Appendix - Practical 1, 2, & 3

Practical 1

Figures

Figure 1: Bitcoin Prices and Negative Log Returns Over Time on Common Scale

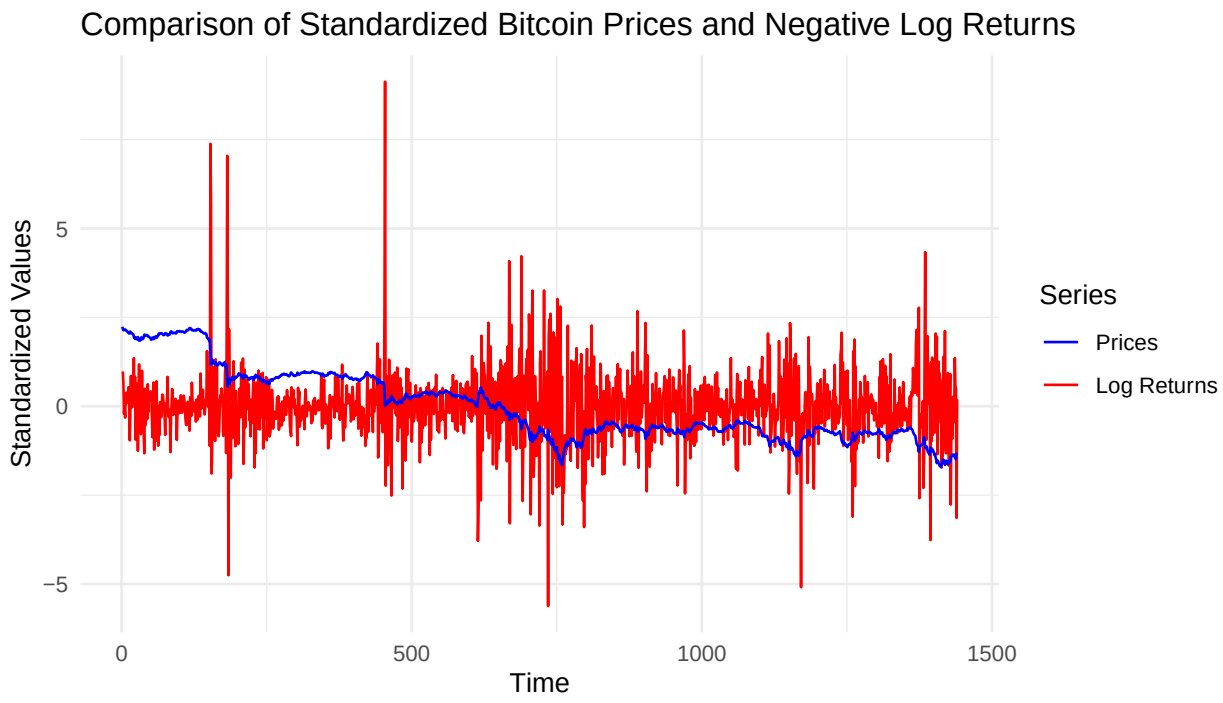


Figure 2: Bitcoin Prices Over Time

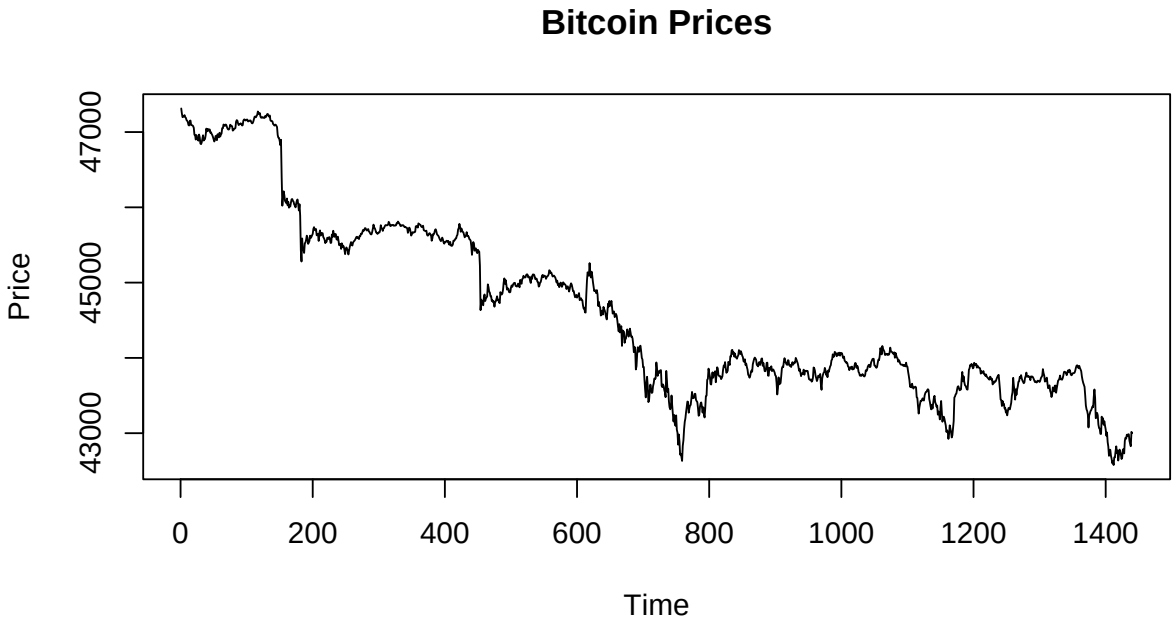


Figure 3: Negative Log Returns of Bitcoin Over Time

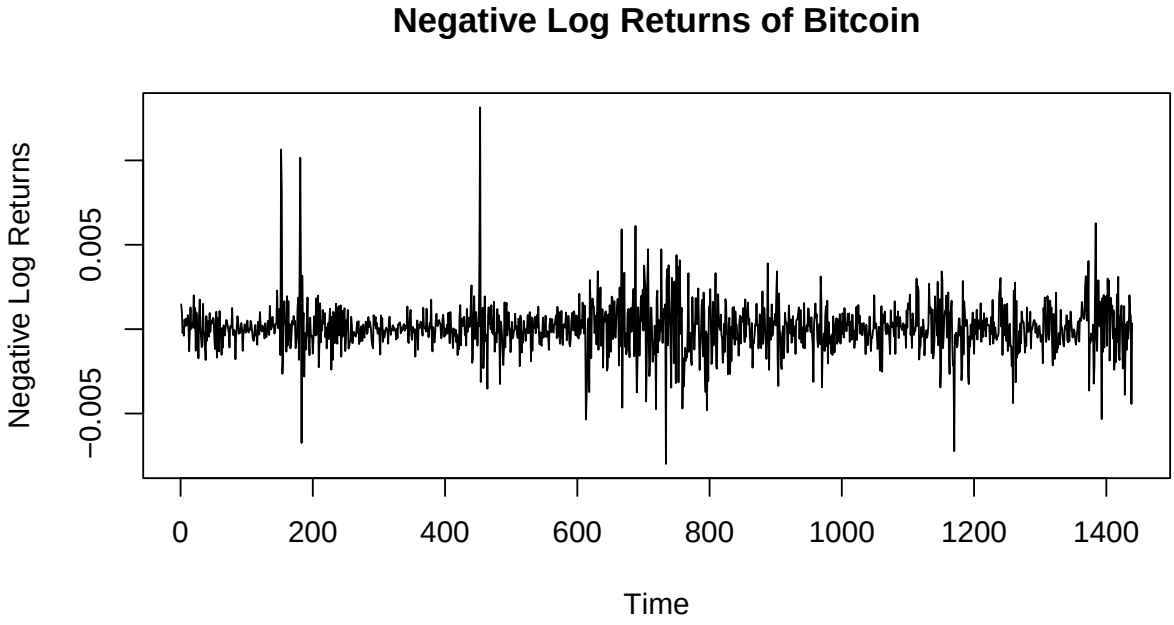


