Project 425
Time Series Analysis
Forecasting

Cryptocurrency

Time Series

We are working on 4 different cryptocurrencies to check if there is any spurious correlation present among the series and identify the pattern between those series.

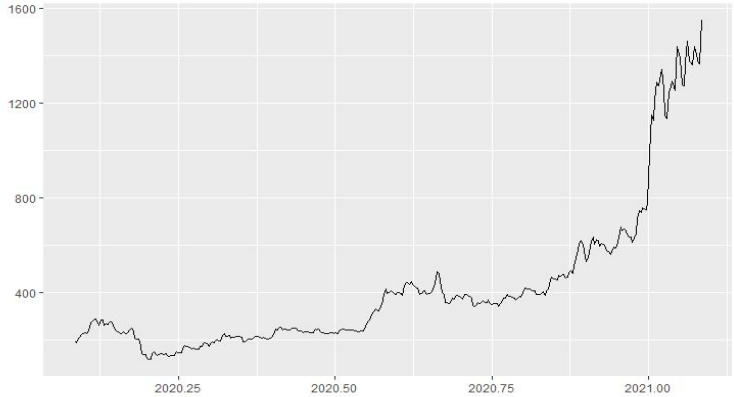
Cryptocurrencies we chose :

1. Ethereum - Chinmay Patil
2. Tether - Vaidehi Madhu
3. LiteCoin - Ashay Kargaonkar
4. Bitcoin Cash - Pramathesh Shukla

Ethereum

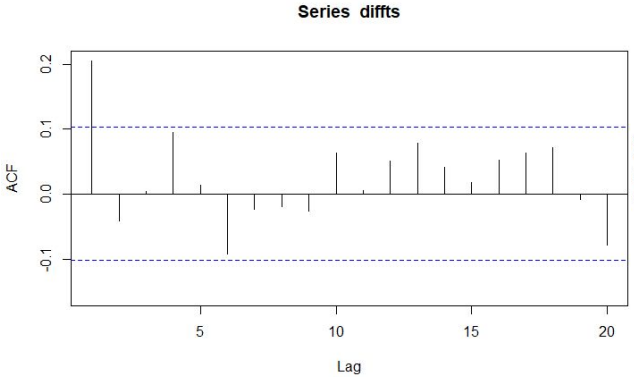
Chinmay Patil

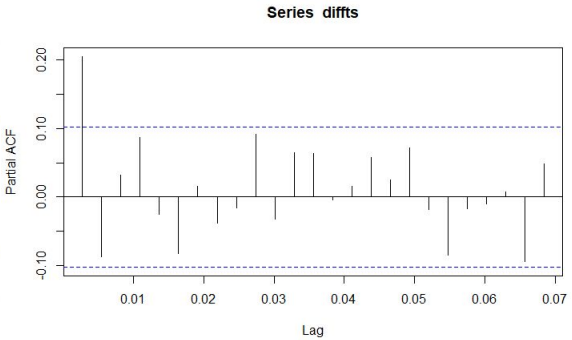
Ethereum - Initial Analysis



- Multiplicative and Non-stationary
- Multiplicative is converted to additive by taking log
- Differencing made the series stationary

