

Time series analysis

Arti Mukati

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```
setwd("F:/Spring 2018/Adv Stats/final project")
eth = read.csv("ethereum_price.csv")
library(ggplot2)
library(forecast)
```

```
## Warning: package 'forecast' was built under R version 3.4.4
```

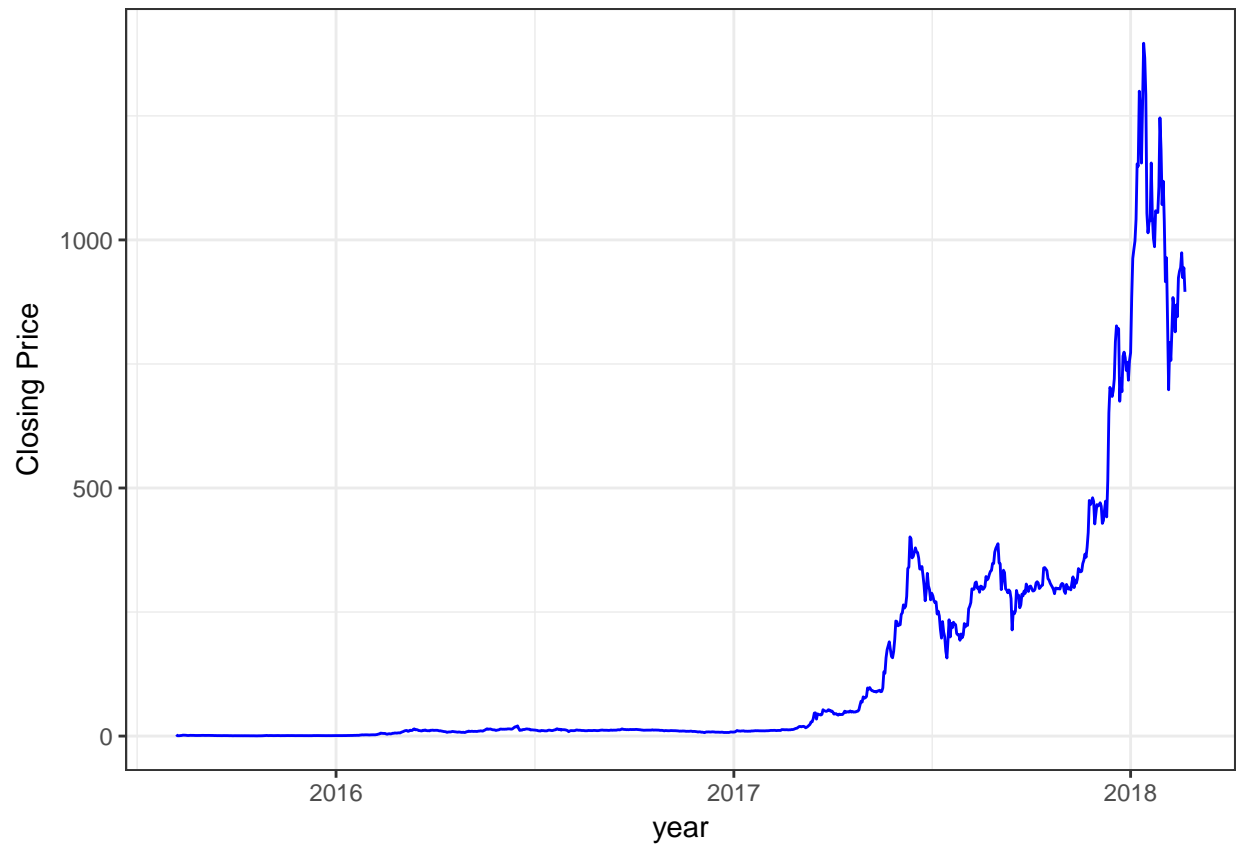
Time Series Analysis:

A time series is a set of observations measured at successive points in time or over successive periods of time. The objective of time series analysis is to discover a pattern in the historical data or time series and then extrapolate the pattern into the future. The forecast is based solely on past values of the variable and/or past forecast errors. Time series Decomposition For time series analysis dataset 2 is used which has the Opening, closing prices of the currency for each day. We will be modeling the time series for the closing prices of Ethereum over time. Figure 15 show the basic plot of ether prices over time.

```
summary(eth)
```

```
##           Date           Open           High
## 1/1/2016 : 1   Min.    : 0.4316   Min.    : 0.483
## 1/1/2017 : 1   1st Qu.: 7.8900   1st Qu.: 8.270
## 1/1/2018 : 1   Median : 12.0500   Median : 12.430
## 1/10/2016: 1   Mean    : 146.8975   Mean    : 154.363
## 1/10/2017: 1   3rd Qu.: 245.2600   3rd Qu.: 257.000
## 1/10/2018: 1   Max.    :1397.4800   Max.    :1432.880
## (Other)    :923
##           Low           Close           Volume
## Min.      : 0.4209   Min.      : 0.4348   1,005,550,000: 1
## 1st Qu.: 7.5700   1st Qu.: 7.9100   1,005,910    : 1
## Median : 11.7200   Median : 12.0200   1,006,130,000: 1
## Mean     : 139.1148   Mean     : 147.7843   1,011,800,000: 1
## 3rd Qu.: 223.9800   3rd Qu.: 245.9900   1,011,920    : 1
## Max.     :1290.6000   Max.     :1396.4200   1,020,390,000: 1
##                                     (Other)    :923
##           Market.Cap
## 1,014,280,000: 2
## 1,112,590,000: 2
## 684,258,000  : 2
## -           : 1
## 1,000,220,000: 1
## 1,002,130,000: 1
## (Other)      :920
```

```
eth$NDate <- as.Date(eth$Date, format = "%m/%d/%Y")
eth$Days <- 1:nrow(eth)
ggplot(eth, aes(NDate, Close)) + geom_line(color = "blue") + scale_x_date("year") + ylab("Closing Price")
```

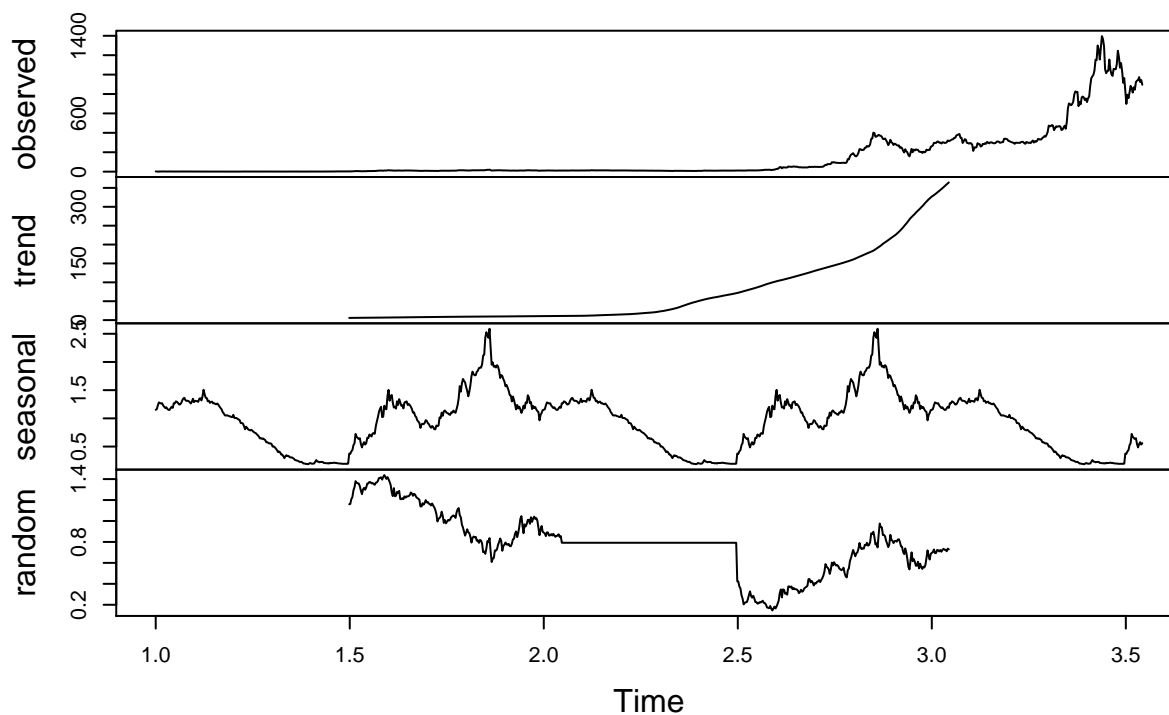


Here we are not seeing any seasonality component to the time series. But we can decompose the time series to get a closer look the data. Figure shows the decomposed plot for the data. The plot shows that the data has a decreasing trend and there is some seasonality to it. Decomposition is done for a frequency of 365(a year)

```
eth_ts = ts(data = eth$Close, frequency = 365)
eth_ts_decom = decompose(eth_ts , type = "multiplicative" )

plot(eth_ts_decom)
```

Decomposition of multiplicative time series



The regression summary for the deseasonalized timeseries. The model appears to be significant for significance level lower than 0.001. The achieved Adjusted r sqr is very less. That means only 25% of total variance is explained by the model. Which makes is not a very good fit

