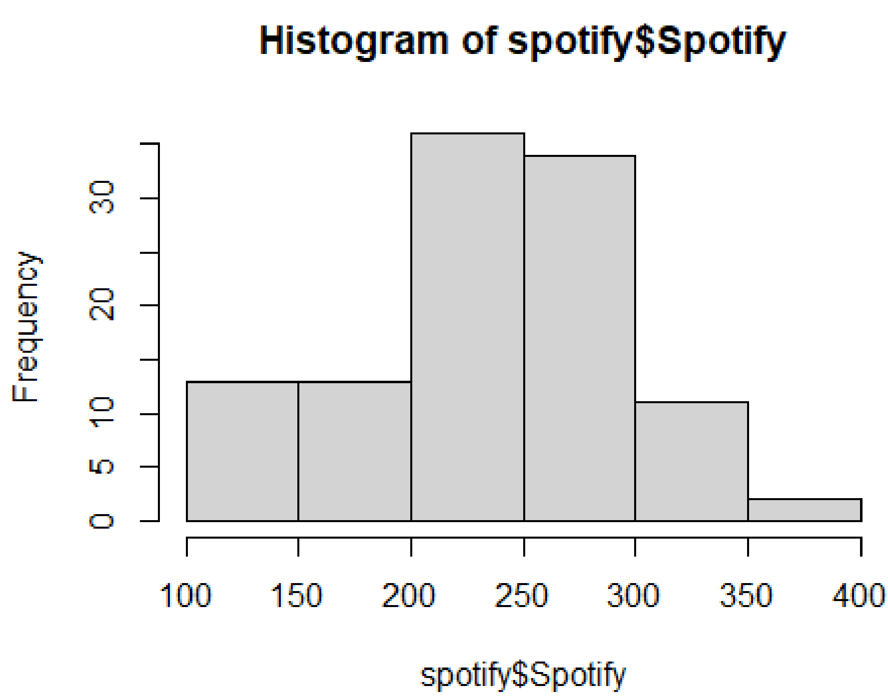
Import Data

```
library(readxl)
spotify <- read_excel("___.xlsx")View(spotify)
head(spotify)


## # A tibble: 6 x 2
##   Tanggal              Spotify
##   <dttm>                 <dbl>
## 1 2020-03-02 00:00:00    145.
## 2 2020-03-09 00:00:00    132.
## 3 2020-03-16 00:00:00    124.
## 4 2020-03-23 00:00:00    123.
## 5 2020-03-30 00:00:00    122.
## 6 2020-04-06 00:00:00    132.
```

Summary Data

```
summary(spotify)

##     Tanggal                Spotify
##  Min.   :2020-03-02   Min.   :122.1
##  1st Qu.:2020-09-07   1st Qu.:216.6
##  Median :2021-03-15   Median :243.7
##  Mean   :2021-03-15   Mean   :237.4
##  3rd Qu.:2021-09-20   3rd Qu.:272.1
##  Max.   :2022-03-28   Max.   :364.6

hist(spotify$Spotify)
```



Mengubah menjadi objek timeseries

```
spotify.timeseries<-ts(spotify$Spotify,start =c(1,109),frequency =109)

# Cetak data timeseries.
print(spotify.timeseries)
```

```
## Time Series:
## Start = c(1, 109)
## End = c(2, 108)
## Frequency = 109
##   [1] 145.14 131.56 124.36 122.54 122.12 131.86 141.86 137.84 144.84 152.1
5
##  [11] 158.83 190.17 180.93 184.28 180.07 231.29 264.95 271.49 278.24 263.2
3
##  [21] 268.74 257.82 252.12 251.32 270.98 279.36 248.21 241.60 233.89 235.9
8
##  [31] 240.28 250.00 262.55 283.49 239.89 276.10 253.50 260.00 277.62 319.7
7
##  [41] 341.22 336.10 328.39 314.66 353.11 319.82 338.96 315.00 310.77 339.7
0
##  [51] 364.59 307.38 274.98 279.89 272.11 261.31 273.10 279.20 292.02 284.1
1
##  [61] 252.12 239.41 223.59 229.14 241.57 236.17 243.66 247.64 266.38 267.8
3
##  [71] 262.83 243.24 243.64 228.67 221.97 211.48 216.64 226.02 249.04 247.7
6
##  [81] 248.10 230.20 229.33 232.88 247.40 252.96 289.40 289.05 280.56 259.5
5
##  [91] 250.89 228.80 233.26 235.28 236.63 234.03 223.58 218.56 195.53 172.9
8
## [101] 174.43 161.93 152.27 151.91 135.17 124.29 144.78 146.04 153.70
```

Plot Time Series

```
library(TSA)
```

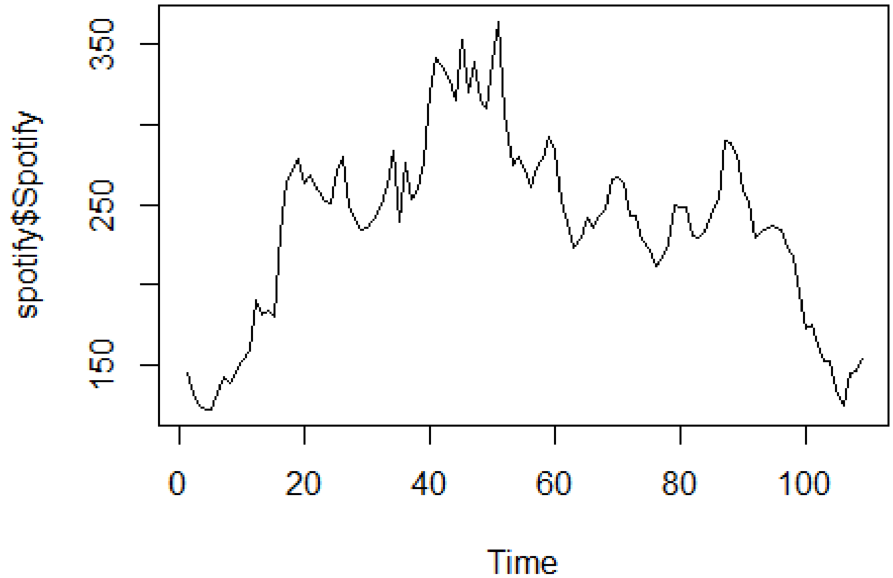
```
## Warning: package 'TSA' was built under R version 4.1.3
```

```
##
## Attaching package: 'TSA'
```

```
## The following objects are masked from 'package:stats':
##
##     acf, arima
```

```
## The following object is masked from 'package:utils':
##
##     tar
```

```
plot.ts(spotify$Spotify)
```