Autocorrelation Analysis



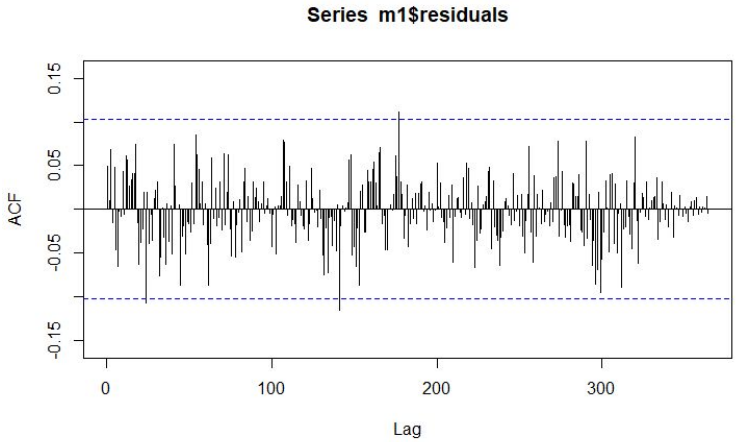



```
> eacf(diffts)
AR/MA
  0 1 2 3 4 5 6 7 8 9 10 11 12 13
0 x o o o o o o o o o o  o  o  o
1 x o o o o o o o o o o  o  o  o
2 x o o o o x o o o o o  o  o  o
3 x x o o o x o o o o o  o  o  o
4 x x x o o o o o o o o  o  o  o
5 x x o o x x o o o o o  o  o  o
6 x x x x o x o o o o o  o  o  o
7 x x o x x x o o o o o  o  o  o
```

- MA behavior suggested by the ACF plot
- MA(1) order term
- No significant seasonality present

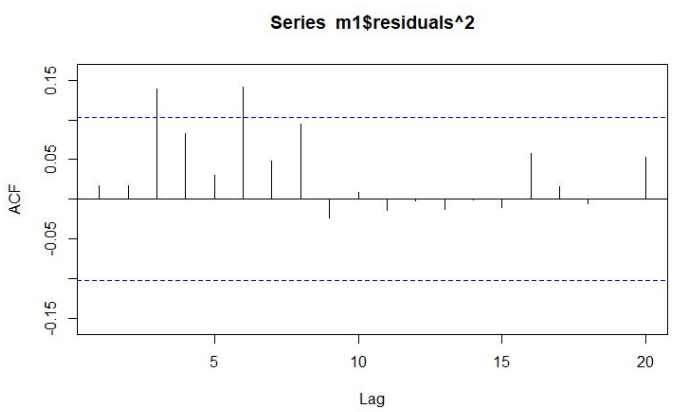
ARIMA MODEL

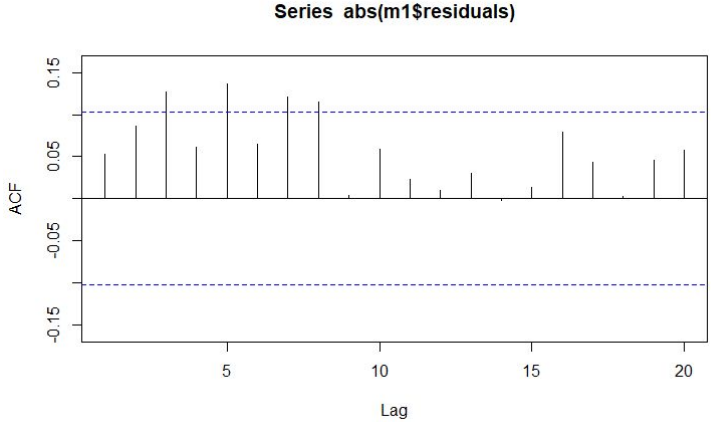
```
z test of coefficients:

            Estimate Std. Error z value  Pr(>|z|)
ar1       -0.7461482  0.1241274 -6.0111 1.842e-09 ***
ar2       -0.7144998  0.1347892 -5.3009 1.153e-07 ***
ma1        0.9341534  0.0932800 10.0145 < 2.2e-16 ***
ma2        0.8174269  0.1273781  6.4173 1.387e-10 ***
intercept  0.0056978  0.0025931  2.1973     0.028 *
---
```



