Training Project - ARIMA

Library

```r
library(fpp3)
```

```
## Warning: package 'fpp3' was built under R version 4.0.5

## -- Attaching packages ----------------------------------------- fpp3 0.4.0 --

## v tibble      3.1.4      v tsibble     1.0.1
## v dplyr       1.0.7      v tsibbledata 0.3.0
## v tidyr       1.1.4      v feasts      0.2.2
## v lubridate   1.7.10     v fable       0.3.1
## v ggplot2     3.3.5

## Warning: package 'tibble' was built under R version 4.0.5

## Warning: package 'dplyr' was built under R version 4.0.5

## Warning: package 'tidyr' was built under R version 4.0.5

## Warning: package 'lubridate' was built under R version 4.0.5

## Warning: package 'ggplot2' was built under R version 4.0.5

## Warning: package 'tsibble' was built under R version 4.0.5

## Warning: package 'tsibbledata' was built under R version 4.0.5

## Warning: package 'feasts' was built under R version 4.0.5

## Warning: package 'fabletools' was built under R version 4.0.5

## Warning: package 'fable' was built under R version 4.0.5

## -- Conflicts -------------------------------------------- fpp3_conflicts --
## x lubridate::date()    masks base::date()
## x dplyr::filter()      masks stats::filter()
## x tsibble::intersect() masks base::intersect()
## x tsibble::interval()  masks lubridate::interval()
## x dplyr::lag()         masks stats::lag()
## x tsibble::setdiff()   masks base::setdiff()
## x tsibble::union()     masks base::union()
```

```r
library(TTR)
```

```
## Warning: package 'TTR' was built under R version 4.0.5
```

```r
library(ggplot2)
library(tsibble)
library(tsibbledata)
library(dplyr)
library(forecast)
```

```
## Warning: package 'forecast' was built under R version 4.0.5
```

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

```r
library(fpp)
```

```
## Warning: package 'fpp' was built under R version 4.0.5
```

```
## Loading required package: fma
```

```
## Warning: package 'fma' was built under R version 4.0.5
```

```
## Loading required package: expsmooth
```

```
## Warning: package 'expsmooth' was built under R version 4.0.5
```

```
## Loading required package: lmtest
```

```
## Warning: package 'lmtest' was built under R version 4.0.5
```

```
## Loading required package: zoo
```

```
## Warning: package 'zoo' was built under R version 4.0.5
```

```
##
## Attaching package: 'zoo'
```

```
## The following object is masked from 'package:tsibble':
##
##     index
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
## Loading required package: tseries
```

```
## Warning: package 'tseries' was built under R version 4.0.5
```

```
##
## Attaching package: 'fpp'
```

```
## The following object is masked from 'package:fpp3':
##
##     insurance
```

```r
library(fpp2)
```

```
## Warning: package 'fpp2' was built under R version 4.0.5
```

```
##
## Attaching package: 'fpp2'
```

```
## The following objects are masked from 'package:fpp':
##
##     ausair, ausbeer, austa, austourists, debitcards, departures,
##     elecequip, euretail, guinearice, oil, sunspotarea, usmelec
```

```
## The following object is masked from 'package:fpp3':
##
##     insurance
```

```r
library(bsts)
```

```
## Warning: package 'bsts' was built under R version 4.0.5
```

```
## Loading required package: BoomSpikeSlab
```

```
## Warning: package 'BoomSpikeSlab' was built under R version 4.0.5
```

```
## Loading required package: Boom
```

```
## Warning: package 'Boom' was built under R version 4.0.5
```

```
## Loading required package: MASS
```

```
##
## Attaching package: 'MASS'
```

```
## The following objects are masked from 'package:fma':
##
##     cement, housing, petrol
```

```
## The following object is masked from 'package:dplyr':
##
##     select
```

```
## 
## Attaching package: 'Boom'

## The following object is masked from 'package:stats':
## 
##      rWishart


## 
## Attaching package: 'BoomSpikeSlab'

## The following object is masked from 'package:stats':
## 
##      knots


## Loading required package: xts

## Warning: package 'xts' was built under R version 4.0.5


## 
## Attaching package: 'xts'

## The following objects are masked from 'package:dplyr':
## 
##      first, last


## 
## Attaching package: 'bsts'

## The following object is masked from 'package:BoomSpikeSlab':
## 
##      SuggestBurn
```

```r
library(prophet)
```

```
## Warning: package 'prophet' was built under R version 4.0.5

## Loading required package: Rcpp

## Warning: package 'Rcpp' was built under R version 4.0.5

## Loading required package: rlang

## Warning: package 'rlang' was built under R version 4.0.5
```

```r
library(repr)
```

```
## Warning: package 'repr' was built under R version 4.0.5
```

```r
library(readxl)
```

```
## Warning: package 'readxl' was built under R version 4.0.5
```

```r
Tng_Ctr_Hour <- read_excel("C:/Users/prach/Desktop/Rutgers/BF/Project/Tng_Ctr_Hour.xlsx")
View(Tng_Ctr_Hour)
summary(Tng_Ctr_Hour)
```

```
##      Year              Quarter             Month            Device_Hrs
##  Length:81          Length:81          Length:81          Min.   : 222.8
##  Class :character   Class :character   Class :character   1st Qu.: 899.0
##  Mode  :character   Mode  :character   Mode  :character   Median :1008.0
##                                                           Mean   : 990.1
##                                                           3rd Qu.:1101.7
##                                                           Max.   :1519.9
##  DH_Prev_Year       DH_YoY_Change      DH_YoY_Ch_Per      Total_Inst_Hrs
##  Length:81          Length:81          Length:81          Min.   : 504.6
##  Class :character   Class :character   Class :character   1st Qu.:1937.3
##  Mode  :character   Mode  :character   Mode  :character   Median :2203.2
##                                                           Mean   :2165.7
##                                                           3rd Qu.:2446.8
##                                                           Max.   :3084.1
##  Total_Inst_Hrs_Prev_Year Inst_Hrs_YoY_Change Total_Inst_Hrs_YoY_Change_Per2
##  Length:81                Length:81           Length:81
##  Class :character         Class :character    Class :character
##  Mode  :character         Mode  :character    Mode  :character
##
##
##
```

```r
df_Tng = Tng_Ctr_Hour[,c(4)]
df_Tng
```