Figure 4: Histogram of Negative Log Returns

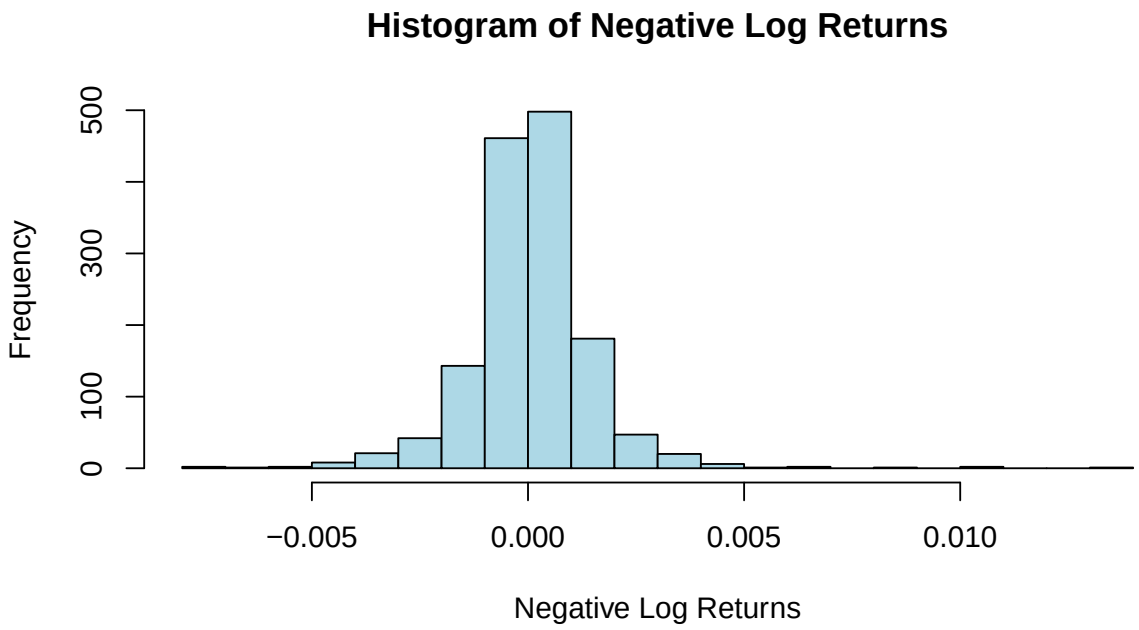


Figure 5: QQ-Plot of Negative Log Returns

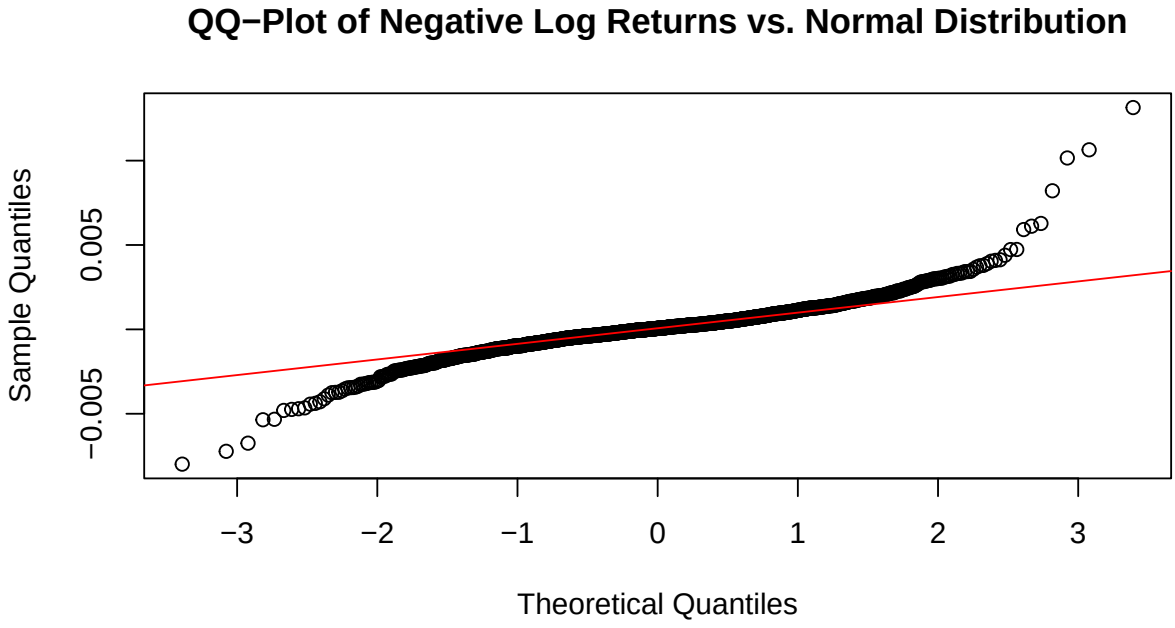


Figure 6: QQ-Plot of Negative Log Returns with t-Distribution

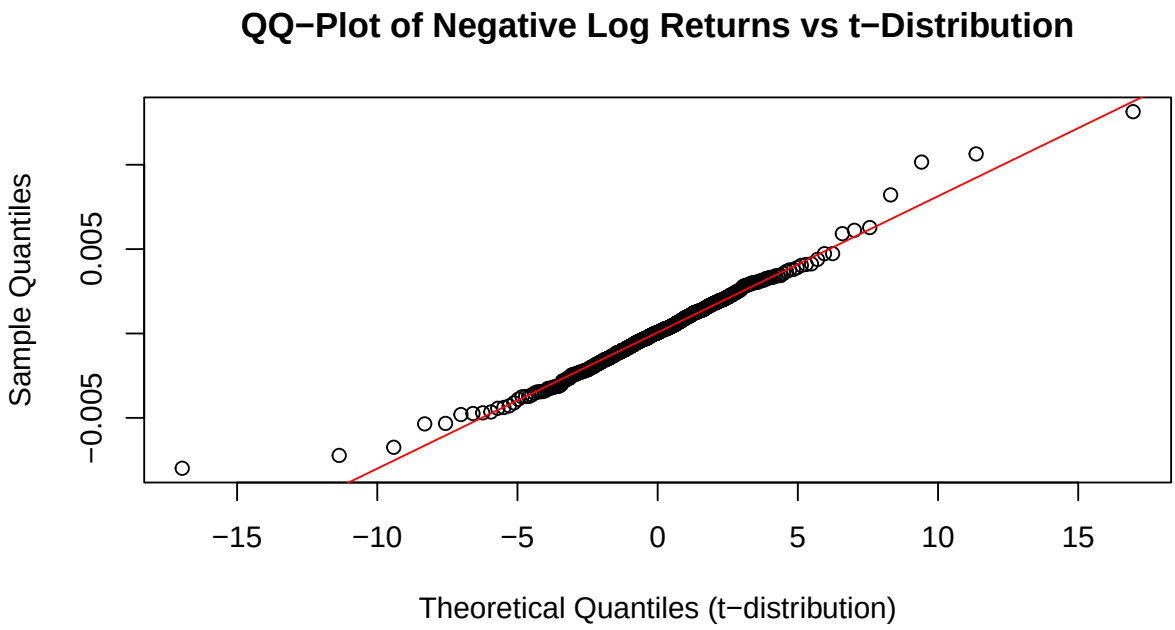


Figure 7: Histogram of Bitcoin Negative Log Returns with Fitted t and Normal Distribution