```
eth$SI = eth_ts_decom$seasonal
eth_ts_decom$trend
```

```
## Time Series:
## Start = c(1, 1)
## End = c(3, 199)
## Frequency = 365
##      [1]      NA      NA      NA      NA      NA      NA
##      [7]      NA      NA      NA      NA      NA      NA
##     [13]      NA      NA      NA      NA      NA      NA
##     [19]      NA      NA      NA      NA      NA      NA
##     [25]      NA      NA      NA      NA      NA      NA
##     [31]      NA      NA      NA      NA      NA      NA
##     [37]      NA      NA      NA      NA      NA      NA
##     [43]      NA      NA      NA      NA      NA      NA
##     [49]      NA      NA      NA      NA      NA      NA
##     [55]      NA      NA      NA      NA      NA      NA
##     [61]      NA      NA      NA      NA      NA      NA
##     [67]      NA      NA      NA      NA      NA      NA
##     [73]      NA      NA      NA      NA      NA      NA
##     [79]      NA      NA      NA      NA      NA      NA
##     [85]      NA      NA      NA      NA      NA      NA
##     [91]      NA      NA      NA      NA      NA      NA
```

## [97]	NA	NA	NA	NA	NA	NA
## [103]	NA	NA	NA	NA	NA	NA
## [109]	NA	NA	NA	NA	NA	NA
## [115]	NA	NA	NA	NA	NA	NA
## [121]	NA	NA	NA	NA	NA	NA
## [127]	NA	NA	NA	NA	NA	NA
## [133]	NA	NA	NA	NA	NA	NA
## [139]	NA	NA	NA	NA	NA	NA
## [145]	NA	NA	NA	NA	NA	NA
## [151]	NA	NA	NA	NA	NA	NA
## [157]	NA	NA	NA	NA	NA	NA
## [163]	NA	NA	NA	NA	NA	NA
## [169]	NA	NA	NA	NA	NA	NA
## [175]	NA	NA	NA	NA	NA	NA
## [181]	NA	NA	5.846985	5.869204	5.897030	5.925929
## [187]	5.957523	5.987851	6.016536	6.043797	6.070482	6.096509
## [193]	6.122947	6.150180	6.176646	6.202673	6.228125	6.255112
## [199]	6.281961	6.308728	6.335577	6.362701	6.390646	6.418454
## [205]	6.445742	6.472454	6.498920	6.525961	6.554235	6.583550
## [211]	6.613276	6.642016	6.670345	6.698892	6.727495	6.755742
## [217]	6.783523	6.812235	6.842884	6.871925	6.901936	6.932195
## [223]	6.962265	6.992492	7.024508	7.056963	7.088601	7.122167
## [229]	7.159183	7.194438	7.228292	7.262583	7.295854	7.329591
## [235]	7.362740	7.397033	7.431578	7.465362	7.499691	7.533914
## [241]	7.568195	7.603213	7.637875	7.671818	7.705354	7.738363
## [247]	7.770060	7.801354	7.831833	7.862419	7.893439	7.924774
## [253]	7.955947	7.987299	8.018539	8.050025	8.083178	8.114919
## [259]	8.146844	8.178658	8.210248	8.241690	8.272797	8.302054
## [265]	8.331260	8.360027	8.387096	8.412849	8.440968	8.468201
## [271]	8.494996	8.521681	8.548807	8.576737	8.604337	8.631575
## [277]	8.658370	8.685303	8.711949	8.738601	8.764339	8.788931
## [283]	8.814167	8.838999	8.864453	8.889248	8.913896	8.937251
## [289]	8.961183	8.984755	9.008459	9.033015	9.057508	9.080430
## [295]	9.103761	9.126945	9.149093	9.170577	9.190568	9.211706
## [301]	9.232606	9.251642	9.271039	9.289059	9.305455	9.324794
## [307]	9.345501	9.365878	9.386727	9.406453	9.426215	9.446947
## [313]	9.467295	9.487185	9.505922	9.524879	9.543947	9.563021
## [319]	9.581476	9.599994	9.619298	9.637714	9.654993	9.672526
## [325]	9.689856	9.707427	9.724756	9.742967	9.763153	9.782952
## [331]	9.802190	9.822006	9.842302	9.866345	9.894564	9.920041
## [337]	9.945542	9.969880	9.995368	10.020932	10.046932	10.070438
## [343]	10.094356	10.117863	10.140986	10.164767	10.187534	10.211836
## [349]	10.236110	10.260411	10.285205	10.310986	10.334904	10.358685
## [355]	10.380959	10.403671	10.426137	10.448082	10.470192	10.492192
## [361]	10.514822	10.538164	10.560877	10.583589	10.606959	10.631315
## [367]	10.655479	10.678575	10.701425	10.721671	10.739726	10.754164
## [373]	10.770055	10.786521	10.803041	10.824247	10.847808	10.872849
## [379]	10.895534	10.917644	10.940712	10.962027	10.981342	11.000548
## [385]	11.019397	11.038493	11.059397	11.081562	11.106027	11.132000
## [391]	11.158575	11.187507	11.215370	11.237863	11.260603	11.283151
## [397]	11.308740	11.327370	11.343397	11.365397	11.393863	11.421014
## [403]	11.459699	11.504082	11.564493	11.657178	11.755123	11.818575
## [409]	11.912301	12.002904	12.088630	12.173753	12.259397	12.374137
## [415]	12.485123	12.593479	12.701014	12.808137	12.921753	13.032055

## [421]	13.137918	13.244877	13.346658	13.436356	13.528082	13.623589
## [427]	13.712767	13.800685	13.895452	13.988932	14.083452	14.178712
## [433]	14.285151	14.400712	14.508055	14.620000	14.729890	14.836712
## [439]	14.950877	15.059370	15.172247	15.282164	15.393753	15.503890
## [445]	15.619041	15.735041	15.859205	16.008274	16.180849	16.347753
## [451]	16.540110	16.724904	16.908740	17.101644	17.341562	17.573260
## [457]	17.815616	18.047507	18.272000	18.496274	18.715890	18.934740
## [463]	19.150082	19.370164	19.590849	19.816740	20.031178	20.243945
## [469]	20.472301	20.786712	21.095973	21.490274	21.928548	22.390164
## [475]	22.875973	23.319589	23.724986	24.126247	24.560822	25.060986
## [481]	25.661479	26.254877	26.825397	27.400849	27.977644	28.612137
## [487]	29.254575	29.940986	30.608274	31.285671	32.018110	32.905123
## [493]	33.799425	34.856274	35.897205	36.829151	37.770466	38.728384
## [499]	39.725726	40.712384	41.692740	42.643863	43.530329	44.416000
## [505]	45.314795	46.162384	46.954082	47.663233	48.428192	49.293260
## [511]	50.088521	50.862384	51.581288	52.337068	53.080027	53.797370
## [517]	54.504658	55.217041	55.863288	56.521671	57.155014	57.715041
## [523]	58.227205	58.830630	59.376466	59.891945	60.326767	60.725973
## [529]	61.225315	61.837260	62.352548	62.941068	63.504521	64.093068
## [535]	64.672932	65.253644	65.782055	66.307973	66.832219	67.326137
## [541]	67.854904	68.363178	68.889178	69.480493	70.059014	70.648192
## [547]	71.229096	71.901918	72.588740	73.296329	74.078575	74.856082
## [553]	75.633479	76.447644	77.266329	78.051233	78.842767	79.606055
## [559]	80.403671	81.200137	81.980493	82.766027	83.561041	84.411479
## [565]	85.243452	86.083151	86.944986	87.823233	88.707014	89.629589
## [571]	90.552384	91.537836	92.544027	93.561479	94.590932	95.513863
## [577]	96.433644	97.210329	98.035726	98.919699	99.790603	100.571836
## [583]	101.346493	102.104247	102.879288	103.645233	104.371781	104.925178
## [589]	105.578658	106.219644	106.874575	107.644630	108.383288	109.121123
## [595]	109.791836	110.479671	111.227178	111.965808	112.730822	113.483205
## [601]	114.286959	115.070192	115.832932	116.622630	117.414877	118.193726
## [607]	118.958137	119.723562	120.498411	121.308658	122.126329	122.938356
## [613]	123.720110	124.509452	125.308548	126.109123	127.004466	127.902247
## [619]	128.791616	129.672247	130.508055	131.334712	132.145863	132.945616
## [625]	133.734685	134.511068	135.264247	136.048795	136.833781	137.614603
## [631]	138.397945	139.179342	139.986603	140.799123	141.607014	142.376658
## [637]	143.134685	143.942658	144.735479	145.517014	146.306110	147.083781
## [643]	147.900877	148.750795	149.541836	150.375781	151.192301	152.032356
## [649]	152.930055	153.815370	154.694438	155.577726	156.504110	157.448575
## [655]	158.427068	159.388110	160.403836	161.500630	162.776466	164.028192
## [661]	165.293945	166.585342	167.857068	169.005973	170.207397	171.462438
## [667]	172.710904	173.965507	175.233342	176.483918	177.636575	178.803781
## [673]	180.030630	181.304740	182.492658	183.881562	185.642959	187.545288
## [679]	189.428986	191.282740	193.168630	195.119589	197.275123	199.519452
## [685]	201.742548	203.970356	205.798521	207.749808	209.631671	211.710164
## [691]	213.810356	215.880685	217.879315	219.921260	221.864000	223.915397
## [697]	226.009836	228.410000	231.020932	233.677562	236.382959	239.208795
## [703]	242.341123	245.459589	248.992219	252.403918	255.541479	259.002685
## [709]	262.801726	266.519863	270.032247	272.892658	275.643205	278.454301
## [715]	281.272658	284.408411	287.254082	289.973425	292.645781	295.517425
## [721]	298.381699	301.243562	304.247753	307.632548	310.843178	313.748822
## [727]	316.783288	319.594411	322.073753	324.684466	326.939945	328.821041
## [733]	330.962767	333.005370	335.214630	337.605973	339.932356	342.133205
## [739]	344.482000	346.766904	349.261507	351.793178	354.344712	356.978795

```
## [745] 359.474986 362.025973 364.444986      NA      NA      NA
## [751]      NA      NA      NA      NA      NA      NA
## [757]      NA      NA      NA      NA      NA      NA
## [763]      NA      NA      NA      NA      NA      NA
## [769]      NA      NA      NA      NA      NA      NA
## [775]      NA      NA      NA      NA      NA      NA
## [781]      NA      NA      NA      NA      NA      NA
## [787]      NA      NA      NA      NA      NA      NA
## [793]      NA      NA      NA      NA      NA      NA
## [799]      NA      NA      NA      NA      NA      NA
## [805]      NA      NA      NA      NA      NA      NA
## [811]      NA      NA      NA      NA      NA      NA
## [817]      NA      NA      NA      NA      NA      NA
## [823]      NA      NA      NA      NA      NA      NA
## [829]      NA      NA      NA      NA      NA      NA
## [835]      NA      NA      NA      NA      NA      NA
## [841]      NA      NA      NA      NA      NA      NA
## [847]      NA      NA      NA      NA      NA      NA
## [853]      NA      NA      NA      NA      NA      NA
## [859]      NA      NA      NA      NA      NA      NA
## [865]      NA      NA      NA      NA      NA      NA
## [871]      NA      NA      NA      NA      NA      NA
## [877]      NA      NA      NA      NA      NA      NA
## [883]      NA      NA      NA      NA      NA      NA
## [889]      NA      NA      NA      NA      NA      NA
## [895]      NA      NA      NA      NA      NA      NA
## [901]      NA      NA      NA      NA      NA      NA
## [907]      NA      NA      NA      NA      NA      NA
## [913]      NA      NA      NA      NA      NA      NA
## [919]      NA      NA      NA      NA      NA      NA
## [925]      NA      NA      NA      NA      NA      NA
```

```
eth$deseasonalized = seasadj(eth_ts_decom)
eth_deseasonalized_regression = lm(deseasonalized ~ Days, data = eth)
summary(eth_deseasonalized_regression)
```

```
##
## Call:
## lm(formula = deseasonalized ~ Days, data = eth)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -849.8 -618.0 -190.0  251.1 5513.5
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -590.4006    62.6320  -9.426  <2e-16 ***
## Days         2.0838     0.1167  17.860  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 953.7 on 927 degrees of freedom
## Multiple R-squared:  0.256, Adjusted R-squared:  0.2552
## F-statistic: 319 on 1 and 927 DF, p-value: < 2.2e-16
```

Figure shows the forecast plot and we can see that the plot is not that accurate. The Forecast accuracy for the model is extremely low .

```
eth$SI = eth_ts_decom$seasonal

newdata = data.frame(Days = c(930:1294))
(deseasonalized_prediction = predict(eth_deseasonalized_regression, newdata = newdata))
```

##	1	2	3	4	5	6	7	8
##	1347.569	1349.653	1351.737	1353.821	1355.904	1357.988	1360.072	1362.156
##	9	10	11	12	13	14	15	16
##	1364.240	1366.324	1368.407	1370.491	1372.575	1374.659	1376.743	1378.827
##	17	18	19	20	21	22	23	24
##	1380.910	1382.994	1385.078	1387.162	1389.246	1391.330	1393.414	1395.497
##	25	26	27	28	29	30	31	32
##	1397.581	1399.665	1401.749	1403.833	1405.917	1408.000	1410.084	1412.168
##	33	34	35	36	37	38	39	40
##	1414.252	1416.336	1418.420	1420.503	1422.587	1424.671	1426.755	1428.839
##	41	42	43	44	45	46	47	48
##	1430.923	1433.006	1435.090	1437.174	1439.258	1441.342	1443.426	1445.509
##	49	50	51	52	53	54	55	56
##	1447.593	1449.677	1451.761	1453.845	1455.929	1458.012	1460.096	1462.180
##	57	58	59	60	61	62	63	64
##	1464.264	1466.348	1468.432	1470.516	1472.599	1474.683	1476.767	1478.851
##	65	66	67	68	69	70	71	72
##	1480.935	1483.019	1485.102	1487.186	1489.270	1491.354	1493.438	1495.522
##	73	74	75	76	77	78	79	80
##	1497.605	1499.689	1501.773	1503.857	1505.941	1508.025	1510.108	1512.192
##	81	82	83	84	85	86	87	88
##	1514.276	1516.360	1518.444	1520.528	1522.611	1524.695	1526.779	1528.863
##	89	90	91	92	93	94	95	96
##	1530.947	1533.031	1535.115	1537.198	1539.282	1541.366	1543.450	1545.534
##	97	98	99	100	101	102	103	104
##	1547.618	1549.701	1551.785	1553.869	1555.953	1558.037	1560.121	1562.204
##	105	106	107	108	109	110	111	112
##	1564.288	1566.372	1568.456	1570.540	1572.624	1574.707	1576.791	1578.875
##	113	114	115	116	117	118	119	120
##	1580.959	1583.043	1585.127	1587.210	1589.294	1591.378	1593.462	1595.546
##	121	122	123	124	125	126	127	128
##	1597.630	1599.713	1601.797	1603.881	1605.965	1608.049	1610.133	1612.217
##	129	130	131	132	133	134	135	136
##	1614.300	1616.384	1618.468	1620.552	1622.636	1624.720	1626.803	1628.887
##	137	138	139	140	141	142	143	144
##	1630.971	1633.055	1635.139	1637.223	1639.306	1641.390	1643.474	1645.558
##	145	146	147	148	149	150	151	152
##	1647.642	1649.726	1651.809	1653.893	1655.977	1658.061	1660.145	1662.229
##	153	154	155	156	157	158	159	160
##	1664.312	1666.396	1668.480	1670.564	1672.648	1674.732	1676.816	1678.899
##	161	162	163	164	165	166	167	168
##	1680.983	1683.067	1685.151	1687.235	1689.319	1691.402	1693.486	1695.570
##	169	170	171	172	173	174	175	176
##	1697.654	1699.738	1701.822	1703.905	1705.989	1708.073	1710.157	1712.241
##	177	178	179	180	181	182	183	184
##	1714.325	1716.408	1718.492	1720.576	1722.660	1724.744	1726.828	1728.911
##	185	186	187	188	189	190	191	192