- ARMA(2,2) model
- All AR and MA terms are significant

ARCH Effects



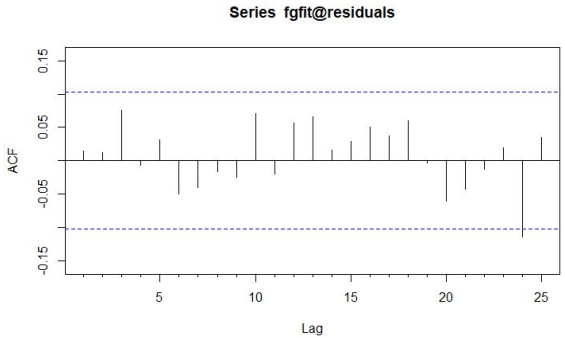


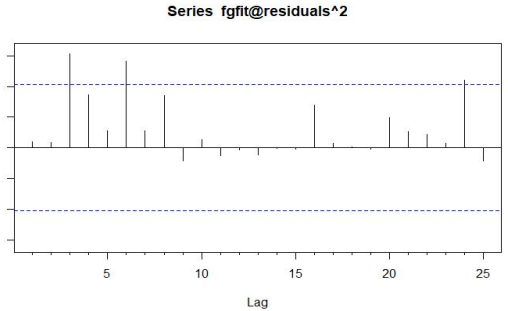
- Significant autocorrelation in the square and absolute residual series
- So we can say that there is an ARCH effect present in the model

GARCH Model

Error Analysis:

	Estimate	Std. Error	t value	Pr(>|t|)	
mu	1.381e-02	5.772e-03	2.393	0.01673	*
ar1	-5.032e-01	1.665e-01	-3.022	0.00251	**
ar2	-5.717e-01	2.950e-01	-1.938	0.05258	.
ma1	7.244e-01	1.461e-01	4.957	7.16e-07	***
ma2	6.418e-01	2.347e-01	2.734	0.00625	**
omega	6.179e-05	3.670e-05	1.684	0.09226	.
alpha1	7.677e-02	2.846e-02	2.697	0.00699	**
beta1	8.981e-01	3.497e-02	25.686	< 2e-16	***





- All parameters pass the test of significance
- AR(2) term is quite close so will consider it in model
- Variance intercept (omega) is also close to significance

Final Model and Forecast

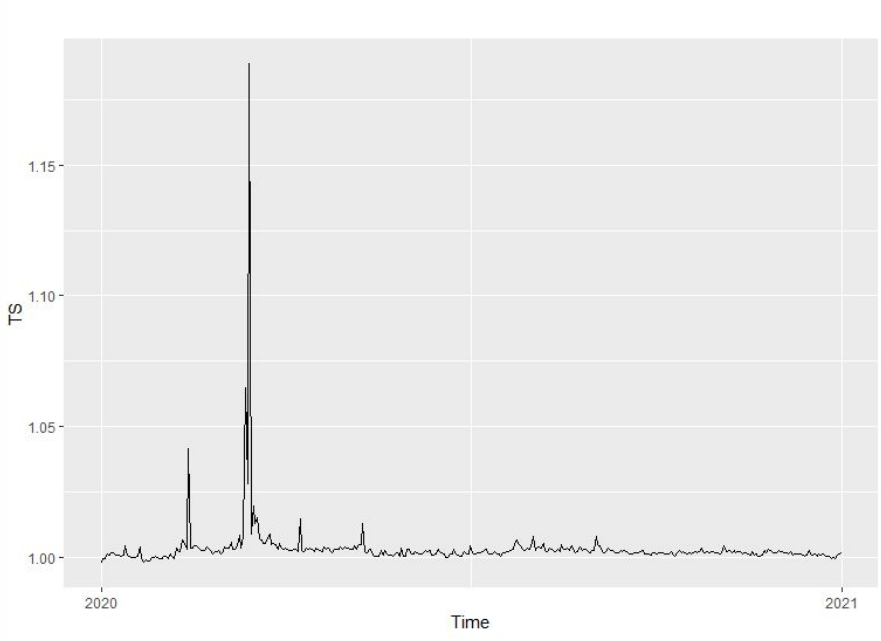
	meanForecast	meanError	standardDeviation
1	0.034429684	0.05918662	0.05918662
2	0.006637042	0.06049748	0.05902366
3	0.006637042	0.06033354	0.05886385
4	0.006637042	0.06017278	0.05870713
5	0.006637042	0.06001513	0.05855344

