   -78.934034    -8.296951     402.152008
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2014-09-23	33.144421	-38.716227	-11.527058	435.790985
2014-09-24	42.862017	-53.763689	-8.264314	423.204987
2014-09-25	46.616907	-67.669362	-5.888602	411.574005
2014-09-26	34.116809	-76.216523	-3.736702	404.424988
2014-09-27	24.677771	-82.080801	-2.247520	404.034545
2014-09-28	14.912876	-96.964047	-6.049202	402.288769
2014-09-29	8.106314	-96.636209	-13.276501	401.599367
2014-09-30	7.242318	-84.672789	-18.023336	401.146576
2014-10-01	10.711151	-86.557551	-20.731467	400.771869
2014-10-02	10.951746	-95.914422	-23.483704	399.707420
2014-10-03	6.500989	-98.025061	-25.199150	388.527846
2014-10-04	2.878933	-97.423719	-28.639430	370.557029
2014-10-05	8.350519	-79.499664	-37.488265	355.667673
2014-10-06	16.620519	-73.215061	-46.314571	350.509179
2014-10-07	26.407968	-68.061370	-53.197108	348.345401
2014-10-08	35.379946	-52.583731	-56.376136	348.519717
2014-10-09	46.543113	-39.725560	-51.406301	348.741326
2014-10-10	56.428132	-38.406314	-40.778008	349.244453
2014-10-11	62.404056	-34.655959	-32.275256	349.664140
2014-10-12	71.456512	-12.568191	-24.045325	349.858515
2014-10-13	82.154781	-6.311508	-15.556549	351.914502
2014-10-14	90.758013	-8.846263	-8.925149	365.042089
2014-10-15	90.338284	-13.827378	-3.007538	373.820089
2014-10-16	84.505976	-23.808431	1.831121	375.173189
…	…	…	…	…
2020-02-13	92.157375	-18.087766	1006.084326	9699.998864
2020-02-14	88.605847	-10.820127	991.096764	9812.052833
2020-02-15	76.280265	-42.251311	958.737770	9813.879100
2020-02-16	69.341363	-38.904473	890.980625	9816.018640
2020-02-17	53.924783	-57.069867	740.349443	9814.838461
2020-02-18	59.877444	-24.393329	629.358151	9820.830220
2020-02-19	43.924564	-86.763111	530.419436	9815.026854
2020-02-20	33.152732	-89.385365	401.643423	9811.674610
2020-02-21	14.224393	-81.178344	333.618546	9805.941974
2020-02-22	15.269841	-83.626768	296.596912	9796.045182
2020-02-23	26.359091	-56.117616	243.020919	9798.761576
2020-02-24	25.086564	-84.995924	179.425141	9790.536901
2020-02-25	20.689709	-96.817333	137.618454	9770.159292
2020-02-26	8.269558	-93.378069	-2.998883	9676.953244
2020-02-27	7.184545	-88.250961	-192.600169	9605.119583
2020-02-28	9.360705	-90.288855	-423.026669	9393.403332
2020-02-29	9.244669	-93.726175	-640.968589	9247.937968
2020-03-01	7.096088	-94.696706	-811.399000	9121.348779
2020-03-02	11.578998	-76.840126	-859.968244	9096.180299
2020-03-03	15.621212	-81.599531	-834.593382	9063.316932
2020-03-04	20.248288	-80.815479	-799.290323	8998.343282
2020-03-05	26.206956	-58.964122	-734.326853	9003.459999

2020-03-06	34.737846	-56.006863	-626.021151	9006.092071
2020-03-07	38.221005	-70.366000	-556.714829	9004.985849
2020-03-08	24.594068	-99.844934	-589.393325	8941.716660
2020-03-09	13.896225	-88.100391	-720.298868	8862.213221
2020-03-10	8.416094	-86.806394	-872.216298	8793.680300
2020-03-11	14.236281	-82.384373	-1077.377948	8733.955214
2020-03-12	11.124364	-97.436143	-1504.250212	7507.742890
2020-03-13	13.158767	-80.703184	-2069.215316	6804.988914

	momentum_roc	others_dr	others_dlr	others_cr
Date				
2014-09-17	0.000000	-88.414661	0.000000	0.000000
2014-09-18	0.000000	-7.192558	-7.464335	-7.192558
2014-09-19	0.000000	-6.984264	-7.240151	-13.674475
2014-09-20	0.000000	3.573492	3.511124	-10.589639
2014-09-21	0.000000	-2.465855	-2.496766	-12.794369
2014-09-22	0.000000	0.835210	0.831742	-12.066019
2014-09-23	0.000000	8.364742	8.033259	-4.710568
2014-09-24	0.000000	-2.888081	-2.930607	-7.462604
2014-09-25	0.000000	-2.748309	-2.786782	-10.005818
2014-09-26	0.000000	-1.736994	-1.752257	-11.569012
2014-09-27	0.000000	-1.212833	-1.220248	-12.641532
2014-09-28	0.000000	-5.591457	-5.753862	-17.526143
2014-09-29	-17.900922	-0.454421	-0.455457	-17.900922
2014-09-30	-8.834229	3.056724	3.010937	-15.391380
2014-10-01	-2.832096	-0.860334	-0.864056	-16.119296
2014-10-02	-8.273825	-2.226972	-2.252144	-17.987296
2014-10-03	-9.856306	-4.148536	-4.237045	-21.389623
2014-10-04	-18.223460	-8.524332	-8.909717	-28.090633
2014-10-05	-26.453272	-2.540849	-2.573686	-29.917741
2014-10-06	-22.004934	2.985554	2.941854	-27.825397
2014-10-07	-18.316753	1.850467	1.833554	-26.489830
2014-10-08	-12.730417	4.983235	4.863049	-22.826645
2014-10-09	-8.633858	3.424378	3.367051	-20.183938
2014-10-10	-4.140980	-0.948970	-0.953502	-20.941369
2014-10-11	-3.507099	0.203838	0.203630	-20.780218
2014-10-12	-2.169562	4.485245	4.387568	-17.227016
2014-10-13	1.772353	3.134334	3.086217	-14.632634
2014-10-14	6.878147	2.678181	2.642946	-12.346342
2014-10-15	9.808022	-1.520938	-1.532623	-13.679500
2014-10-16	16.325799	-3.094692	-3.143589	-16.350854
…	…	…	…	…
2020-02-13	8.746043	-1.081486	-1.087376	2133.461660
2020-02-14	10.356519	0.956850	0.952302	2154.832545
2020-02-15	6.412029	-4.098978	-4.185355	2062.407449
2020-02-16	8.206881	0.455120	0.454088	2072.249006
2020-02-17	0.798038	-2.459033	-2.489772	2018.832682

```
2020-02-18      4.236410   4.663022    4.557569  2117.634324
2020-02-19     -1.659428  -5.014884   -5.144998  2006.422528
2020-02-20     -2.601525  -0.258592   -0.258927  2000.975495
2020-02-21     -4.252706   0.811428    0.808153  2018.023390
2020-02-22     -1.962436  -0.240127   -0.240416  2012.937443
2020-02-23     -2.779331   2.704430    2.668507  2070.080357
2020-02-24     -6.545384  -2.764274   -2.803199  2010.093387
2020-02-25     -8.543591  -3.196520   -3.248724  1942.643838
2020-02-26    -14.464478  -5.579095   -5.740769  1828.682795
2020-02-27    -11.172851  -0.408460   -0.409297  1820.804894
2020-02-28    -12.703075  -1.275418   -1.283622  1796.306593
2020-02-29    -11.255085  -0.841126   -0.844684  1780.356262
2020-03-01    -15.574271  -0.430893   -0.431824  1772.253937
2020-03-02     -7.927812   3.587941    3.525074  1839.429308
2020-03-03     -8.541308  -0.923189   -0.927476  1821.524716
2020-03-04     -9.613389  -0.370287   -0.370974  1814.409558
2020-03-05     -6.047894   3.695117    3.628484  1885.149234
2020-03-06     -8.080694   0.482260    0.481100  1894.722806
2020-03-07     -7.670542  -2.330400   -2.357983  1848.237789
2020-03-08    -13.205179  -8.999349   -9.430353  1672.909065
2020-03-09    -10.168082  -2.275148   -2.301429  1632.572752
2020-03-10     -9.958054  -0.175614   -0.175769  1629.530110
2020-03-11     -8.775196   0.021501    0.021499  1629.901979
2020-03-12    -42.196837 -37.169539  -46.473018   986.905396
2020-03-13    -40.494834   2.500900    2.470140  1014.087816

[2005 rows x 69 columns]
```

1.2.1 Shifting the Data

Done so that the technical indicators would be seen in the "past"