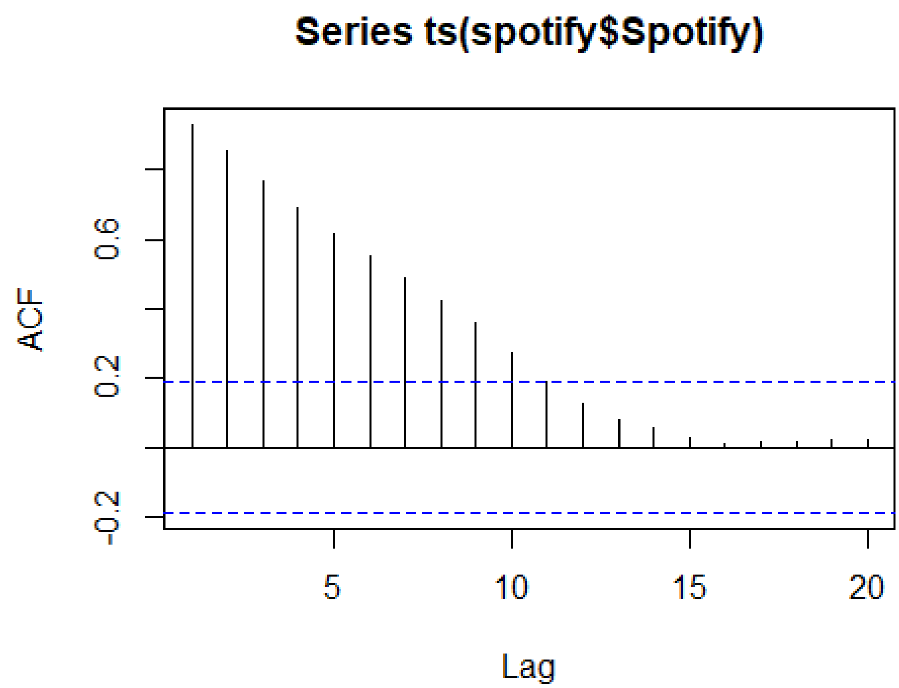


Uji Formal Stasioneritas Data

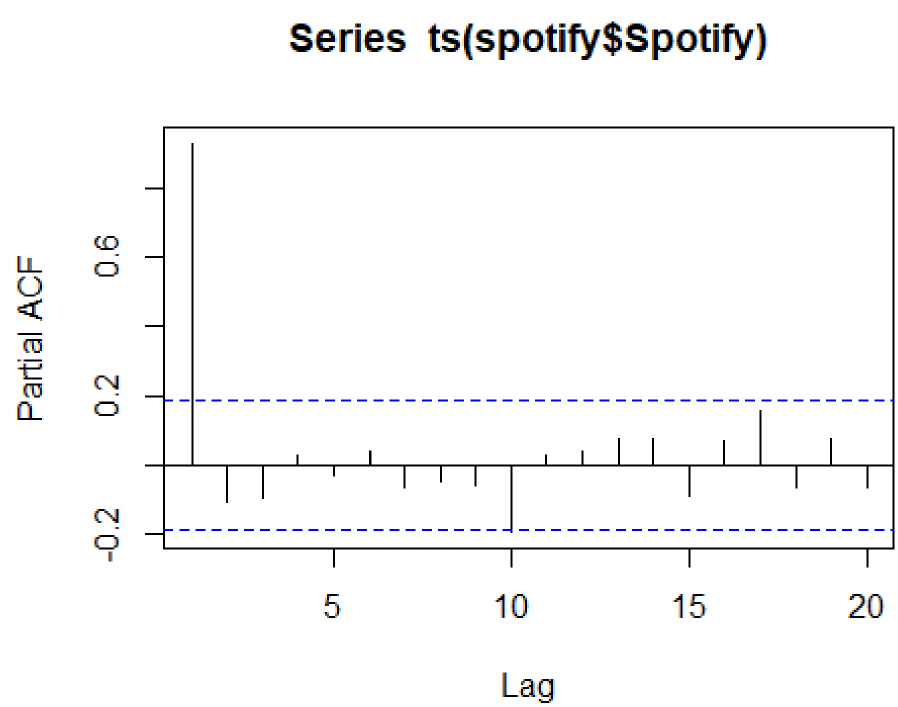
```
tseries::adf.test(ts(spotify$Spotify))

## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo

##
##  Augmented Dickey-Fuller Test
##
## data:  ts(spotify$Spotify)
## Dickey-Fuller = -2.0139, Lag order = 4, p-value = 0.5709
## alternative hypothesis: stationary

##dari niali p-value(0,5709) yang lebih besar dari alpha (0,05) maka dapat di
simpukan bahwa data tidak stasioner
```

Plot ACF dan PACF Data Asli

```
##plot acf
acf(ts(spotify$Spotify))
```




```r
##Pada plot acf lag menurun secara lambat

##plot pacf
pacf(ts(spotify$Spotify))
```

