Time Series Analysis on Tata motors sales

```
library(ggplot2)
library(tseries)
```

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

```
library(imputeTS)
```

```
##
## Attaching package: 'imputeTS'
```

```
## The following object is masked from 'package:tseries':
##
##     na.remove
```

```
library(forecast)
# library(greybox)
# library(smooth)
library(graphics)
library(datasets)
library(fpp2)
```

```
## ── Attaching packages ─────────────────────────────────────── fpp2 2.4 ──
```

```
## ✓ fma       2.4     ✓ expsmooth 2.3
```

```
##
```

```
library(TTR)
```

Importing data

```
data = read.csv("Data/tata_data.csv")
head(data)
```

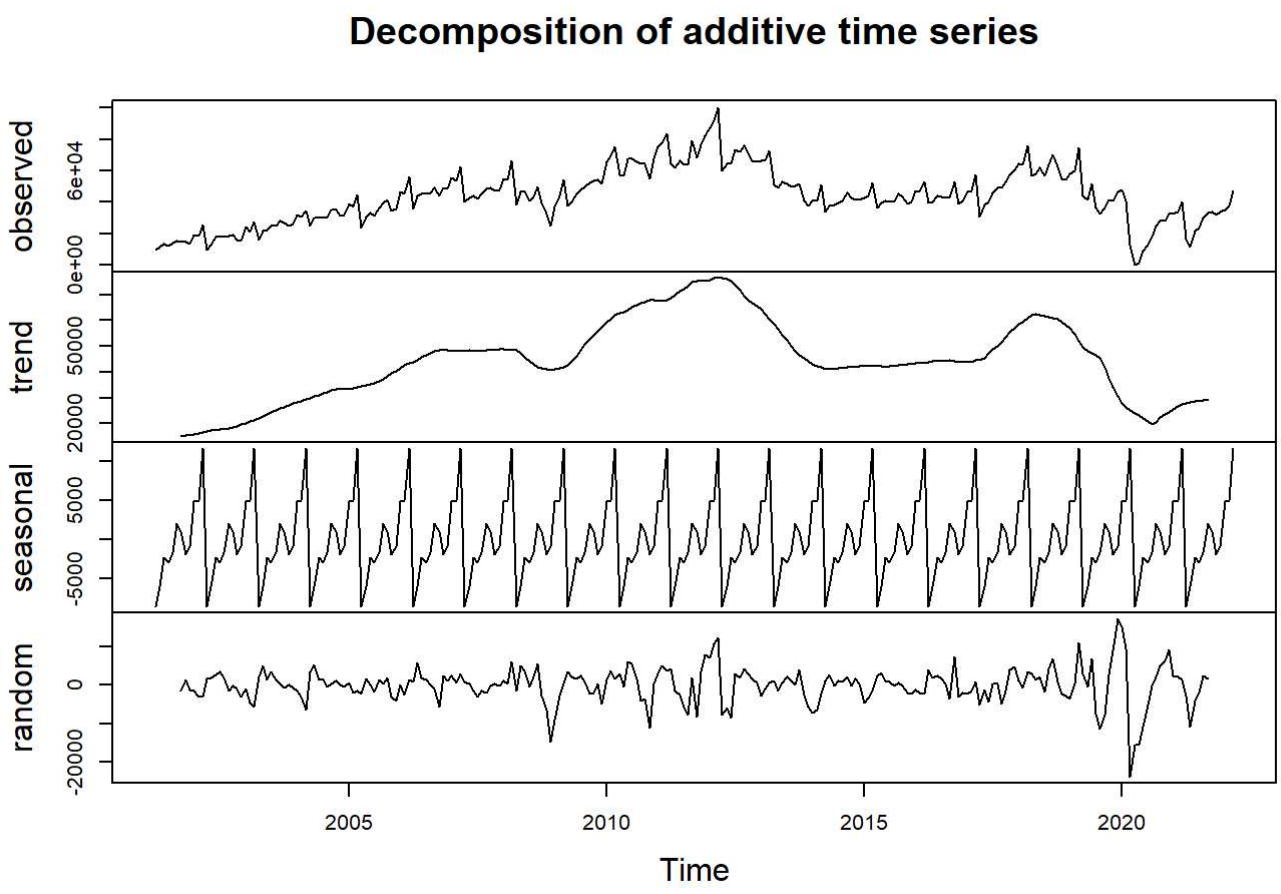
```
##         Date Sales
## 1 01-04-2001  9683
## 2 01-05-2001 11831
## 3 01-06-2001 13823
## 4 01-07-2001 12249
## 5 01-08-2001 14423
## 6 01-09-2001 15358
```

Converting data into time-series object

```
df = ts(data$Sales, start = c(2001,4), frequency = 12)
df
```