[54]:
```
df = df[['Close']].join(df[df.columns[1:]].shift(-1)).dropna()
df
```

[54]:
```
                 Close    volume_adi    volume_obv  volume_cmf  \
Date
2014-09-17  457.334015 -2.454020e+07 -1.342640e+07   -0.441847
2014-09-18  424.440002 -4.448391e+07 -5.134610e+07   -0.475969
2014-09-19  394.795990 -3.937687e+07 -1.448250e+07   -0.302148
2014-09-20  408.903992 -5.037763e+07 -4.106260e+07   -0.321074
2014-09-21  398.821014 -4.974146e+07 -1.693500e+07   -0.274768
2014-09-22  402.152008 -1.610777e+07  2.816450e+07   -0.071232
2014-09-23  435.790985 -3.825869e+07 -2.463200e+06   -0.149007
2014-09-24  423.204987 -5.703557e+07 -2.927760e+07   -0.201132
2014-09-25  411.574005 -6.580018e+07 -5.073840e+07   -0.215715
2014-09-26  404.424988 -7.385019e+07 -6.576770e+07   -0.230737
```

2014-09-27	399.519989	-9.242139e+07	-8.938100e+07	-0.268920
2014-09-28	377.181000	-1.087491e+08	-1.218787e+08	-0.289093
2014-09-29	375.467010	-9.000780e+07	-8.717140e+07	-0.219061
2014-09-30	386.944000	-1.022057e+08	-1.134008e+08	-0.233821
2014-10-01	383.614990	-1.166056e+08	-1.351785e+08	-0.254105
2014-10-02	375.071991	-1.423567e+08	-1.660797e+08	-0.290649
2014-10-03	359.511993	-1.822998e+08	-2.133162e+08	-0.339462
2014-10-04	328.865997	-1.665553e+08	-2.966243e+08	-0.268493
2014-10-05	320.510010	-1.434237e+08	-2.176125e+08	-0.205083
2014-10-06	330.079010	-1.102698e+08	-1.684126e+08	-0.140683
2014-10-07	336.187012	-6.126977e+07	-1.136763e+08	-0.049121
2014-10-08	352.940002	-6.213157e+07	-3.003519e+07	-0.022241
2014-10-09	365.026001	-7.182317e+07	-7.370089e+07	-0.040544
2014-10-10	361.562012	-7.009444e+07	-6.035569e+07	-0.025052
2014-10-11	362.299011	-5.387418e+07	-4.280289e+07	-0.005295
2014-10-12	378.549011	-3.559150e+07	-7.581492e+06	-0.025285
2014-10-13	390.414001	-3.801354e+07	3.091001e+07	0.000315
2014-10-14	400.869995	-4.072957e+07	5.642908e+06	0.020989
2014-10-15	394.773010	-4.782394e+07	-2.134709e+07	0.022975
2014-10-16	382.556000	-3.886061e+07	-7.746392e+06	0.044801
…	…	…	…	…
2020-02-12	10326.054688	8.775369e+11	6.258967e+11	0.255428
2020-02-13	10214.379883	9.165162e+11	6.692350e+11	0.306716
2020-02-14	10312.116211	8.754678e+11	6.253699e+11	0.209350
2020-02-15	9889.424805	8.875694e+11	6.687447e+11	0.196351
2020-02-16	9934.433594	8.805105e+11	6.227464e+11	0.136835
2020-02-17	9690.142578	9.242217e+11	6.700174e+11	0.204697
2020-02-18	10141.996094	8.808182e+11	6.230254e+11	0.113443
2020-02-19	9633.386719	9.026752e+11	5.781001e+11	0.145818
2020-02-20	9608.475586	9.211409e+11	6.190307e+11	0.157686
2020-02-21	9686.441406	9.312132e+11	5.831927e+11	0.168945
2020-02-22	9663.181641	9.686016e+11	6.243778e+11	0.239247
2020-02-23	9924.515625	9.481172e+11	5.792973e+11	0.223677
2020-02-24	9650.174805	9.145725e+11	5.367821e+11	0.153098
2020-02-25	9341.705078	8.821537e+11	4.863620e+11	0.097671
2020-02-26	8820.522461	8.896827e+11	4.408918e+11	0.093664
2020-02-27	8784.494141	8.853651e+11	3.962864e+11	0.051889
2020-02-28	8672.455078	8.495727e+11	3.604940e+11	-0.026877
2020-02-29	8599.508789	8.394622e+11	3.251448e+11	-0.010338
2020-03-01	8562.454102	8.709320e+11	3.680025e+11	-0.017061
2020-03-02	8869.669922	8.642452e+11	3.256158e+11	-0.039484
2020-03-03	8787.786133	8.522222e+11	2.908691e+11	-0.029679
2020-03-04	8755.246094	8.788612e+11	3.305671e+11	-0.044336
2020-03-05	9078.762695	8.925038e+11	3.713940e+11	0.020131
2020-03-06	9122.545898	8.613936e+11	3.351771e+11	-0.031195
2020-03-07	8909.954102	8.217034e+11	2.952040e+11	-0.070590
2020-03-08	8108.116211	8.197206e+11	2.482670e+11	-0.125490

2020-03-09	7923.644531	8.023926e+11	2.060531e+11	-0.094721
2020-03-10	7909.729492	8.311826e+11	2.447358e+11	-0.087003
2020-03-11	7911.430176	7.810874e+11	1.907555e+11	-0.167774
2020-03-12	4970.788086	7.906391e+11	2.615307e+11	-0.161633

Date	volume_fi	volume_em	volume_sma_em	volume_vpt \
2014-09-17	-1.134291e+09	-3212.366691	-3212.366691	-2.109752e+07
2014-09-18	-1.132834e+09	-3288.687640	-3250.527166	-5.128636e+06
2014-09-19	-8.967045e+08	36.798834	-2154.751832	-1.331094e+06
2014-09-20	-8.068905e+08	-274.120355	-1684.593963	6.618911e+05
2014-09-21	-6.801392e+08	-31.656617	-1354.006494	-4.539104e+05
2014-09-22	-3.662477e+08	1695.136068	-845.816067	3.973973e+06
2014-09-23	-3.689952e+08	476.627823	-656.895511	2.887904e+06
2014-09-24	-3.608356e+08	-635.564367	-654.229118	-1.621496e+06
2014-09-25	-3.312053e+08	-627.501292	-651.259360	-1.109716e+06
2014-09-26	-2.944215e+08	-337.063812	-619.839805	-5.550532e+05
2014-09-27	-3.277180e+08	-1618.618146	-710.637836	-1.502608e+06
2014-09-28	-2.888584e+08	-357.187199	-681.183616	-1.468004e+06
2014-09-29	-1.906879e+08	176.035474	-615.243686	9.132299e+05
2014-09-30	-1.759207e+08	156.362329	-560.128971	8.352460e+05
2014-10-01	-1.773673e+08	-395.241741	-358.905760	-7.106437e+05
2014-10-02	-2.207181e+08	-734.641854	-176.473918	-1.766931e+06
2014-10-03	-3.959883e+08	-1846.065618	-310.964236	-5.308544e+06
2014-10-04	-4.388645e+08	-1867.937739	-424.808335	-6.143329e+06
2014-10-05	-2.681604e+08	447.149313	-390.607911	2.422075e+05
2014-10-06	-1.869213e+08	229.509613	-495.295515	3.269368e+06
2014-10-07	-2.921876e+07	541.745022	-490.644287	3.638066e+06
2014-10-08	1.193677e+08	1023.445024	-372.143616	5.591826e+06
2014-10-09	8.070694e+07	-60.315468	-331.630343	2.449813e+06
2014-10-10	7.058243e+07	-205.846382	-322.257669	-3.871721e+05
2014-10-11	1.012468e+08	824.937812	-147.717958	8.144887e+05
2014-10-12	1.464832e+08	1228.425980	-34.459874	1.891242e+06
2014-10-13	1.830523e+08	976.552879	22.719941	2.134828e+06
2014-10-14	1.348944e+08	-320.421918	-11.336077	6.465751e+05
2014-10-15	6.851845e+07	-911.425792	-48.206366	-1.219554e+06
2014-10-16	6.106553e+07	-408.360819	-24.900578	-7.925239e+05
…	…	…	…	…
2020-02-12	2.270028e+12	-7.683225	50.028022	-3.236642e+07
2020-02-13	2.550842e+12	-28.617726	49.097370	-1.190965e+08
2020-02-14	-4.623330e+11	-123.289499	40.289586	-1.383337e+09
2020-02-15	-1.173931e+11	-168.038571	30.203590	-1.600612e+09
2020-02-16	-1.705904e+12	-154.621530	15.710703	-9.337059e+08
2020-02-17	1.589165e+12	194.847679	38.630816	1.073145e+09
2020-02-18	-2.052228e+12	5.299720	16.064290	-1.523370e+08
2020-02-19	-1.918929e+12	-98.159507	-4.447305	-2.472768e+09
2020-02-20	-1.188913e+12	26.315414	-4.775144	2.159488e+08