```

## 1730.995 1733.079 1735.163 1737.247 1739.331 1741.414 1743.498 1745.582
##      193      194      195      196      197      198      199      200
## 1747.666 1749.750 1751.834 1753.918 1756.001 1758.085 1760.169 1762.253
##      201      202      203      204      205      206      207      208
## 1764.337 1766.421 1768.504 1770.588 1772.672 1774.756 1776.840 1778.924
##      209      210      211      212      213      214      215      216
## 1781.007 1783.091 1785.175 1787.259 1789.343 1791.427 1793.510 1795.594
##      217      218      219      220      221      222      223      224
## 1797.678 1799.762 1801.846 1803.930 1806.013 1808.097 1810.181 1812.265
##      225      226      227      228      229      230      231      232
## 1814.349 1816.433 1818.517 1820.600 1822.684 1824.768 1826.852 1828.936
##      233      234      235      236      237      238      239      240
## 1831.020 1833.103 1835.187 1837.271 1839.355 1841.439 1843.523 1845.606
##      241      242      243      244      245      246      247      248
## 1847.690 1849.774 1851.858 1853.942 1856.026 1858.109 1860.193 1862.277
##      249      250      251      252      253      254      255      256
## 1864.361 1866.445 1868.529 1870.612 1872.696 1874.780 1876.864 1878.948
##      257      258      259      260      261      262      263      264
## 1881.032 1883.116 1885.199 1887.283 1889.367 1891.451 1893.535 1895.619
##      265      266      267      268      269      270      271      272
## 1897.702 1899.786 1901.870 1903.954 1906.038 1908.122 1910.205 1912.289
##      273      274      275      276      277      278      279      280
## 1914.373 1916.457 1918.541 1920.625 1922.708 1924.792 1926.876 1928.960
##      281      282      283      284      285      286      287      288
## 1931.044 1933.128 1935.211 1937.295 1939.379 1941.463 1943.547 1945.631
##      289      290      291      292      293      294      295      296
## 1947.714 1949.798 1951.882 1953.966 1956.050 1958.134 1960.218 1962.301
##      297      298      299      300      301      302      303      304
## 1964.385 1966.469 1968.553 1970.637 1972.721 1974.804 1976.888 1978.972
##      305      306      307      308      309      310      311      312
## 1981.056 1983.140 1985.224 1987.307 1989.391 1991.475 1993.559 1995.643
##      313      314      315      316      317      318      319      320
## 1997.727 1999.810 2001.894 2003.978 2006.062 2008.146 2010.230 2012.313
##      321      322      323      324      325      326      327      328
## 2014.397 2016.481 2018.565 2020.649 2022.733 2024.817 2026.900 2028.984
##      329      330      331      332      333      334      335      336
## 2031.068 2033.152 2035.236 2037.320 2039.403 2041.487 2043.571 2045.655
##      337      338      339      340      341      342      343      344
## 2047.739 2049.823 2051.906 2053.990 2056.074 2058.158 2060.242 2062.326
##      345      346      347      348      349      350      351      352
## 2064.409 2066.493 2068.577 2070.661 2072.745 2074.829 2076.912 2078.996
##      353      354      355      356      357      358      359      360
## 2081.080 2083.164 2085.248 2087.332 2089.415 2091.499 2093.583 2095.667
##      361      362      363      364      365
## 2097.751 2099.835 2101.919 2104.002 2106.086

```

```
(eth$adjusted_prediction = eth_deseasonalized_regression$fitted.values * eth$SI) # this is the prediction
```

```

## Time Series:
## Start = c(1, 1)
## End = c(3, 199)
## Frequency = 365
##      1      2      3      4      5
## -677.2523689 -681.9079516 -719.1983039 -746.9631390 -737.7849322
##      6      7      8      9     10

```


##	-730.8878889	-730.3481436	-704.6526596	-688.7811497	-673.9747201
##	11	12	13	14	15
##	-678.7641604	-659.5960280	-648.5948062	-644.8253091	-659.7380816
##	16	17	18	19	20
##	-671.7710780	-658.0411850	-701.1907451	-697.9606092	-714.2504001
##	21	22	23	24	25
##	-706.5554194	-693.2059128	-675.5740417	-674.5681915	-685.6632297
##	26	27	28	29	30
##	-708.0793703	-722.7942348	-725.3735558	-700.2457268	-691.3485773
##	31	32	33	34	35
##	-689.5969193	-683.5555143	-671.5756104	-656.3814900	-669.7296361
##	36	37	38	39	40
##	-695.0649046	-660.5330729	-669.7121896	-666.0854008	-659.8938820
##	41	42	43	44	45
##	-653.0505875	-678.4259678	-679.4777347	-657.0542063	-689.0737815
##	46	47	48	49	50
##	-745.3673839	-703.3261245	-669.1946491	-664.1581051	-633.3181179
##	51	52	53	54	55
##	-635.8564815	-614.3414228	-619.8177195	-619.6385659	-602.4953640
##	56	57	58	59	60
##	-601.8519272	-592.1175224	-586.3383646	-590.8210480	-576.8151753
##	61	62	63	64	65
##	-559.9017677	-545.6899662	-532.2028654	-507.4860482	-494.8156221
##	66	67	68	69	70
##	-477.4691408	-473.2832460	-473.1376030	-468.3358632	-461.9279691
##	71	72	73	74	75
##	-457.7706345	-451.0831506	-447.9541383	-463.7858349	-437.4982848
##	76	77	78	79	80
##	-435.0352361	-432.6647792	-423.5862259	-417.4885255	-409.9848305
##	81	82	83	84	85
##	-386.0153025	-385.1082155	-378.6392775	-359.4422875	-333.2399278
##	86	87	88	89	90
##	-350.9317526	-339.7361588	-327.3402415	-321.3929667	-316.7821043
##	91	92	93	94	95
##	-319.3390277	-310.8140120	-301.6096180	-294.7030125	-290.1276821
##	96	97	98	99	100
##	-280.7239204	-272.3732673	-262.0086769	-247.3687279	-248.6718928
##	101	102	103	104	105
##	-241.3493057	-243.4102992	-235.7738363	-230.2377244	-213.9792041
##	106	107	108	109	110
##	-213.6408644	-206.8112760	-202.3698407	-203.0078218	-196.1613512
##	111	112	113	114	115
##	-179.4592217	-178.5991088	-173.3033357	-163.2515522	-154.1003231
##	116	117	118	119	120
##	-140.1644179	-143.1783223	-137.0205204	-122.4440962	-121.6475035
##	121	122	123	124	125
##	-111.0566369	-98.9529379	-110.8782334	-114.7692388	-109.5822532
##	126	127	128	129	130
##	-109.2433751	-101.6229464	-99.0266878	-99.2501544	-94.6238620
##	131	132	133	134	135
##	-89.9955866	-82.5384478	-80.2713476	-77.9332947	-75.4394774
##	136	137	138	139	140
##	-71.0305958	-69.1555147	-69.4801735	-64.8048224	-59.6673924
##	141	142	143	144	145

##	-58.9743708	-56.8598867	-56.3147088	-54.2732463	-55.5222158
##	146	147	148	149	150
##	-59.7279380	-57.5446172	-55.0148450	-55.1702809	-55.3809143
##	151	152	153	154	155
##	-62.9693649	-71.3184499	-63.6522869	-62.4331674	-58.9588360
##	156	157	158	159	160
##	-60.3128928	-59.4889103	-59.7447271	-54.0451280	-53.8826532
##	161	162	163	164	165
##	-52.5020917	-51.0625803	-51.6121249	-49.4324983	-51.8559466
##	166	167	168	169	170
##	-50.6462175	-50.5716669	-50.6476875	-51.2023371	-49.3312135
##	171	172	173	174	175
##	-49.0042461	-47.3318279	-46.2719571	-45.5789386	-44.6190382
##	176	177	178	179	180
##	-43.9458748	-42.8853458	-42.5196698	-42.3896274	-41.6366171
##	181	182	183	184	185
##	-41.2327428	-41.5821980	-78.3150300	-76.7563439	-85.0277685
##	186	187	188	189	190
##	-88.6174676	-105.2818807	-111.2753244	-142.2628783	-130.7763974
##	191	192	193	194	195
##	-125.5819269	-120.4360189	-122.1108203	-101.4241502	-89.1925038
##	196	197	198	199	200
##	-99.2606095	-104.0059266	-95.0220589	-98.4493416	-113.9428375
##	201	202	203	204	205
##	-111.4085894	-121.0669887	-116.5905705	-112.1909037	-119.4800156
##	206	207	208	209	210
##	-118.9850379	-115.3058730	-134.7381527	-146.2441485	-155.9609443
##	211	212	213	214	215
##	-168.3180956	-174.1737003	-176.4985032	-147.5871799	-146.7314638
##	216	217	218	219	220
##	-171.7634772	-162.1154812	-157.9808475	-186.7431304	-198.5652460
##	221	222	223	224	225
##	-170.5616758	-178.5062813	-177.7653654	-158.2813257	-144.8276717
##	226	227	228	229	230
##	-144.0956491	-137.7421756	-150.1734106	-140.2311447	-149.0117160
##	231	232	233	234	235
##	-140.0332579	-130.9589802	-129.4150694	-120.8372924	-129.2039633
##	236	237	238	239	240
##	-127.0783058	-125.6444942	-116.8102567	-116.0063607	-111.4189340
##	241	242	243	244	245
##	-106.3855652	-100.1953215	-92.5818021	-90.6484985	-83.4111288
##	246	247	248	249	250
##	-79.4902545	-73.0913807	-69.5692403	-65.5573254	-57.6783644
##	251	252	253	254	255
##	-60.2471590	-59.0617789	-56.6309576	-56.1775067	-57.1416567
##	256	257	258	259	260
##	-54.3333695	-50.0540279	-47.2944843	-43.4213542	-40.4771139
##	261	262	263	264	265
##	-40.2401638	-37.6055105	-34.2054640	-32.4536410	-33.3431085
##	266	267	268	269	270
##	-31.0994381	-29.6515522	-32.4902056	-29.9680847	-30.5929177
##	271	272	273	274	275
##	-26.8455261	-26.5430036	-24.5235373	-21.6605881	-18.9988542
##	276	277	278	279	280

##	-16.6018691	-14.0915565	-11.7865628	-9.9657358	-7.6258382
##	281	282	283	284	285
##	-5.5122643	-3.0743726	-0.7398082	1.6449427	4.3236836
##	286	287	288	289	290
##	7.5767683	12.0407152	14.3627179	19.1742725	23.6304181
##	291	292	293	294	295
##	26.6173498	29.6098509	31.3608748	33.0668700	33.8407535
##	296	297	298	299	300
##	38.9279544	45.3381736	53.4769873	59.7427872	61.9881956
##	301	302	303	304	305
##	64.9570535	68.7022972	74.8674116	79.4759703	85.4220383
##	306	307	308	309	310
##	89.7608627	93.6435771	100.7156992	112.9673170	118.4424714
##	311	312	313	314	315
##	140.2957668	151.0701654	152.6411887	155.1641038	170.9196594
##	316	317	318	319	320
##	153.8469573	136.9368299	143.9156918	142.4478483	147.4644649
##	321	322	323	324	325
##	149.2397049	156.7127074	158.7994236	156.4124842	148.9869936
##	326	327	328	329	330
##	157.2364989	159.2476793	157.7737547	157.2706776	152.5782116
##	331	332	333	334	335
##	158.2851216	156.5667299	154.3560963	149.2541036	151.0598550
##	336	337	338	339	340
##	142.7412493	155.1721414	151.0159461	144.5048866	136.9398054
##	341	342	343	344	345
##	148.8226077	143.8387760	150.0379443	146.1139972	141.1191401
##	346	347	348	349	350
##	149.5885130	162.6483364	158.4619561	175.6043813	176.2268378
##	351	352	353	354	355
##	198.7392986	196.3670683	184.1166209	189.9026207	173.9870308
##	356	357	358	359	360
##	184.6647253	181.5025869	186.7110885	182.5477651	180.3729920
##	361	362	363	364	365
##	180.1788479	158.1981968	176.0363718	184.2208885	195.6112120
##	366	367	368	369	370
##	198.3284155	202.8255258	217.2458119	229.1146101	229.7632931
##	371	372	373	374	375
##	231.0716573	234.3797240	229.5143554	227.6734476	226.0601743
##	376	377	378	379	380
##	230.9951232	227.7302303	227.1596924	229.0722711	237.7021898
##	381	382	383	384	385
##	245.4560138	243.8129397	263.4223799	265.8414399	275.7915146
##	386	387	388	389	390
##	276.5537372	275.0195485	271.6490687	274.8918452	283.1490810
##	391	392	393	394	395
##	296.2940153	306.4512229	311.5903332	304.7325586	304.7774680
##	396	397	398	399	400
##	307.9430678	309.1796201	307.6572819	304.5353618	314.6766879
##	401	402	403	404	405
##	330.7114283	318.2386593	326.7062322	328.9931606	329.9865571
##	406	407	408	409	410
##	330.6070897	347.6878624	352.5032213	345.0399894	366.2641526
##	411	412	413	414	415

##	400.9960668	382.9557409	368.7635169	370.3843554	357.4137161
##	416	417	418	419	420
##	363.1277839	355.0133007	362.4241032	366.6013223	360.6587419
##	421	422	423	424	425
##	364.5059802	362.8111752	363.4667511	370.5119882	365.9313317
##	426	427	428	429	430
##	359.3175592	354.2449811	349.4732257	337.0761054	332.4321254
##	431	432	433	434	435
##	324.4513157	325.2814455	328.8888782	329.2552288	328.4379950
##	436	437	438	439	440
##	329.1710227	328.0316950	329.4349159	344.9229485	329.0345415
##	441	442	443	444	445
##	330.8585894	332.7476523	329.4152621	328.3054780	326.0067953
##	446	447	448	449	450
##	310.3720147	313.0935962	311.2611628	298.7659645	280.0636670
##	451	452	453	454	455
##	298.2054669	291.8929536	284.3584539	282.2827369	281.3107884
##	456	457	458	459	460
##	286.7163302	282.1453377	276.8132026	273.4596597	272.1842472
##	461	462	463	464	465
##	266.2666017	261.1943822	254.0247356	242.4740715	246.4375390
##	466	467	468	469	470
##	241.8163353	246.5687313	241.4651535	238.3942450	224.0021497
##	471	472	473	474	475
##	226.1140118	221.2999805	218.9367833	222.0514194	216.9323955
##	476	477	478	479	480
##	200.6548073	201.9011648	198.0821884	188.6593354	180.0573330
##	481	482	483	484	485
##	165.5905032	171.0289776	165.4921971	149.5320321	150.2136370
##	486	487	488	489	490
##	138.6647453	124.9313760	141.5522041	148.1596274	143.0492162
##	491	492	493	494	495
##	144.2076851	135.6564961	133.6793675	135.4923450	130.6363770
##	496	497	498	499	500
##	125.6531390	116.5483732	114.6351266	112.5634087	110.2046831
##	501	502	503	504	505
##	104.9504986	103.3509282	105.0287447	99.0891008	92.2866404
##	506	507	508	509	510
##	92.2700196	89.9935717	90.1672049	87.9118224	90.9864749
##	511	512	513	514	515
##	99.0262615	96.5283832	93.3733089	94.7449484	96.2354124
##	516	517	518	519	520
##	110.7246631	126.9036156	114.6199956	113.7767974	108.7420079
##	521	522	523	524	525
##	112.5867642	112.3986321	114.2594213	104.6252495	105.5934669
##	526	527	528	529	530
##	104.1583098	102.5583360	104.9525590	101.7770080	108.1072503
##	531	532	533	534	535
##	106.9168832	108.1120330	109.6526046	112.2709429	109.5579654
##	536	537	538	539	540
##	110.2370056	107.8564520	106.8164585	106.5960115	105.7263133
##	541	542	543	544	545
##	105.5109554	104.3364560	104.8326828	105.9201967	105.4485212
##	546	547	548	549	550

##	105.8491805	108.2101806	206.6128177	205.3122378	230.6150388
##	551	552	553	554	555
##	243.7312882	293.6638450	314.8048446	408.2457263	380.7060965
##	556	557	558	559	560
##	370.9044089	360.9198342	371.3421859	313.0219420	279.3982895
##	561	562	563	564	565
##	315.6343858	335.7598556	311.4663404	327.6948442	385.1851199
##	566	567	568	569	570
##	382.5462143	422.3109934	413.2108946	404.0449014	437.3152358
##	571	572	573	574	575
##	442.6745555	436.1178871	518.1704856	571.9546188	620.4023096
##	576	577	578	579	580
##	681.1433426	717.1638823	739.5802865	629.4833224	637.1409950
##	581	582	583	584	585
##	759.4653038	730.0579721	724.7478123	872.9184564	945.9736097
##	586	587	588	589	590
##	828.3378871	883.9688203	897.8396036	815.5754346	761.5310724
##	591	592	593	594	595
##	773.4133112	754.8836275	840.6026771	801.9813133	870.9734614
##	596	597	598	599	600
##	836.8135981	800.3870780	809.2400581	773.3718960	846.7053572
##	601	602	603	604	605
##	853.0581731	864.3529472	823.8861697	839.2934473	827.2822759
##	606	607	608	609	610
##	811.0868617	784.8025224	745.4475922	750.7471590	711.0097007
##	611	612	613	614	615
##	697.8717065	661.3721016	649.2922694	631.5847971	574.0842980
##	616	617	618	619	620
##	620.0674268	629.1590147	625.0263336	643.0815734	679.2304324
##	621	622	623	624	625
##	671.4744887	643.9894827	634.3815125	608.1597298	592.9649722
##	626	627	628	629	630
##	617.7031417	606.0951138	580.1048715	580.5575027	630.8406771
##	631	632	633	634	635
##	624.1511030	633.3651823	741.4094671	733.6915297	807.5003364
##	636	637	638	639	640
##	768.2647597	829.0330254	842.5282259	826.3079040	814.1245643
##	641	642	643	644	645
##	810.8172249	799.2777783	796.3319224	831.3465757	829.8501696
##	646	647	648	649	650
##	860.3772704	844.7273629	833.7296231	889.2846637	945.7097986
##	651	652	653	654	655
##	1040.8733955	1207.4641939	1135.3930551	1252.1041411	1315.5086683
##	656	657	658	659	660
##	1292.2270333	1275.2404324	1214.3125102	1163.5417240	1091.6898818
##	661	662	663	664	665
##	1159.8059320	1255.3369404	1383.4416594	1450.7579546	1418.7369186
##	666	667	668	669	670
##	1406.2549212	1411.3770933	1463.6681106	1482.4630436	1523.8083275
##	671	672	673	674	675
##	1534.5540149	1537.2709117	1590.4476908	1718.8412884	1739.0319700
##	676	677	678	679	680
##	1990.5344313	2073.9266072	2030.0260540	2001.3679728	2140.3879553
##	681	682	683	684	685

##	1872.3389141	1621.1196780	1658.7563247	1599.8106186	1615.0164096
##	686	687	688	689	690
##	1595.0382645	1635.6541441	1619.6623565	1559.9425285	1453.8080905
##	691	692	693	694	695
##	1502.0386650	1490.0669798	1446.7633296	1414.0201337	1345.7088109
##	696	697	698	699	700
##	1370.0809607	1330.5822770	1288.4956335	1224.2661855	1218.0235283
##	701	702	703	704	705
##	1131.8094258	1210.3439895	1159.1440443	1091.8412578	1018.8416977
##	706	707	708	709	710
##	1090.6332433	1038.5962701	1067.7180481	1025.0653597	976.2600020
##	711	712	713	714	715
##	1020.7266568	1094.9660865	1052.7388385	1151.5347636	1140.9278538
##	716	717	718	719	720
##	1270.6024366	1240.0148797	1148.6119400	1170.6324191	1059.9866301
##	721	722	723	724	725
##	1112.0994906	1080.6838662	1099.3092131	1063.0062663	1038.9962147
##	726	727	728	729	730
##	1026.8359421	892.1201614	982.4642673	1017.6817273	1069.7693274
##	731	732	733	734	735
##	1073.9091999	1087.5590032	1153.6899278	1205.1923593	1197.3115184
##	736	737	738	739	740
##	1193.0312035	1199.1075916	1163.6813704	1144.1280448	1126.0950687
##	741	742	743	744	745
##	1140.7544068	1115.0564886	1102.9141910	1102.9698512	1135.1424611
##	746	747	748	749	750
##	1162.6831056	1145.6670644	1228.0355049	1229.6434891	1265.8334293
##	751	752	753	754	755
##	1259.6628938	1243.2450098	1218.8721790	1224.3518819	1251.9613917
##	756	757	758	759	760
##	1300.6674010	1335.6966806	1348.5542221	1309.7108439	1300.9035132
##	761	762	763	764	765
##	1305.4830548	1301.9147546	1286.8901743	1265.4522136	1299.0830120
##	766	767	768	769	770
##	1356.4877613	1297.0103914	1323.1246539	1324.0717221	1319.8669962
##	771	772	773	774	775
##	1314.2647669	1373.8016926	1384.4841773	1347.1341852	1421.6020867
##	776	777	778	779	780
##	1547.3595175	1469.2376062	1406.7216829	1404.9268159	1348.1455501
##	781	782	783	784	785
##	1362.1120494	1324.3680242	1344.6659260	1352.8412106	1323.8128479
##	786	787	788	789	790
##	1330.8638877	1317.7398728	1313.2718669	1331.8450243	1308.6778387
##	791	792	793	794	795
##	1278.5368861	1254.1799283	1231.1493167	1181.6382590	1159.6798728
##	796	797	798	799	800
##	1126.3717723	1123.8461371	1130.9153593	1126.8463208	1118.8039591
##	801	802	803	804	805
##	1116.1126800	1107.1465406	1106.8239701	1153.6317319	1095.5673678
##	806	807	808	809	810
##	1096.7524149	1098.1600837	1082.4167502	1074.0994815	1061.9984212
##	811	812	813	814	815
##	1006.7593319	1011.2954078	1001.1616030	956.9742165	893.3672617
##	816	817	818	819	820