```
## # A tibble: 81 x 1
##    Device_Hrs
##         <dbl>
##  1       960.
##  2       944.
##  3      1429.
##  4      1097
##  5       916.
##  6       783.
##  7      1035.
##  8      1170.
##  9      1027.
## 10      1262.
## # ... with 71 more rows
```

```r
half_tng = ts(data = df_Tng,frequency = 12,start = c(2015, 1),end = c(2018,12))
half_tng
```

```
##           Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep
## 2015   960.42  944.08 1429.12 1097.00  915.85  783.45 1034.52 1169.50 1027.08
## 2016   796.42  874.55 1091.55 1141.84  871.36 1181.21  757.59  972.73  807.02
## 2017   995.09  962.00 1130.24 1054.71 1044.95 1013.73  693.33  983.25  987.64
## 2018  1060.57 1200.25 1262.25 1184.45 1059.92  993.55  908.37 1096.93 1121.75
##           Oct     Nov     Dec
## 2015  1262.32  999.25  929.42
## 2016  1519.92 1101.67  801.83
## 2017  1252.69  969.31  806.10
## 2018  1412.47 1010.25  970.12
```

```
plot(half_tng)
```
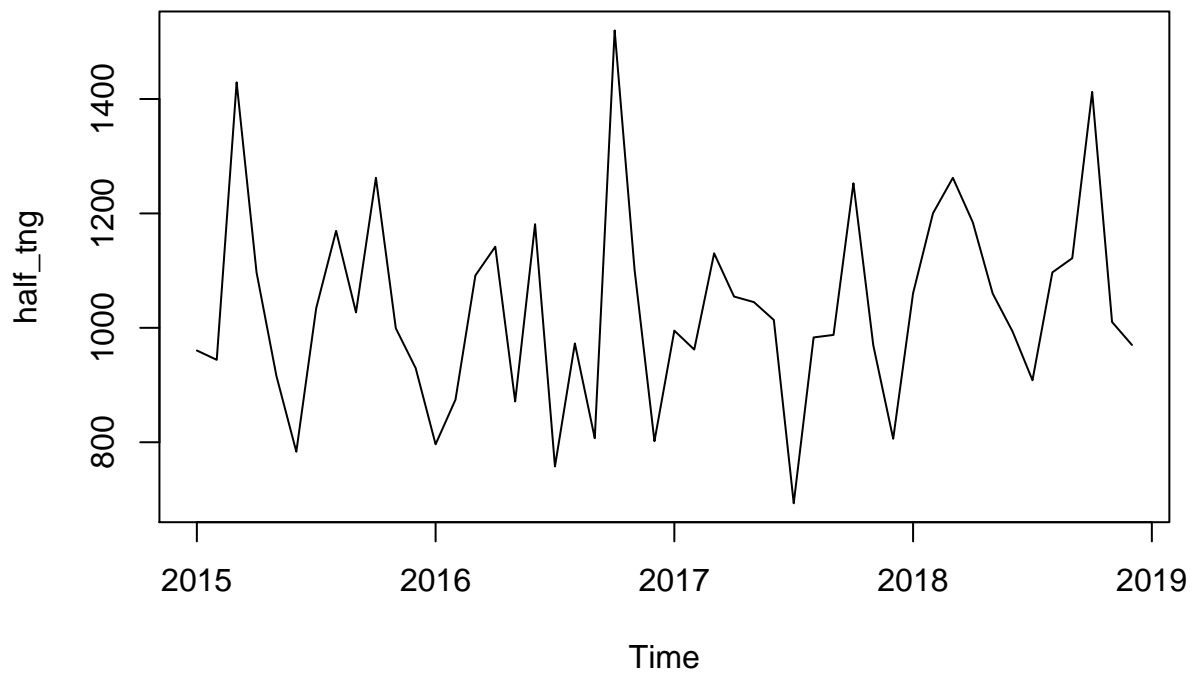


```
adf.test(half_tng)
```

```
## Warning in adf.test(half_tng): p-value smaller than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  half_tng
## Dickey-Fuller = -5.3294, Lag order = 3, p-value = 0.01
## alternative hypothesis: stationary
```