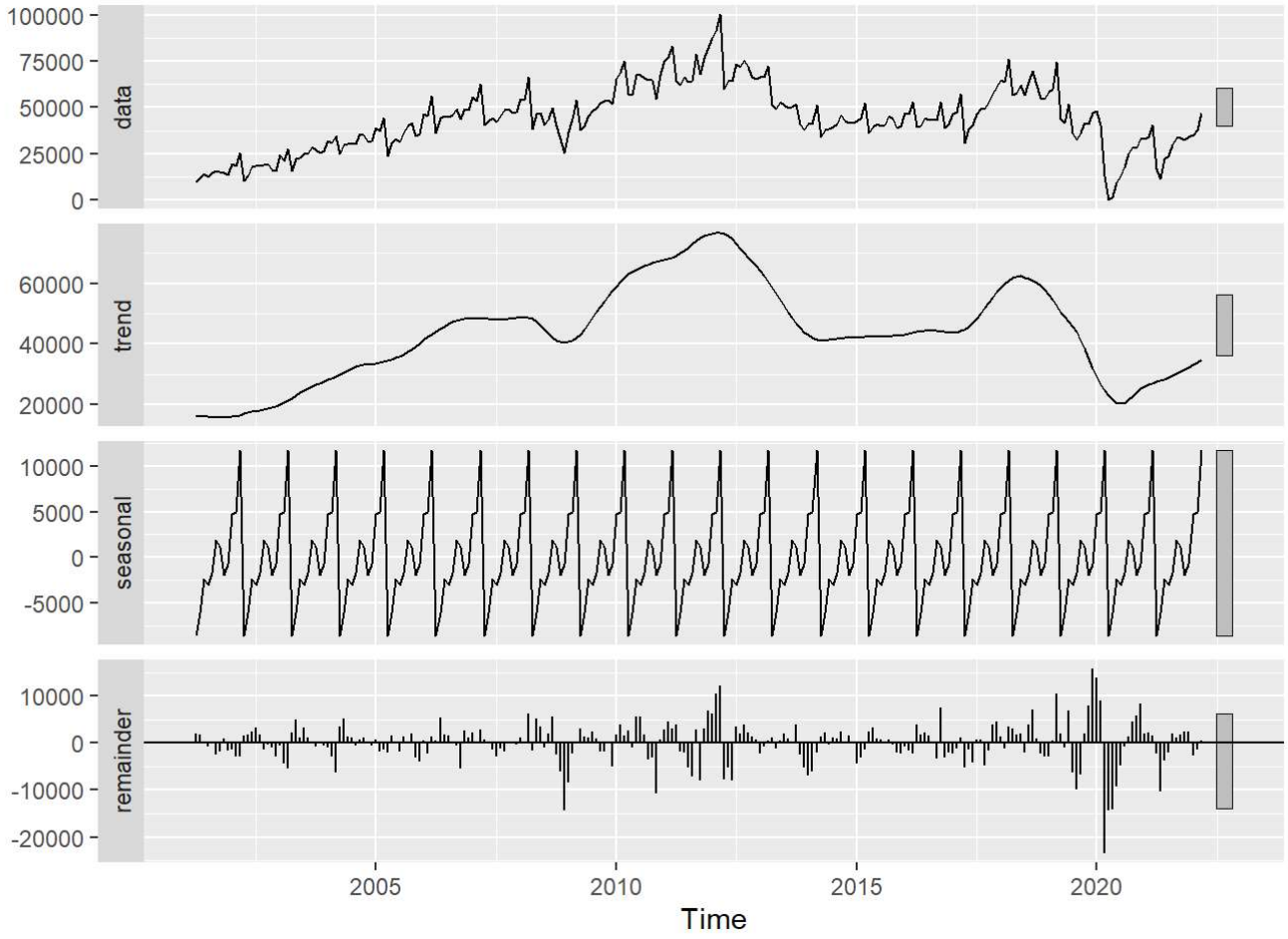
```
##         Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 2001                        9683  11831  13823  12249  14423  15358  14897
## 2002  19325  18342  25402   9970  13066  17733  18107  18113  18885  19294
## 2003  24116  21176  27558  15821  21928  22643  24993  24827  28304  26860
## 2004  31839  30800  34714  24961  29774  30183  30057  30113  35406  35283
## 2005  39000  36977  44432  23889  30593  33017  31173  36206  39707  41338
## 2006  46635  45113  56406  36082  44357  45223  45056  45681  49157  43770
## 2007  55440  53707  62779  40486  42558  44317  42098  45144  48347  49354
## 2008  54796  54181  66495  38149  46339  47245  40729  43576  49647  39729
## 2009  36931  43811  54076  37518  40196  45399  48054  49810  52513  53404
## 2010  65478  69427  75151  57202  56777  67730  67799  65938  64668  64757
## 2011  75423  77543  83363  64383  62105  66360  63761  64078  78783  68008
## 2012  87467  92119 100414  60086  64347  64341  73491  71826  75773  71770
## 2013  66500  66500  72712  51160  49304  52708  51468  49611  50387  51638
## 2014  40863  40863  51184  33892  37525  38557  39619  40883  46119  42819
## 2015  42582  44209  52479  36145  39496  40869  40154  40690  45215  43486
## 2016  47035  46674  53057  39382  40071  44276  43160  43061  43061  52813
## 2017  46349  47574  57145  30972  38361  40358  46216  48988  48988  53197
## 2018  64624  63761  76153  56521  57994  62019  56867  63757  69991  62264
## 2019  58185  60151  74679  43979  41792  51774  36312  32343  36376  41354
## 2020  47862  40634  12924      0   1488   8824  12688  17889  24876  28472
## 2021  32816  33859  40462  16644  11401  22100  23848  29781  33258  33674
## 2022  35268  37552  47050
##         Nov    Dec
## 2001  14726  13406
## 2002  16148  15695
## 2003  25265  26254
## 2004  31428  31951
## 2005  34282  35598
## 2006  49061  48792
## 2007  46947  47678
## 2008  32696  25219
## 2009  54108  51627
## 2010  54622  67494
## 2011  76823  82279
## 2012  66500  65582
## 2013  40863  37836
## 2014  41720  41734
## 2015  38918  39973
## 2016  38900  40944
## 2017  57391  60920
## 2018  55074  54439
## 2019  41124  46903
## 2020  27982  32869
## 2021  32245  34151
## 2022
```

```
plot(decompose(df))
```



Decomposition of time series

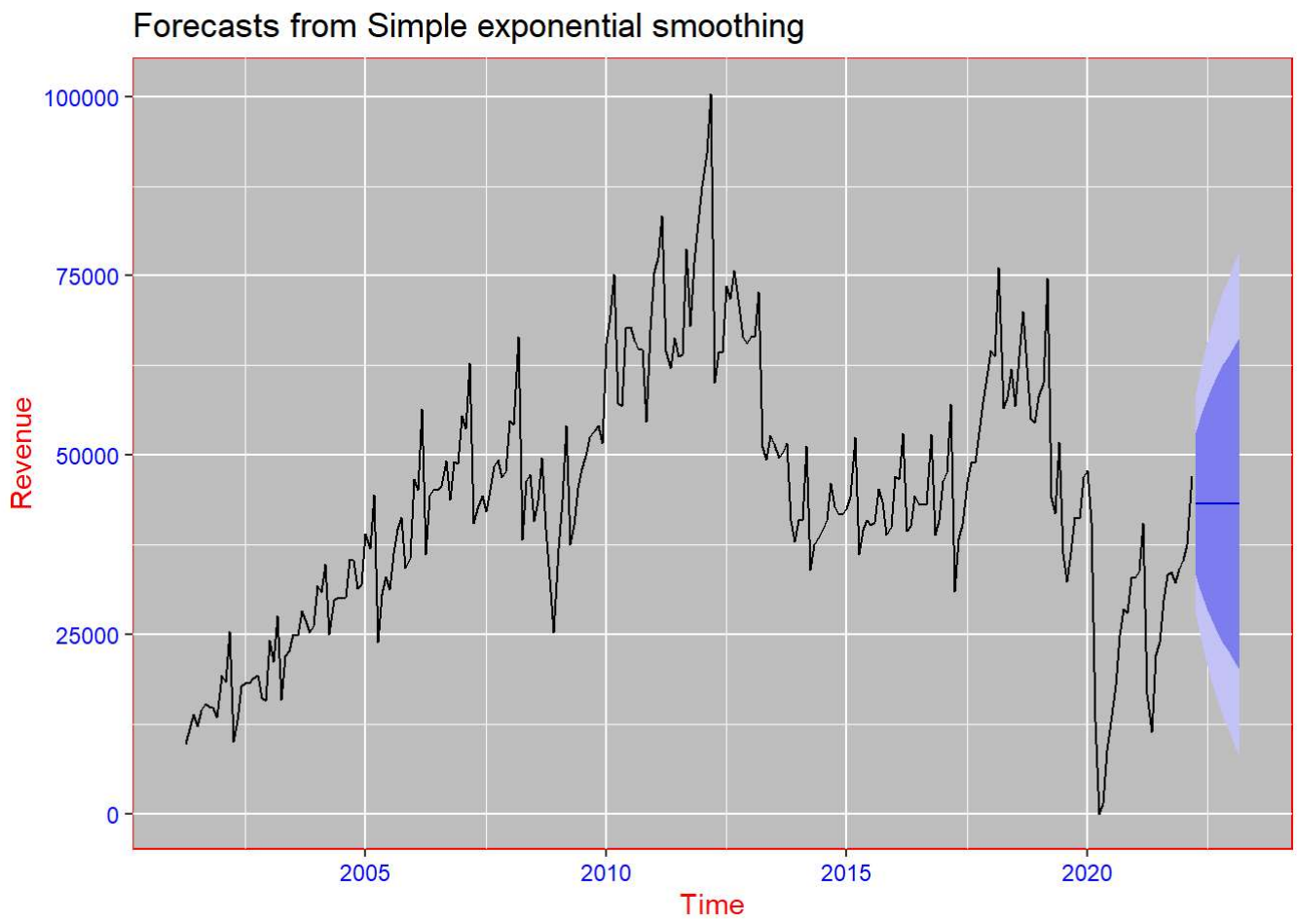
```
df_decom = stl(df, s.window = "p")
autoplot(df_decom)
```