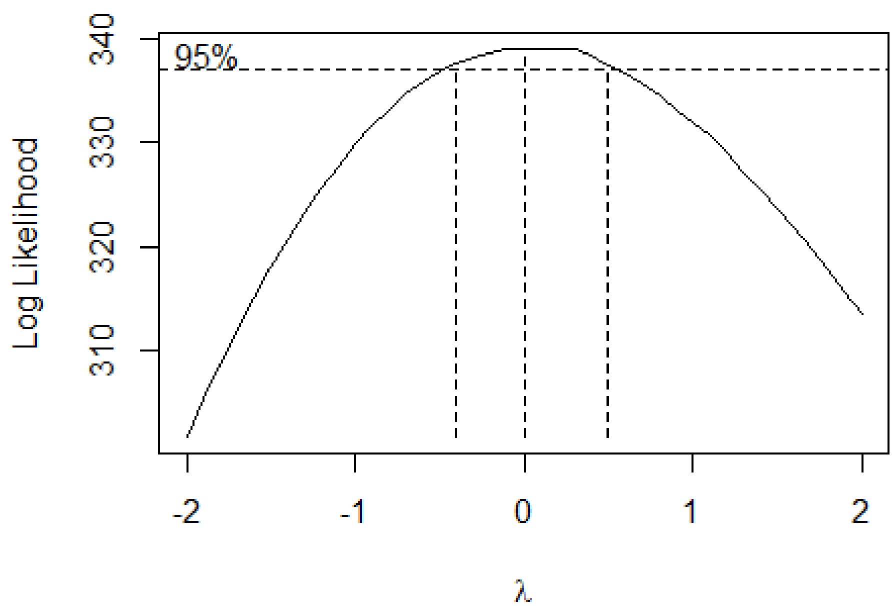


```
##Pada plot pacf hanya 1 lag yang keluar sehingga perlu dilakukan transformas
i boxcox
```

Berdasarkan gambar grafik didapatkan plot harga saham mingguan SPOT mengalami fluktuasi. Kemudian untuk plot ACF pada lag data mengalami penurunan secara lambat dan linier menuju 0. Sedangkan untuk plot PACF terlihat bahwa hanya ada 1 lag yang keluar dari garis batas. Selain itu, pada hasil pengujian ADF didapatkan p-value sebesar 0,5709 atau lebih besar dari α(0,05) sehingga dapat disimpulkan berdasarkan plot ACF, PACF, dan hasil uji ADF data belum statsioner dan perlu dilakukan transformasi Box-Cox serta differencing pada data.

Transformasi Box-Cox

```
library(MASS)
library(car)

BoxCox.ar(spotify$Spotify)
```




```
##Lambda pada plot di bawah maksimum di 0
```

Berdasarkan plot Box-Cox didapatkan nilai *rounded value* (lambda) yang diperoleh adalah sebesar 0 sehingga data ditransformasikan dengan rumus ln (Zt).

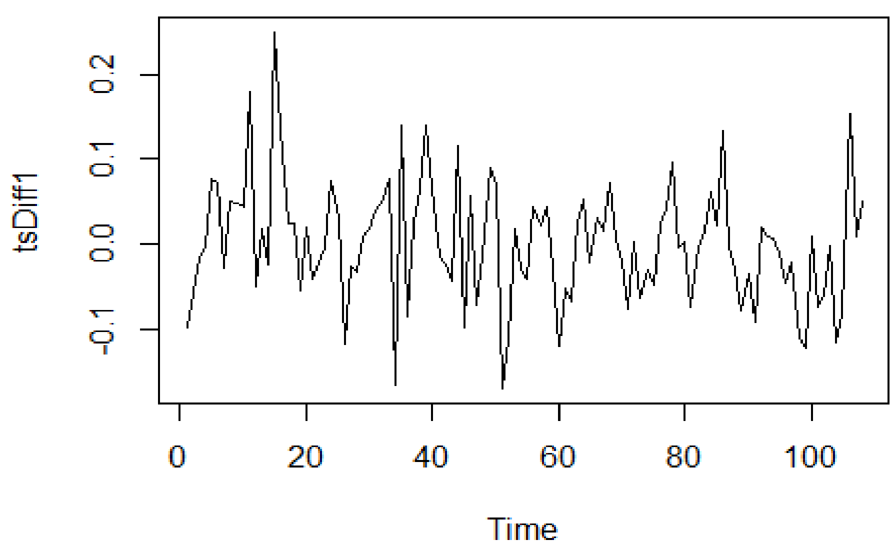
Print Data Hasil Transformasi Box Cox

```
boxcox <- bcPower(spotify$Spotify, 0)
boxcox

##   [1] 4.977699 4.879463 4.823181 4.808438 4.805004 4.881741 4.954841 4.926
094
##   [9] 4.975630 5.024867 5.067834 5.247918 5.198110 5.216456 5.193346 5.443
672
```

```
##  [17] 5.579541 5.603925 5.628484 5.573028 5.593744 5.552262 5.529905 5.526
727
##  [25] 5.602045 5.632501 5.514275 5.487283 5.454851 5.463747 5.481805 5.521
461
##  [33] 5.570441 5.647177 5.480180 5.620763 5.535364 5.560682 5.626253 5.767
602
##  [41] 5.832527 5.817409 5.794202 5.751493 5.866780 5.767758 5.825882 5.752
573
##  [49] 5.739053 5.828063 5.898773 5.728085 5.616698 5.634397 5.606206 5.565
707
##  [57] 5.609838 5.631928 5.676822 5.649361 5.529905 5.478178 5.409814 5.434
333
##  [65] 5.487159 5.464552 5.495774 5.511976 5.584924 5.590352 5.571507 5.494
049
##  [73] 5.495692 5.432280 5.402542 5.354130 5.378237 5.420624 5.517613 5.512
461
##  [81] 5.513832 5.438948 5.435162 5.450523 5.511006 5.533231 5.667810 5.666
600
##  [89] 5.636788 5.558949 5.525015 5.432848 5.452154 5.460776 5.466498 5.455
449
##  [97] 5.409769 5.387061 5.275714 5.153176 5.161523 5.087164 5.025655 5.023
288
## [105] 4.906533 4.822618 4.975215 4.983881 5.035003
```