```

## 947.3426865 923.5220659 896.0571493 885.9584405 879.4036811
##      821      822      823      824      825
## 892.7716880 875.1046873 855.2360232 841.6223318 834.4961766
##      826      827      828      829      830
## 813.2571239 794.7620317 770.0581482 732.3168709 741.5469708
##      831      832      833      834      835
## 724.9819764 736.5477617 718.7041433 707.0262144 661.9835035
##      836      837      838      839      840
## 665.8688880 649.4112369 640.2434074 647.1106605 630.0261422
##      841      842      843      844      845
## 580.7688362 582.4014384 569.4677125 540.5702229 514.2149891
##      846      847      848      849      850
## 471.3454243 485.2362775 468.0049146 421.5081603 422.0747776
##      851      852      853      854      855
## 388.3861275 348.8156899 393.9826416 411.0884937 395.6806857
##      856      857      858      859      860
## 397.6587454 372.9359387 366.3854227 370.2348444 355.8966161
##      861      862      863      864      865
## 341.3018646 315.6351943 309.5416008 303.0601121 295.8488437
##      866      867      868      869      870
## 280.9315930 275.8573712 279.5376630 262.9830241 244.2406733
##      871      872      873      874      875
## 243.5144100 236.8470300 236.6491185 230.0968911 237.4951656
##      876      877      878      879      880
## 257.7804611 250.6013837 241.7614629 244.6601777 247.8517391
##      881      882      883      884      885
## 284.4186912 325.1256812 292.8922781 289.9867621 276.4428519
##      886      887      888      889      890
## 285.4864212 284.2861746 288.2635697 263.2956269 265.0695871
##      891      892      893      894      895
## 260.8187113 256.1792523 261.5172428 252.9865143 268.0704473
##      896      897      898      899      900
## 264.4799840 266.7957330 269.9528968 275.7442229 268.4471442
##      901      902      903      904      905
## 269.4782573 263.0447319 259.9048740 258.7709616 256.0716647
##      906      907      908      909      910
## 254.9677857 251.5582579 252.1850354 254.2300208 252.5336595
##      911      912      913      914      915
## 252.9311038 258.0025592 491.5406655 487.3808195 546.2578461
##      916      917      918      919      920
## 576.0800440 692.6095706 740.8850135 958.7543308 892.1885904
##      921      922      923      924      925
## 867.3907447 842.2756873 864.7951920 727.4680341 647.9890828
##      926      927      928      929
## 730.5293810 775.5256379 717.9547397 753.8390299

```

```
(adjusted_prediction = deseasonalized_prediction * eth_ts_decom$figure) # this is the prediction for pe
```