2020-02-21	-1.138152e+12	-1.876960	-4.807551	2.460650e+08
2020-02-22	5.620254e+11	100.559627	-9.429918	1.027768e+09
2020-02-23	-1.285038e+12	-48.942456	-11.906144	-1.323240e+08
2020-02-24	-2.974986e+12	-217.154536	-26.918226	-2.605157e+09
2020-02-25	-6.303995e+12	-579.507359	-78.633495	-4.171991e+09
2020-02-26	-5.637455e+12	-214.773594	-93.425664	-2.998710e+09
2020-02-27	-5.546041e+12	-56.458865	-95.414317	-7.546338e+08
2020-02-28	-5.126738e+12	-2.029302	-86.752874	-8.699653e+08
2020-02-29	-4.581469e+12	-64.035192	-79.324062	-4.533763e+08
2020-03-01	-2.046037e+12	116.051760	-59.990255	1.385391e+09
2020-03-02	-2.249572e+12	35.402786	-71.379176	1.146399e+09
2020-03-03	-2.089727e+12	-9.569684	-72.441276	-5.199719e+08
2020-03-04	4.351646e+10	166.485743	-53.538044	1.338227e+09
2020-03-05	2.926615e+11	49.903434	-51.853186	1.663781e+09
2020-03-06	-8.490647e+11	-54.849611	-55.636946	-6.471077e+08
2020-03-07	-5.306619e+12	-1046.826168	-137.593074	-4.441318e+09
2020-03-08	-5.785466e+12	-598.335234	-176.835416	-4.665205e+09
2020-03-09	-5.042887e+12	31.985056	-159.039731	-1.142020e+09
2020-03-10	-4.313076e+12	-142.556797	-127.828976	-6.581640e+07
2020-03-11	-2.637362e+13	-7970.760717	-681.828056	-2.005593e+10
2020-03-12	-2.134905e+13	-3431.799535	-922.923818	-1.829423e+10

	volume_nvi	volatility_atr	…	momentum_uo	momentum_stoch	\
Date			…			
2014-09-17	1000.000000	0.000000	…	50.000000	20.584704	
2014-09-18	1000.000000	0.000000	…	50.000000	12.271320	
2014-09-19	1035.734917	0.000000	…	50.000000	29.138447	
2014-09-20	1010.195200	0.000000	…	50.000000	17.083524	
2014-09-21	1018.632454	0.000000	…	50.000000	21.065966	
2014-09-22	1018.632454	0.000000	…	50.000000	61.283773	
2014-09-23	989.213520	0.000000	…	50.000000	46.236311	
2014-09-24	962.026873	0.000000	…	50.000000	32.330638	
2014-09-25	945.316521	25.504999	…	50.000000	23.783477	
2014-09-26	933.851412	23.879596	…	50.000000	17.919199	
2014-09-27	933.851412	24.160136	…	50.000000	3.035953	
2014-09-28	933.851412	23.041224	…	50.000000	3.363791	
2014-09-29	933.851412	22.490501	…	50.000000	15.327211	
2014-09-30	925.817173	21.301351	…	50.000000	13.442449	
2014-10-01	905.199482	20.426315	…	50.000000	4.085578	
2014-10-02	905.199482	20.367284	…	50.000000	1.974939	
2014-10-03	905.199482	22.190657	…	50.000000	2.576281	
2014-10-04	905.199482	25.222091	…	50.000000	20.500336	
2014-10-05	932.224703	26.957283	…	50.000000	26.784939	
2014-10-06	949.475210	26.138056	…	50.000000	31.938630	
2014-10-07	949.475210	26.241853	…	50.000000	47.416269	
2014-10-08	949.475210	27.121568	…	50.000000	60.274440	
2014-10-09	940.464971	26.619808	…	50.000000	61.593686	

2014-10-10	942.381991	25.081830	…	50.000000	65.344041
2014-10-11	942.381991	24.902547	…	50.000000	87.431809
2014-10-12	942.381991	25.245193	…	50.000000	93.688492
2014-10-13	942.381991	24.849073	…	50.000000	91.153737
2014-10-14	928.048943	23.710266	…	56.540246	86.172622
2014-10-15	928.048943	23.912939	…	55.805860	76.191569
2014-10-16	930.964885	22.530544	…	59.957246	77.173575
…	…	…	…	…	…
2020-02-12	395.164153	292.961014	…	63.219808	81.912234
2020-02-13	398.945282	283.311104	…	65.738248	89.179873
2020-02-14	398.945282	301.692787	…	54.687866	57.748689
2020-02-15	400.760963	304.681711	…	53.444037	61.095527
2020-02-16	400.760963	317.331314	…	55.707048	42.930133
2020-02-17	400.760963	338.553456	…	57.571597	75.606671
2020-02-18	380.663265	362.743325	…	48.267008	13.236889
2020-02-19	379.678901	340.000633	…	50.404628	10.614635
2020-02-20	382.759720	319.327718	…	49.132871	18.821656
2020-02-21	381.840611	297.145239	…	54.081452	16.373232
2020-02-22	381.840611	295.392043	…	56.219863	43.882384
2020-02-23	381.840611	307.323152	…	54.413135	15.004076
2020-02-24	369.635001	311.362418	…	40.672249	3.182667
2020-02-25	369.635001	345.261333	…	41.019850	6.621931
2020-02-26	368.125189	346.304535	…	42.023958	11.749039
2020-02-27	363.430052	351.426426	…	41.033552	9.711145
2020-02-28	360.373147	333.896088	…	39.461777	6.273825
2020-02-29	358.820324	326.064877	…	35.203111	5.303294
2020-03-01	358.820324	332.326163	…	41.761759	23.159874
2020-03-02	355.507736	318.754387	…	42.440774	18.400469
2020-03-03	354.191336	299.972405	…	47.867243	19.184521
2020-03-04	354.191336	308.656024	…	51.748405	41.035878
2020-03-05	354.191336	291.352043	…	53.564267	43.993137
2020-03-06	345.937262	289.464495	…	51.244736	29.634000
2020-03-07	345.937262	341.427127	…	37.800594	0.155066
2020-03-08	345.937262	356.053946	…	35.172298	11.899609
2020-03-09	345.329747	352.666764	…	34.430841	13.193606
2020-03-10	345.403997	348.200283	…	39.856198	17.615627
2020-03-11	345.403997	620.256475	…	20.638760	2.563857
2020-03-12	345.403997	729.830193	…	27.714073	19.296816

	momentum_stoch_signal	momentum_wr	momentum_ao	momentum_kama \
Date				
2014-09-17	25.884066	-79.415296	0.000000	424.440002
2014-09-18	21.346484	-87.728680	0.000000	394.795990
2014-09-19	20.664824	-70.861553	0.000000	408.903992
2014-09-20	19.497764	-82.916476	0.000000	398.821014
2014-09-21	22.429312	-78.934034	-8.296951	402.152008
2014-09-22	33.144421	-38.716227	-11.527058	435.790985

2014-09-23	42.862017	-53.763689	-8.264314	423.204987
2014-09-24	46.616907	-67.669362	-5.888602	411.574005
2014-09-25	34.116809	-76.216523	-3.736702	404.424988
2014-09-26	24.677771	-82.080801	-2.247520	404.034545
2014-09-27	14.912876	-96.964047	-6.049202	402.288769
2014-09-28	8.106314	-96.636209	-13.276501	401.599367
2014-09-29	7.242318	-84.672789	-18.023336	401.146576
2014-09-30	10.711151	-86.557551	-20.731467	400.771869
2014-10-01	10.951746	-95.914422	-23.483704	399.707420
2014-10-02	6.500989	-98.025061	-25.199150	388.527846
2014-10-03	2.878933	-97.423719	-28.639430	370.557029
2014-10-04	8.350519	-79.499664	-37.488265	355.667673
2014-10-05	16.620519	-73.215061	-46.314571	350.509179
2014-10-06	26.407968	-68.061370	-53.197108	348.345401
2014-10-07	35.379946	-52.583731	-56.376136	348.519717
2014-10-08	46.543113	-39.725560	-51.406301	348.741326
2014-10-09	56.428132	-38.406314	-40.778008	349.244453
2014-10-10	62.404056	-34.655959	-32.275256	349.664140
2014-10-11	71.456512	-12.568191	-24.045325	349.858515
2014-10-12	82.154781	-6.311508	-15.556549	351.914502
2014-10-13	90.758013	-8.846263	-8.925149	365.042089
2014-10-14	90.338284	-13.827378	-3.007538	373.820089
2014-10-15	84.505976	-23.808431	1.831121	375.173189
2014-10-16	79.845922	-22.826425	4.505106	376.405387
…	…	…	…	…
2020-02-12	92.157375	-18.087766	1006.084326	9699.998864
2020-02-13	88.605847	-10.820127	991.096764	9812.052833
2020-02-14	76.280265	-42.251311	958.737770	9813.879100
2020-02-15	69.341363	-38.904473	890.980625	9816.018640
2020-02-16	53.924783	-57.069867	740.349443	9814.838461
2020-02-17	59.877444	-24.393329	629.358151	9820.830220
2020-02-18	43.924564	-86.763111	530.419436	9815.026854
2020-02-19	33.152732	-89.385365	401.643423	9811.674610
2020-02-20	14.224393	-81.178344	333.618546	9805.941974
2020-02-21	15.269841	-83.626768	296.596912	9796.045182
2020-02-22	26.359091	-56.117616	243.020919	9798.761576
2020-02-23	25.086564	-84.995924	179.425141	9790.536901
2020-02-24	20.689709	-96.817333	137.618454	9770.159292
2020-02-25	8.269558	-93.378069	-2.998883	9676.953244
2020-02-26	7.184545	-88.250961	-192.600169	9605.119583
2020-02-27	9.360705	-90.288855	-423.026669	9393.403332
2020-02-28	9.244669	-93.726175	-640.968589	9247.937968
2020-02-29	7.096088	-94.696706	-811.399000	9121.348779
2020-03-01	11.578998	-76.840126	-859.968244	9096.180299
2020-03-02	15.621212	-81.599531	-834.593382	9063.316932
2020-03-03	20.248288	-80.815479	-799.290323	8998.343282
2020-03-04	26.206956	-58.964122	-734.326853	9003.459999