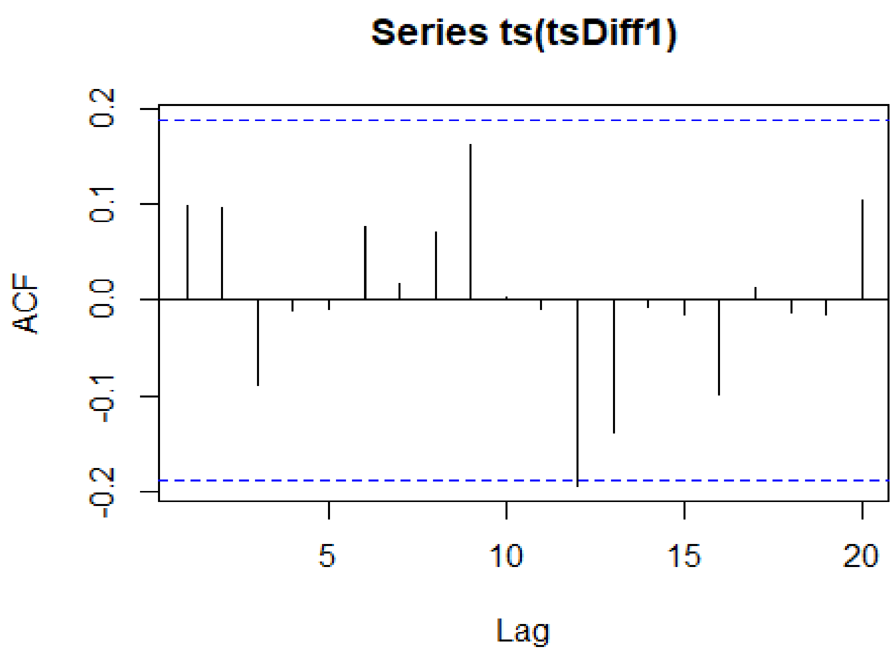
Differencing 1

```r
##Differencing
tsDiff1 <- diff(boxcox)
plot.ts(tsDiff1)
```

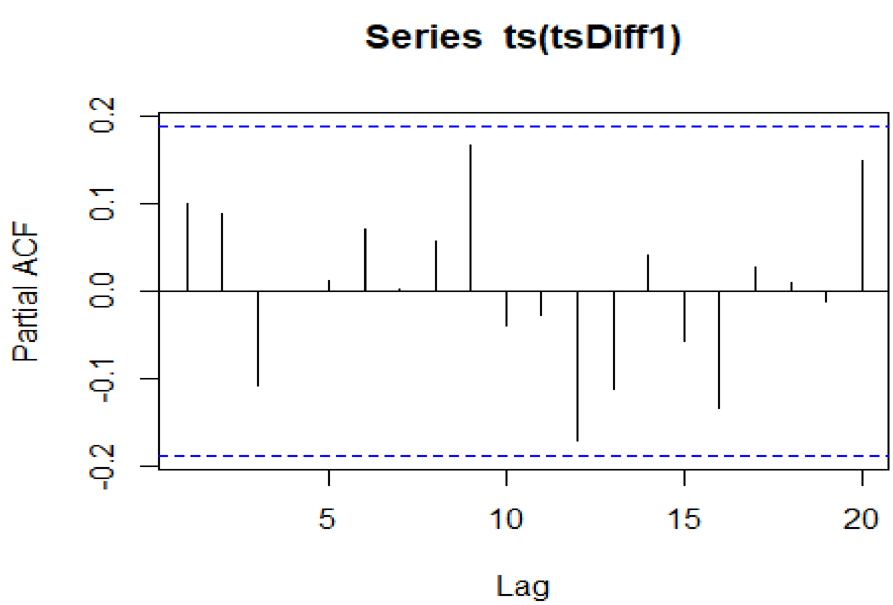


Plot ACF dan PACF Data Hasil Transformasi Box Cox dan Differencing 1

```
##plot ACF
acf(ts(tsDiff1))
```




```
##plot PACF
pacf(ts(tsDiff1))
```

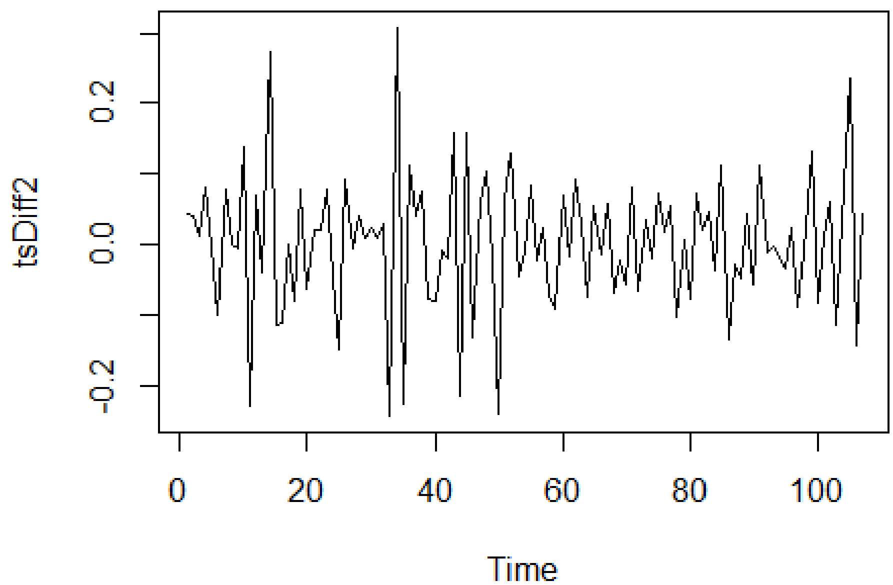


```
##Berdasarkan plot PACF terlihat bahwa belum terdapat lag yang keluar dari ba
tas
```

Berdasarkan gambar grafik masih terdapat kecenderungan menurun, sedangkan plot ACF dan PACF belum terdapat garis yang keluar baik pada lag yang berarti data hasil differencing 1 belum stasioner sehingga dilakukan differencing ke-2.