```

##      1      2      3      4      5      6      7
## 1551.2806 1569.9205 1664.2444 1737.3553 1724.8241 1717.4968 1725.0825
##      8      9     10     11     12     13     14
## 1672.9943 1643.7841 1616.7990 1636.7602 1598.8316 1580.3803 1579.4236
##     15     16     17     18     19     20     21
## 1624.4318 1662.7603 1637.3629 1753.9479 1755.1136 1805.6097 1795.6594
##     22     23     24     25     26     27     28

```

##	1771.1268	1735.3034	1742.0027	1780.1632	1848.2573	1896.8469	1913.9126
##	29	30	31	32	33	34	35
##	1857.6305	1843.9969	1849.3473	1843.1594	1820.7733	1789.3493	1835.7867
##	36	37	38	39	40	41	42
##	1915.7466	1830.6421	1866.3774	1866.5940	1859.5552	1850.5603	1933.2446
##	43	44	45	46	47	48	49
##	1947.1258	1893.4814	1996.9781	2172.3632	2061.4844	1972.6222	1968.9650
##	50	51	52	53	54	55	56
##	1888.2980	1906.7637	1852.8655	1880.1895	1890.5446	1848.9297	1857.7275
##	57	58	59	60	61	62	63
##	1838.3722	1831.1108	1855.9691	1822.6684	1779.7003	1744.8294	1711.8440
##	64	65	66	67	68	69	70
##	1642.0982	1610.6999	1563.5832	1559.2280	1568.1846	1561.6974	1549.7158
##	71	72	73	74	75	76	77
##	1545.1576	1531.9242	1530.6607	1594.5442	1513.4853	1514.3219	1515.4671
##	78	79	80	81	82	83	84
##	1492.9573	1480.7105	1463.2651	1386.4335	1391.9589	1377.2991	1315.8330
##	85	86	87	88	89	90	91
##	1227.7437	1301.2559	1267.8897	1229.5586	1215.0857	1205.4872	1223.1964
##	92	93	94	95	96	97	98
##	1198.3894	1170.5953	1151.3877	1141.0717	1111.4794	1085.6660	1051.4024
##	99	100	101	102	103	104	105
##	999.3818	1011.4833	988.4065	1003.6870	978.8975	962.5269	900.7733
##	106	107	108	109	110	111	112
##	905.6257	882.8198	869.9421	878.8553	855.2471	788.0091	789.8523
##	113	114	115	116	117	118	119
##	771.9491	732.4340	696.3996	638.0447	656.5438	632.9365	569.7910
##	120	121	122	123	124	125	126
##	570.2950	524.5356	470.8786	531.6091	554.4388	533.4167	535.8417
##	127	128	129	130	131	132	133
##	502.3020	493.2580	498.2177	478.7097	458.8747	424.1784	415.8057
##	134	135	136	137	138	139	140
##	406.9200	397.0631	376.8774	369.9088	374.6809	352.3389	327.0868
##	141	142	143	144	145	146	147
##	325.9737	316.9123	316.5119	307.6170	317.3725	344.3341	334.6028
##	148	149	150	151	152	153	154
##	322.6635	326.3948	330.5138	379.1176	433.1974	390.0873	386.0574
##	155	156	157	158	159	160	161
##	367.8743	379.7523	378.0002	383.1316	349.8036	352.0168	346.2308
##	162	163	164	165	166	167	168
##	339.9342	346.8772	335.4268	355.2833	350.3842	353.3110	357.3495
##	169	170	171	172	173	174	175
##	364.8708	355.0744	356.2975	347.6542	343.3695	341.7376	338.0408
##	176	177	178	179	180	181	182
##	336.4525	331.8244	332.5223	335.0893	332.7253	333.1210	339.6702
##	183	184	185	186	187	188	189
##	646.8849	641.1662	718.3480	757.2784	910.1170	973.1863	1258.8946
##	190	191	192	193	194	195	196
##	1171.0516	1138.0778	1104.7135	1133.8285	953.4263	848.9468	956.7324
##	197	198	199	200	201	202	203
##	1015.2884	939.5744	986.1752	1156.4404	1145.8079	1261.9416	1231.8630
##	204	205	206	207	208	209	210
##	1201.7353	1297.6783	1310.5540	1288.1809	1527.0485	1681.7193	1820.0431
##	211	212	213	214	215	216	217


```
## 1993.7358 2094.4636 2155.1103 1830.2169 1848.3850 2198.4051 2108.6493
##      218      219      220      221      222      223      224
## 2088.7450 2510.3133 2714.5213 2371.8430 2525.7112 2559.8703 2320.3842
##      225      226      227      228      229      230      231
## 2162.0416 2191.1532 2134.1739 2371.5553 2257.8932 2447.0601 2346.2427
##      232      233      234      235      236      237      238
## 2239.5081 2259.6551 2155.1088 2354.6858 2367.5704 2394.1024 2277.4554
##      239      240      241      242      243      244      245
## 2315.4279 2277.7685 2228.7703 2152.3060 2040.3752 2050.8763 1938.5531
##      246      247      248      249      250      251      252
## 1899.0557 1796.2691 1760.0810 1708.8126 1550.2874 1671.2933 1692.6016
##      253      254      255      256      257      258      259
## 1678.3269 1723.5805 1817.0766 1792.9968 1716.4293 1687.7110 1614.9864
##      260      261      262      263      264      265      266
## 1571.7632 1634.3607 1600.7448 1529.3406 1527.7857 1657.1411 1636.6478
##      267      268      269      270      271      272      273
## 1657.8623 1937.2435 1913.7026 2102.5266 1996.8735 2151.0738 2182.3014
##      274      275      276      277      278      279      280
## 2136.5935 2101.4714 2089.3497 2056.1005 2045.0410 2131.3470 2123.9227
##      281      282      283      284      285      286      287
## 2198.3545 2154.7553 2123.1564 2260.8704 2400.3448 2637.5290 3054.6391
##      288      289      290      291      292      293      294
## 2867.6153 3157.2341 3311.7260 3247.8541 3199.9956 3042.2159 2910.3577
##      295      296      297      298      299      300      301
## 2726.2842 2891.7927 3125.0337 3438.5104 3600.1622 3515.1925 3478.8357
##      302      303      304      305      306      307      308
## 3486.0855 3609.6506 3650.3664 3746.4107 3767.0563 3767.9718 3892.3897
##      309      310      311      312      313      314      315
## 4200.2465 4243.1757 4849.5334 5045.1349 4930.9714 4854.1323 5183.6212
##      316      317      318      319      320      321      322
## 4527.7621 3914.4871 3999.4964 3851.7356 3882.6857 3829.0941 3920.9226
##      323      324      325      326      327      328      329
## 3876.9958 3728.6848 3470.0248 3580.0343 3546.4563 3438.5171 3355.9563
##      330      331      332      333      334      335      336
## 3189.3408 3242.5545 3144.6775 3040.9743 2885.3807 2866.7016 2660.1230
##      337      338      339      340      341      342      343
## 2840.8013 2716.9091 2555.6706 2381.5613 2545.9242 2421.1805 2485.7224
##      344      345      346      347      348      349      350
## 2383.2258 2266.7242 2366.8141 2535.5886 2434.5804 2659.5477 2631.5891
##      351      352      353      354      355      356      357
## 2926.8512 2852.6652 2638.9554 2686.0615 2429.0381 2545.1768 2470.1037
##      358      359      360      361      362      363      364
## 2509.4608 2423.4956 2365.7455 2335.0951 2026.1804 2228.5611 2305.5500
##      365
## 2420.5232
```

```
(newdata = data.frame(Days = c(1:1294), closingPrice = c(eth$Close, rep(NA,365)), Forecast = c(eth$adj
```