- 5 step ahead forecast is displayed above
- Above generated GARCH model is the best as the backtest suggests the minimum error estimates for this model
- SMAPE of the model is 1.67

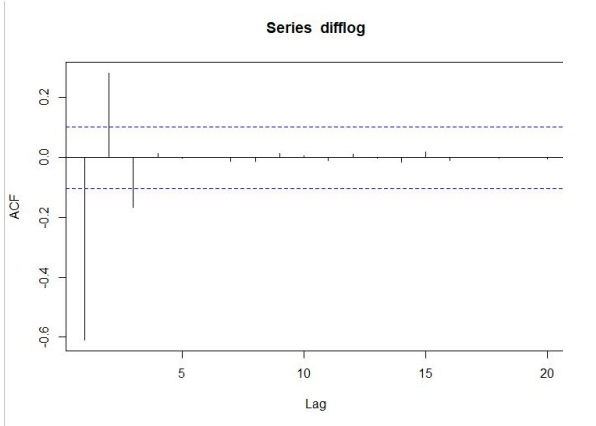
Tether (Vaidehi Madhu)

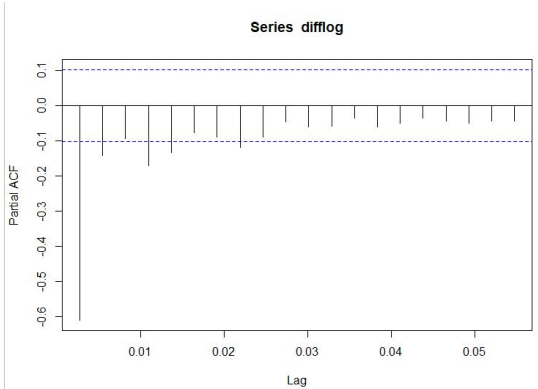
- Multiplicative time series
- Non Stationary
- No seasonal components
- Took log to convert it to

  Additive time series



Autocorrelation Analysis





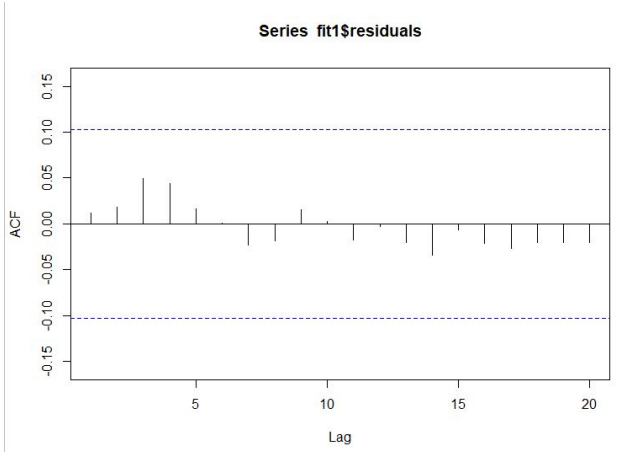

```
> eacf(difflog)
AR/MA
  0 1 2 3 4 5 6 7 8 9 10 11 12 13
0 x x x o o o o o o o o  o  o  o
1 x x x o o o o o o o o  o  o  o
2 x o x o o o o o o o o  o  o  o
3 x x x o o o o o o o o  o  o  o
4 x x x o o o o o o o o  o  o  o
5 x x x x o o o o o o o  o  o  o
6 x o x o o o o o o o o  o  o  o
7 x x x o o o o o o o o  o  o  o
```

- MA(3)