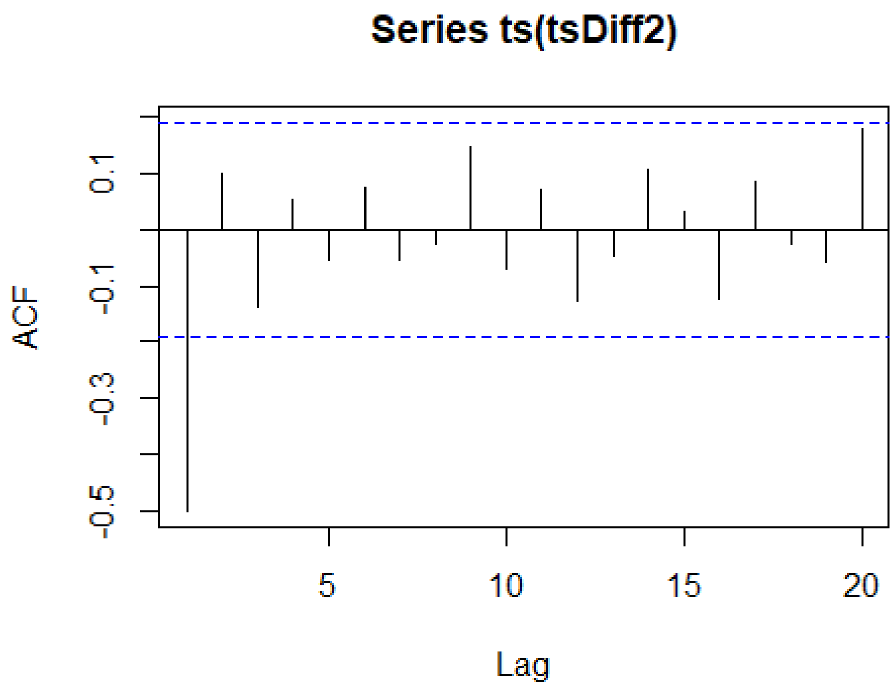
Differencing 2

```
##Differencing
tsDiff2 <- diff(tsDiff1)
plot.ts(tsDiff2)
```

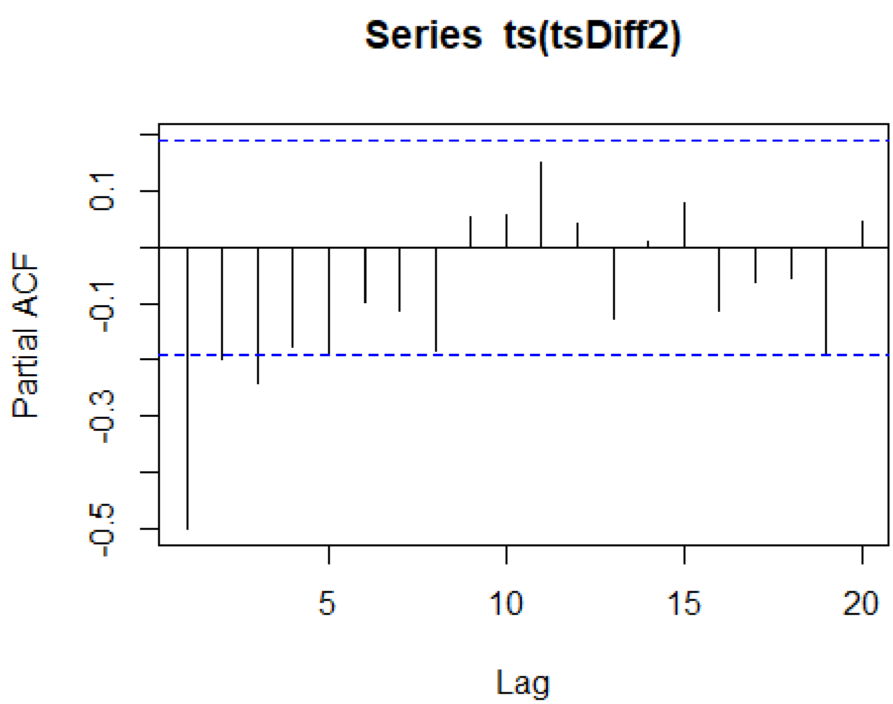


#Plot ACF, PACF, dan EACF Data Hasil Differencing 2

```
##plot ACF
acf(ts(tsDiff2))
```




```
##plot PACF
pacf(ts(tsDiff2))
```



```
##plot EACF
eacf(ts(tsDiff2))

## 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 x o o o o o o o o o  o  o  o
## 2 x x o o o o o o o o o  o  o  o
## 3 x x o x o o o o o o o  o  o  o
## 4 x x o x o o o o o o o  o  o  o
## 5 x x x o o o o o o o o  o  o  o
## 6 x o x o o o x o o o o  o  o  o
## 7 x o x o o o o o o o o  o  o  o
```

Berdasarkan hasil plot EACF, dapat diduga kemungkinan modelnya adalah IMA(2,1). Sementara itu dari plot ACF dan PACF, terlihat bahwa lag 1 yang secara signifikan keluar da ri garis. Maka, dapat diduga bahwa modelnya adalah ARI(1,2), IMA(2,1), dan ARIMA(1,2,1).