Simple exponential smoothing method

```
df_ses = ses(df, h=12)

autoplot(df_ses)+ xlab("Time")+ ylab("Revenue")+theme(panel.background = element_rect(fill = "gr
ay", colour = "red"), axis.text.x = element_text(colour = "blue"),axis.text.y = element_text(col
our = "blue"), axis.title.x.bottom = element_text(colour = "red"), axis.title.y.left = element_t
ext(color = "red"))
```




```
summary(df_ses)
```

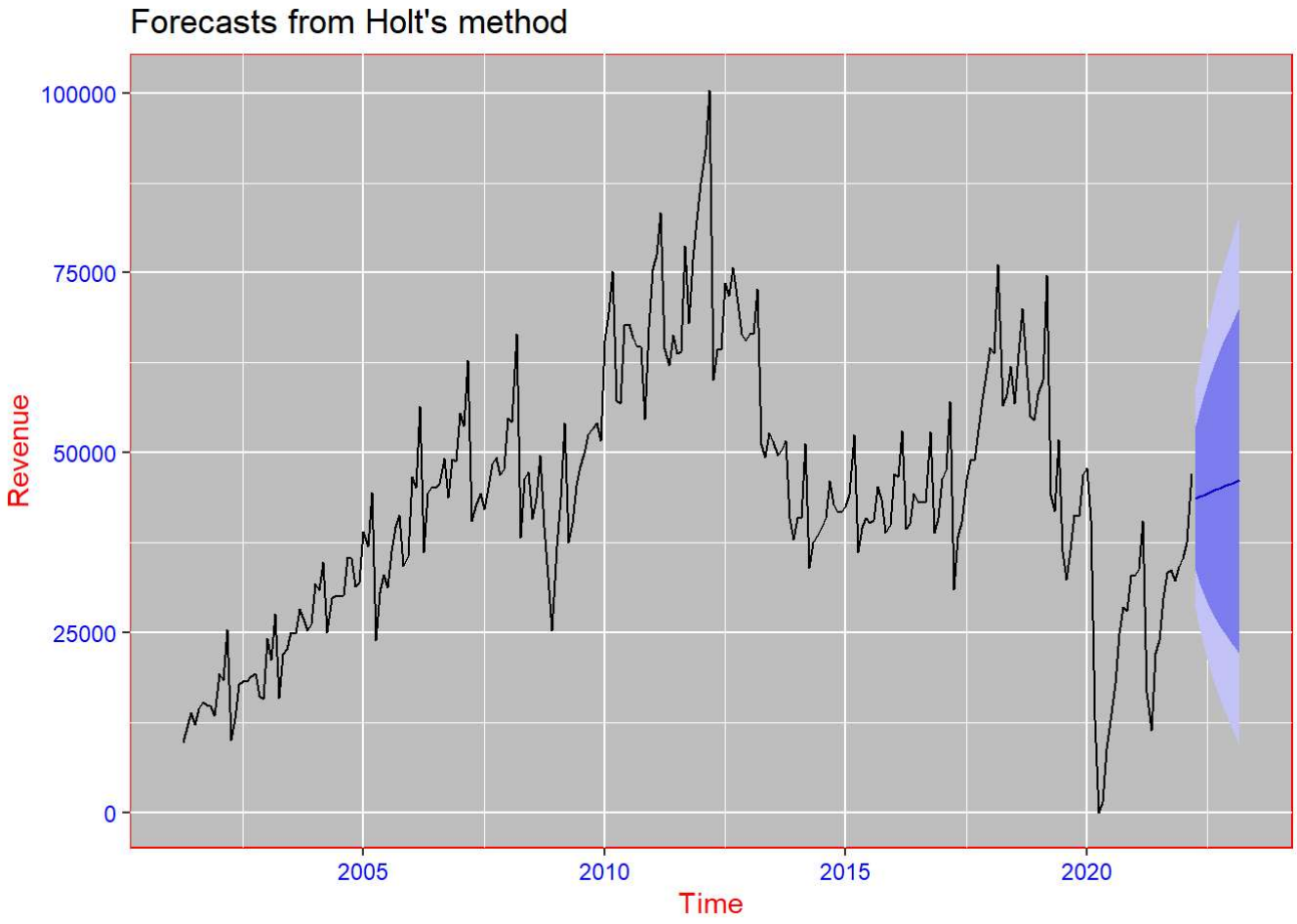
```
##
## Forecast method: Simple exponential smoothing
##
## Model Information:
## Simple exponential smoothing
##
## Call:
##  ses(y = df, h = 12)
##
##   Smoothing parameters:
##     alpha = 0.6354
##
##   Initial states:
##     l = 10693.3147
##
##   sigma:  7746.86
##
##      AIC     AICc      BIC
## 5910.750 5910.847 5921.338
##
## Error measures:
##                     ME     RMSE      MAE  MPE MAPE      MASE       ACF1
## Training set 202.9963 7716.057 5399.643 -Inf  Inf 0.5463252 0.05347263
##
## Forecasts:
##          Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## Apr 2022       43198.94 33270.94 53126.94 28015.373 58382.51
## May 2022       43198.94 31436.14 54961.74 25209.295 61188.58
## Jun 2022       43198.94 29851.22 56546.66 22785.367 63612.51
## Jul 2022       43198.94 28435.48 57962.40 20620.175 65777.70
## Aug 2022       43198.94 27144.10 59253.78 18645.177 67752.70
## Sep 2022       43198.94 25949.12 60448.76 16817.623 69580.26
## Oct 2022       43198.94 24831.73 61566.15 15108.718 71289.16
## Nov 2022       43198.94 23778.52 62619.36 13497.977 72899.90
## Dec 2022       43198.94 22779.57 63618.31 11970.206 74427.67
## Jan 2023       43198.94 21827.25 64570.63 10513.768 75884.11
## Feb 2023       43198.94 20915.60 65482.28  9119.516 77278.36
## Mar 2023       43198.94 20039.81 66358.07  7780.107 78617.77
```