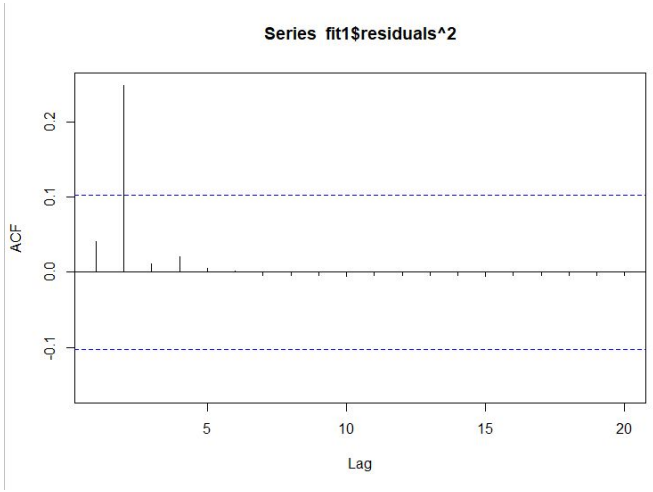
ARIMA Model

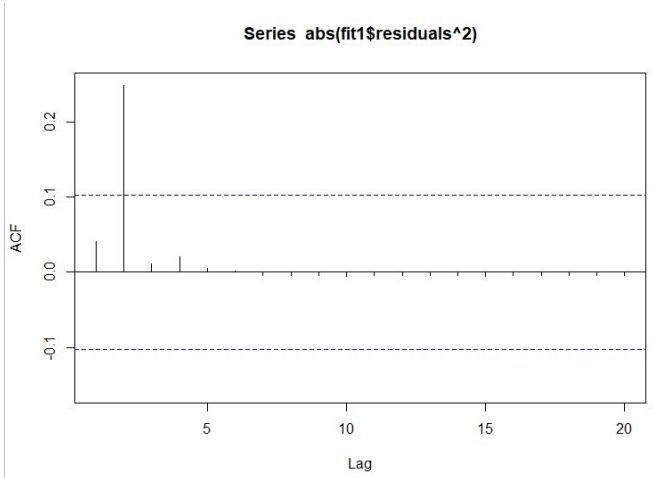
```
z test of coefficients:

             Estimate  Std. Error  z value  Pr(>|z|)
ma1       -8.4340e-01  5.0245e-02 -16.7855 < 2.2e-16 ***
ma2        2.5132e-01  6.5372e-02   3.8445 0.0001208 ***
ma3       -3.4757e-01  5.1275e-02  -6.7786 1.214e-11 ***
intercept -1.9101e-06  6.1695e-05  -0.0310 0.9753009
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

- ARIMA(0,0,3) model
- All MA terms are significant



ARCH Effect





- Significant autocorrelation in the square and absolute residual series
- So we can say that there is an ARCH effect present in the model

GARCH Model

```
Error Analysis:
        Estimate  Std. Error  t value Pr(>|t|)
mu     1.056e-04   6.782e-05    1.557     0.12
omega  6.422e-07   1.223e-07    5.251 1.52e-07 ***
alpha1 1.000e+00   9.210e-02   10.858  < 2e-16 ***
beta1  4.254e-01   4.209e-02   10.106  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

- GARCH(1,1)
- All parameters pass the test of significance

Final Model and Forecast

	meanForecast	meanError	standardDeviation
1	0.0001055769	0.001251099	0.001251099
2	0.0001055769	0.001695068	0.001695068
3	0.0001055769	0.002176620	0.002176620
4	0.0001055769	0.002719413	0.002719413
5	0.0001055769	0.003344134	0.003344134

```
[1] "RMSE of out-of-sample forecasts"
[1] 0.001641634
[1] "Mean absolute error of out-of-sample forecasts"
[1] 0.00149738
[1] "Mean Absolute Percentage error"
[1] 0.001496001
[1] "Symmetric Mean Absolute Percentage error"
[1] 0.00149466
```

- 5 step ahead forecast is displayed above
- MAPE of the ARIMA model is 0.001
- GARCH model is the good fit