2020-03-05	34.737846	-56.006863	-626.021151	9006.092071
2020-03-06	38.221005	-70.366000	-556.714829	9004.985849
2020-03-07	24.594068	-99.844934	-589.393325	8941.716660
2020-03-08	13.896225	-88.100391	-720.298868	8862.213221
2020-03-09	8.416094	-86.806394	-872.216298	8793.680300
2020-03-10	14.236281	-82.384373	-1077.377948	8733.955214
2020-03-11	11.124364	-97.436143	-1504.250212	7507.742890
2020-03-12	13.158767	-80.703184	-2069.215316	6804.988914

	momentum_roc	others_dr	others_dlr	others_cr
Date				
2014-09-17	0.000000	-7.192558	-7.464335	-7.192558
2014-09-18	0.000000	-6.984264	-7.240151	-13.674475
2014-09-19	0.000000	3.573492	3.511124	-10.589639
2014-09-20	0.000000	-2.465855	-2.496766	-12.794369
2014-09-21	0.000000	0.835210	0.831742	-12.066019
2014-09-22	0.000000	8.364742	8.033259	-4.710568
2014-09-23	0.000000	-2.888081	-2.930607	-7.462604
2014-09-24	0.000000	-2.748309	-2.786782	-10.005818
2014-09-25	0.000000	-1.736994	-1.752257	-11.569012
2014-09-26	0.000000	-1.212833	-1.220248	-12.641532
2014-09-27	0.000000	-5.591457	-5.753862	-17.526143
2014-09-28	-17.900922	-0.454421	-0.455457	-17.900922
2014-09-29	-8.834229	3.056724	3.010937	-15.391380
2014-09-30	-2.832096	-0.860334	-0.864056	-16.119296
2014-10-01	-8.273825	-2.226972	-2.252144	-17.987296
2014-10-02	-9.856306	-4.148536	-4.237045	-21.389623
2014-10-03	-18.223460	-8.524332	-8.909717	-28.090633
2014-10-04	-26.453272	-2.540849	-2.573686	-29.917741
2014-10-05	-22.004934	2.985554	2.941854	-27.825397
2014-10-06	-18.316753	1.850467	1.833554	-26.489830
2014-10-07	-12.730417	4.983235	4.863049	-22.826645
2014-10-08	-8.633858	3.424378	3.367051	-20.183938
2014-10-09	-4.140980	-0.948970	-0.953502	-20.941369
2014-10-10	-3.507099	0.203838	0.203630	-20.780218
2014-10-11	-2.169562	4.485245	4.387568	-17.227016
2014-10-12	1.772353	3.134334	3.086217	-14.632634
2014-10-13	6.878147	2.678181	2.642946	-12.346342
2014-10-14	9.808022	-1.520938	-1.532623	-13.679500
2014-10-15	16.325799	-3.094692	-3.143589	-16.350854
2014-10-16	19.733545	0.314201	0.313709	-16.088027
…	…	…	…	…
2020-02-12	8.746043	-1.081486	-1.087376	2133.461660
2020-02-13	10.356519	0.956850	0.952302	2154.832545
2020-02-14	6.412029	-4.098978	-4.185355	2062.407449
2020-02-15	8.206881	0.455120	0.454088	2072.249006
2020-02-16	0.798038	-2.459033	-2.489772	2018.832682

```
2020-02-17      4.236410   4.663022    4.557569  2117.634324
2020-02-18     -1.659428  -5.014884   -5.144998  2006.422528
2020-02-19     -2.601525  -0.258592   -0.258927  2000.975495
2020-02-20     -4.252706   0.811428    0.808153  2018.023390
2020-02-21     -1.962436  -0.240127   -0.240416  2012.937443
2020-02-22     -2.779331   2.704430    2.668507  2070.080357
2020-02-23     -6.545384  -2.764274   -2.803199  2010.093387
2020-02-24     -8.543591  -3.196520   -3.248724  1942.643838
2020-02-25    -14.464478  -5.579095   -5.740769  1828.682795
2020-02-26    -11.172851  -0.408460   -0.409297  1820.804894
2020-02-27    -12.703075  -1.275418   -1.283622  1796.306593
2020-02-28    -11.255085  -0.841126   -0.844684  1780.356262
2020-02-29    -15.574271  -0.430893   -0.431824  1772.253937
2020-03-01     -7.927812   3.587941    3.525074  1839.429308
2020-03-02     -8.541308  -0.923189   -0.927476  1821.524716
2020-03-03     -9.613389  -0.370287   -0.370974  1814.409558
2020-03-04     -6.047894   3.695117    3.628484  1885.149234
2020-03-05     -8.080694   0.482260    0.481100  1894.722806
2020-03-06     -7.670542  -2.330400   -2.357983  1848.237789
2020-03-07    -13.205179  -8.999349   -9.430353  1672.909065
2020-03-08    -10.168082  -2.275148   -2.301429  1632.572752
2020-03-09     -9.958054  -0.175614   -0.175769  1629.530110
2020-03-10     -8.775196   0.021501    0.021499  1629.901979
2020-03-11    -42.196837 -37.169539  -46.473018   986.905396
2020-03-12    -40.494834   2.500900    2.470140  1014.087816

[2004 rows x 69 columns]
```

1.2.2 Removing Rows

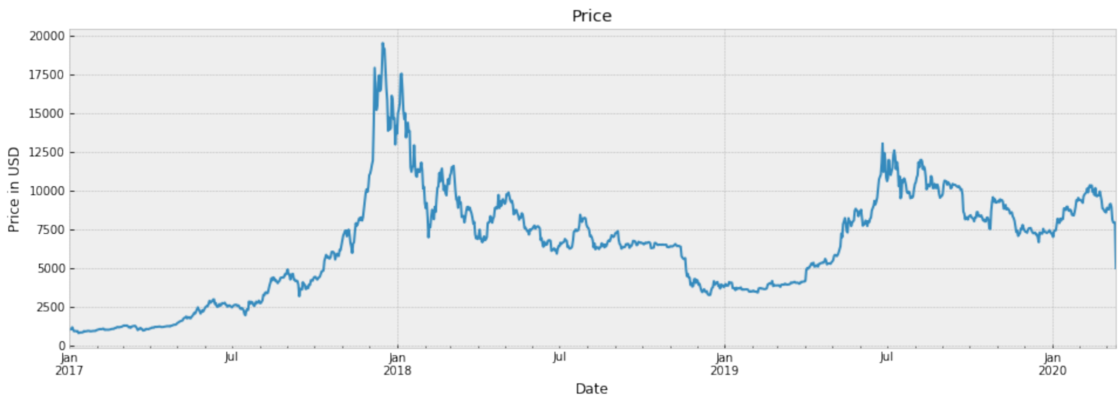
Removing data points so the data reflects only the current market volatility from 2017 onwards

[55]:
```
df = df['2017':]
```

1.3 Plotting Historical Prices

[56]:
```
df.Close.plot(figsize=(16,5))

plt.xlabel('Date')
plt.ylabel('Price in USD')
plt.title('Price')
plt.show()
```



1.4 Detrending

1.4.1 Taking the Log then Plotting

[58]:
```
df['Close'] = df.Close.apply(np.log)

df.Close.plot(figsize=(16,5))

plt.xlabel('Date')
plt.ylabel('Log Price in USD')
plt.title('Log Price')
plt.show()
```