```
kpss.test(half_tng)
```

```
## Warning in kpss.test(half_tng): p-value greater than printed p-value
```

```
##
##  KPSS Test for Level Stationarity
##
## data:  half_tng
## KPSS Level = 0.16197, Truncation lag parameter = 3, p-value = 0.1
```
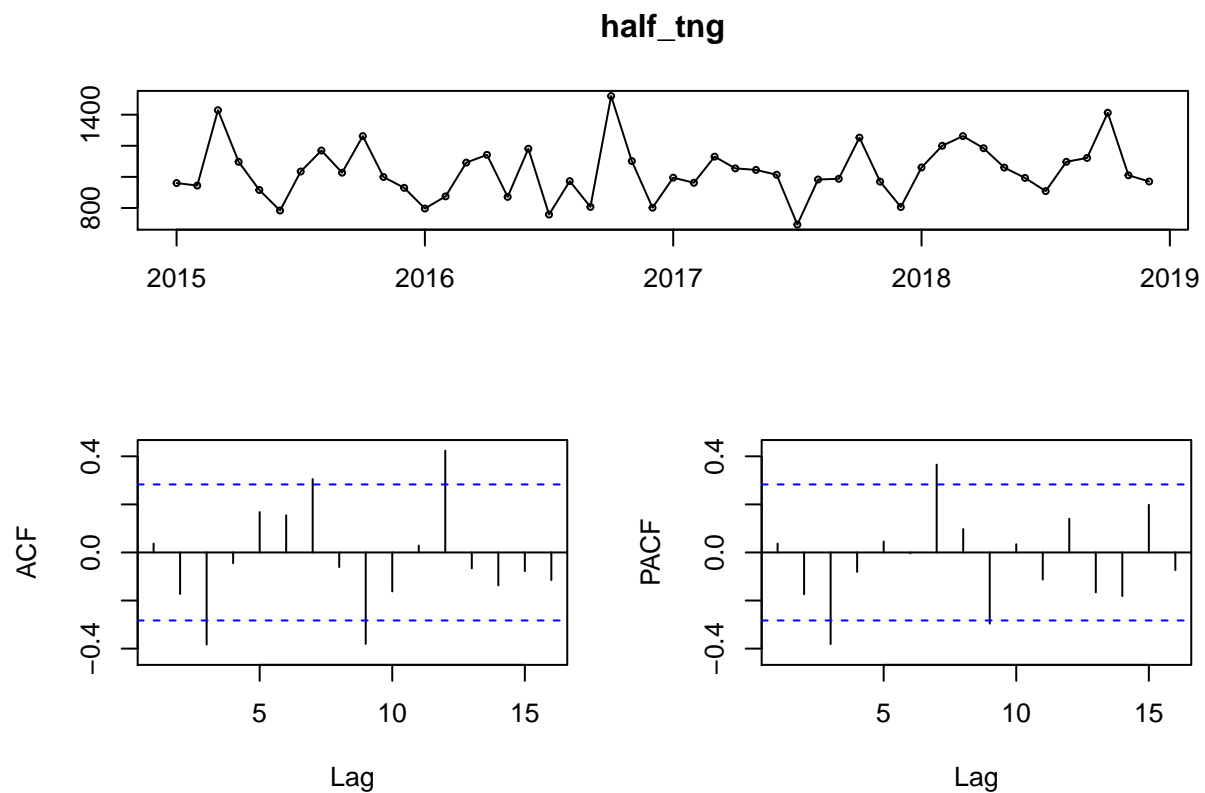
```
nsdiffs(half_tng)
```
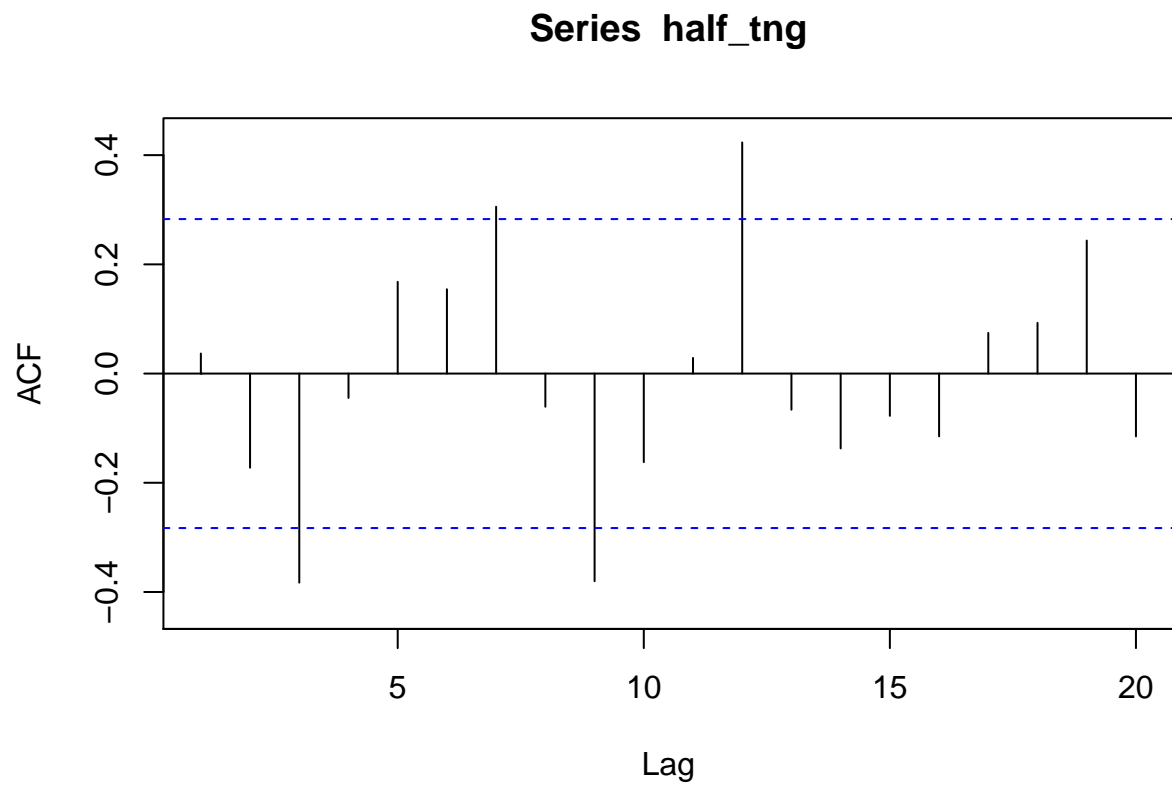
```
## [1] 1
```

```
ndiffs(half_tng)
```
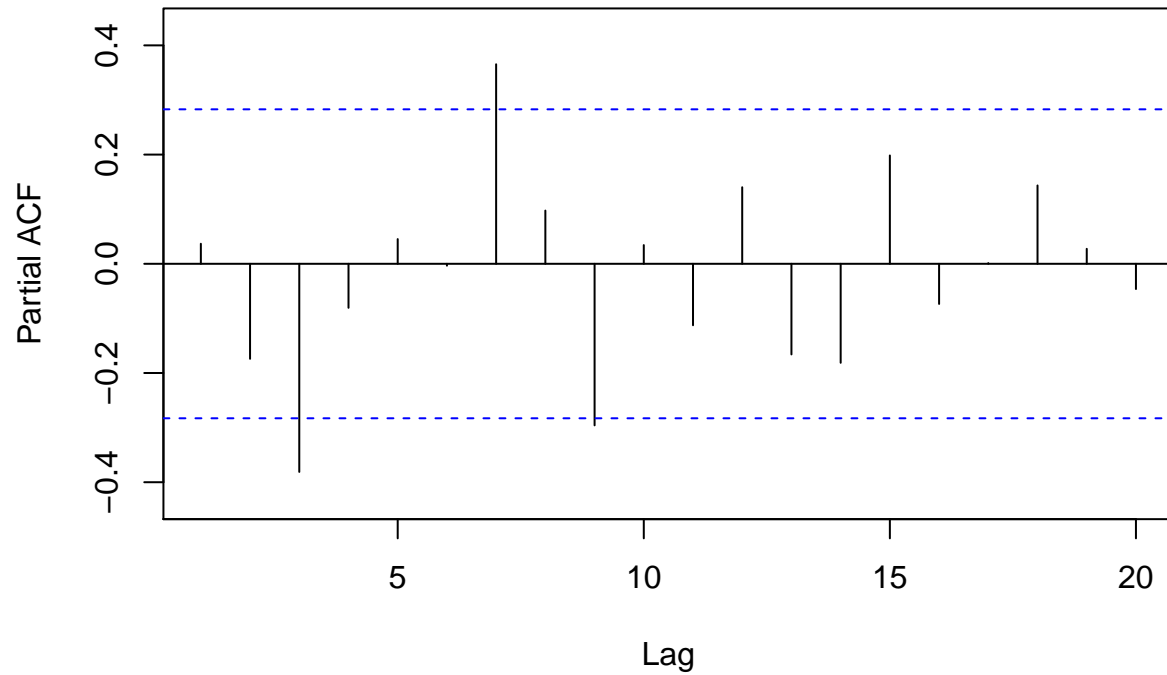
```
## [1] 0
```

```
tsdisplay(half_tng)
```

half_tng

```
Acf(half_tng, lag.max=20)
```

Series half_tng


```
Pacf(half_tng, lag.max=20) ## p is 1,2,3
```

Series half_tng


```
auto.arima(half_tng)
```

```
## Series: half_tng
## ARIMA(0,1,1)(1,1,0)[12]
##
## Coefficients:
##           ma1      sar1
##       -0.8729   -0.3746
## s.e.   0.0903    0.1942
##
## sigma^2 estimated as 27192:  log likelihood=-229.02
## AIC=464.03    AICc=464.8   BIC=468.7
```

```
auto.arima(half_tng,trace = TRUE, stepwise = FALSE) ##run all the models
```

```