LiteCoin

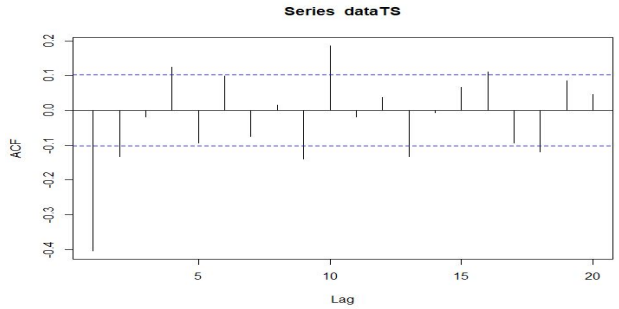
Ashay Kargaonkar

Initial Analysis


```
> adf.test(diff2)

        Augmented Dickey-Fuller Test

data:  diff2
Dickey-Fuller = -10.322, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary
```

The above series was non-stationary therefore I took differencing twice to make the series stationary. The adf test also suggests that.

Autocorrelation Analysis



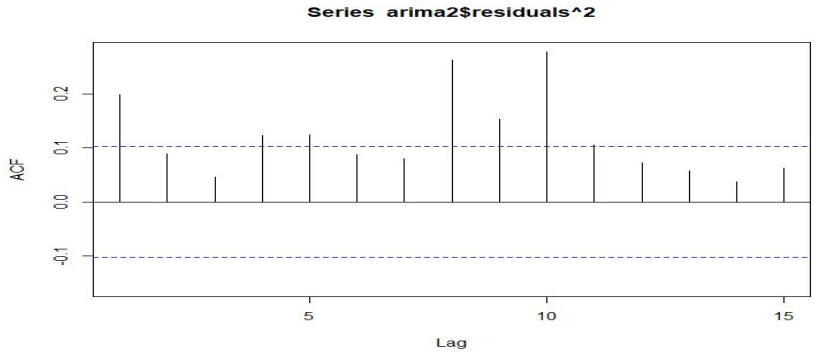

```
> eacf(dataTS)
AR/MA
  0 1 2 3 4 5 6 7 8 9 10 11 12 13
0 x x o x o o o o x x o  o  x  o
1 x x o o o o o o o x o  o  x  o
2 x x x o o o o o o x o  o  x  o
3 x x o x o x o o o o o  o  o  o
4 x x o x o x o o o o o  o  o  o
5 x x o x o x x o o o o  o  o  o
6 x x o x o o x o o o o  o  o  o
7 x x o x o x x o o o o  o  o  o
```

By looking at the above ACF plot, we can say that the time-series have an arch effect and may have to use Garch for it.

EACF suggests that the ARMA model might be (1, 2). Also, autoarima suggests that the model might be of order (1, 0, 1). But after manual building, by trying different AR and MA order values, I think MA1 model will be the best fit.

Arima model

```
> arima2 = Arima(dataTS, order = c(0,0,1)) #I think this is the best model to fit.
> arima2
Series: dataTS
ARIMA(0,0,1) with non-zero mean

Coefficients:
          ma1    mean
      -1.0000  0.0070
s.e.   0.0086  0.0024

sigma^2 estimated as 23.7:  log likelihood=-1094.58
AIC=2195.16   AICc=2195.23   BIC=2206.85
> coeftest(arima2)

z test of coefficients:

            Estimate Std. Error   z value  Pr(>|z|)
ma1       -0.9999990  0.0086345 -115.8148 < 2.2e-16 ***
intercept  0.0070115  0.0024197    2.8977  0.003759 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```



From the above coeftest of the MA1 model, we can say that this is the best fit.

ACF graph of residual-square also suggest that their is GARCH effect.