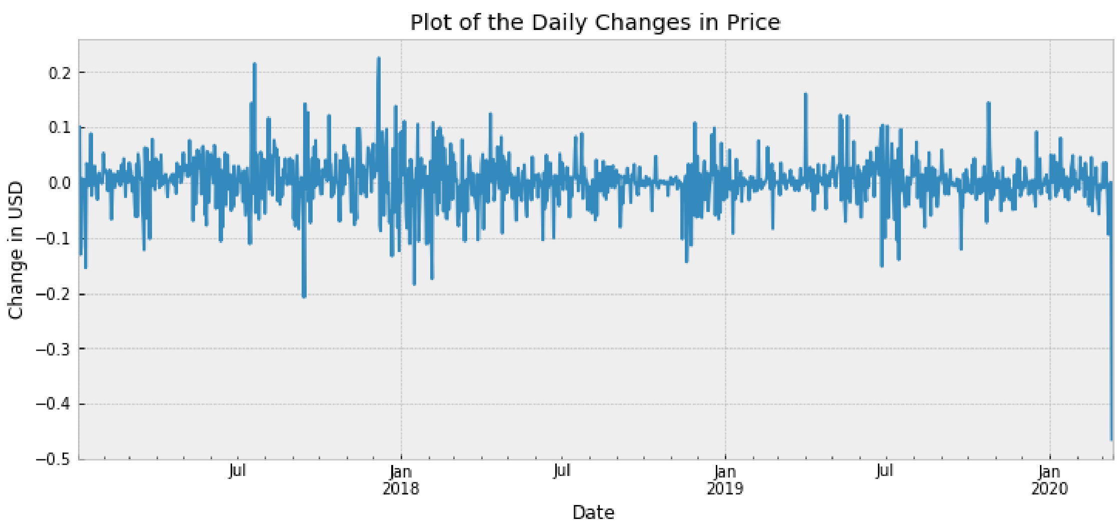
```
/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:1:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/indexing.html#indexing-view-versus-copy
  """Entry point for launching an IPython kernel.
```

1.4.2 Differencing the Data

[59]:
```
# Differencing the price
df_diff = df.Close.diff(1).dropna()

# Plotting the differences daily
df_diff.plot(figsize=(12,8))
plt.title('Plot of the Daily Changes in Price')
plt.ylabel('Change in USD')
plt.show()
```



1.4.3 Testing for Stationarity

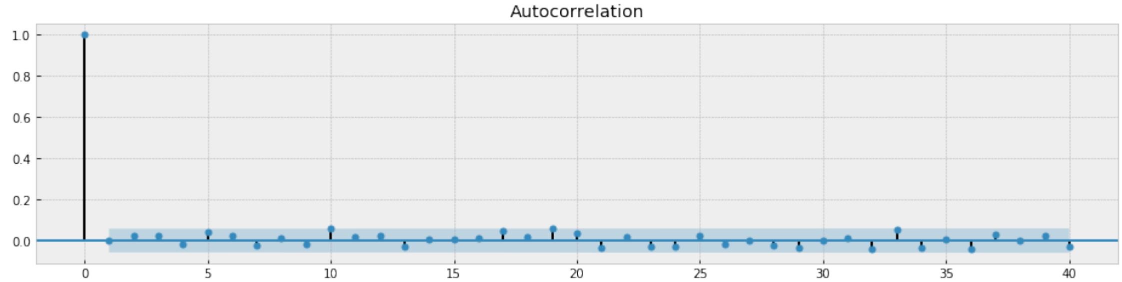
[60]:
```
results = adfuller(df_diff)
print(f"P-value: {results[1]}")
```

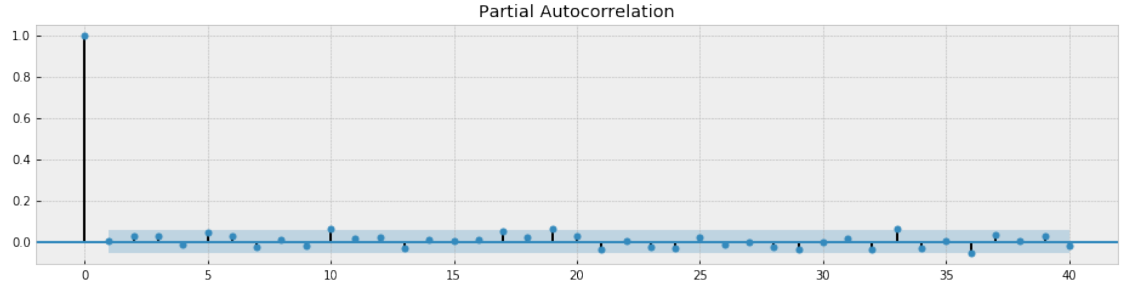
```
P-value: 0.0
```

1.5 PACF and ACF

ACF and PACF for the Differencing

[61]:
```
fig, (ax1, ax2) = plt.subplots(2,1,figsize=(16,8))
plot_acf(df_diff, ax=ax1, lags=40)
plot_pacf(df_diff, ax=ax2, lags=40)
plt.show()
```





Appears to be some correlation at day 5 and 10 mostly.

1.6 Modeling

1.6.1 Finding the Best Parameters for ARIMA

[62]:
```python
def best_param(model, data, pdq, pdqs, exog=None):
    """
    Loops through each possible combo for pdq and pdqs
    Runs the model for each combo
    Retrieves the model with lowest AIC score
    """
    # Instantiating an empty list to append the combinations and AIC score
    ans = []

    # Iterating through all the different possible combinations
    for comb in tqdm(pdq):
        for combs in pdqs:

            # Running a model with different combinations
            try:
                mod = model(data,
                            order=comb,
                            exog=exog,
                            seasonal_order=combs,
                            enforce_stationarity=False,
                            enforce_invertibility=False,
                            freq='D')
```

```
                output = mod.fit()

                # Appending the results to the empty list
                ans.append([comb, combs, output.aic])
            except:
                continue

    # Creating a DataFrame with the different combinations and respective␣
 ↪scores
    ans_df = pd.DataFrame(ans, columns=['pdq', 'pdqs', 'aic'])

    # Returning the parameters with the lowest AIC score
    return ans_df.loc[ans_df.aic.idxmin()]
```

[81]:
```
# Assigning variables for p, d, q.
p = d = q = range(0,2)

# Creating a list of all possible combinations of p, d, and q.
pdq = list(itertools.product(p, d, q))

# Seasonality
s = [12]
pdqs = list(itertools.product(p, d, q, s))
```

[82]:
```
# Finding the best parameters
best_param(SARIMAX, df.Close, pdq, pdqs, exog=df[df.columns[1:]])
```

```
HBox(children=(IntProgress(value=0, max=8), HTML(value='')))
```

```
/anaconda3/lib/python3.7/site-packages/statsmodels/tsa/base/tsa_model.py:191:
FutureWarning: Creating a DatetimeIndex by passing range endpoints is
deprecated.  Use `pandas.date_range` instead.
  start=index[0], end=index[-1], freq=freq)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
mle_retvals
  "Check mle_retvals", ConvergenceWarning)
/anaconda3/lib/python3.7/site-
packages/statsmodels/tsa/statespace/representation.py:375: FutureWarning: Using
a non-tuple sequence for multidimensional indexing is deprecated; use
`arr[tuple(seq)]` instead of `arr[seq]`. In the future this will be interpreted
as an array index, `arr[np.array(seq)]`, which will result either in an error or
a different result.
  return matrix[[slice(None)]*(matrix.ndim-1) + [0]]
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
mle_retvals
  "Check mle_retvals", ConvergenceWarning)
```

```
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
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  "Check mle_retvals", ConvergenceWarning)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
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  "Check mle_retvals", ConvergenceWarning)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
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  "Check mle_retvals", ConvergenceWarning)
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/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
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/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
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  "Check mle_retvals", ConvergenceWarning)
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  "Check mle_retvals", ConvergenceWarning)
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  "Check mle_retvals", ConvergenceWarning)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
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```

```
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
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/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
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  "Check mle_retvals", ConvergenceWarning)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
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  "Check mle_retvals", ConvergenceWarning)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
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  "Check mle_retvals", ConvergenceWarning)
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```

```
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```

```
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
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ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
mle_retvals
  "Check mle_retvals", ConvergenceWarning)
```

[82]:
```
pdq          (0, 1, 1)
pdqs     (0, 0, 0, 12)
aic           -7380.95
Name: 24, dtype: object
```

Best Parameters according to the function

[83]:
```python
pdq    =     (0, 1, 1)
pdqs  =  (0, 0, 0, 12)
# aic          -7380.95
```

1.6.2 Fitting and Training SARIMAX

Train, test, split To get a more accurate depiction and to be fair to the predictive power of the model, we will be using a smaller size than the usual 80/20 split

[84]:
```python
# Splitting 95/5
index = round(len(df)*.95)

train = df.iloc[:index]
test  = df.iloc[index:]
```

[85]:
```python
# Fitting the model to the training set
model = SARIMAX(train.Close,
                order=pdq,
                exog=train[train.columns[1:]],
                seasonal_order=pdqs,
                freq='D',
                enforce_stationarity=False,
                enforce_invertibility=False)
output = model.fit()
```