Double exponential exponential smoothing

```
df_dex = holt(df, h = 12)
df_dex
```

```
##          Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## Apr 2022       43627.54 33622.43 53632.66 28326.038 58929.05
## May 2022       43857.20 31943.83 55770.57 25637.279 62077.12
## Jun 2022       44086.86 30515.73 57657.98 23331.612 64842.10
## Jul 2022       44316.52 29255.11 59377.92 21282.082 67350.95
## Aug 2022       44546.17 28116.26 60976.08 19418.796 69673.55
## Sep 2022       44775.83 27070.88 62480.78 17698.440 71853.22
## Oct 2022       45005.49 26099.97 63911.00 16091.995 73918.98
## Nov 2022       45235.14 25190.11 65280.18 14578.907 75891.38
## Dec 2022       45464.80 24331.36 66598.24 13143.994 77785.60
## Jan 2023       45694.46 23516.15 67872.76 11775.672 79613.24
## Feb 2023       45924.11 22738.56 69109.67 10464.867 81383.36
## Mar 2023       46153.77 21993.82 70313.72  9204.319 83103.22
```

```
autoplot(df_dex)+ xlab("Time")+ ylab("Revenue")+theme(panel.background = element_rect(fill = "gr
ay", colour = "red"), axis.text.x = element_text(colour = "blue"),axis.text.y = element_text(col
our = "blue"), axis.title.x.bottom = element_text(colour = "red"), axis.title.y.left = element_t
ext(color = "red"))
```




```
summary(df_dex)
```

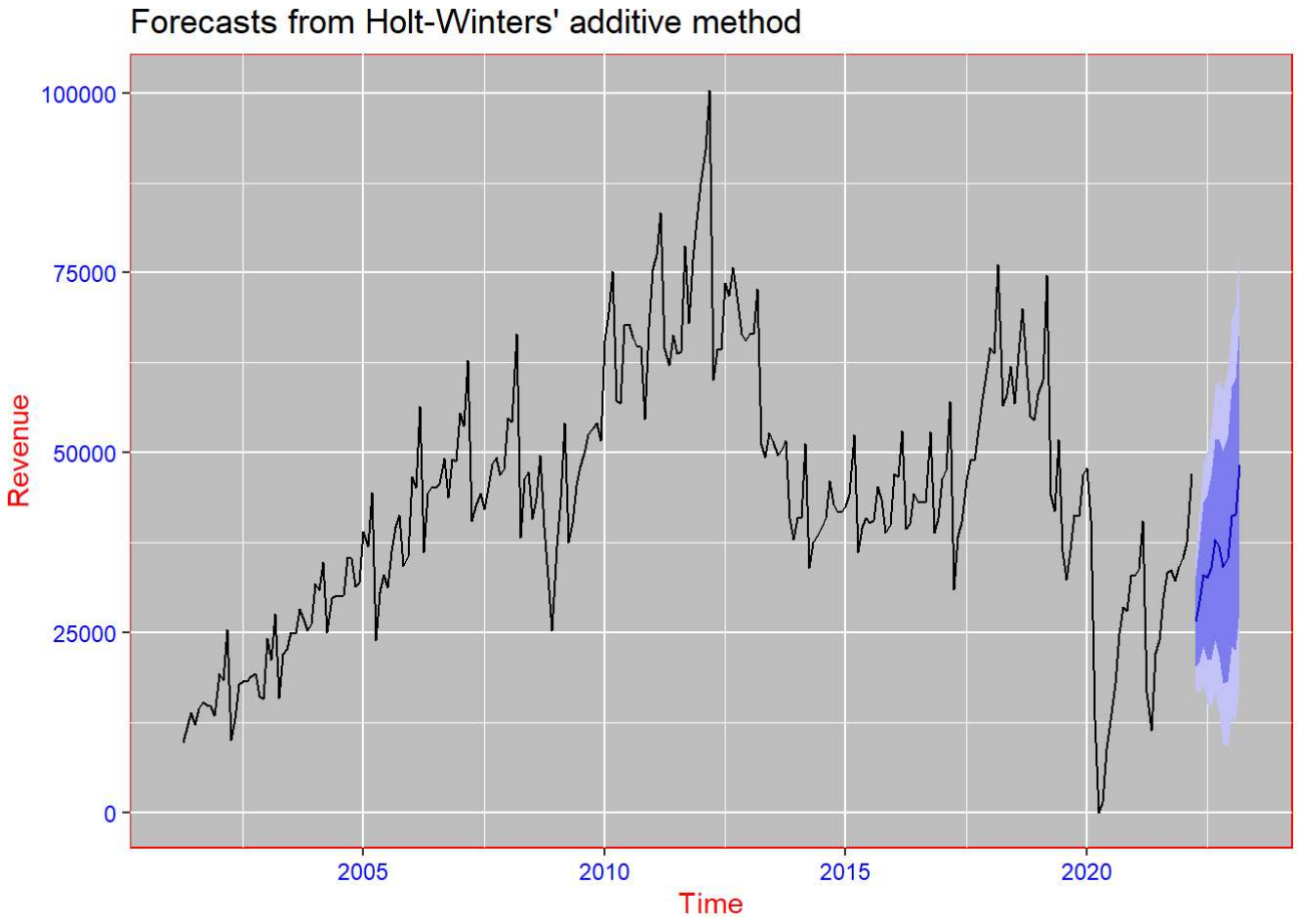
```
##
## Forecast method: Holt's method
##
## Model Information:
## Holt's method
##
## Call:
##  holt(y = df, h = 12)
##
##   Smoothing parameters:
##     alpha = 0.6432
##     beta  = 0.0032
##
##   Initial states:
##     l = 11185.9782
##     b = 673.9394
##
##   sigma:  7807.035
##
##      AIC     AICc      BIC
## 5916.625 5916.869 5934.273
##
## Error measures:
##                      ME     RMSE      MAE  MPE MAPE      MASE       ACF1
## Training set -543.0159 7744.826 5304.082 -Inf  Inf 0.5366565 0.04637631
##
## Forecasts:
##          Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## Apr 2022       43627.54 33622.43 53632.66 28326.038 58929.05
## May 2022       43857.20 31943.83 55770.57 25637.279 62077.12
## Jun 2022       44086.86 30515.73 57657.98 23331.612 64842.10
## Jul 2022       44316.52 29255.11 59377.92 21282.082 67350.95
## Aug 2022       44546.17 28116.26 60976.08 19418.796 69673.55
## Sep 2022       44775.83 27070.88 62480.78 17698.440 71853.22
## Oct 2022       45005.49 26099.97 63911.00 16091.995 73918.98
## Nov 2022       45235.14 25190.11 65280.18 14578.907 75891.38
## Dec 2022       45464.80 24331.36 66598.24 13143.994 77785.60
## Jan 2023       45694.46 23516.15 67872.76 11775.672 79613.24
## Feb 2023       45924.11 22738.56 69109.67 10464.867 81383.36
## Mar 2023       46153.77 21993.82 70313.72  9204.319 83103.22
```