```
> gfit

Title:
 GARCH Modelling

Call:
 garchFit(formula = ~arma(0, 1) + garch(1, 1), data = dataTS,
    trace = F)

Mean and Variance Equation:
 data ~ arma(0, 1) + garch(1, 1)
<environment: 0x000002a86bb08000>
 [data = dataTS]

Conditional Distribution:
 norm

Coefficient(s):
        mu         ma1       omega      alpha1       beta1
 0.0091485  -0.9657144   0.1078231   0.1411344   0.8720013

Std. Errors:
 based on Hessian

Error Analysis:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.009148    0.004214    2.171   0.0299 *
ma1    -0.965714    0.013927  -69.339  < 2e-16 ***
omega   0.107823    0.045030    2.394   0.0166 *
alpha1  0.141134    0.032320    4.367 1.26e-05 ***
beta1   0.872001    0.024304   35.879  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log Likelihood:
 -938.6385    normalized:  -2.578677

Description:
 Mon Mar 08 20:07:42 2021 by user: ashay
```

```
> predict = predict(gfit,n.ahead =5)
> predict
  meanForecast meanError standardDeviation
1 15.230236490  13.94950           13.94950
2  0.009148478  19.46090           14.04466
3  0.009148478  19.59362           14.14042
4  0.009148478  19.72717           14.23677
5  0.009148478  19.86156           14.33373
```

```
> backtestGarch(gfit, dataTS, testLen, 1)
[1] "Testing 0 of 18\n"
[1] "Testing 10 of 18\n"
[1] "RMSE of out-of-sample forecasts"
[1] 11.13237
[1] "Mean absolute error of out-of-sample forecasts"
[1] 8.936243
[1] "Mean Absolute Percentage error"
[1] 1.134341
[1] "Symmetric Mean Absolute Percentage error"
[1] 1.16982
```

Result

By looking at the table in the previous slide, we can see that the values of GARCH model are significant.

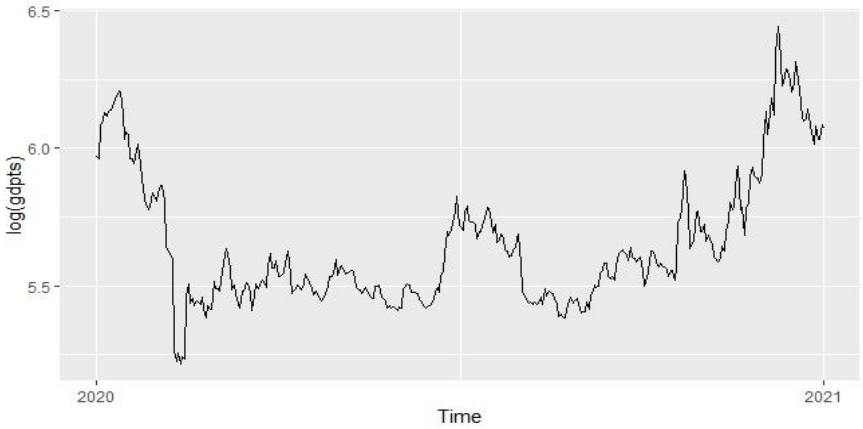
Also, I have put the table which shows the forecast for 5 steps ahead.

As we can see that Mean Absolute Percentage error is 1.13 which is less, which states that this model is a good fit.

Bitcoin Cash

Pramathesh Shukla

Bitcoin Cash Analysis




```
> kpss.test(dataTs)
KPSS Unit Root Test
alternative: nonstationary

Type 1: no drift no trend
 lag  stat p.value
   4 0.108     0.1
-----
 Type 2: with drift no trend
 lag  stat p.value
   4 0.371  0.0896
-----
 Type 1: with drift and trend
 lag   stat p.value
   4 0.0767     0.1
-----------
Note: p.value = 0.01 means p.value <= 0.01
    : p.value = 0.10 means p.value >= 0.10
```

Additive and Non- Stationary
From the above table KPSS test suggest that the series is stationary and can be used for further analysis.

Eacf and Autocorrelation analysis

```
> eacf(dataTs)
AR/MA
  0 1 2 3 4 5 6 7 8 9 10 11 12 13
0 x x x x x x x x x x x  x  x  x
1 x x o o o o o o o x o  o  o  o
2 x x x o o o o o o o x  o  o  o
3 x x o o o o o o o o o  o  o  o
4 x x o o o o o o o o o  o  o  o
5 x x o x o o o o o o o  o  o  o
6 x o o x o o o o o o o  o  o  o
7 x o x o o o o o o o o  o  o  o
```