##
##   ARIMA(0,1,0)(0,1,0)[12]                 : 484.0533
##   ARIMA(0,1,0)(0,1,1)[12]                 : Inf
##   ARIMA(0,1,0)(1,1,0)[12]                 : 481.0162
##   ARIMA(0,1,0)(1,1,1)[12]                 : Inf
##   ARIMA(0,1,1)(0,1,0)[12]                 : 465.4676
##   ARIMA(0,1,1)(0,1,1)[12]                 : Inf
##   ARIMA(0,1,1)(1,1,0)[12]                 : 464.8046
##   ARIMA(0,1,1)(1,1,1)[12]                 : Inf
```

```
##  ARIMA(0,1,2)(0,1,0)[12]                    : 467.7442
##  ARIMA(0,1,2)(0,1,1)[12]                    : Inf
##  ARIMA(0,1,2)(1,1,0)[12]                    : 467.3637
##  ARIMA(0,1,2)(1,1,1)[12]                    : Inf
##  ARIMA(0,1,3)(0,1,0)[12]                    : 470.1542
##  ARIMA(0,1,3)(0,1,1)[12]                    : Inf
##  ARIMA(0,1,3)(1,1,0)[12]                    : 469.8397
##  ARIMA(0,1,3)(1,1,1)[12]                    : Inf
##  ARIMA(0,1,4)(0,1,0)[12]                    : 466.5286
##  ARIMA(0,1,4)(0,1,1)[12]                    : Inf
##  ARIMA(0,1,4)(1,1,0)[12]                    : 466.677
##  ARIMA(0,1,5)(0,1,0)[12]                    : Inf
##  ARIMA(1,1,0)(0,1,0)[12]                    : 475.7162
##  ARIMA(1,1,0)(0,1,1)[12]                    : Inf
##  ARIMA(1,1,0)(1,1,0)[12]                    : 475.5616
##  ARIMA(1,1,0)(1,1,1)[12]                    : Inf
##  ARIMA(1,1,1)(0,1,0)[12]                    : 467.7553
##  ARIMA(1,1,1)(0,1,1)[12]                    : Inf
##  ARIMA(1,1,1)(1,1,0)[12]                    : Inf
##  ARIMA(1,1,1)(1,1,1)[12]                    : Inf
##  ARIMA(1,1,2)(0,1,0)[12]                    : 469.5689
##  ARIMA(1,1,2)(0,1,1)[12]                    : Inf
##  ARIMA(1,1,2)(1,1,0)[12]                    : 469.8107
##  ARIMA(1,1,2)(1,1,1)[12]                    : Inf
##  ARIMA(1,1,3)(0,1,0)[12]                    : 470.9884
##  ARIMA(1,1,3)(0,1,1)[12]                    : Inf
##  ARIMA(1,1,3)(1,1,0)[12]                    : 472.2383
##  ARIMA(1,1,4)(0,1,0)[12]                    : Inf
##  ARIMA(2,1,0)(0,1,0)[12]                    : 476.926
##  ARIMA(2,1,0)(0,1,1)[12]                    : Inf
##  ARIMA(2,1,0)(1,1,0)[12]                    : 476.5811
##  ARIMA(2,1,0)(1,1,1)[12]                    : Inf
##  ARIMA(2,1,1)(0,1,0)[12]                    : 470.298
##  ARIMA(2,1,1)(0,1,1)[12]                    : Inf
##  ARIMA(2,1,1)(1,1,0)[12]                    : 469.8879
##  ARIMA(2,1,1)(1,1,1)[12]                    : Inf
##  ARIMA(2,1,2)(0,1,0)[12]                    : 472.0187
##  