```
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
mle_retvals
  "Check mle_retvals", ConvergenceWarning)
```

1.6.3 Summary and Diagnostics from fitting the model

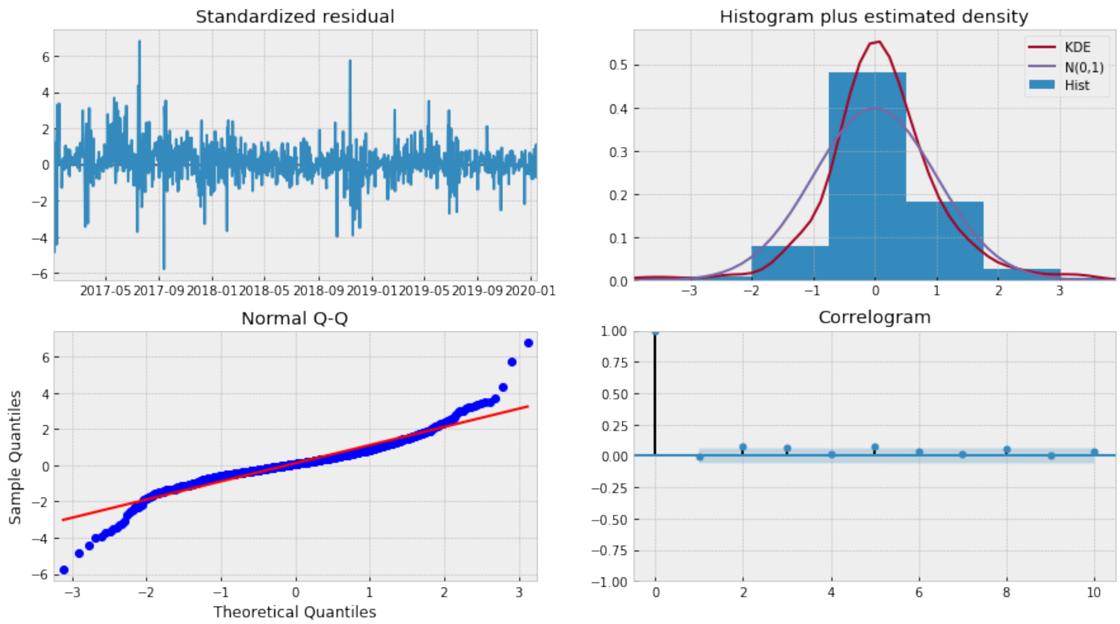
[86]:
```
print(output.summary())
output.plot_diagnostics(figsize=(15,8))
plt.show()
```

```
                           Statespace Model Results
==============================================================================
Dep. Variable:                  Close   No. Observations:                 1109
Model:               SARIMAX(0, 1, 1)   Log Likelihood                3587.093
Date:                Tue, 24 Mar 2020   AIC                          -7034.187
Time:                        13:09:01   BIC                          -6683.592
Sample:                    01-01-2017   HQIC                         -6901.590
                         - 01-14-2020
Covariance Type:                  opg
================================================================================
=============
                               coef    std err          z      P>|z|
[0.025      0.975]
--------------------------------------------------------------------------------
-------------
volume_adi               -1.265e-13   6.83e-14     -1.852      0.064
-2.6e-13    7.36e-15
volume_obv                2.365e-15   4.87e-14      0.049      0.961
-9.31e-14    9.78e-14
volume_cmf                   0.0111   6.65e-24   1.66e+21      0.000
0.011       0.011
volume_fi                -8.293e-15   3.09e-16    -26.804      0.000
-8.9e-15   -7.69e-15
volume_em                 8.955e-08   5.65e-19   1.58e+11      0.000
8.96e-08    8.96e-08
volume_sma_em             1.369e-06   3.26e-20    4.2e+13      0.000
1.37e-06    1.37e-06
volume_vpt                5.192e-12   2.94e-13     17.683      0.000
4.62e-12    5.77e-12
volume_nvi                1.997e-05   4.64e-22   4.31e+16      0.000
2e-05       2e-05
volatility_atr           -3.614e-06   2.26e-22    -1.6e+16      0.000
-3.61e-06   -3.61e-06
volatility_bbm            7.113e-06   8.73e-22   8.14e+15      0.000
7.11e-06    7.11e-06
volatility_bbh            3.184e-06   4.09e-21   7.79e+14      0.000
3.18e-06    3.18e-06
volatility_bbl            1.104e-05   5.79e-21   1.91e+15      0.000
1.1e-05     1.1e-05
volatility_bbw              -0.0002   1.12e-22     -2e+18      0.000
-0.000      -0.000
volatility_bbp              -0.0117   1.94e-23  -6.01e+20      0.000
```

```
-0.012      -0.012
volatility_bbhi             0.0005   9.53e-24   4.79e+19      0.000
0.000       0.000
volatility_bbli            -0.0022   8.98e-24  -2.49e+20      0.000
-0.002      -0.002
volatility_kcc          -2.849e-05   8.39e-22   -3.4e+16      0.000
-2.85e-05   -2.85e-05
volatility_kch          -2.849e-05   8.39e-22   -3.4e+16      0.000
-2.85e-05   -2.85e-05
volatility_kcl          -9.299e-06   1.37e-22  -6.78e+16      0.000
-9.3e-06    -9.3e-06
volatility_kchi            -0.0007   6.88e-24  -1.07e+20      0.000
-0.001      -0.001
volatility_kcli            -0.0008   1.48e-23  -5.29e+19      0.000
-0.001      -0.001
volatility_dcl           9.335e-07   1.17e-20   7.99e+13      0.000
9.33e-07    9.33e-07
volatility_dch          -6.076e-07    4.7e-21  -1.29e+14      0.000
-6.08e-07   -6.08e-07
volatility_dchi            -0.0022   8.45e-24  -2.59e+20      0.000
-0.002      -0.002
volatility_dcli             0.0005      1e-23   4.98e+19      0.000
0.000       0.000
trend_macd               4.755e-05   1.49e-21   3.19e+16      0.000
4.76e-05    4.76e-05
trend_macd_signal          -0.0002   4.44e-22  -3.59e+17      0.000
-0.000      -0.000
trend_macd_diff             0.0002   1.93e-21   1.07e+17      0.000
0.000       0.000
trend_ema_fast           9.165e-05   2.81e-21   3.26e+16      0.000
9.16e-05    9.16e-05
trend_ema_slow           4.409e-05   1.33e-21   3.33e+16      0.000
4.41e-05    4.41e-05
trend_adx                  -0.0002   5.04e-23  -4.07e+18      0.000
-0.000      -0.000
trend_adx_pos               0.0004   6.26e-22   7.03e+17      0.000
0.000       0.000
trend_adx_neg              -0.0003   4.22e-22  -6.59e+17      0.000
-0.000      -0.000
trend_vortex_ind_pos       -0.0041   5.62e-24  -7.37e+20      0.000
-0.004      -0.004
trend_vortex_ind_neg        0.0013   1.04e-23   1.24e+20      0.000
0.001       0.001
trend_vortex_ind_diff      -0.0054    1.6e-23  -3.39e+20      0.000
-0.005      -0.005
trend_trix                 -0.0198    7.3e-25  -2.71e+22      0.000
-0.020      -0.020
trend_mass_index            0.0013   5.19e-24   2.51e+20      0.000
```

```
0.001       0.001
trend_cci                  4.52e-05   8.21e-21   5.51e+15      0.000
4.52e-05    4.52e-05
trend_dpo                -2.203e-06   5.23e-21  -4.21e+14      0.000
-2.2e-06    -2.2e-06
trend_kst                    0.0003   7.74e-23   3.87e+18      0.000
0.000       0.000
trend_kst_sig                0.0001   1.21e-22   1.08e+18      0.000
0.000       0.000
trend_kst_diff               0.0002   1.89e-22   8.93e+17      0.000
0.000       0.000
trend_ichimoku_a           2.46e-06   1.12e-20    2.2e+14      0.000
2.46e-06    2.46e-06
trend_ichimoku_b         -1.474e-06      8e-21  -1.84e+14      0.000
-1.47e-06   -1.47e-06
trend_visual_ichimoku_a  -8.975e-07   3.97e-22  -2.26e+15      0.000
-8.98e-07   -8.98e-07
trend_visual_ichimoku_b   4.429e-07   8.03e-22   5.52e+14      0.000
4.43e-07    4.43e-07
trend_aroon_up            7.697e-06   6.25e-22   1.23e+16      0.000
7.7e-06     7.7e-06
trend_aroon_down          1.573e-05   2.42e-23   6.49e+17      0.000
1.57e-05    1.57e-05
trend_aroon_ind          -8.033e-06   6.29e-22  -1.28e+16      0.000
-8.03e-06   -8.03e-06
trend_psar                3.719e-07   5.22e-20   7.13e+12      0.000
3.72e-07    3.72e-07
trend_psar_up            -1.742e-07   1.86e-20  -9.36e+12      0.000
-1.74e-07   -1.74e-07
trend_psar_down          -3.002e-07   3.53e-20  -8.51e+12      0.000
-3e-07      -3e-07
trend_psar_up_indicator      0.0011   1.89e-23   5.62e+19      0.000
0.001       0.001
trend_psar_down_indicator    0.0035   2.41e-23   1.45e+20      0.000
0.003       0.003
momentum_rsi                 0.0022   6.18e-22   3.51e+18      0.000
0.002       0.002
momentum_mfi                 0.0003   3.32e-22   7.57e+17      0.000
0.000       0.000
momentum_tsi                 0.0012   2.85e-22   4.23e+18      0.000
0.001       0.001
momentum_uo               2.856e-05   4.14e-22    6.9e+16      0.000
2.86e-05    2.86e-05
momentum_stoch           -2.235e-05   1.16e-21  -1.93e+16      0.000
-2.23e-05   -2.23e-05
momentum_stoch_signal        0.0002   3.61e-22   6.01e+17      0.000
0.000       0.000
momentum_wr              -2.235e-05   1.16e-21  -1.93e+16      0.000
```