Triple(Hold Winter)exponential smoothing

```
df_hw = hw(df, h=12)
df_hw
```

```
##          Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## Apr 2022       26463.27 20243.70 32682.83 16951.258 35975.27
## May 2022       29270.55 20953.18 37587.93 16550.223 41990.88
## Jun 2022       33049.80 23049.79 43049.82 17756.103 48343.51
## Jul 2022       32594.58 21142.54 44046.63 15080.191 50108.98
## Aug 2022       33978.28 21225.72 46730.83 14474.924 53481.63
## Sep 2022       37872.95 23928.88 51817.01 16547.335 59198.56
## Oct 2022       36911.86 21859.32 51964.41 13890.983 59932.75
## Nov 2022       34024.71 17929.50 50119.92  9409.217 58640.20
## Dec 2022       35261.70 18177.55 52345.86  9133.741 61389.67
## Jan 2023       41146.16 23117.88 59174.45 13574.281 68718.05
## Feb 2023       41421.80 22487.46 60356.15 12464.221 70379.38
## Mar 2023       48183.61 28376.01 67991.22 17890.499 78476.73
```

```
autoplot(df_hw)+ xlab("Time")+ ylab("Revenue")+theme(panel.background = element_rect(fill = "gra
y", colour = "red"), axis.text.x = element_text(colour = "blue"),axis.text.y = element_text(colo
ur = "blue"), axis.title.x.bottom = element_text(colour = "red"), axis.title.y.left = element_te
xt(color = "red"))
```




```
summary(df_hw)
```

```
##
## Forecast method: Holt-Winters' additive method
##
## Model Information:
## Holt-Winters' additive method
##
## Call:
##  hw(y = df, h = 12)
##
##   Smoothing parameters:
##     alpha = 0.8832
##     beta  = 0.0047
##     gamma = 1e-04
##
##   Initial states:
##     l = 15488.6332
##     b = 513.675
##     s = 11659.04 5020.318 4868.248 -893.8113 -2008.002 1001.713
##            2086.399 -1685.689 -2946.29 -2368.218 -6024.297 -8709.416
##
##   sigma:  4853.155
##
##      AIC     AICc      BIC
## 5688.527 5691.143 5748.528
##
## Error measures:
##                      ME    RMSE      MAE MPE MAPE      MASE         ACF1
## Training set -327.8063 4696.56 3181.131 Inf  Inf 0.3218605 -0.008629628
##
## Forecasts:
##          Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## Apr 2022       26463.27 20243.70 32682.83 16951.258 35975.27
## May 2022       29270.55 20953.18 37587.93 16550.223 41990.88
## Jun 2022       33049.80 23049.79 43049.82 17756.103 48343.51
## Jul 2022       32594.58 21142.54 44046.63 15080.191 50108.98
## Aug 2022       33978.28 21225.72 46730.83 14474.924 53481.63
## Sep 2022       37872.95 23928.88 51817.01 16547.335 59198.56
## Oct 2022       36911.86 21859.32 51964.41 13890.983 59932.75
## Nov 2022       34024.71 17929.50 50119.92  9409.217 58640.20
## Dec 2022       35261.70 18177.55 52345.86  9133.741 61389.67
## Jan 2023       41146.16 23117.88 59174.45 13574.281 68718.05
## Feb 2023       41421.80 22487.46 60356.15 12464.221 70379.38
## Mar 2023       48183.61 28376.01 67991.22 17890.499 78476.73
```

Training and testing of data for holt-Winter

```
df_train = window(df,start = c(2013,4), end = c(2021,2), frequency = 12)
df_train
```

```
##        Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
## 2013                   51160 49304 52708 51468 49611 50387 51638 40863 37836
## 2014 40863 40863 51184 33892 37525 38557 39619 40883 46119 42819 41720 41734
## 2015 42582 44209 52479 36145 39496 40869 40154 40690 45215 43486 38918 39973
## 2016 47035 46674 53057 39382 40071 44276 43160 43061 43061 52813 38900 40944
## 2017 46349 47574 57145 30972 38361 40358 46216 48988 48988 53197 57391 60920
## 2018 64624 63761 76153 56521 57994 62019 56867 63757 69991 62264 55074 54439
## 2019 58185 60151 74679 43979 41792 51774 36312 32343 36376 41354 41124 46903
## 2020 47862 40634 12924     0  1488  8824 12688 17889 24876 28472 27982 32869
## 2021 32816 33859
```