ARIMA(2,1,2)(0,1,1)[12]                    : Inf
##  ARIMA(2,1,2)(1,1,0)[12]                    : 471.8468
##  ARIMA(2,1,3)(0,1,0)[12]                    : Inf
##  ARIMA(3,1,0)(0,1,0)[12]                    : 468.4805
##  ARIMA(3,1,0)(0,1,1)[12]                    : Inf
##  ARIMA(3,1,0)(1,1,0)[12]                    : 467.4776
##  ARIMA(3,1,0)(1,1,1)[12]                    : Inf
##  ARIMA(3,1,1)(0,1,0)[12]                    : 468.2049
##  ARIMA(3,1,1)(0,1,1)[12]                    : Inf
##  ARIMA(3,1,1)(1,1,0)[12]                    : 468.4294
##  ARIMA(3,1,2)(0,1,0)[12]                    : 470.7111
##  ARIMA(4,1,0)(0,1,0)[12]                    : 470.3022
##  ARIMA(4,1,0)(0,1,1)[12]                    : Inf
##  ARIMA(4,1,0)(1,1,0)[12]                    : 469.8215
##  ARIMA(4,1,1)(0,1,0)[12]                    : 470.7823
##  ARIMA(5,1,0)(0,1,0)[12]                    : 472.0753
##
```

```
##
##
##  Best model: ARIMA(0,1,1)(1,1,0)[12]


## Series: half_tng
## ARIMA(0,1,1)(1,1,0)[12]
##
## Coefficients:
##           ma1      sar1
##       -0.8729   -0.3746
## s.e.   0.0903    0.1942
##
## sigma^2 estimated as 27192:  log likelihood=-229.02
## AIC=464.03   AICc=464.8   BIC=468.7
```