```
##      Days closingPrice      Forecast
## 1      1      2.770000 -677.2523689
## 2      2      0.753325 -681.9079516
## 3      3      0.701897 -719.1983039
## 4      4      0.708448 -746.9631390
## 5      5      1.070000 -737.7849322
## 6      6      1.220000 -730.8878889
```

## 7	7	1.830000	-730.3481436
## 8	8	1.830000	-704.6526596
## 9	9	1.690000	-688.7811497
## 10	10	1.570000	-673.9747201
## 11	11	1.200000	-678.7641604
## 12	12	1.090000	-659.5960280
## 13	13	1.260000	-648.5948062
## 14	14	1.460000	-644.8253091
## 15	15	1.400000	-659.7380816
## 16	16	1.380000	-671.7710780
## 17	17	1.350000	-658.0411850
## 18	18	1.230000	-701.1907451
## 19	19	1.140000	-697.9606092
## 20	20	1.160000	-714.2504001
## 21	21	1.150000	-706.5554194
## 22	22	1.190000	-693.2059128
## 23	23	1.180000	-675.5740417
## 24	24	1.320000	-674.5681915
## 25	25	1.360000	-685.6632297
## 26	26	1.350000	-708.0793703
## 27	27	1.290000	-722.7942348
## 28	28	1.260000	-725.3735558
## 29	29	1.270000	-700.2457268
## 30	30	1.340000	-691.3485773
## 31	31	1.300000	-689.5969193
## 32	32	1.250000	-683.5555143
## 33	33	1.240000	-671.5756104
## 34	34	1.210000	-656.3814900
## 35	35	1.170000	-669.7296361
## 36	36	0.982978	-695.0649046
## 37	37	1.040000	-660.5330729
## 38	38	0.936003	-669.7121896
## 39	39	0.875622	-666.0854008
## 40	40	0.944410	-659.8938820
## 41	41	0.907175	-653.0505875
## 42	42	0.874231	-678.4259678
## 43	43	0.853685	-679.4777347
## 44	44	0.882391	-657.0542063
## 45	45	0.938445	-689.0737815
## 46	46	0.919047	-745.3673839
## 47	47	0.901796	-703.3261245
## 48	48	0.893406	-669.1946491
## 49	49	0.813610	-664.1581051
## 50	50	0.736223	-633.3181179
## 51	51	0.785964	-635.8564815
## 52	52	0.720839	-614.3414228
## 53	53	0.582886	-619.8177195
## 54	54	0.661146	-619.6385659
## 55	55	0.738644	-602.4953640
## 56	56	0.690215	-601.8519272
## 57	57	0.678574	-592.1175224
## 58	58	0.687171	-586.3383646
## 59	59	0.668379	-590.8210480
## 60	60	0.628643	-576.8151753

## 61	61	0.650645	-559.9017677
## 62	62	0.609388	-545.6899662
## 63	63	0.621716	-532.2028654
## 64	64	0.650628	-507.4860482
## 65	65	0.627857	-494.8156221
## 66	66	0.634963	-477.4691408
## 67	67	0.626030	-473.2832460
## 68	68	0.607655	-473.1376030
## 69	69	0.522968	-468.3358632
## 70	70	0.561878	-461.9279691
## 71	71	0.536495	-457.7706345
## 72	72	0.547178	-451.0831506
## 73	73	0.517734	-447.9541383
## 74	74	0.489014	-463.7858349
## 75	75	0.434829	-437.4982848
## 76	76	0.447329	-435.0352361
## 77	77	0.567702	-432.6647792
## 78	78	0.539657	-423.5862259
## 79	79	0.563590	-417.4885255
## 80	80	0.616039	-409.9848305
## 81	81	0.731317	-386.0153025
## 82	82	0.869641	-385.1082155
## 83	83	1.000000	-378.6392775
## 84	84	1.210000	-359.4422875
## 85	85	1.040000	-333.2399278
## 86	86	0.916627	-350.9317526
## 87	87	1.060000	-339.7361588
## 88	88	0.989789	-327.3402415
## 89	89	1.010000	-321.3929667
## 90	90	0.899050	-316.7821043
## 91	91	0.895637	-319.3390277
## 92	92	0.926032	-310.8140120
## 93	93	0.927974	-301.6096180
## 94	94	1.030000	-294.7030125
## 95	95	0.999278	-290.1276821
## 96	96	0.934348	-280.7239204
## 97	97	0.791829	-272.3732673
## 98	98	0.895711	-262.0086769
## 99	99	0.904096	-247.3687279
## 100	100	0.888812	-248.6718928
## 101	101	0.906368	-241.3493057
## 102	102	0.928962	-243.4102992
## 103	103	1.010000	-235.7738363
## 104	104	0.993319	-230.2377244
## 105	105	0.955532	-213.9792041
## 106	106	0.924920	-213.6408644
## 107	107	0.976140	-206.8112760
## 108	108	0.968018	-202.3698407
## 109	109	0.946969	-203.0078218
## 110	110	0.900191	-196.1613512
## 111	111	0.863537	-179.4592217
## 112	112	0.884183	-178.5991088
## 113	113	0.867951	-173.3033357
## 114	114	0.915703	-163.2515522

## 115	115	0.878614	-154.1003231
## 116	116	0.873119	-140.1644179
## 117	117	0.874800	-143.1783223
## 118	118	0.821210	-137.0205204
## 119	119	0.812143	-122.4440962
## 120	120	0.840041	-121.6475035
## 121	121	0.862438	-111.0566369
## 122	122	0.835500	-98.9529379
## 123	123	0.811264	-110.8782334
## 124	124	0.822118	-114.7692388
## 125	125	0.792167	-109.5822532
## 126	126	0.840396	-109.2433751
## 127	127	0.929762	-101.6229464
## 128	128	0.976973	-99.0266878
## 129	129	0.952884	-99.2501544
## 130	130	0.993022	-94.6238620
## 131	131	1.010000	-89.9955866
## 132	132	0.991182	-82.5384478
## 133	133	0.940701	-80.2713476
## 134	134	0.920127	-77.9332947
## 135	135	0.908072	-75.4394774
## 136	136	0.903885	-71.0305958
## 137	137	0.900771	-69.1555147
## 138	138	0.864202	-69.4801735
## 139	139	0.858077	-64.8048224
## 140	140	0.863262	-59.6673924
## 141	141	0.870363	-58.9743708
## 142	142	0.854603	-56.8598867
## 143	143	0.856365	-56.3147088
## 144	144	0.845005	-54.2732463
## 145	145	0.873054	-55.5222158
## 146	146	0.911958	-59.7279380
## 147	147	0.933542	-57.5446172
## 148	148	0.948024	-55.0148450
## 149	149	0.937124	-55.1702809
## 150	150	0.971905	-55.3809143
## 151	151	0.954480	-62.9693649
## 152	152	0.950176	-71.3184499
## 153	153	0.950860	-63.6522869
## 154	154	0.942005	-62.4331674
## 155	155	0.986789	-58.9588360
## 156	156	0.986833	-60.3128928
## 157	157	0.999231	-59.4889103
## 158	158	1.060000	-59.7447271
## 159	159	1.140000	-54.0451280
## 160	160	1.130000	-53.8826532
## 161	161	1.190000	-52.5020917
## 162	162	1.210000	-51.0625803
## 163	163	1.220000	-51.6121249
## 164	164	1.330000	-49.4324983
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## 177	177	2.450000	-42.8853458
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##	621	621	50.710000	671.4744887
##	622	622	48.310000	643.9894827
##	623	623	49.670000	634.3815125
##	624	624	48.220000	608.1597298
##	625	625	48.550000	592.9649722
##	626	626	48.490000	617.7031417
##	627	627	50.030000	606.0951138
##	628	628	49.890000	580.1048715
##	629	629	52.720000	580.5575027
##	630	630	62.170000	630.8406771
##	631	631	70.160000	624.1511030
##	632	632	68.380000	633.3651823
##	633	633	79.020000	741.4094671
##	634	634	76.300000	733.6915297
##	635	635	77.260000	807.5003364
##	636	636	79.720000	768.2647597
##	637	637	96.980000	829.0330254
##	638	638	94.400000	842.5282259
##	639	639	97.810000	826.3079040
##	640	640	94.010000	814.1245643
##	641	641	91.420000	810.8172249
##	642	642	91.160000	799.2777783
##	643	643	89.520000	796.3319224
##	644	644	89.880000	831.3465757
##	645	645	88.660000	829.8501696
##	646	646	90.840000	860.3772704
##	647	647	90.790000	844.7273629
##	648	648	92.410000	833.7296231
##	649	649	89.440000	889.2846637
##	650	650	89.860000	945.7097986
##	651	651	96.910000	1040.8733955
##	652	652	129.530000	1207.4641939
##	653	653	126.520000	1135.3930551
##	654	654	157.940000	1252.1041411

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##	656	656	181.950000	1292.2270333
##	657	657	190.050000	1275.2404324
##	658	658	174.450000	1214.3125102
##	659	659	160.400000	1163.5417240
##	660	660	157.760000	1091.6898818
##	661	661	170.510000	1159.8059320
##	662	662	194.910000	1255.3369404
##	663	663	231.910000	1383.4416594
##	664	664	230.670000	1450.7579546
##	665	665	222.240000	1418.7369186
##	666	666	223.780000	1406.2549212
##	667	667	224.380000	1411.3770933
##	668	668	245.330000	1463.6681106
##	669	669	248.460000	1482.4630436
##	670	670	264.470000	1523.8083275
##	671	671	258.070000	1534.5540149
##	672	672	261.670000	1537.2709117
##	673	673	281.740000	1590.4476908
##	674	674	337.670000	1718.8412884
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## 716	716	229.480000	1270.6024366
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## 720	720	203.950000	1059.9866301
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## 729	729	223.070000	1017.6817273
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## 732	732	269.180000	1087.5590032
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## 734	734	296.030000	1205.1923593
## 735	735	295.890000	1197.3115184
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## 737	737	310.600000	1199.1075916
## 738	738	298.060000	1163.6813704
## 739	739	300.100000	1144.1280448
## 740	740	289.820000	1126.0950687
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## 747	747	314.790000	1145.6670644
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## 750	750	331.920000	1265.8334293
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## 756	756	383.040000	1300.6674010
## 757	757	387.740000	1335.6966806
## 758	758	348.980000	1348.5542221
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## 762	762	334.340000	1301.9147546

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## 765	765	294.400000	1299.0830120
## 766	766	288.750000	1356.4877613
## 767	767	294.530000	1297.0103914
## 768	768	291.460000	1323.1246539
## 769	769	277.110000	1324.0717221
## 770	770	213.910000	1319.8669962
## 771	771	250.460000	1314.2647669
## 772	772	246.520000	1373.8016926
## 773	773	251.750000	1384.4841773
## 774	774	293.500000	1347.1341852
## 775	775	282.800000	1421.6020867
## 776	776	283.740000	1547.3595175
## 777	777	258.580000	1469.2376062
## 778	778	264.310000	1406.7216829
## 779	779	286.170000	1404.9268159
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## 781	781	292.330000	1362.1120494
## 782	782	287.440000	1324.3680242
## 783	783	306.470000	1344.6659260
## 784	784	299.150000	1352.8412106
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## 788	788	297.480000	1313.2718669
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## 791	791	295.860000	1278.5368861
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## 794	794	308.610000	1181.6382590
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## 797	797	303.460000	1123.8461371
## 798	798	304.140000	1130.9153593
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## 801	801	336.600000	1116.1126800
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## 813	813	297.420000	1001.1616030
## 814	814	296.300000	956.9742165
## 815	815	305.090000	893.3672617
## 816	816	307.750000	947.3426865

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## 818	818	291.690000	896.0571493
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## 821	821	300.470000	892.7716880
## 822	822	296.260000	875.1046873
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## 824	824	294.660000	841.6223318
## 825	825	309.070000	834.4961766
## 826	826	320.880000	813.2571239
## 827	827	299.250000	794.7620317
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## 831	831	337.630000	724.9819764
## 832	832	333.360000	736.5477617
## 833	833	330.920000	718.7041433
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## 857	857	441.720000	372.9359387
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## 875	875	737.020000	237.4951656
## 876	876	753.590000	257.7804611
## 877	877	717.260000	250.6013837
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## 1074 1074	NA 317.3725065
## 1075 1075	NA 344.3341206
## 1076 1076	NA 334.6028278
## 1077 1077	NA 322.6634975
## 1078 1078	NA 326.3947822
## 1079 1079	NA 330.5137911
## 1080 1080	NA 379.1176270
## 1081 1081	NA 433.1974375
## 1082 1082	NA 390.0873034
## 1083 1083	NA 386.0574004
## 1084 1084	NA 367.8742709
## 1085 1085	NA 379.7522616
## 1086 1086	NA 378.0002046

## 1087 1087	NA 383.1315849
## 1088 1088	NA 349.8035862
## 1089 1089	NA 352.0168417
## 1090 1090	NA 346.2308206
## 1091 1091	NA 339.9342176
## 1092 1092	NA 346.8771664
## 1093 1093	NA 335.4267656
## 1094 1094	NA 355.2832588
## 1095 1095	NA 350.3842498
## 1096 1096	NA 353.3109557
## 1097 1097	NA 357.3494944
## 1098 1098	NA 364.8707509
## 1099 1099	NA 355.0743952
## 1100 1100	NA 356.2974603
## 1101 1101	NA 347.6542324
## 1102 1102	NA 343.3695170
## 1103 1103	NA 341.7375782
## 1104 1104	NA 338.0407741
## 1105 1105	NA 336.4524685
## 1106 1106	NA 331.8243909
## 1107 1107	NA 332.5223455
## 1108 1108	NA 335.0893496
## 1109 1109	NA 332.7252828
## 1110 1110	NA 333.1209743
## 1111 1111	NA 339.6701848
## 1112 1112	NA 646.8848894
## 1113 1113	NA 641.1661559
## 1114 1114	NA 718.3480342
## 1115 1115	NA 757.2784067
## 1116 1116	NA 910.1169662
## 1117 1117	NA 973.1862563
## 1118 1118	NA 1258.8946385
## 1119 1119	NA 1171.0516487
## 1120 1120	NA 1138.0778155
## 1121 1121	NA 1104.7135359
## 1122 1122	NA 1133.8284748
## 1123 1123	NA 953.4263145
## 1124 1124	NA 848.9468030
## 1125 1125	NA 956.7324059
## 1126 1126	NA 1015.2883521
## 1127 1127	NA 939.5744424
## 1128 1128	NA 986.1751750
## 1129 1129	NA 1156.4403745
## 1130 1130	NA 1145.8078835
## 1131 1131	NA 1261.9416287
## 1132 1132	NA 1231.8630214
## 1133 1133	NA 1201.7352962
## 1134 1134	NA 1297.6783090
## 1135 1135	NA 1310.5540367
## 1136 1136	NA 1288.1809027
## 1137 1137	NA 1527.0484911
## 1138 1138	NA 1681.7192894
## 1139 1139	NA 1820.0430635
## 1140 1140	NA 1993.7358115

## 1141 1141	NA 2094.4635990
## 1142 1142	NA 2155.1102518
## 1143 1143	NA 1830.2169204
## 1144 1144	NA 1848.3850137
## 1145 1145	NA 2198.4051187
## 1146 1146	NA 2108.6492808
## 1147 1147	NA 2088.7449741
## 1148 1148	NA 2510.3133467
## 1149 1149	NA 2714.5213211
## 1150 1150	NA 2371.8429650
## 1151 1151	NA 2525.7111691
## 1152 1152	NA 2559.8702955
## 1153 1153	NA 2320.3842370
## 1154 1154	NA 2162.0415701
## 1155 1155	NA 2191.1531840
## 1156 1156	NA 2134.1739094
## 1157 1157	NA 2371.5553166
## 1158 1158	NA 2257.8931662
## 1159 1159	NA 2447.0601466
## 1160 1160	NA 2346.2427125
## 1161 1161	NA 2239.5081104
## 1162 1162	NA 2259.6551045
## 1163 1163	NA 2155.1088336
## 1164 1164	NA 2354.6857867
## 1165 1165	NA 2367.5704309
## 1166 1166	NA 2394.1024183
## 1167 1167	NA 2277.4554423
## 1168 1168	NA 2315.4279450
## 1169 1169	NA 2277.7685289
## 1170 1170	NA 2228.7702830
## 1171 1171	NA 2152.3060400
## 1172 1172	NA 2040.3752043
## 1173 1173	NA 2050.8763392
## 1174 1174	NA 1938.5531195
## 1175 1175	NA 1899.0556681
## 1176 1176	NA 1796.2690990
## 1177 1177	NA 1760.0810132
## 1178 1178	NA 1708.8126247
## 1179 1179	NA 1550.2874257
## 1180 1180	NA 1671.2932526
## 1181 1181	NA 1692.6015561
## 1182 1182	NA 1678.3269151
## 1183 1183	NA 1723.5805356
## 1184 1184	NA 1817.0766194
## 1185 1185	NA 1792.9967682
## 1186 1186	NA 1716.4293183
## 1187 1187	NA 1687.7109978
## 1188 1188	NA 1614.9863911
## 1189 1189	NA 1571.7631545
## 1190 1190	NA 1634.3607426
## 1191 1191	NA 1600.7448456
## 1192 1192	NA 1529.3405680
## 1193 1193	NA 1527.7856810
## 1194 1194	NA 1657.1411020

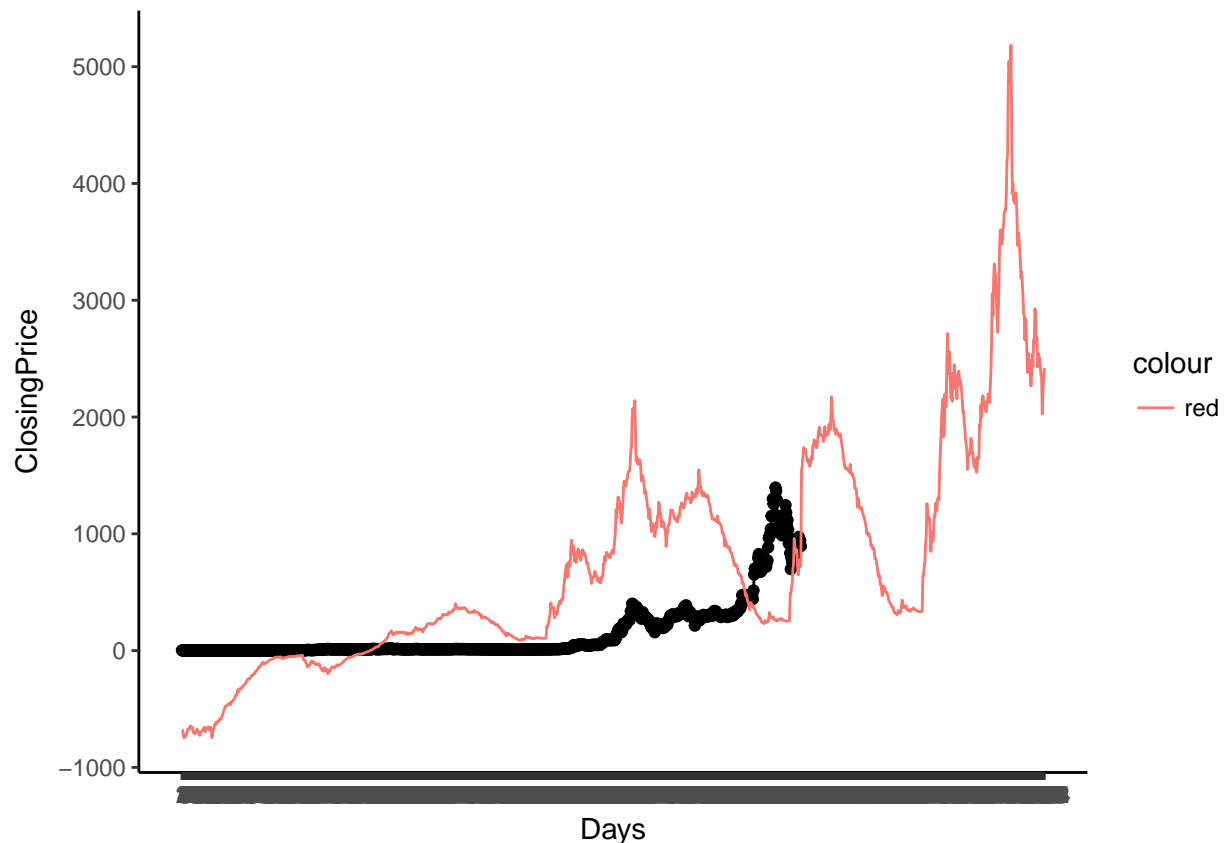
## 1195 1195	NA 1636.6478294
## 1196 1196	NA 1657.8622734
## 1197 1197	NA 1937.2434819
## 1198 1198	NA 1913.7025502
## 1199 1199	NA 2102.5266250
## 1200 1200	NA 1996.8735302
## 1201 1201	NA 2151.0737935
## 1202 1202	NA 2182.3013615
## 1203 1203	NA 2136.5934645
## 1204 1204	NA 2101.4714358
## 1205 1205	NA 2089.3497427
## 1206 1206	NA 2056.1005314
## 1207 1207	NA 2045.0410336
## 1208 1208	NA 2131.3469695
## 1209 1209	NA 2123.9226859
## 1210 1210	NA 2198.3545239
## 1211 1211	NA 2154.7552502
## 1212 1212	NA 2123.1563609
## 1213 1213	NA 2260.8704243
## 1214 1214	NA 2400.3447817
## 1215 1215	NA 2637.5290058
## 1216 1216	NA 3054.6391036
## 1217 1217	NA 2867.6152748
## 1218 1218	NA 3157.2341299
## 1219 1219	NA 3311.7260194
## 1220 1220	NA 3247.8540510
## 1221 1221	NA 3199.9956322
## 1222 1222	NA 3042.2158592
## 1223 1223	NA 2910.3576627
## 1224 1224	NA 2726.2841513
## 1225 1225	NA 2891.7927247
## 1226 1226	NA 3125.0336651
## 1227 1227	NA 3438.5103583
## 1228 1228	NA 3600.1622133
## 1229 1229	NA 3515.1924797
## 1230 1230	NA 3478.8357358
## 1231 1231	NA 3486.0855453
## 1232 1232	NA 3609.6505607
## 1233 1233	NA 3650.3663570
## 1234 1234	NA 3746.4107032
## 1235 1235	NA 3767.0563103
## 1236 1236	NA 3767.9717793
## 1237 1237	NA 3892.3897272
## 1238 1238	NA 4200.2465483
## 1239 1239	NA 4243.1757432
## 1240 1240	NA 4849.5333538
## 1241 1241	NA 5045.1349172
## 1242 1242	NA 4930.9714349
## 1243 1243	NA 4854.1323074
## 1244 1244	NA 5183.6211577
## 1245 1245	NA 4527.7621021
## 1246 1246	NA 3914.4871475
## 1247 1247	NA 3999.4963712
## 1248 1248	NA 3851.7355567