Model Estimasi

```
library(forecast)

## Warning: package 'forecast' was built under R version 4.1.3

## Registered S3 methods overwritten by 'forecast':
##   method       from
##   fitted.Arima TSA
##   plot.Arima   TSA

#model ar
model.ar<-arima(ts(boxcox), order = c(1,2,0), method = "ML")

#model ma
model.ma<-arima(ts(boxcox), order = c(0,2,1), method = "ML")

#model arma
model.arma<-arima(ts(boxcox), order = c(1,2,1), method = "ML")

#Pengujian parameter
lmtest::coeftest(model.ar)

##
## z test of coefficients:
##
##      Estimate Std. Error z value  Pr(>|z|)
## ar1 -0.496170   0.083283 -5.9576 2.559e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lmtest::coeftest(model.ma)
```

```
##
## z test of coefficients:
##
##      Estimate Std. Error z value  Pr(>|z|)
## ma1 -0.962119   0.030179  -31.88 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lmtest::coeftest(model.arma)
```

```
##
## z test of coefficients:
##
##      Estimate Std. Error  z value Pr(>|z|)
## ar1  0.084573   0.101521   0.8331   0.4048
## ma1 -0.968569   0.029659 -32.6563   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

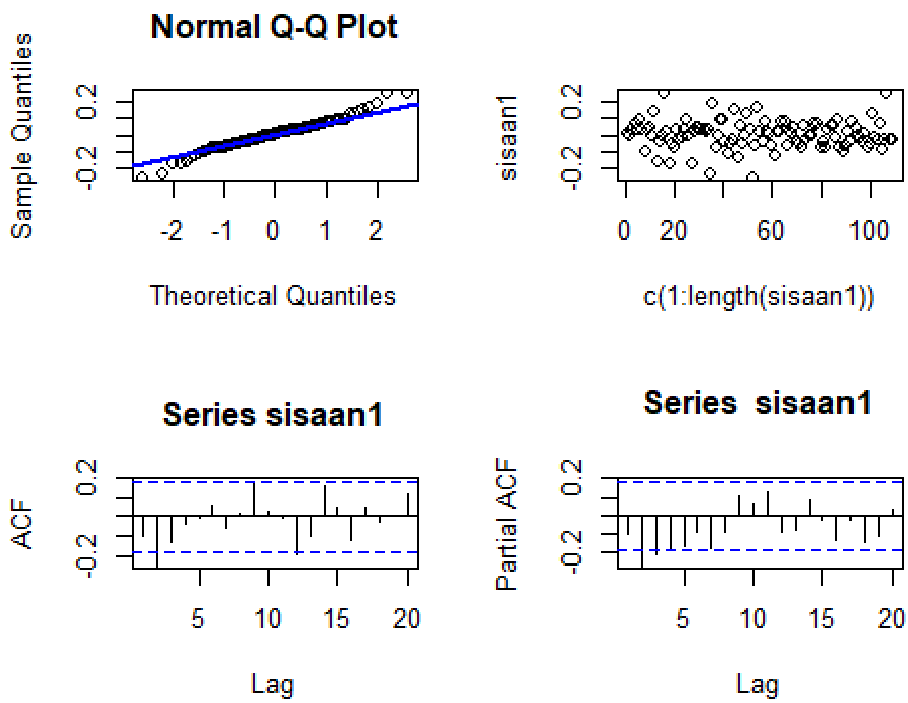
Diagnostik