```
-2.23e-05   -2.23e-05
momentum_ao              -3.279e-05   1.21e-21  -2.72e+16      0.000
-3.28e-05   -3.28e-05
momentum_kama             1.377e-05   7.41e-21   1.86e+15      0.000
1.38e-05    1.38e-05
momentum_roc                 0.0004   4.53e-22    9.4e+17      0.000
0.000       0.000
others_dr                   -0.0028   1.25e-22  -2.25e+19      0.000
-0.003      -0.003
others_dlr                  -0.0046   1.34e-22  -3.45e+19      0.000
-0.005      -0.005
others_cr                    0.0001   5.04e-21   1.99e+16      0.000
0.000       0.000
ma.L1                        0.2672    1.9e-25   1.41e+24      0.000
0.267       0.267
sigma2                    8.761e-05   6.36e-22   1.38e+17      0.000
8.76e-05    8.76e-05
================================================================================
===
Ljung-Box (Q):                       95.63   Jarque-Bera (JB):
1755.71
Prob(Q):                              0.00   Prob(JB):
0.00
Heteroskedasticity (H):               0.33   Skew:
0.13
Prob(H) (two-sided):                  0.00   Kurtosis:
9.17
================================================================================
===

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-
step).
[2] Covariance matrix is singular or near-singular, with condition number
3.96e+45. Standard errors may be unstable.
```



1.6.4 Creating Future Exogenous Variables

Using the same model and same parameters as before

[87]:
```python
def create_exog(df, start, end, pdq=(0,0,0), pdqs=(0,0,0,0)):
    """
    Creates future exogenous variables using parameter from the same model used
    """
    print('Creating future exogenous variables...')

    # Instantiating a new DF containing the forecasted technical indicators
    future_indicators = pd.DataFrame(columns=df.columns[1:])

    # Iterating through each tech indicator and running a time series model
    for i in tqdm(df.columns):
        tech_models = SARIMAX(df[i],
                              order=pdq,
                              seasonal_order=pdqs,
                              freq='D',
                              enforce_stationarity=False,
                              enforce_invertibility=False)
        tech_output = tech_models.fit()

        # Forecasting the future exogenous variables
        tech_future = tech_output.predict(start=start, end=end)

        # Assigning the values to the respective columns
```

```
        future_indicators[i] = tech_future

    return future_indicators
```

1.6.5 Predictions with SARIMAX

1.6.6 Assigning Variables for Plotting

[88]:
```
# Creating test exog variables for the test set
test_exog = create_exog(train[train.columns[1:]],
                        pdq=pdq,
                        pdqs=pdqs,
                        start=test.index[0],
                        end=test.index[-1])
```

```
Creating future exogenous variables…

HBox(children=(IntProgress(value=0, max=68), HTML(value='')))

/anaconda3/lib/python3.7/site-packages/statsmodels/tsa/base/tsa_model.py:191:
FutureWarning: Creating a DatetimeIndex by passing range endpoints is
deprecated.  Use `pandas.date_range` instead.
  start=index[0], end=index[-1], freq=freq)
/anaconda3/lib/python3.7/site-
packages/statsmodels/tsa/statespace/representation.py:375: FutureWarning: Using
a non-tuple sequence for multidimensional indexing is deprecated; use
`arr[tuple(seq)]` instead of `arr[seq]`. In the future this will be interpreted
as an array index, `arr[np.array(seq)]`, which will result either in an error or
a different result.
  return matrix[[slice(None)]*(matrix.ndim-1) + [0]]
/anaconda3/lib/python3.7/site-packages/statsmodels/tsa/base/tsa_model.py:336:
FutureWarning: Creating a DatetimeIndex by passing range endpoints is
deprecated.  Use `pandas.date_range` instead.
  freq=base_index.freq)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
mle_retvals
  "Check mle_retvals", ConvergenceWarning)
```

[89]:
```
# Values to test against the test set
fc   = output.get_prediction(start=test.index[0], end=test.index[-1],␣
 ↪exog=test_exog)
conf = fc.conf_int()

# Assigning the values as a series
fc_series    = np.exp(pd.Series(fc.predicted_mean, index=test.index))
lower_series = np.exp(pd.Series(conf.iloc[:, 0], index=test.index))
```

```
upper_series = np.exp(pd.Series(conf.iloc[:, 1], index=test.index))

train = np.exp(train)
test  = np.exp(test)

# Values to test against the train set, see how the model fits
predictions = output.get_prediction(start=pd.to_datetime('2018'), end=train.
 ↪index[-1], dynamic=False)
pred        = np.exp(predictions.predicted_mean)

# Confidence interval for the training set
conf_int   = predictions.conf_int()
low_conf   = pd.Series(conf_int.iloc[:,0], index=train.index)
upper_conf = pd.Series(conf_int.iloc[:,1], index=train.index)
```

[91]:
```
fc_series
```

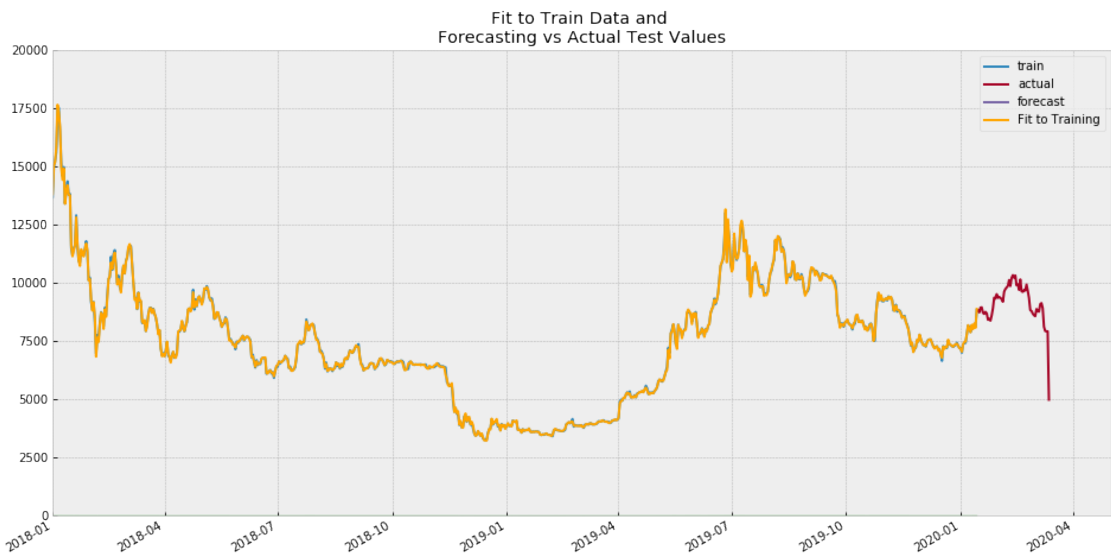
[91]:
```
Date
2020-01-15    inf
2020-01-16    inf
2020-01-17    inf
2020-01-18    inf
2020-01-19    inf
2020-01-20    inf
2020-01-21    inf
2020-01-22    inf
2020-01-23    inf
2020-01-24    inf
2020-01-25    inf
2020-01-26    inf
2020-01-27    inf
2020-01-28    inf
2020-01-29    inf
2020-01-30    inf
2020-01-31    inf
2020-02-01    inf
2020-02-02    inf
2020-02-03    inf
2020-02-04    inf
2020-02-05    inf
2020-02-06    inf
2020-02-07    inf
2020-02-08    inf
2020-02-09    inf
2020-02-10    inf
2020-02-11    inf
2020-02-12    inf
```

```
2020-02-13    inf
2020-02-14    inf
2020-02-15    inf
2020-02-16    inf
2020-02-17    inf
2020-02-18    inf
2020-02-19    inf
2020-02-20    inf
2020-02-21    inf
2020-02-22    inf
2020-02-23    inf
2020-02-24    inf
2020-02-25    inf
2020-02-26    inf
2020-02-27    inf
2020-02-28    inf
2020-02-29    inf
2020-03-01    inf
2020-03-02    inf
2020-03-03    inf
2020-03-04    inf
2020-03-05    inf
2020-03-06    inf
2020-03-07    inf
2020-03-08    inf
2020-03-09    inf
2020-03-10    inf
2020-03-11    inf
2020-03-12    inf
dtype: float64
```

1.6.7 Plotting the Fitted Model and Testing against the Test set

[90]:
```
rcParams['figure.figsize'] = 16, 8