```
## 1249 1249      NA 3882.6857158
## 1250 1250      NA 3829.0941210
## 1251 1251      NA 3920.9225558
## 1252 1252      NA 3876.9957653
## 1253 1253      NA 3728.6848437
## 1254 1254      NA 3470.0247990
## 1255 1255      NA 3580.0343408
## 1256 1256      NA 3546.4562550
## 1257 1257      NA 3438.5170836
## 1258 1258      NA 3355.9562795
## 1259 1259      NA 3189.3407507
## 1260 1260      NA 3242.5545313
## 1261 1261      NA 3144.6775332
## 1262 1262      NA 3040.9742609
## 1263 1263      NA 2885.3807450
## 1264 1264      NA 2866.7016426
## 1265 1265      NA 2660.1229918
## 1266 1266      NA 2840.8013109
## 1267 1267      NA 2716.9091057
## 1268 1268      NA 2555.6706095
## 1269 1269      NA 2381.5613341
## 1270 1270      NA 2545.9241981
## 1271 1271      NA 2421.1804527
## 1272 1272      NA 2485.7223729
## 1273 1273      NA 2383.2258212
## 1274 1274      NA 2266.7242379
## 1275 1275      NA 2366.8140900
## 1276 1276      NA 2535.5885825
## 1277 1277      NA 2434.5803773
## 1278 1278      NA 2659.5477379
## 1279 1279      NA 2631.5891497
## 1280 1280      NA 2926.8512306
## 1281 1281      NA 2852.6651965
## 1282 1282      NA 2638.9553920
## 1283 1283      NA 2686.0614774
## 1284 1284      NA 2429.0380657
## 1285 1285      NA 2545.1767716
## 1286 1286      NA 2470.1037058
## 1287 1287      NA 2509.4608358
## 1288 1288      NA 2423.4955669
## 1289 1289      NA 2365.7455232
## 1290 1290      NA 2335.0951233
## 1291 1291      NA 2026.1804027
## 1292 1292      NA 2228.5610702
## 1293 1293      NA 2305.5499824
## 1294 1294      NA 2420.5232371
```

```
ggplot(newdata, aes(Days, closingPrice)) + geom_point() + geom_line() + xlab("Days") + ylab("ClosingPrice") +
  geom_line(aes(Days, Forecast, color = 'red'), data = newdata) + theme_classic()
```

```
## Warning: Removed 365 rows containing missing values (geom_point).
```

```
## Warning: Removed 365 rows containing missing values (geom_path).
```



Forecast accuracy Measures of forecast accuracy are used to determine how well a forecasting method is able to reproduce the time-series data that are already available. Measures of forecast accuracy are important factors in comparing different forecasting methods. By selecting the method that has the best accuracy for the data already known, there is an increased likelihood that the model will produce better forecasts for future time periods. Forecast error is the difference between the actual value and forecast value. A positive forecast error indicates the forecasting method underestimated the actual value. A negative forecast error indicates the forecasting method overestimated the actual method. Two measures will be used to determine the effectiveness of the forecast models listed above: the mean squared error (MSE) and the mean absolute percentage error (MAPE).

```
#####Carlson Data #####
newdata$fc_error = newdata$closingPrice - newdata$Forecast
```

```
####Mean Sq Error####
(MSE =(sum((newdata$fc_error[1:929])^2 ))/929)
```

```
## [1] 317099.4
```

```
abs_value= (abs(newdata$fc_error[1:929]))
abs_per = ((abs(newdata$fc_error[1:929]))/ newdata$closingPrice[1:929])
##### Mean Abs Percentage error #####
(MAPE = sum(abs_per*100) /929)
```

```
## [1] 8573.836
```

Time series Nonlinear trend regression: Sometimes time series have a curvilinear or nonlinear trend. A variety of nonlinear functions can be used to develop an estimate of the trend in a time series. Polynomial regression of order 3 is used to model the data, it was giving the best results without increasing the complexity. As the time series does not seem to forecast the data accurately next we will try the Nonlinear trend regression.

Modeling a polynomial with a degree of 3 . Below fig 19 shows the fit of the polynomial regression. It appears the non-linear model has increased the model accuracy and the adjusted r square has improved a lot. Regression summary shown in figure 20 below.

```
eth = read.csv("ethereum_price.csv")
summary(eth)
```

```
##           Date           Open           High
## 1/1/2016 : 1   Min.      : 0.4316   Min.      : 0.483
## 1/1/2017 : 1   1st Qu.:  7.8900   1st Qu.:  8.270
## 1/1/2018 : 1   Median : 12.0500   Median : 12.430
## 1/10/2016: 1   Mean    : 146.8975   Mean    : 154.363
## 1/10/2017: 1   3rd Qu.: 245.2600   3rd Qu.: 257.000
## 1/10/2018: 1   Max.     :1397.4800   Max.     :1432.880
## (Other)    :923
##           Low           Close           Volume
## Min.      : 0.4209   Min.      : 0.4348   1,005,550,000: 1
## 1st Qu.:  7.5700   1st Qu.:  7.9100   1,005,910    : 1
## Median : 11.7200   Median : 12.0200   1,006,130,000: 1
## Mean    : 139.1148   Mean    : 147.7843   1,011,800,000: 1
## 3rd Qu.: 223.9800   3rd Qu.: 245.9900   1,011,920    : 1
## Max.     :1290.6000   Max.     :1396.4200   1,020,390,000: 1
##                                     (Other)      :923
##           Market.Cap
## 1,014,280,000: 2
## 1,112,590,000: 2
## 684,258,000  : 2
## -            : 1
## 1,000,220,000: 1
## 1,002,130,000: 1
## (Other)      :920
```

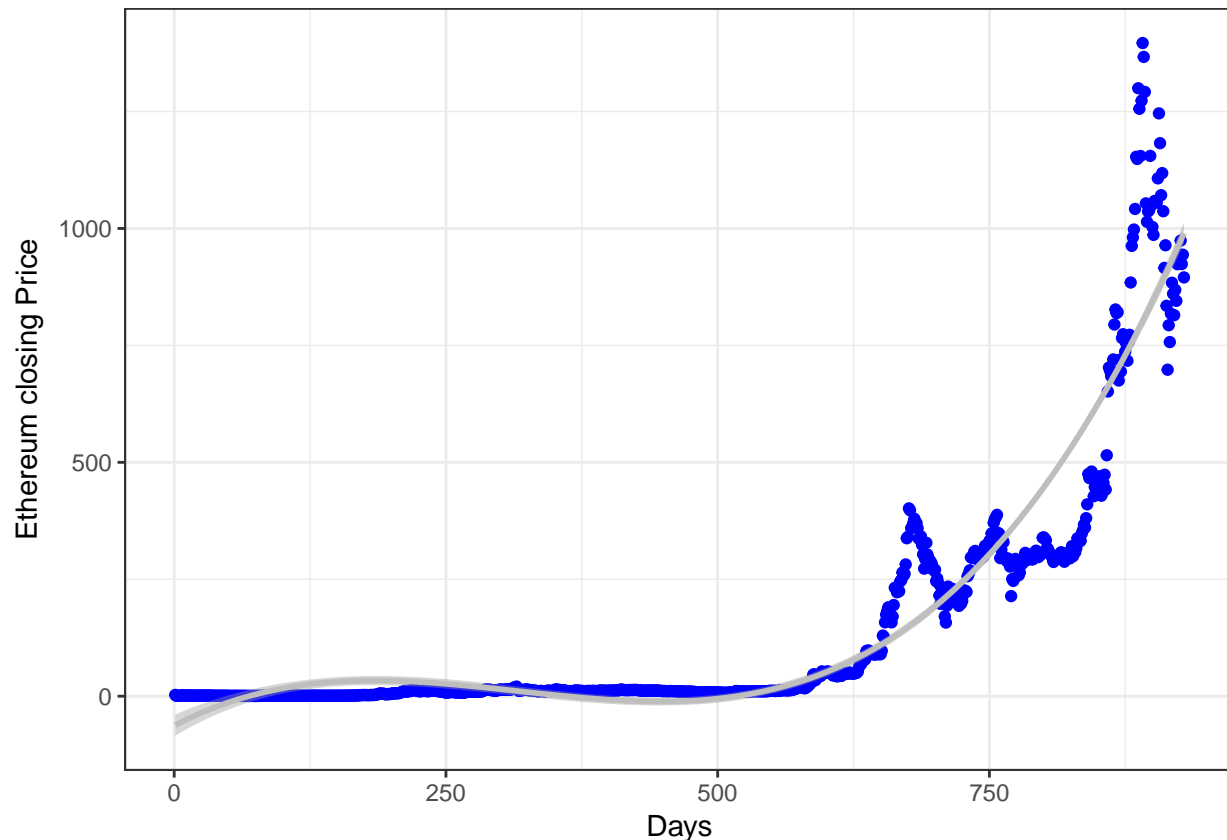
```
eth$NDate <- as.Date(eth$Date, format = "%m/%d/%Y")
eth$Days <- 1:nrow(eth)
time_quadm = lm(Close ~ poly(Days,3) , data = eth)
summary(time_quadm)
```

```
##
## Call:
## lm(formula = Close ~ poly(Days, 3), data = eth)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -238.94  -21.98   -0.65   19.54   595.33
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    147.784     2.886   51.21  <2e-16 ***
## poly(Days, 3)1  5808.038     87.954   66.03  <2e-16 ***
## poly(Days, 3)2  4322.962     87.954   49.15  <2e-16 ***
## poly(Days, 3)3  2272.669     87.954   25.84  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 87.95 on 925 degrees of freedom
```

```
## Multiple R-squared:  0.8895, Adjusted R-squared:  0.8891
## F-statistic:  2481 on 3 and 925 DF,  p-value: < 2.2e-16
```

```
time_quadm_predicted = time_quadm$fitted.values
```

```
ts_nonlinear = data.frame(Days = eth$Days, quadratic_trend = time_quadm_predicted)
ggplot(eth, aes( Days, Close)) + geom_point(color = "blue") + xlab("Days") + ylab("Ethereum closing Price")
  stat_smooth(method = "lm", formula = y ~ poly(x,3), col = "grey") + theme_bw()
```



The model is highly significant for P values less 0.0001. About 89% of the total variance can be explained by the model. Which makes it a good fit compared to the earlier time series decomposition. Now trying to forecast using the nonlinear model developed. Figure 21 shows the forecast plot and the forecast has improved tremendously compared to the previous model.