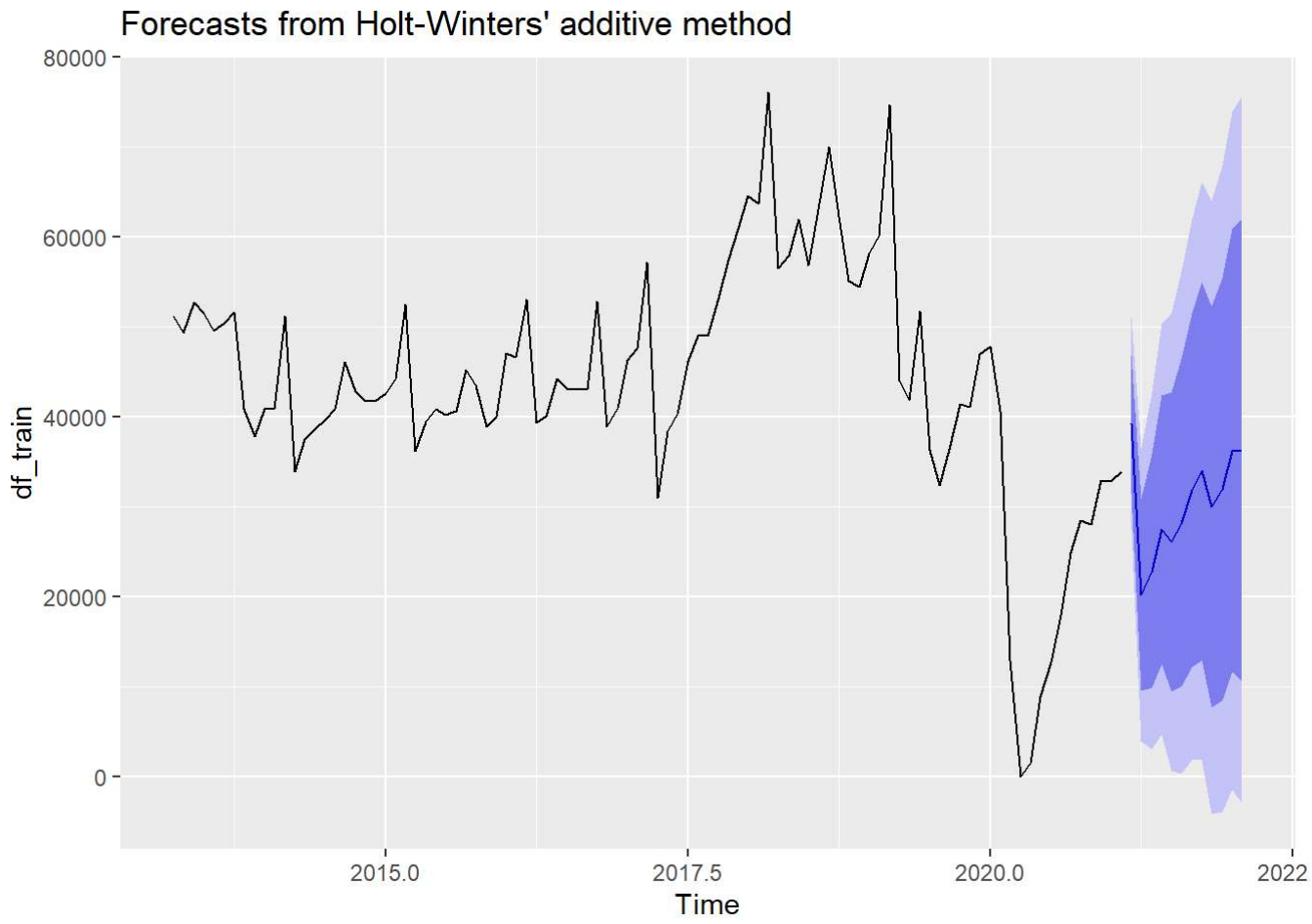
```
df_test = window(df, start = c(2021,3), frequency = 12)
df_test
```

```
##        Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
## 2021             40462 16644 11401 22100 23848 29781 33258 33674 32245 34151
## 2022 35268 37552 47050
```

```
df_hw_train = hw(df_train,h = 12)
df_hw_train
```

```
##          Point Forecast     Lo 80    Hi 80      Lo 95    Hi 95
## Mar 2021       39201.42 31527.146 46875.69 27464.6302 50938.21
## Apr 2021       20166.14  9504.763 30827.53  3860.9685 36471.32
## May 2021       22849.17  9870.452 35827.88  2999.9360 42698.40
## Jun 2021       27442.78 12501.546 42384.00  4592.1367 50293.41
## Jul 2021       26061.85  9387.164 42736.53   560.1197 51563.57
## Aug 2021       28157.34  9912.861 46401.83   254.8154 56059.87
## Sep 2021       31877.22 12187.413 51567.03  1764.2570 61990.19
## Oct 2021       33973.39 12937.053 55009.73  1801.0895 66145.69
## Nov 2021       29973.36  7671.390 52275.32 -4134.5578 64081.27
## Dec 2021       31977.53  8477.755 55477.30 -3962.2737 67917.33
## Jan 2022       36212.51 11572.855 60852.16 -1470.5874 73895.60
## Feb 2022       36320.85 10591.555 62050.15 -3028.7124 75670.42
```

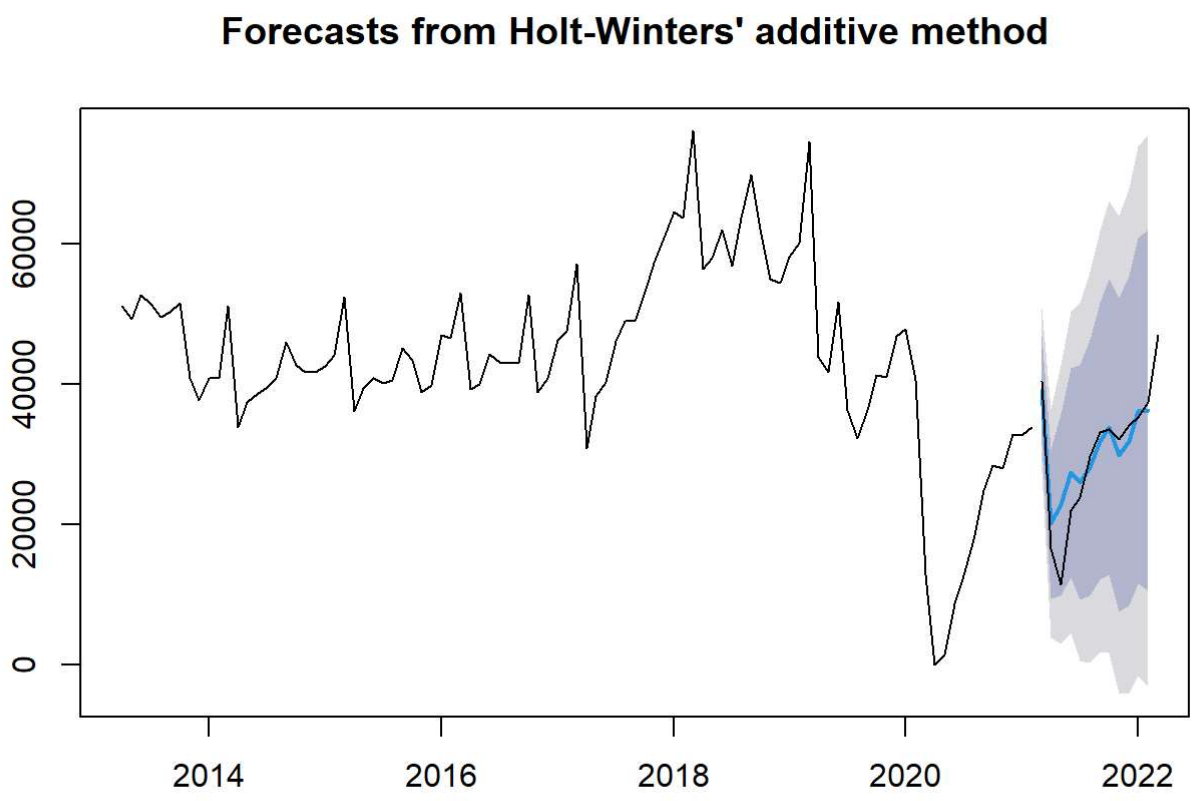
```
autoplot(df_hw_train)
```




```
accuracy(df_hw_train, df_test)
```

```
##                      ME     RMSE      MAE       MPE     MAPE      MASE
## Training set  -478.9344 5460.759 3615.728       Inf      Inf 0.3331588
## Test set     -1152.4626 4035.530 2809.342 -10.76618 15.66734 0.2588571
##                      ACF1 Theil's U
## Training set -0.009780104        NA
## Test set      0.490355570 0.7164281
```