```
(aic.model<- data.frame(Model = c("AR(1)","MA(1)","ARMA(1,1)"),
                       AIC = c(model.ar$aic, model.ma$aic, model.arma$aic)))
```

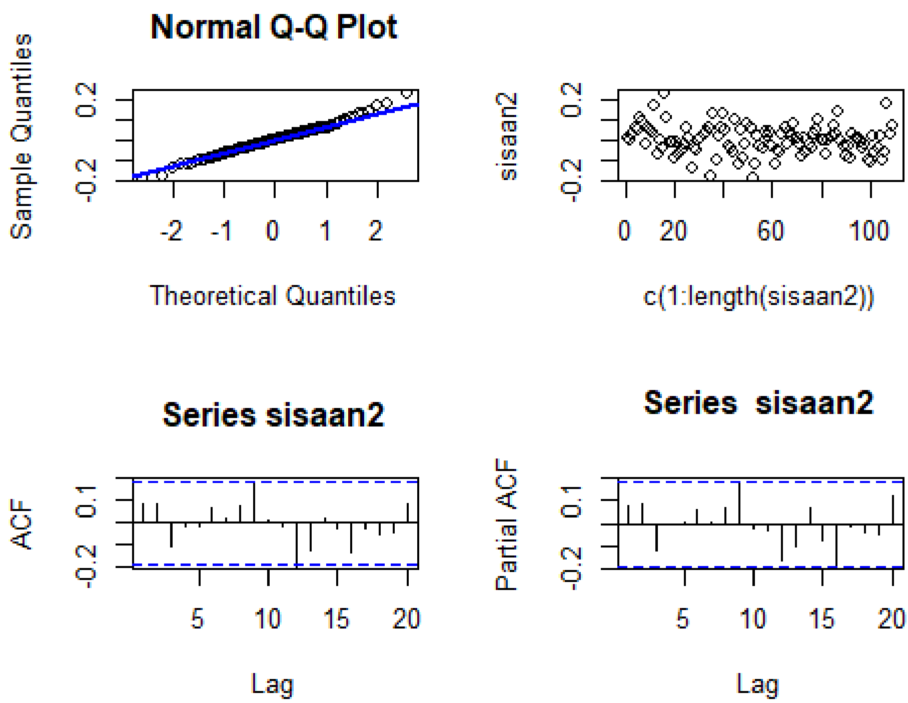
```
##       Model       AIC
## 1     AR(1) -225.5005
## 2     MA(1) -253.2999
## 3 ARMA(1,1) -251.9947
```

#Pengujian sisaan

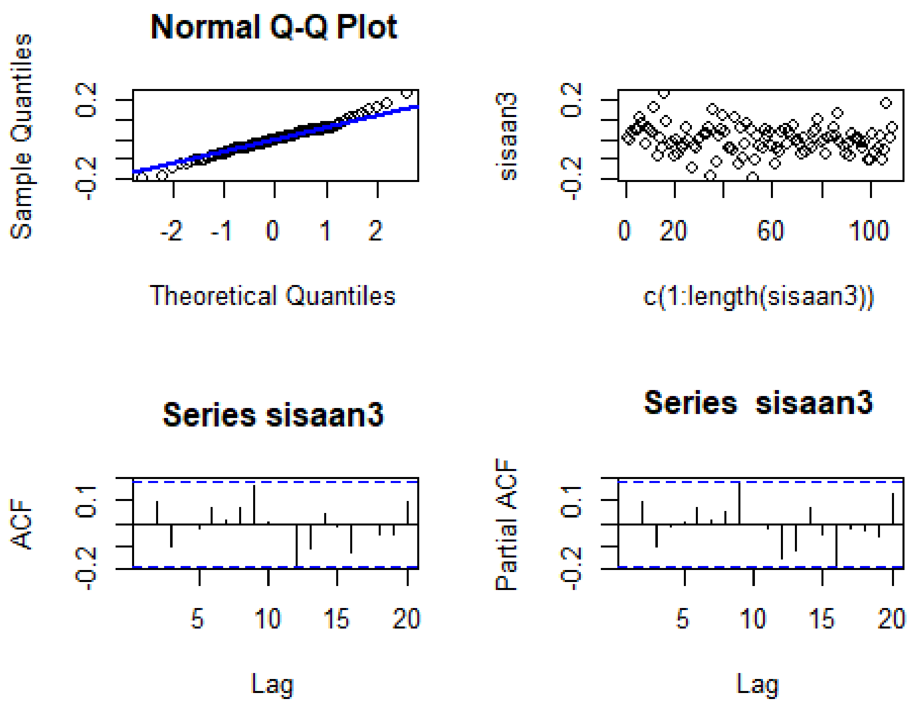
```
#model ar
sisaan1 <- model.ar$residuals
# Eksplorasi
par(mfrow=c(2,2))
qqnorm(sisaan1)
qqline(sisaan1, col = "blue", lwd = 2)
plot(c(1:length(sisaan1)),sisaan1)
acf(sisaan1)
pacf(sisaan1)
```




```
#model ma
sisaan2 <- model.ma$residuals
# Eksplorasi
par(mfrow=c(2,2))
qqnorm(sisaan2)
qqline(sisaan2, col = "blue", lwd = 2)
plot(c(1:length(sisaan2)),sisaan2)
acf(sisaan2)
pacf(sisaan2)
```




```r
#model arma
sisaan3 <- model.arma$residuals
# Eksplorasi
par(mfrow=c(2,2))
qqnorm(sisaan3)
qqline(sisaan3, col = "blue", lwd = 2)
plot(c(1:length(sisaan3)),sisaan3)
acf(sisaan3)
pacf(sisaan3)
```




```
# Uji formal normalitas data
#model ar
ks.test(sisaan1,"pnorm")

##
##  One-sample Kolmogorov-Smirnov test
##
## data:  sisaan1
## D = 0.41379, p-value < 2.2e-16
## alternative hypothesis: two-sided

#model ma
ks.test(sisaan2,"pnorm")

##
##  One-sample Kolmogorov-Smirnov test
##
## data:  sisaan2
## D = 0.42522, p-value < 2.2e-16
## alternative hypothesis: two-sided

#model arma
ks.test(sisaan3,"pnorm")

##
##  One-sample Kolmogorov-Smirnov test
##
## data:  sisaan3
```

```
## D = 0.42463, p-value < 2.2e-16
## alternative hypothesis: two-sided
```

Setelah memperoleh model mana yang memenuhi tes diagnostik, yaitu model IMA(2 ,1) Probabilistik, selanjutnya dilakukan uji nilai tengah residualnya dengan uji t. Model dap at diterima jika $p - value$ lebih dari $alpha$ (5%).

```
# Uji nilai tengah sisaan
#model ar
t.test(sisaan1, mu = 0, alternative = "two.sided")

##
##  One Sample t-test
##
## data:  sisaan1
## t = 0.22163, df = 108, p-value = 0.825
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -0.01400641  0.01753286
## sample estimates:
##   mean of x
## 0.001763224

#model ma
t.test(sisaan2, mu = 0, alternative = "two.sided")

##
##  One Sample t-test
##
## data:  sisaan2
## t = -0.45607, df = 108, p-value = 0.6493
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -0.01683935  0.01053981
## sample estimates:
##    mean of x
## -0.003149773

#model arma
t.test(sisaan3, mu = 0, alternative = "two.sided")

##
##  One Sample t-test
##
## data:  sisaan3
## t = -0.48831, df = 108, p-value = 0.6263
## alternative hypothesis: true mean is not equal to 0
```

```
## 95 percent confidence interval:
##  -0.01700282  0.01028136
## sample estimates:
##   mean of x
## -0.00336073
```

Berdasarkan hasil uji t pada model IMA(2,1) Probabilistik, diketahui bahwa nilai $p-value$ yang diperoleh lebih dari $alpha$ (5%), sehingga kesimpulannya adalah rata-rata residual pada model IMA(2,1) Probabilistik memiliki rata-rata residual sama dengan nol.