```
#Forecasting
```

```
newdata = data.frame(Days = c(930:1294))
```

```
(prediction = predict(time_quadm, newdata= newdata))
```

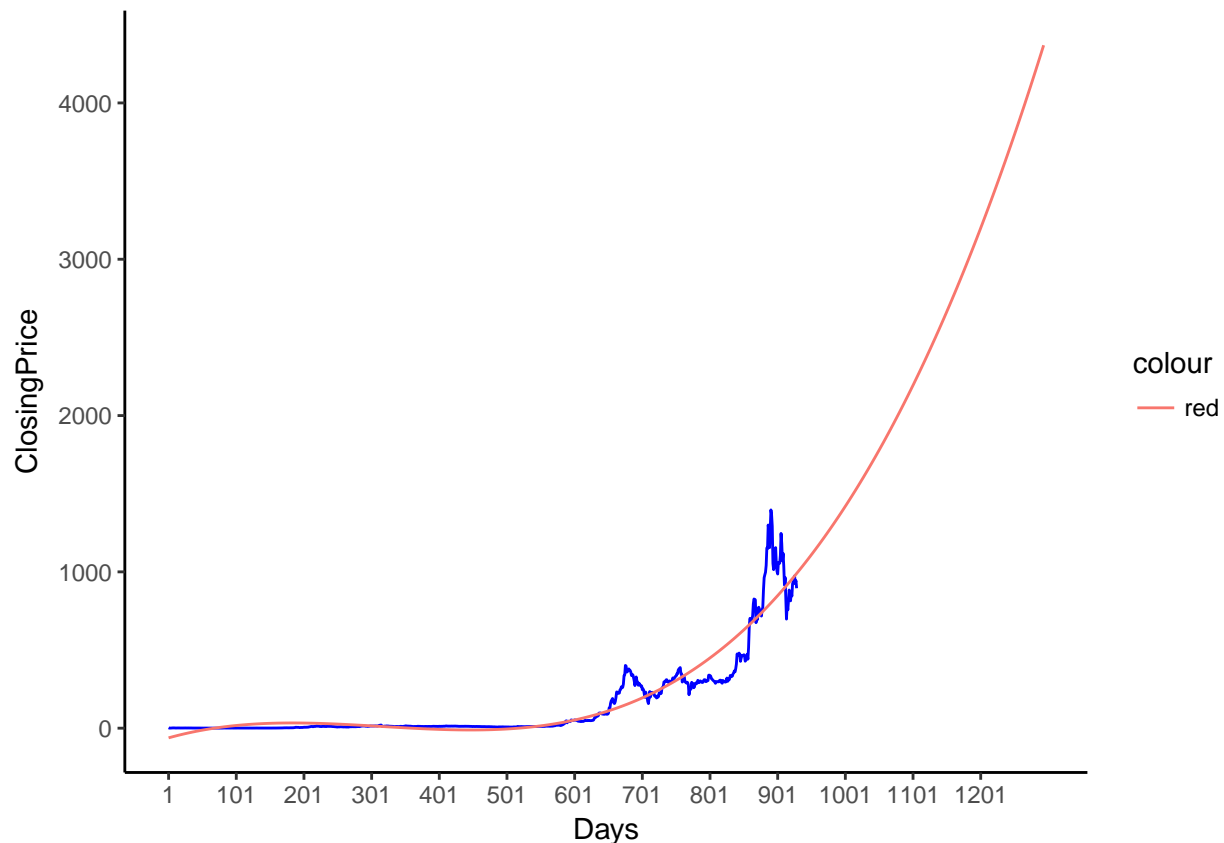
```
##          1          2          3          4          5          6          7
## 994.9186 1000.2439 1005.5873 1010.9490 1016.3289 1021.7270 1027.1434
##          8          9         10         11         12         13         14
## 1032.5782 1038.0312 1043.5027 1048.9926 1054.5009 1060.0276 1065.5729
##         15         16         17         18         19         20         21
## 1071.1367 1076.7190 1082.3199 1087.9395 1093.5776 1099.2345 1104.9100
##         22         23         24         25         26         27         28
## 1110.6043 1116.3173 1122.0491 1127.7998 1133.5693 1139.3576 1145.1649
```

##	29	30	31	32	33	34	35
##	1150.9911	1156.8363	1162.7005	1168.5837	1174.4859	1180.4073	1186.3477
##	36	37	38	39	40	41	42
##	1192.3073	1198.2861	1204.2840	1210.3012	1216.3377	1222.3935	1228.4685
##	43	44	45	46	47	48	49
##	1234.5630	1240.6768	1246.8100	1252.9626	1259.1348	1265.3264	1271.5375
##	50	51	52	53	54	55	56
##	1277.7682	1284.0185	1290.2884	1296.5780	1302.8872	1309.2162	1315.5648
##	57	58	59	60	61	62	63
##	1321.9333	1328.3215	1334.7295	1341.1574	1347.6052	1354.0729	1360.5605
##	64	65	66	67	68	69	70
##	1367.0681	1373.5957	1380.1434	1386.7110	1393.2988	1399.9067	1406.5348
##	71	72	73	74	75	76	77
##	1413.1830	1419.8514	1426.5401	1433.2490	1439.9782	1446.7278	1453.4977
##	78	79	80	81	82	83	84
##	1460.2880	1467.0987	1473.9298	1480.7814	1487.6535	1494.5462	1501.4594
##	85	86	87	88	89	90	91
##	1508.3932	1515.3476	1522.3227	1529.3184	1536.3349	1543.3721	1550.4300
##	92	93	94	95	96	97	98
##	1557.5088	1564.6084	1571.7288	1578.8701	1586.0324	1593.2156	1600.4197
##	99	100	101	102	103	104	105
##	1607.6449	1614.8911	1622.1584	1629.4467	1636.7562	1644.0868	1651.4386
##	106	107	108	109	110	111	112
##	1658.8116	1666.2059	1673.6214	1681.0582	1688.5164	1695.9959	1703.4968
##	113	114	115	116	117	118	119
##	1711.0191	1718.5629	1726.1281	1733.7149	1741.3231	1748.9530	1756.6044
##	120	121	122	123	124	125	126
##	1764.2775	1771.9722	1779.6886	1787.4267	1795.1866	1802.9682	1810.7716
##	127	128	129	130	131	132	133
##	1818.5969	1826.4440	1834.3130	1842.2039	1850.1168	1858.0516	1866.0085
##	134	135	136	137	138	139	140
##	1873.9874	1881.9883	1890.0114	1898.0566	1906.1239	1914.2134	1922.3252
##	141	142	143	144	145	146	147
##	1930.4592	1938.6154	1946.7940	1954.9949	1963.2181	1971.4638	1979.7318
##	148	149	150	151	152	153	154
##	1988.0223	1996.3353	2004.6708	2013.0289	2021.4095	2029.8127	2038.2386
##	155	156	157	158	159	160	161
##	2046.6871	2055.1582	2063.6521	2072.1688	2080.7082	2089.2704	2097.8555
##	162	163	164	165	166	167	168
##	2106.4634	2115.0942	2123.7480	2132.4247	2141.1243	2149.8470	2158.5927
##	169	170	171	172	173	174	175
##	2167.3615	2176.1534	2184.9685	2193.8066	2202.6680	2211.5526	2220.4605
##	176	177	178	179	180	181	182
##	2229.3916	2238.3460	2247.3238	2256.3249	2265.3494	2274.3974	2283.4688
##	183	184	185	186	187	188	189
##	2292.5636	2301.6820	2310.8240	2319.9895	2329.1786	2338.3914	2347.6278
##	190	191	192	193	194	195	196
##	2356.8879	2366.1717	2375.4793	2384.8106	2394.1658	2403.5448	2412.9476
##	197	198	199	200	201	202	203
##	2422.3744	2431.8251	2441.2997	2450.7984	2460.3210	2469.8677	2479.4385
##	204	205	206	207	208	209	210
##	2489.0333	2498.6523	2508.2955	2517.9629	2527.6544	2537.3703	2547.1104
##	211	212	213	214	215	216	217
##	2556.8748	2566.6636	2576.4767	2586.3142	2596.1762	2606.0626	2615.9735

```
##      218      219      220      221      222      223      224
## 2625.9090 2635.8689 2645.8535 2655.8626 2665.8964 2675.9549 2686.0380
##      225      226      227      228      229      230      231
## 2696.1459 2706.2785 2716.4359 2726.6182 2736.8252 2747.0572 2757.3140
##      232      233      234      235      236      237      238
## 2767.5958 2777.9025 2788.2342 2798.5910 2808.9728 2819.3796 2829.8116
##      239      240      241      242      243      244      245
## 2840.2687 2850.7510 2861.2585 2871.7912 2882.3491 2892.9324 2903.5409
##      246      247      248      249      250      251      252
## 2914.1748 2924.8341 2935.5188 2946.2289 2956.9645 2967.7255 2978.5121
##      253      254      255      256      257      258      259
## 2989.3242 3000.1620 3011.0253 3021.9142 3032.8289 3043.7692 3054.7353
##      260      261      262      263      264      265      266
## 3065.7271 3076.7447 3087.7881 3098.8574 3109.9525 3121.0736 3132.2206
##      267      268      269      270      271      272      273
## 3143.3935 3154.5925 3165.8174 3177.0684 3188.3455 3199.6488 3210.9781
##      274      275      276      277      278      279      280
## 3222.3336 3233.7154 3245.1233 3256.5575 3268.0180 3279.5049 3291.0180
##      281      282      283      284      285      286      287
## 3302.5576 3314.1235 3325.7159 3337.3348 3348.9801 3360.6520 3372.3504
##      288      289      290      291      292      293      294
## 3384.0755 3395.8271 3407.6054 3419.4103 3431.2420 3443.1003 3454.9855
##      295      296      297      298      299      300      301
## 3466.8974 3478.8362 3490.8018 3502.7943 3514.8136 3526.8600 3538.9333
##      302      303      304      305      306      307      308
## 3551.0336 3563.1609 3575.3153 3587.4967 3599.7053 3611.9411 3624.2040
##      309      310      311      312      313      314      315
## 3636.4941 3648.8114 3661.1560 3673.5279 3685.9271 3698.3537 3710.8077
##      316      317      318      319      320      321      322
## 3723.2890 3735.7978 3748.3341 3760.8979 3773.4892 3786.1080 3798.7545
##      323      324      325      326      327      328      329
## 3811.4286 3824.1303 3836.8597 3849.6168 3862.4016 3875.2142 3888.0546
##      330      331      332      333      334      335      336
## 3900.9228 3913.8189 3926.7428 3939.6947 3952.6745 3965.6823 3978.7181
##      337      338      339      340      341      342      343
## 3991.7819 4004.8738 4017.9937 4031.1418 4044.3181 4057.5225 4070.7551
##      344      345      346      347      348      349      350
## 4084.0160 4097.3051 4110.6225 4123.9683 4137.3424 4150.7449 4164.1758
##      351      352      353      354      355      356      357
## 4177.6351 4191.1229 4204.6393 4218.1841 4231.7576 4245.3596 4258.9902
##      358      359      360      361      362      363      364
## 4272.6495 4286.3375 4300.0541 4313.7996 4327.5738 4341.3767 4355.2086
##      365
## 4369.0692
```

```
newdata = data.frame(Days = c(1:1294), closingPrice = c(eth$Close, rep(NA,365)), Forecast = c(time_qua
ggplot(newdata, aes(Days, closingPrice)) + geom_line(color = "blue") + xlab("Days") + ylab("ClosingPrice")
theme_classic()
```

```
## Warning: Removed 365 rows containing missing values (geom_path).
```



Forecast accuracy

```
newdata$fc_error = newdata$closingPrice - newdata$Forecast
```

```
####Mean Sq Error####
```

```
(MSE =(sum((newdata$fc_error[1:929])^2 ))/929)
```

```
## [1] 7702.573
```

```
abs_value= (abs(newdata$fc_error[1:929]))
```

```
abs_per = ((abs(newdata$fc_error[1:929]))/ newdata$closingPrice[1:929])
```

```
##### Mean Abs Percentage error #####
```

```
(MAPE = sum(abs_per*100) /929)
```

```
## [1] 525.0042
```

Time series decomposition was not significant as it had very high error percentage. Nonlinear regression model is better than toe series decomposition but still has unacceptably high MAPE. Although, if we look to the forecasting accuracy the Multiple regression model with three variables appears to have a low MAPE and is the best among all. But the residual analysis results observer indeterministic patterns. Moreover, the cryptocurrency market is very influential and unpredictable. It is difficult choose the factors the prices depend. The analysis could be further proceeded using the Bitcoin prices and see if the Bitcoin prices affect the Ethereum prices as well.