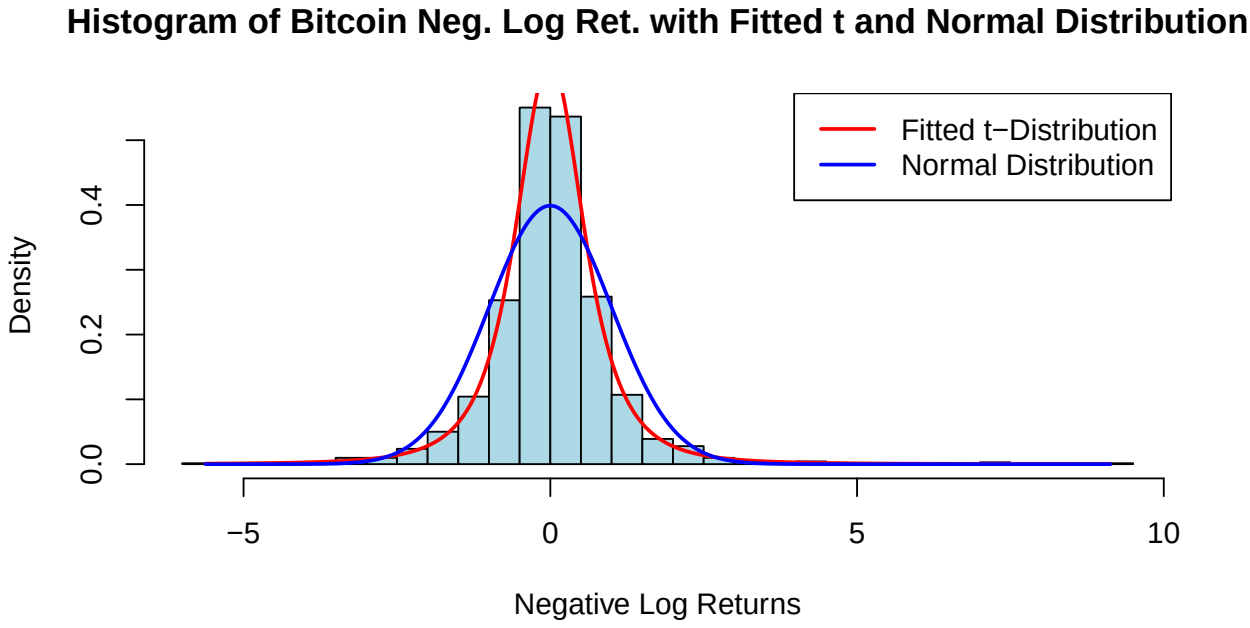


Figure 8: Density Comparison: Normal vs t-Distribution

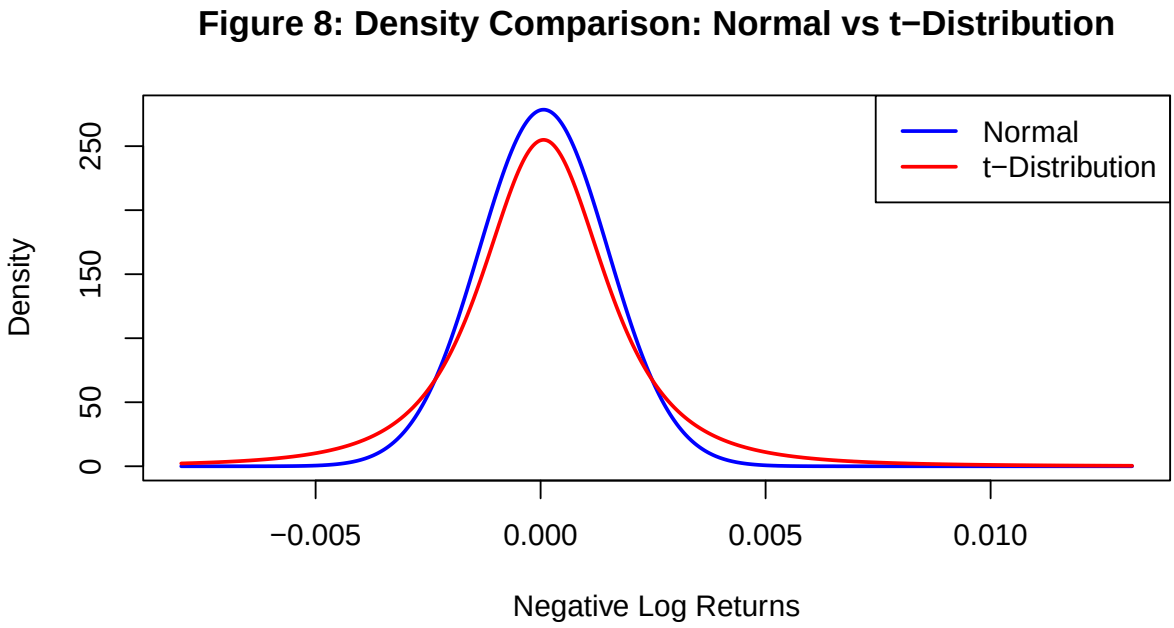


Figure 9: ACF of Bitcoin Prices

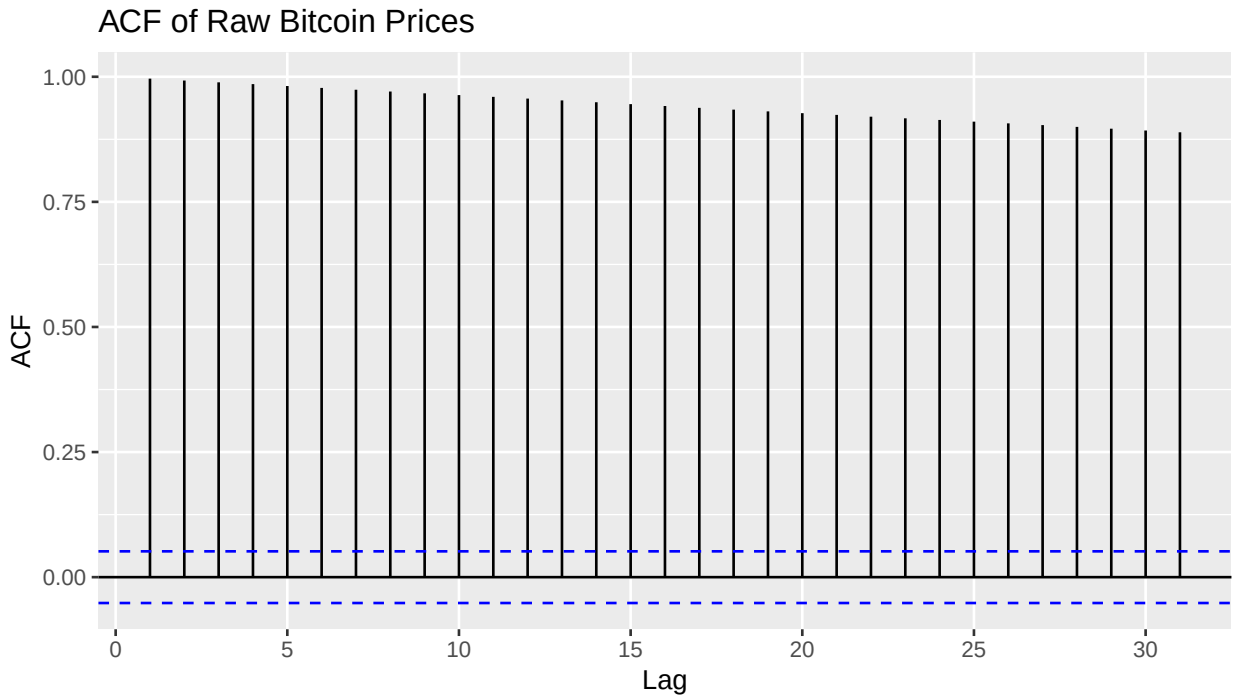


Figure 10: ACF of Negative Log Returns

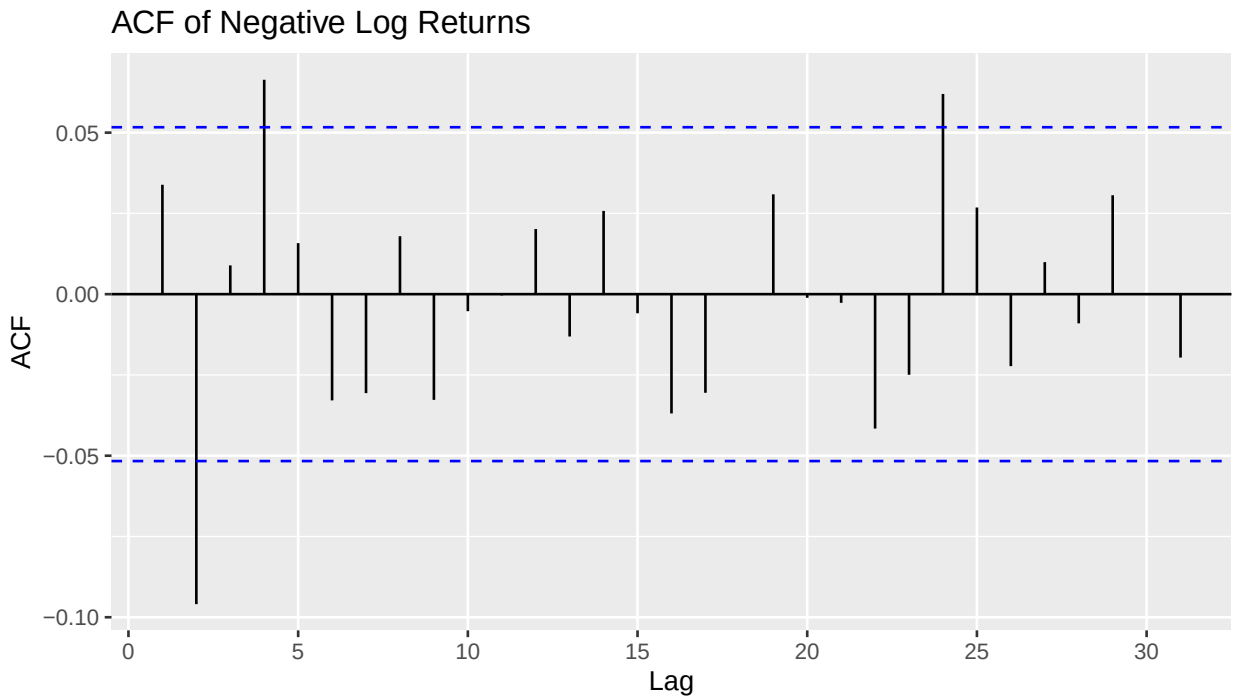


Figure 11: PACF of Negative Log Returns

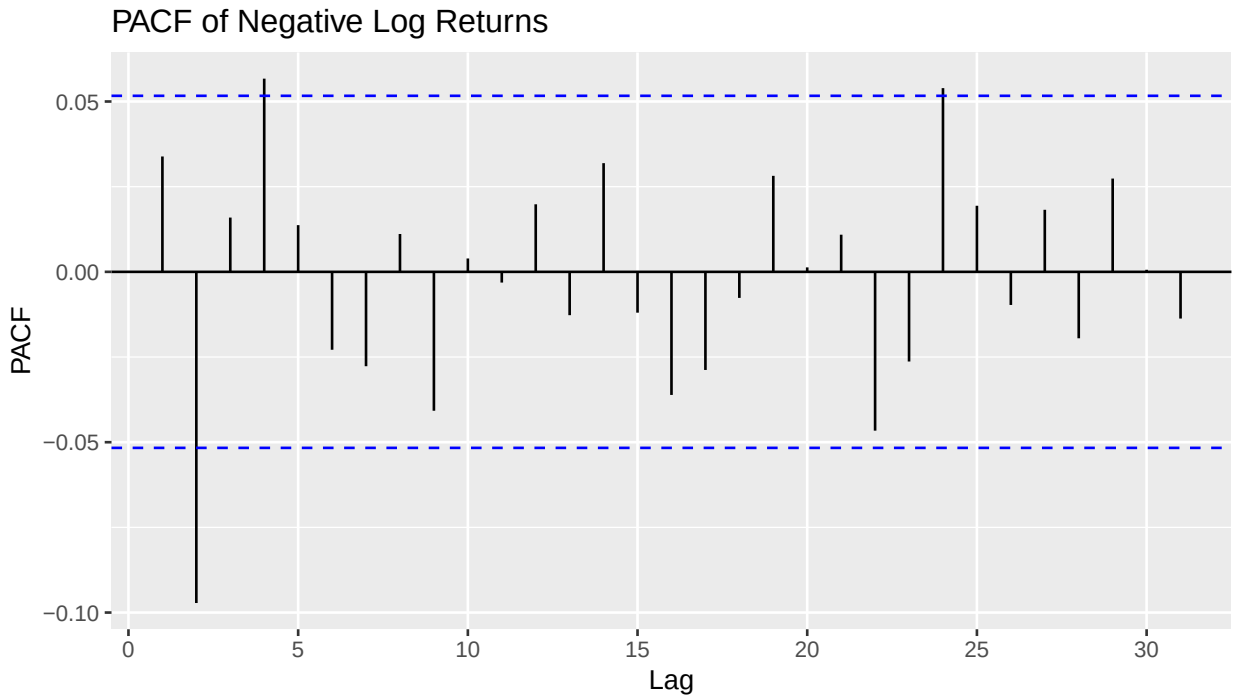


Figure 12: ACF of ARIMA(2, 0, 2) Residuals

```
##
## Call:
## arima(x = bitcoin_negative_log_returns, order = c(2, 0, 2))
##
## Coefficients:
##          ar1      ar2     ma1     ma2  intercept
##       -0.0520  -0.5415  0.0853  0.4479      1e-04
## s.e.   0.1717   0.1664  0.1824  0.1773      0e+00
##
## sigma^2 estimated as 2.022e-06:  log likelihood = 7391.82,  aic = -14771.65
```