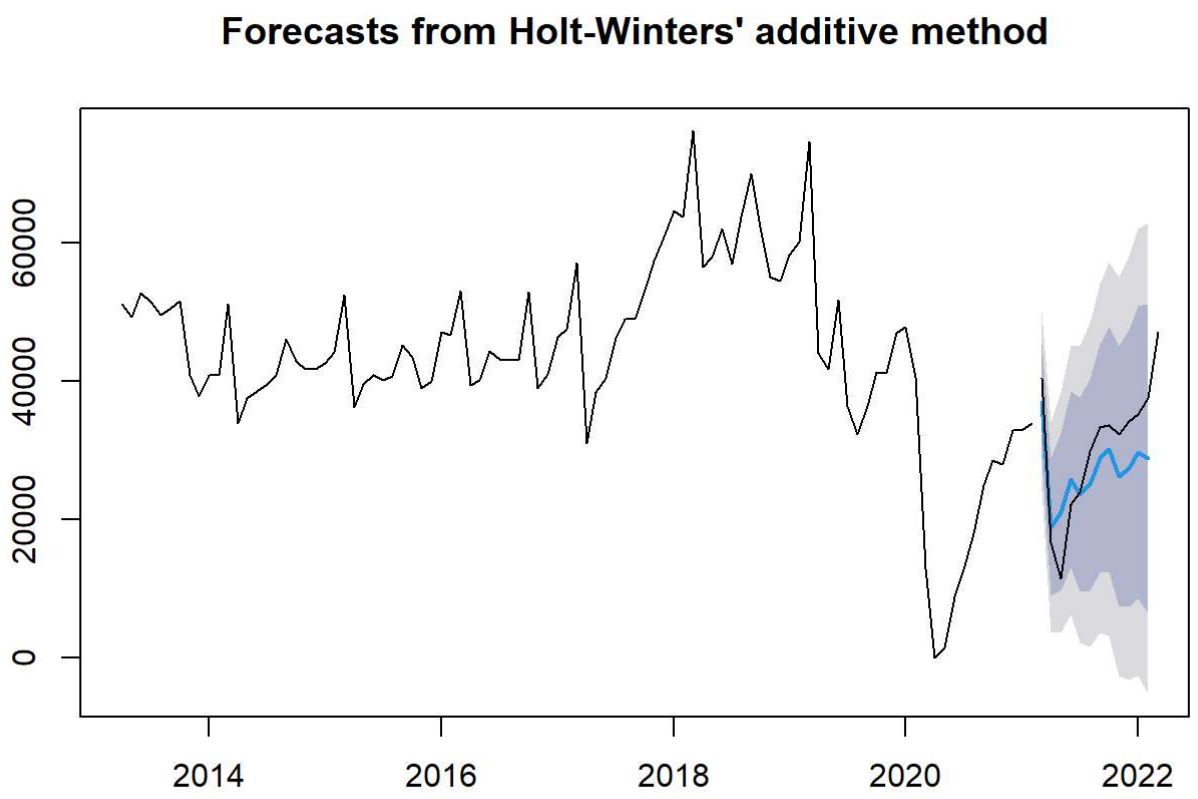
```
plot(df_hw_train)
lines(df_test)
```




```
summary(df_hw_train)
```

```
##
## Forecast method: Holt-Winters' additive method
##
## Model Information:
## Holt-Winters' additive method
##
## Call:
##  hw(y = df_train, h = 12)
##
##   Smoothing parameters:
##     alpha = 0.9643
##     beta  = 1e-04
##     gamma = 1e-04
##
##   Initial states:
##     l = 52913.2716
##     b = 212.0459
##     s = 9991.502 4828.538 4928.23 900.0585 -896.6439 3311.234
##           1422.19 -2089.809 -3978.229 -2389.644 -6775.394 -9252.032
##
##   sigma:  5988.268
##
##      AIC     AICc      BIC
## 2101.633 2109.582 2145.049
##
## Error measures:
##                      ME     RMSE      MAE MPE MAPE      MASE         ACF1
## Training set -478.9344 5460.759 3615.728 Inf  Inf 0.3331588 -0.009780104
##
## Forecasts:
##          Point Forecast     Lo 80    Hi 80      Lo 95    Hi 95
## Mar 2021       39201.42 31527.146 46875.69 27464.6302 50938.21
## Apr 2021       20166.14  9504.763 30827.53  3860.9685 36471.32
## May 2021       22849.17  9870.452 35827.88  2999.9360 42698.40
## Jun 2021       27442.78 12501.546 42384.00  4592.1367 50293.41
## Jul 2021       26061.85  9387.164 42736.53   560.1197 51563.57
## Aug 2021       28157.34  9912.861 46401.83   254.8154 56059.87
## Sep 2021       31877.22 12187.413 51567.03  1764.2570 61990.19
## Oct 2021       33973.39 12937.053 55009.73  1801.0895 66145.69
## Nov 2021       29973.36  7671.390 52275.32 -4134.5578 64081.27
## Dec 2021       31977.53  8477.755 55477.30 -3962.2737 67917.33
## Jan 2022       36212.51 11572.855 60852.16 -1470.5874 73895.60
## Feb 2022       36320.85 10591.555 62050.15 -3028.7124 75670.42
```

```
df_hw_train2 = hw(df_train, alpha = 0.62, beta = .02, gamma = .1, h=12)
plot(df_hw_train2)
lines(df_test)
```