```
auto_fit = auto.arima(half_tng)
auto_fit
```

```
## Series: half_tng
## ARIMA(0,1,1)(1,1,0)[12]
##
## Coefficients:
##           ma1      sar1
##       -0.8729   -0.3746
## s.e.   0.0903    0.1942
##
## sigma^2 estimated as 27192:  log likelihood=-229.02
## AIC=464.03   AICc=464.8   BIC=468.7
```

```
attributes(auto_fit)
```

```
## $names
##  [1] "coef"      "sigma2"    "var.coef"  "mask"      "loglik"    "aic"
##  [7] "arma"      "residuals" "call"      "series"    "code"      "n.cond"
## [13] "nobs"      "model"     "bic"       "aicc"      "x"         "fitted"
##
## $class
## [1] "forecast_ARIMA" "ARIMA"          "Arima"
```

```
forecast_ts = forecast(auto_fit, h=5)
forecast_ts
```

```
##          Point Forecast    Lo 80     Hi 80    Lo 95    Hi 95
## Jan 2019       1113.566  902.2265 1324.905 790.3504 1436.781
## Feb 2019       1188.517  975.4772 1401.557 862.7006 1514.334
## Mar 2019       1290.320 1075.5923 1505.048 961.9223 1618.718
## Apr 2019       1213.371  996.9683 1429.773 882.4119 1544.329
## May 2019       1131.839  913.7752 1349.903 798.3392 1465.339
```

```
plot(forecast_ts)
```

Forecasts from ARIMA(0,1,1)(1,1,0)[12]