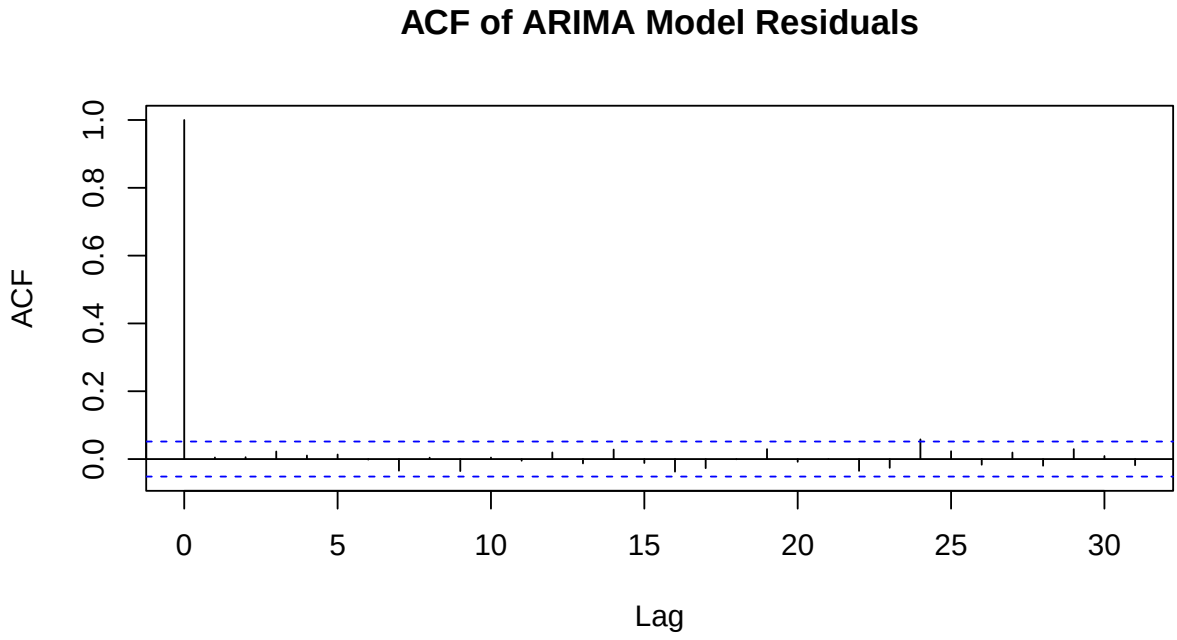


Figure 13: QQ-Plot of ARIMA(2, 0, 2) Residuals

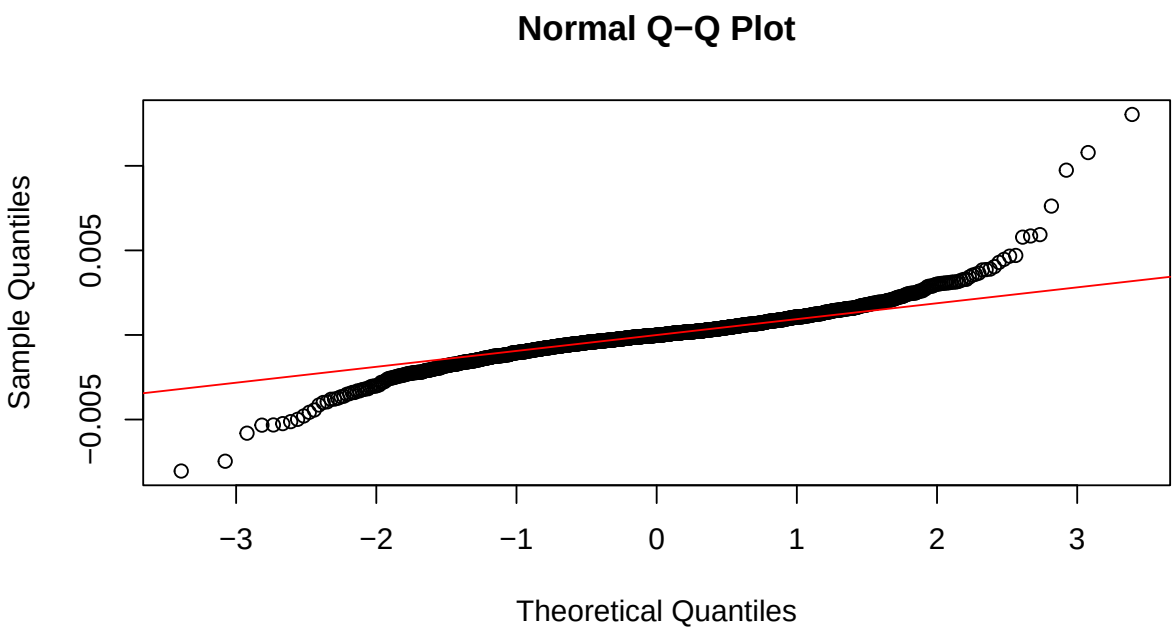


Figure 14: Residuals of ARIMA(2, 0, 2) Over Time