```
> autoarima
Series: dataTs
ARIMA(2,1,0)

Coefficients:
         ar1      ar2
      0.1340  -0.1811
s.e.  0.0515   0.0521

sigma^2 estimated as 281.2:  log likelihood=-1546.08
AIC=3098.15   AICc=3098.22   BIC=3109.85
```

Eacf graph suggests arma model of order (1,2).

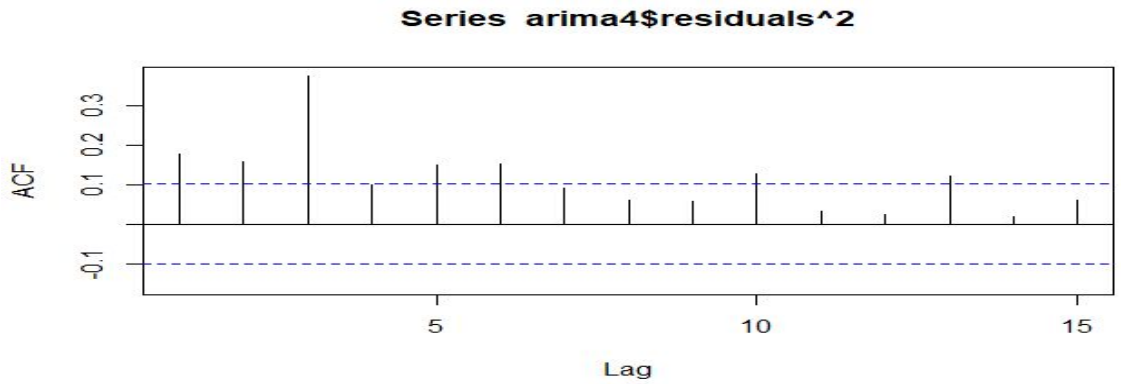
Auto arima graph suggests models of AR2.

Arima Modeling

```
> coeftest(arima4)

z test of coefficients:

             Estimate Std. Error z value  Pr(>|z|)
ar1          0.980193   0.010105 96.9989 < 2.2e-16 ***
intercept 316.547975  40.695307  7.7785  7.34e-15 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

After looking at eacf table and auto arima table, I did some manual model building and saw that AR1 model is the best fit and this model will be used for further analysis.

ARCH Effect



By looking at the above Acf graph of residual square value we can see Garch effect in it.

GARCH Model

By looking at above garch model fit

Table we can see that except omega

Other values are significant.

```
> gfit

Title:
 GARCH Modelling

Call:
 garchFit(formula = ~arma(1, 0) + garch(1, 1), data = dataTs,
    trace = F)

Mean and Variance Equation:
 data ~ arma(1, 0) + garch(1, 1)
<environment: 0x00000208d38a4190>
 [data = dataTs]

Conditional Distribution:
 norm

Coefficient(s):
     mu      ar1    omega   alpha1    beta1
8.42964  0.96643  4.84369  0.21192  0.79793

Std. Errors:
 based on Hessian

Error Analysis:
        Estimate  Std. Error  t value Pr(>|t|)
mu      8.429635    0.357876    23.55  < 2e-16 ***
ar1     0.966427    0.002179   443.57  < 2e-16 ***
omega   4.843690          NA       NA       NA
alpha1  0.211921    0.058701     3.61 0.000306 ***
beta1   0.797929    0.037728    21.15  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log Likelihood:
 -1457.405    normalized:  -3.981982

Description:
 Mon Mar 08 20:51:19 2021 by user: PBS
```

Result

```
> predict = predict(gfit,n.ahead =5)
> predict
  meanForecast meanError standardDeviation
1     426.6411  20.51227          20.51227
2     420.7471  28.68304          20.73020
3     415.0510  34.74507          20.94798
4     409.5462  39.69263          21.16563
5     404.2261  43.91733          21.38318
```

Above graph predicts five steps ahead values after using garch models.

Thank you !