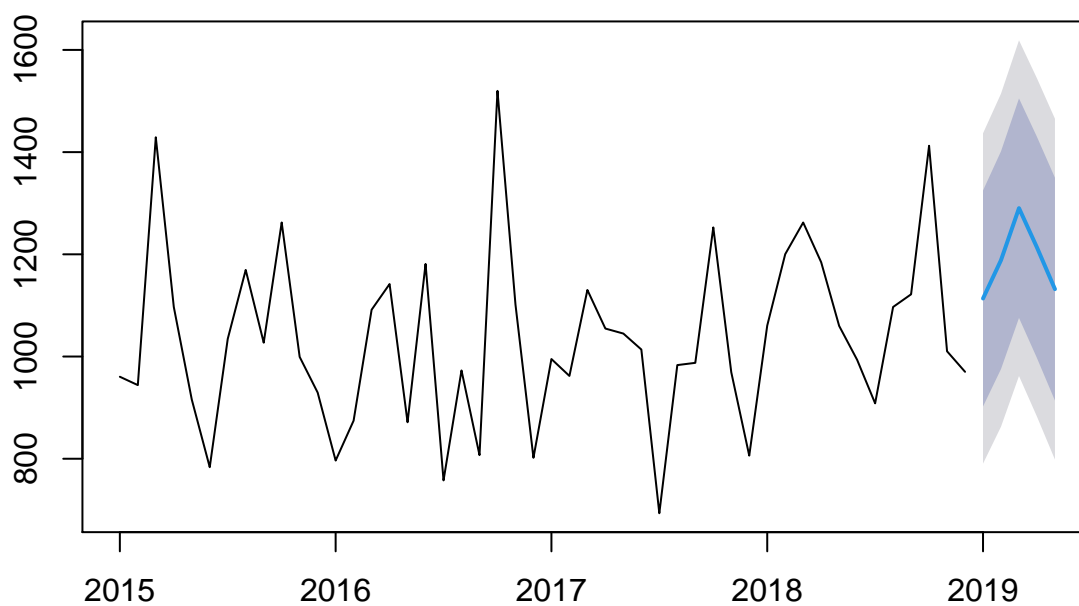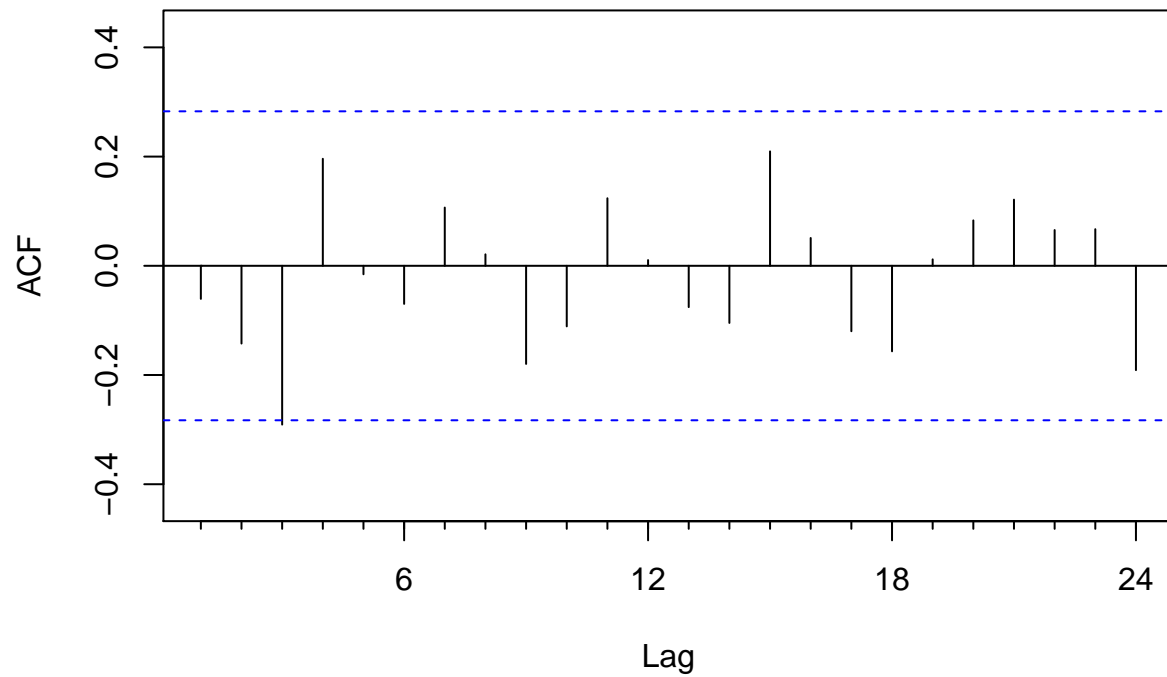


```r
attributes((forecast_ts))
```

```
## $names
##  [1] "method"    "model"     "level"     "mean"      "lower"     "upper"
##  [7] "x"         "series"    "fitted"    "residuals"
##
## $class
## [1] "forecast"
```
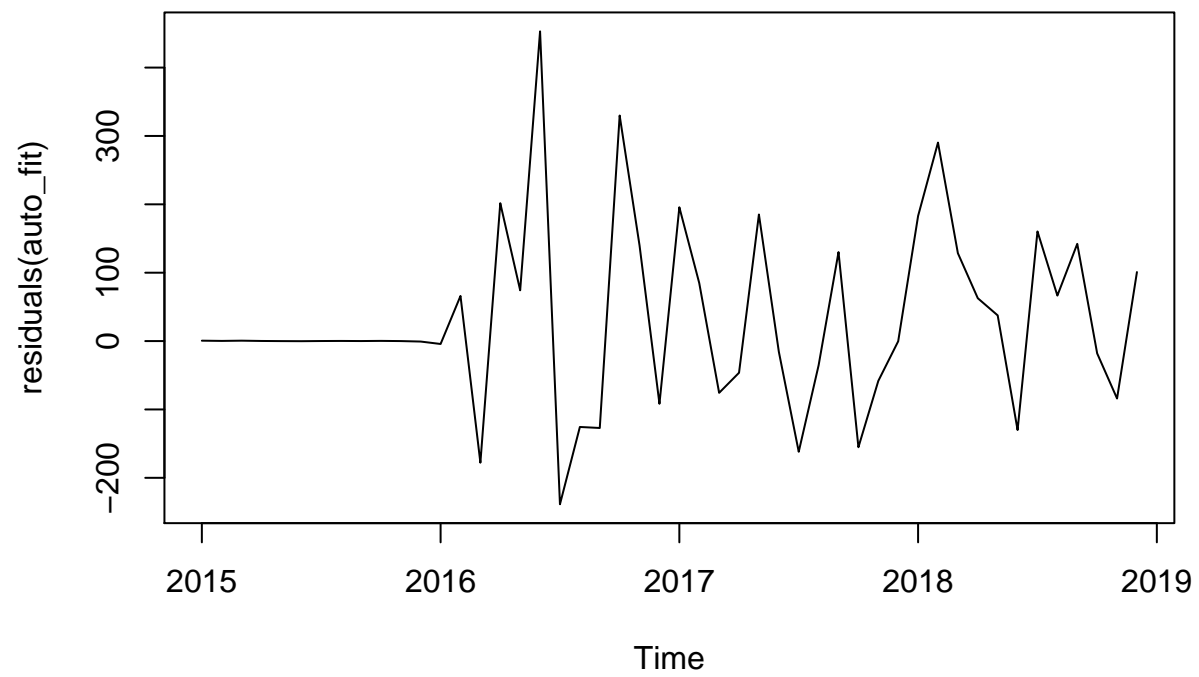
```r
Acf(auto_fit$residuals)
```

Series auto_fit$residuals


```r
Box.test(residuals(auto_fit), lag=20, type="Ljung")
```
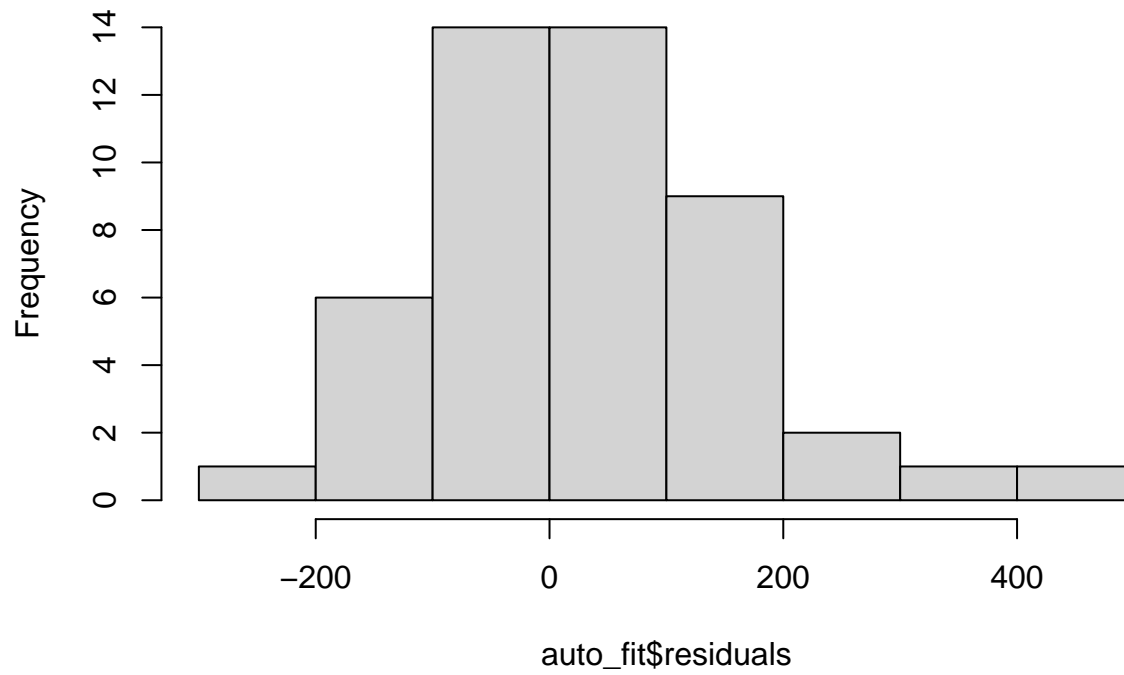
```
##
##   Box-Ljung test
##
## data:  residuals(auto_fit)
## X-squared = 20.832, df = 20, p-value = 0.4071
```
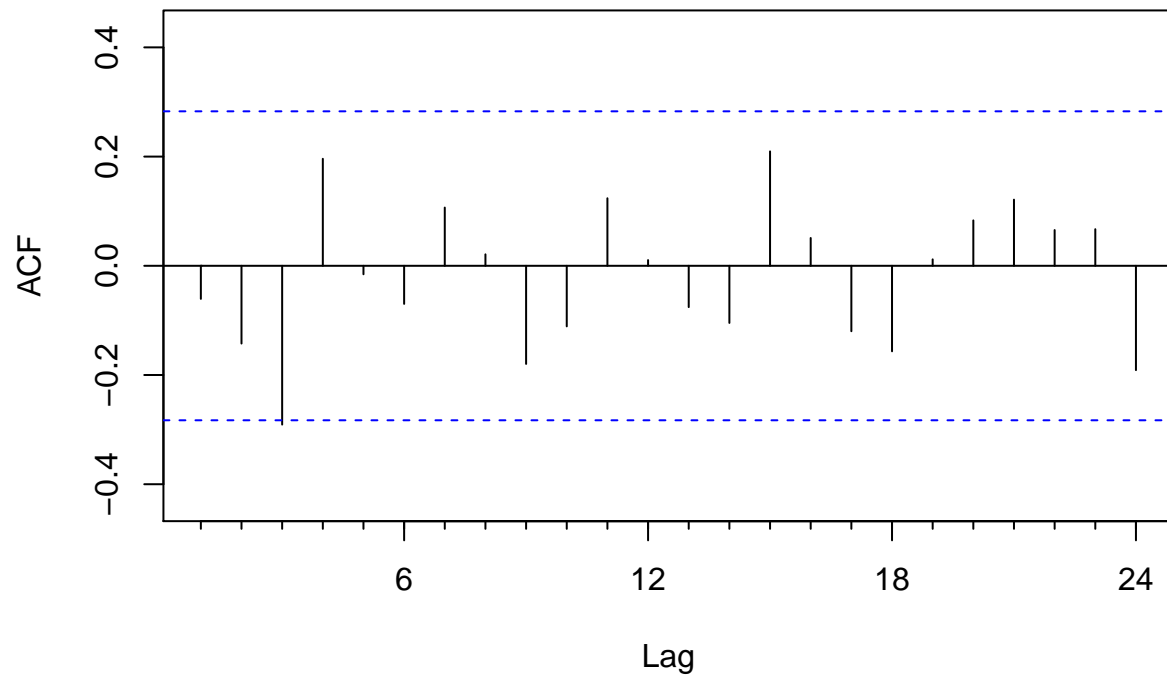
```r
plot.ts(residuals(auto_fit))
```

```r
hist(auto_fit$residuals)
```

Histogram of auto_fit$residuals

Frequency / auto_fit$residuals

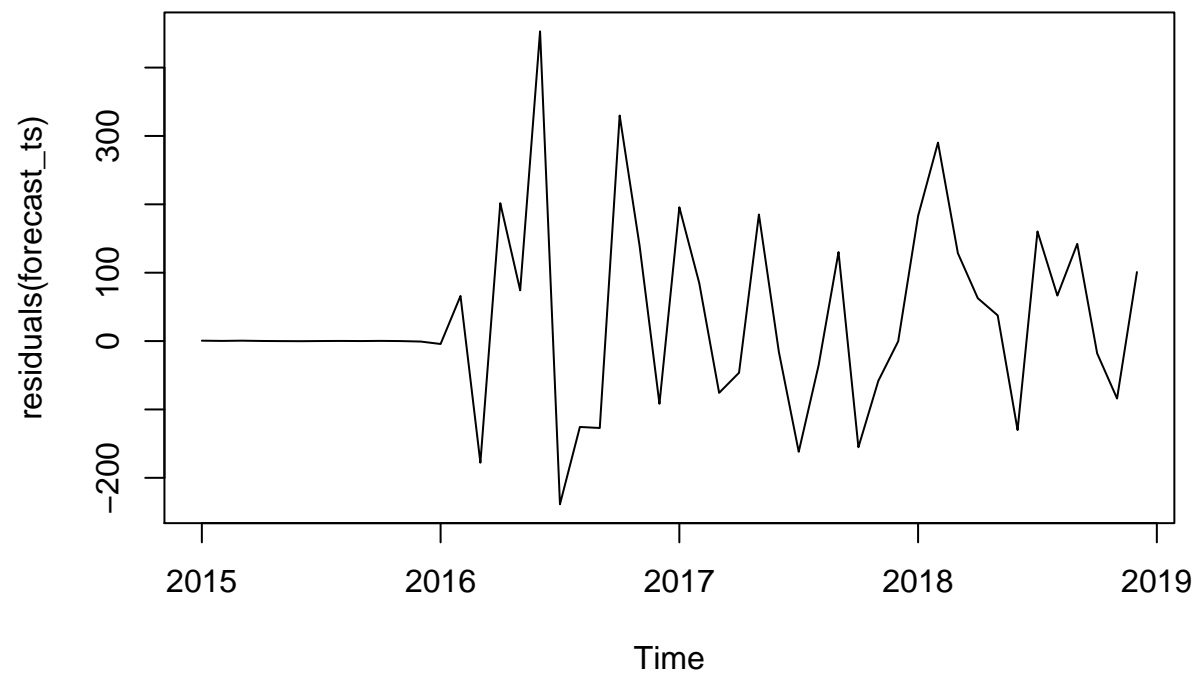```
Acf(forecast_ts$residuals)
```

**Series forecast_ts$residuals**



```
Box.test(residuals(forecast_ts), lag=20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  residuals(forecast_ts)
## X-squared = 20.832, df = 20, p-value = 0.4071
```

```
plot.ts(residuals(forecast_ts))
```

```r
hist(forecast_ts$residuals)
```

Histogram of forecast_ts$residuals