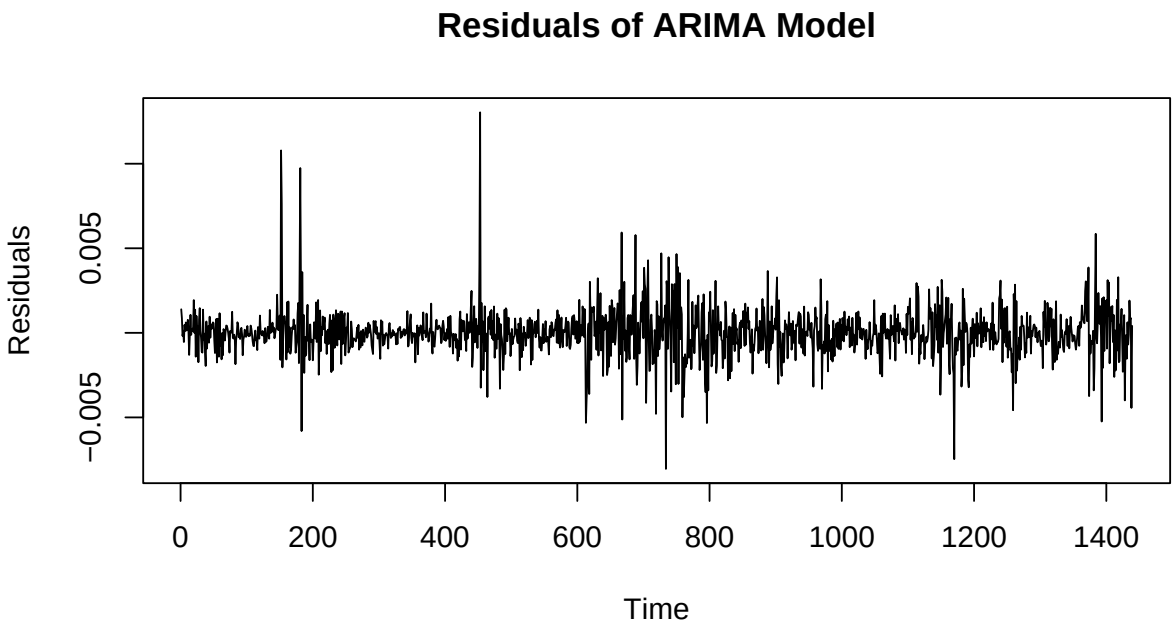


Figure 15: ACF of GARCH Normal(1, 1)

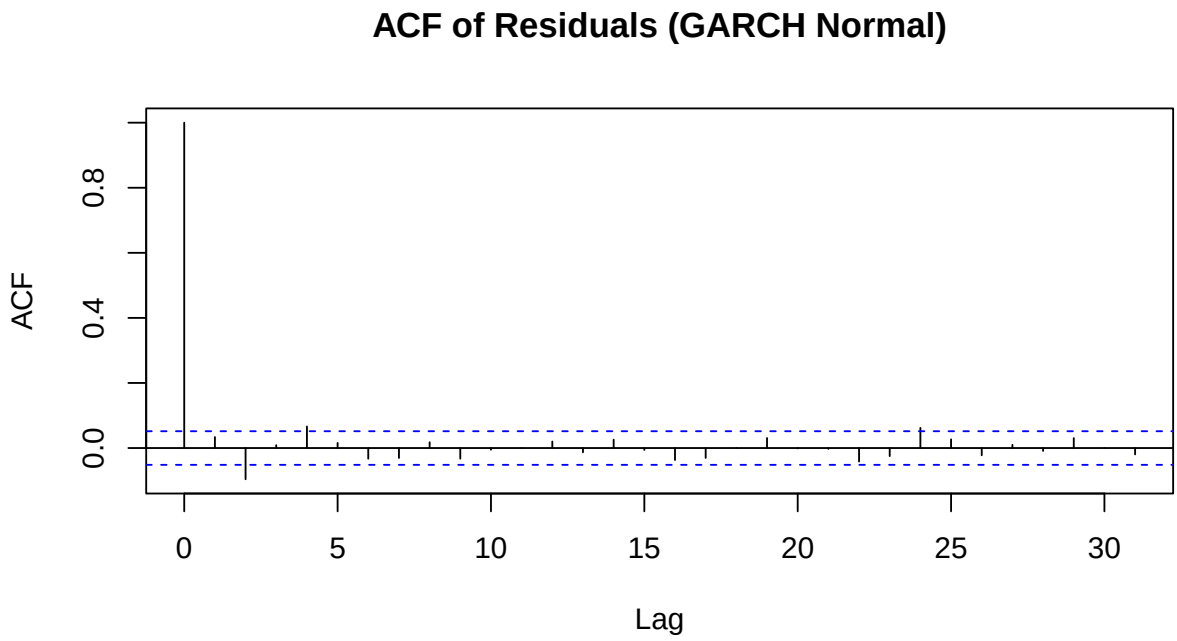


Figure 16: ACF of GARCH t-Distribution(1, 1)