```
# Uji autokorelasi
#model ar
Box.test(sisaan1,lag=106, type = "Ljung")

##
##  Box-Ljung test
##
## data:  sisaan1
## X-squared = 142.12, df = 106, p-value = 0.01104

#model ma
Box.test(sisaan2,lag=106, type = "Ljung")

##
##  Box-Ljung test
##
## data:  sisaan2
## X-squared = 111.3, df = 106, p-value = 0.3433

#model arma
Box.test(sisaan3,lag=106, type = "Ljung")

##
##  Box-Ljung test
##
## data:  sisaan3
## X-squared = 106.31, df = 106, p-value = 0.4732

(model.ma2<- arima(ts(boxcox), order = c(0,2,2), method = "ML"))

##
## Call:
## arima(x = ts(boxcox), order = c(0, 2, 2), method = "ML")
##
## Coefficients:
##           ma1      ma2
##       -0.8969  -0.0679
## s.e.   0.0892   0.0881
##
## sigma^2 estimated as 0.005228:  log likelihood = 127.94,  aic = -251.88

lmtest::coeftest(model.ma2)
```

```
##
## z test of coefficients:
##
##      Estimate Std. Error z value Pr(>|z|)
## ma1 -0.896922   0.089232 -10.052   <2e-16 ***
## ma2 -0.067897   0.088062  -0.771   0.4407
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

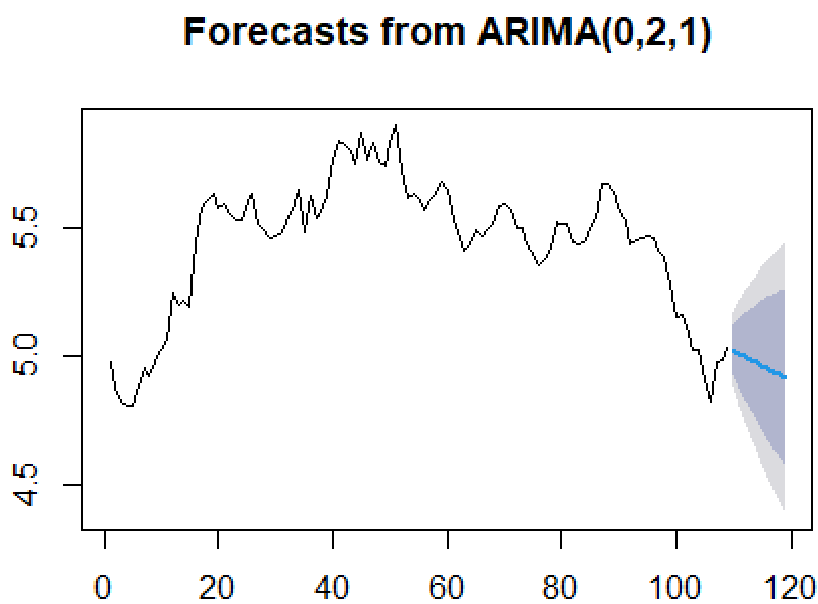
MAPE & Forecasting

```
library(forecast)
ramalan<- forecast::forecast(ts(boxcox),model=model.ma)
summary(ramalan)
```

```
##
## Forecast method: ARIMA(0,2,1)
##
## Model Information:
## Series: object
## ARIMA(0,2,1)
##
## Coefficients:
##           ma1
##       -0.9621
## s.e.   0.0000
##
## sigma^2 = 0.005257:  log likelihood = 127.65
## AIC=-253.3   AICc=-253.26   BIC=-250.63
##
## Error measures:
##                        ME       RMSE         MAE         MPE     MAPE      M
ASE
## Training set -0.003149773 0.07184196 0.05524467 -0.05218996 1.017865 1.003
883
##                    ACF1
## Training set 0.08014466
##
## Forecasts:
##     Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## 110       5.023272 4.930350 5.116194 4.881160 5.165384
## 111       5.011541 4.877616 5.145466 4.806720 5.216361
## 112       4.999810 4.832690 5.166929 4.744223 5.255397
## 113       4.988079 4.791512 5.184645 4.687456 5.288701
## 114       4.976348 4.752542 5.200153 4.634067 5.318629
## 115       4.964617 4.715006 5.214228 4.582870 5.346364
## 116       4.952886 4.678454 5.227318 4.533178 5.372593
## 117       4.941155 4.642599 5.239711 4.484553 5.397757
## 118       4.929424 4.607245 5.251603 4.436694 5.422154
## 119       4.917693 4.572255 5.263131 4.389391 5.445995
```

#Plot Forecasting

```
plot(ramalan)
```



Hasil Forecast ditransformasikan kembali dalam satuan yang sesuai dengan data awal yaitu e^{z_t}.

	Forecast	Lo 80	Hi 80	Lo 95	Hi 95
##110	151,9075	138,428	166,6997	131,7834	175,1047
##111	150,1359	131,3172	171,6515	122,3297	184,2624
##112	148,385	125,5482	175,3754	114,9185	191,5975
##113	146,6544	120,4834	178,5101	108,5766	198,0859
##114	144,9441	115,8785	181,3	102,9318	204,1039
##115	143,2537	111,6095	183,8698	97,79466	209,8439
##116	141,583	107,6036	186,2925	93,05382	215,4207
##117	139,9318	103,8138	188,6156	88,63732	220,9104
##118	138,2998	100,2077	190,872	84,49514	226,3662
##119	136,6869	96,76206	193,0851	80,59132	231,8278

Berdasarkan hasil forecast data saham mingguan SPOT, dapat dilihat bahwa setiap minggunya saham mengalami penurunan. Selanjutnya, untuk keakuratan peramalan dapat dilihat melalui pengukuran MAPE dan didapatkan nilai sebesar 1,017865% yang berarti peramalan harga saham mingguan SPOT dengan model IMA(2,1) sangat akurat karena kurang dari 10%.