# Plotting the training set, test set,forecast, and confidence interval.
plt.plot(train.Close, label='train')
plt.plot(test.Close, label='actual')
plt.plot(fc_series, label='forecast')
plt.fill_between(lower_series.index, lower_series, upper_series, color='k',␣
 ↪alpha=.15)

# Plotting against the training data
pred.plot(label='Fit to Training', color='orange')

# Confidence interval for the fitted data
```

```
plt.fill_between(conf_int.index, conf_int.iloc[:,0], conf_int.iloc[:,1],␣
↪color='g',alpha=.5)

# Limiting the viewing size
plt.xlim(['2018-01', '2020-05'])
plt.ylim([0, 20000])

plt.title('Fit to Train Data and \nForecasting vs Actual Test Values')
plt.legend()
plt.show()
```



1.6.8 Calculating the RMSE for SARIMA

[92]:
```
forecast = pred
actual_val = train.Close

# Calculating our errors
rmse = np.sqrt(((forecast - actual_val) ** 2).mean())

print("The Root Mean Squared Error: ", rmse)
```

```
The Root Mean Squared Error:  61.95635841905774
```

1.6.9 Forecasting Future Values

Fitting the model to the entire dataset

[93]:
```
model = SARIMAX(df.Close,
                order=pdq,
```

```
                 exog=df[df.columns[1:]],
                 seasonal_order=pdqs,
                 freq='D',
                 enforce_stationarity=False,
                 enforce_invertibility=False)
output = model.fit()
```

```
/anaconda3/lib/python3.7/site-packages/statsmodels/tsa/base/tsa_model.py:191:
FutureWarning: Creating a DatetimeIndex by passing range endpoints is
deprecated.  Use `pandas.date_range` instead.
  start=index[0], end=index[-1], freq=freq)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
mle_retvals
  "Check mle_retvals", ConvergenceWarning)
/anaconda3/lib/python3.7/site-
packages/statsmodels/tsa/statespace/representation.py:375: FutureWarning: Using
a non-tuple sequence for multidimensional indexing is deprecated; use
`arr[tuple(seq)]` instead of `arr[seq]`. In the future this will be interpreted
as an array index, `arr[np.array(seq)]`, which will result either in an error or
a different result.
  return matrix[[slice(None)]*(matrix.ndim-1) + [0]]
```

[94]:
```
# Creating future exog variables
future_exog = create_exog(df[df.columns[1:]], start=df.index[-1], end=datetime.
 ↪timedelta(29)+df.index[-1], pdq=pdq, pdqs=pdqs)
```

```
Creating future exogenous variables…
```

```
HBox(children=(IntProgress(value=0, max=68), HTML(value='')))
```

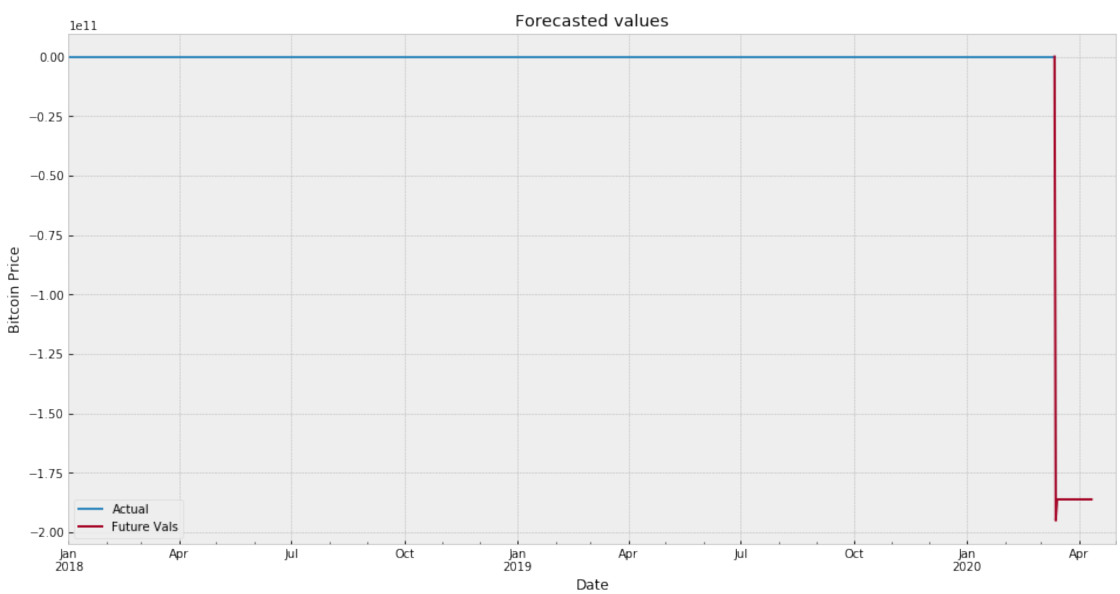
```
/anaconda3/lib/python3.7/site-packages/statsmodels/tsa/base/tsa_model.py:336:
FutureWarning: Creating a DatetimeIndex by passing range endpoints is
deprecated.  Use `pandas.date_range` instead.
  freq=base_index.freq)
/anaconda3/lib/python3.7/site-packages/statsmodels/base/model.py:508:
ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check
mle_retvals
  "Check mle_retvals", ConvergenceWarning)
```

[95]:
```
# Getting the forecast of future values
future = output.get_prediction(start=df.index[-1],
                               end=datetime.timedelta(30)+df.index[-1],
                               exog=future_exog)


# Transforming values back
pred_fut = future.predicted_mean
```

```
# Confidence interval for our forecasted values
pred_conf = future.conf_int()

# Transforming value back
pred_conf = pred_conf
```

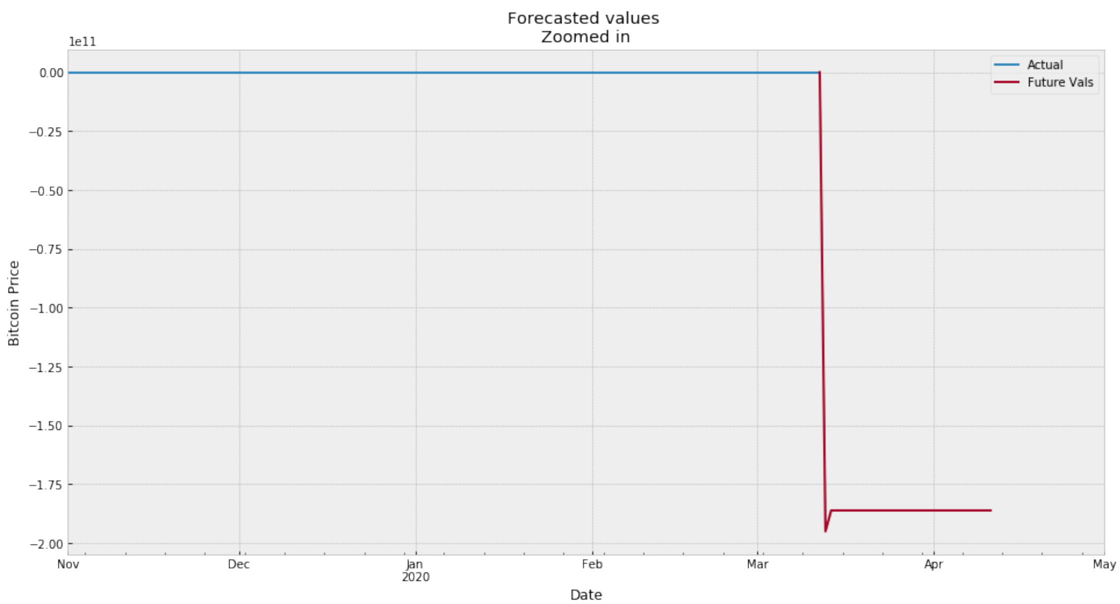
1.6.10 Plotting the forecasted values

[96]:
```
# Plotting the prices up to the most recent
ax = df.Close.plot(label='Actual', figsize=(16,8))

# Plotttting the forecast
pred_fut.plot(ax=ax, label='Future Vals')

# Shading in the confidence interval
ax.fill_between(pred_conf.index,
                pred_conf.iloc[:, 0],
                pred_conf.iloc[:, 1], color='k', alpha=.25)

ax.set_xlabel('Date')
ax.set_ylabel('Bitcoin Price')
ax.set_xlim(['2018-01', '2020-05'])

plt.title('Forecasted values')
plt.legend()
plt.show()
```



1.6.11 Zooming in on the Graph above

[97]:
```
ax = df.Close.plot(label='Actual', figsize=(16,8))
pred_fut.plot(ax=ax, label='Future Vals')

ax.fill_between(pred_conf.index,
                pred_conf.iloc[:, 0],
                pred_conf.iloc[:, 1], color='k', alpha=.25)

ax.set_xlabel('Date')
ax.set_ylabel('Bitcoin Price')
ax.set_xlim(['2019-11','2020-05'])

plt.title('Forecasted values \nZoomed in')
plt.legend()
plt.show()
```



[ ]:
```
```