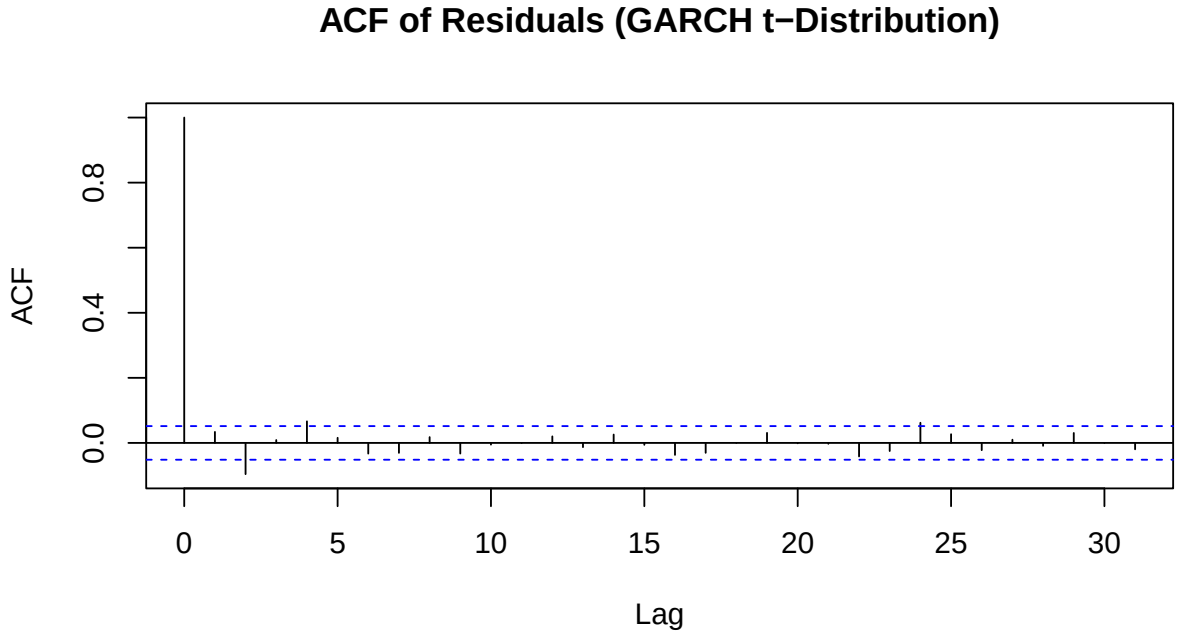


Figure 17: QQ-Plot of GARCH Normal(1, 1) Residuals

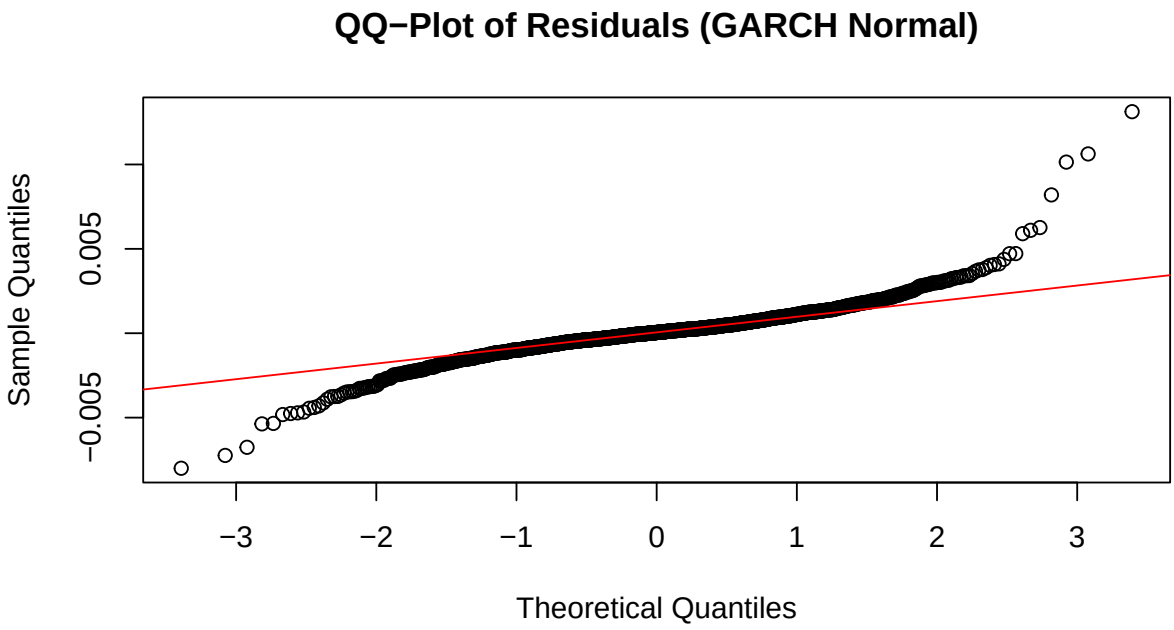


Figure 18: QQ-Plot of GARCH t-Distribution(1, 1) Residuals

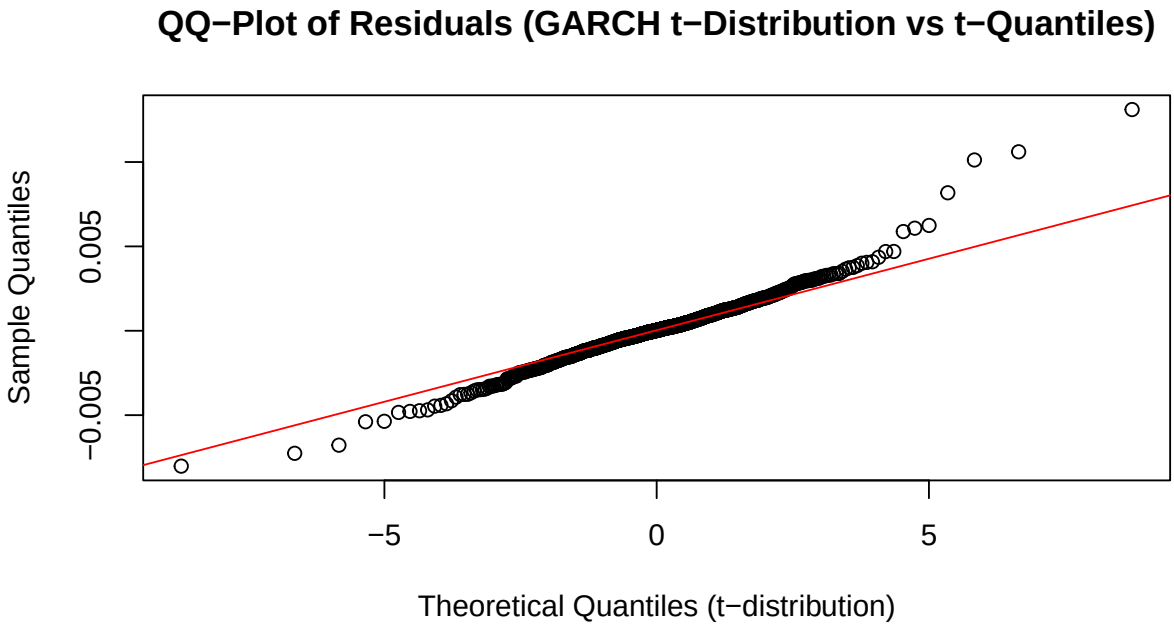
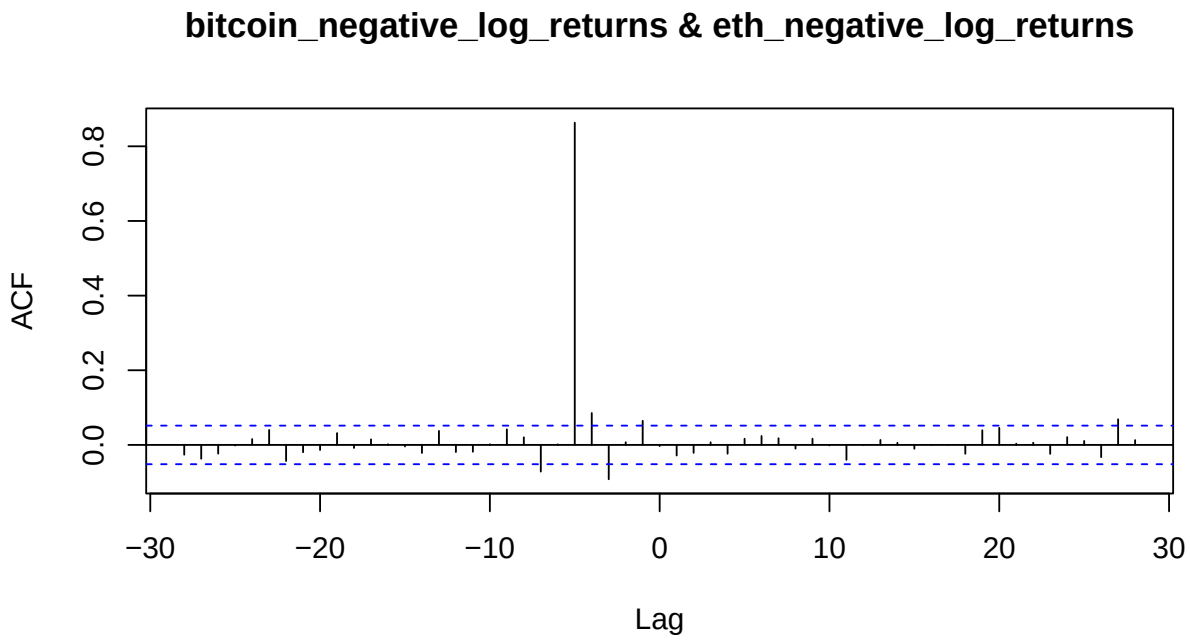


Figure 19: Cross-Correlation Function (CCF) between Bitcoin and Ethereum



Results tables

Table 1: Augmented Dickey-Fuller Test for Bitcoin Prices

```
##
##  Augmented Dickey-Fuller Test
##
## data:  bitcoin_prices
## Dickey-Fuller = -2.4484, Lag order = 11, p-value = 0.3885
## alternative hypothesis: stationary
```

Table 2: Augmented Dickey-Fuller Test for Negative Log Returns

```
##
##  Augmented Dickey-Fuller Test
##
## data:  bitcoin_negative_log_returns
## Dickey-Fuller = -11.035, Lag order = 11, p-value = 0.01
## alternative hypothesis: stationary
```

Table 3: Anderson-Darling Test for Normality of Negative Log Returns

```
##
##  Anderson-Darling normality test
##
## data:  bitcoin_negative_log_returns
## A = 26.277, p-value < 2.2e-16
```

Table 4: Ljung-Box Test for Autocorrelation in Bitcoin Prices

```
##
##  Box-Ljung test
##
## data:  bitcoin_prices
## X-squared = 26873, df = 20, p-value < 2.2e-16
```

Table 5: Ljung-Box Test for Autocorrelation in Negative Log Returns

```
##
##  Box-Ljung test
##
## data:  bitcoin_negative_log_returns
## X-squared = 33.356, df = 20, p-value = 0.03082
```

Table 6: Ljung-Box Test for ARIMA(2, 0, 2) Residuals

```
##
##  Box-Ljung test
##
## data:  residuals_arima
## X-squared = 11.355, df = 20, p-value = 0.9365
```

Table 7: Shapiro-Wilk Test for Normality of ARIMA(2, 0, 2) Residuals

```
##
##  Shapiro-Wilk normality test
##
## data:  residuals_arima
## W = 0.89619, p-value < 2.2e-16
```

Table 8: Ljung-Box Test for GARCH Normal(1, 1) Residuals

```
##
##  Box-Ljung test
##
## data:  garch_normal_residuals
## X-squared = 33.356, df = 20, p-value = 0.03082
```

Table 9: Ljung-Box Test for GARCH t-Distribution(1, 1) Residuals

```
##
##  Box-Ljung test
##
## data:  garch_t_residuals
## X-squared = 33.356, df = 20, p-value = 0.03082
```

Table 10: Shapiro-Wilk Test for Normality of GARCH Normal(1, 1) Residuals

```
##
##  Shapiro-Wilk normality test
##
## data:  garch_normal_residuals
## W = 0.89321, p-value < 2.2e-16
```

Table 11: Ljung-Box Test for ARIMA-GARCH Residuals

```
##
##  Box-Ljung test
##
## data:  garch_residuals
## X-squared = 11.355, df = 20, p-value = 0.9365
```

Table 12: Correlation Test for Bitcoin and Ethereum Negative Log Returns

```
##
##  Pearson's product-moment correlation
##
## data:  bitcoin_negative_log_returns and eth_negative_log_returns
## t = -0.11935, df = 1437, p-value = 0.905
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.05481486  0.04853492
## sample estimates:
##         cor
## -0.00314838
```

Table 13: Granger Causality Test: Bitcoin Predicting Ethereum

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##      6      6      6      6
##
## $criteria
##                  1           2           3           4           5
## AIC(n)     11.74758    11.74842    11.73190    11.70473    11.70439
## HQ(n)      11.75588    11.76226    11.75127    11.72963    11.73482
## SC(n)      11.76980    11.78545    11.78374    11.77138    11.78585
## FPE(n) 126447.48020 126553.88745 124480.02097 121143.07359 121101.78267
##                  6           7           8           9          10          11
## AIC(n)    10.33822    10.34235    10.34261    10.34300    10.34724    10.34978
## HQ(n)     10.37418    10.38385    10.38964    10.39557    10.40534    10.41341
## SC(n)     10.43450    10.45344    10.46852    10.48372    10.50277    10.52012
## FPE(n) 30890.87400 31018.93079 31026.98120 31039.12344 31171.09002 31250.37386
##                 12          13          14          15          16          17
## AIC(n)    10.35202    10.35351    10.35204    10.35342    10.35812    10.36156
## HQ(n)     10.42119    10.42821    10.43227    10.43919    10.44942    10.45839
## SC(n)     10.53718    10.55348    10.56682    10.58302    10.60253    10.62078
## FPE(n) 31320.59749 31367.26535 31321.09895 31364.65641 31512.45178 31621.09687
```

```
##                 18          19          20
## AIC(n)    10.36068    10.35837    10.36011
## HQ(n)     10.46304    10.46627    10.47354
## SC(n)     10.63471    10.64722    10.66376
## FPE(n) 31593.29845 31520.72453 31575.63915
```

```
## Granger causality test
##
## Model 1: eth_negative_log_returns ~ Lags(eth_negative_log_returns, 1:6) + Lags(bitcoin_negative_log_
## Model 2: eth_negative_log_returns ~ Lags(eth_negative_log_returns, 1:6)
##   Res.Df Df      F    Pr(>F)
## 1   1420
## 2   1426 -6 811.12 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 14: Granger Causality Test: Ethereum Predicting Bitcoin

```
## Granger causality test
##
## Model 1: bitcoin_negative_log_returns ~ Lags(bitcoin_negative_log_returns, 1:6) + Lags(eth_negative_l
## Model 2: bitcoin_negative_log_returns ~ Lags(bitcoin_negative_log_returns, 1:6)
##   Res.Df Df      F Pr(>F)
## 1   1420
## 2   1426 -6 0.4948 0.8126
```

Code

Practical 1

Practical 2

Practical 3

Cleaning

EDA

Risk Analysis