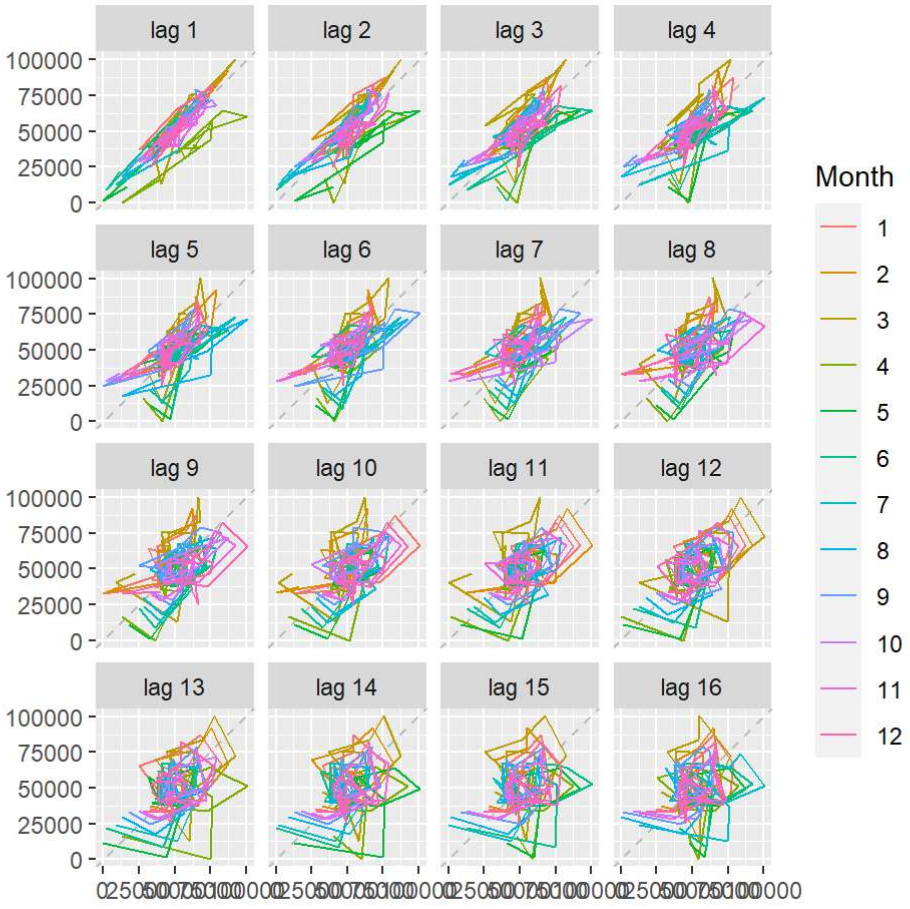


ARIMA Model

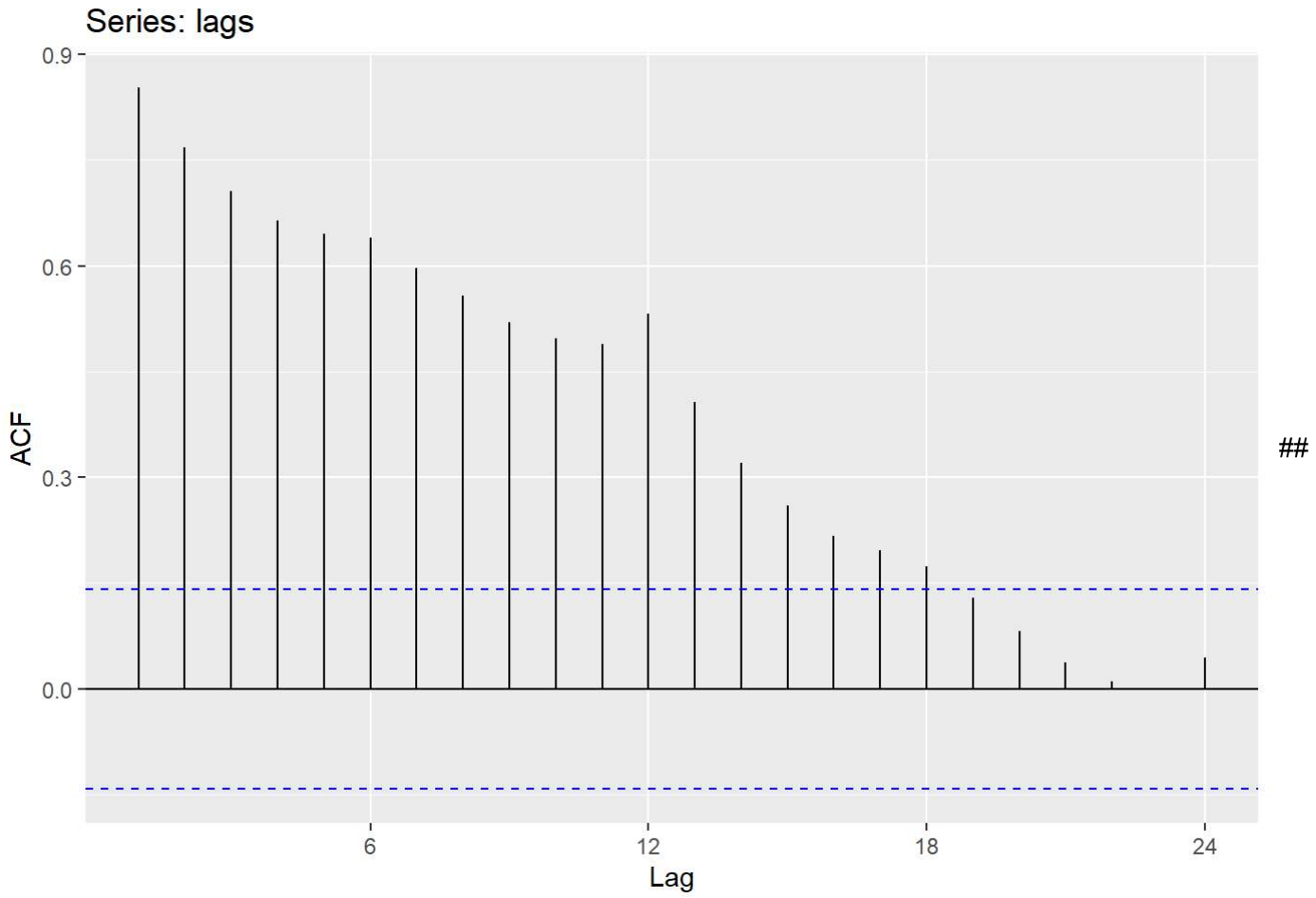
```
lags = window(df, start = c(2006,4))
lags
```

```
##         Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 2006                       36082  44357  45223  45056  45681  49157  43770
## 2007  55440  53707  62779  40486  42558  44317  42098  45144  48347  49354
## 2008  54796  54181  66495  38149  46339  47245  40729  43576  49647  39729
## 2009  36931  43811  54076  37518  40196  45399  48054  49810  52513  53404
## 2010  65478  69427  75151  57202  56777  67730  67799  65938  64668  64757
## 2011  75423  77543  83363  64383  62105  66360  63761  64078  78783  68008
## 2012  87467  92119 100414  60086  64347  64341  73491  71826  75773  71770
## 2013  66500  66500  72712  51160  49304  52708  51468  49611  50387  51638
## 2014  40863  40863  51184  33892  37525  38557  39619  40883  46119  42819
## 2015  42582  44209  52479  36145  39496  40869  40154  40690  45215  43486
## 2016  47035  46674  53057  39382  40071  44276  43160  43061  43061  52813
## 2017  46349  47574  57145  30972  38361  40358  46216  48988  48988  53197
## 2018  64624  63761  76153  56521  57994  62019  56867  63757  69991  62264
## 2019  58185  60151  74679  43979  41792  51774  36312  32343  36376  41354
## 2020  47862  40634  12924      0   1488   8824  12688  17889  24876  28472
## 2021  32816  33859  40462  16644  11401  22100  23848  29781  33258  33674
## 2022  35268  37552  47050
##         Nov    Dec
## 2006  49061  48792
## 2007  46947  47678
## 2008  32696  25219
## 2009  54108  51627
## 2010  54622  67494
## 2011  76823  82279
## 2012  66500  65582
## 2013  40863  37836
## 2014  41720  41734
## 2015  38918  39973
## 2016  38900  40944
## 2017  57391  60920
## 2018  55074  54439
## 2019  41124  46903
## 2020  27982  32869
## 2021  32245  34151
## 2022
```

```
gglagplot(lags)
```


lag 1
lag 2
lag 3
lag 4
lag 5
lag 6
lag 7
lag 8
lag 9
lag 10
lag 11
lag 12
lag 13
lag 14
lag 15
lag 16
100000
75000
50000
25000
0
Month
1
2
3
4
5
6
7
8
9
10
11
12

```
ggAcf(lags)
```



##

Checking stationarity of the data ### H0 : Data is not stationary ### H1 : Data is stationary

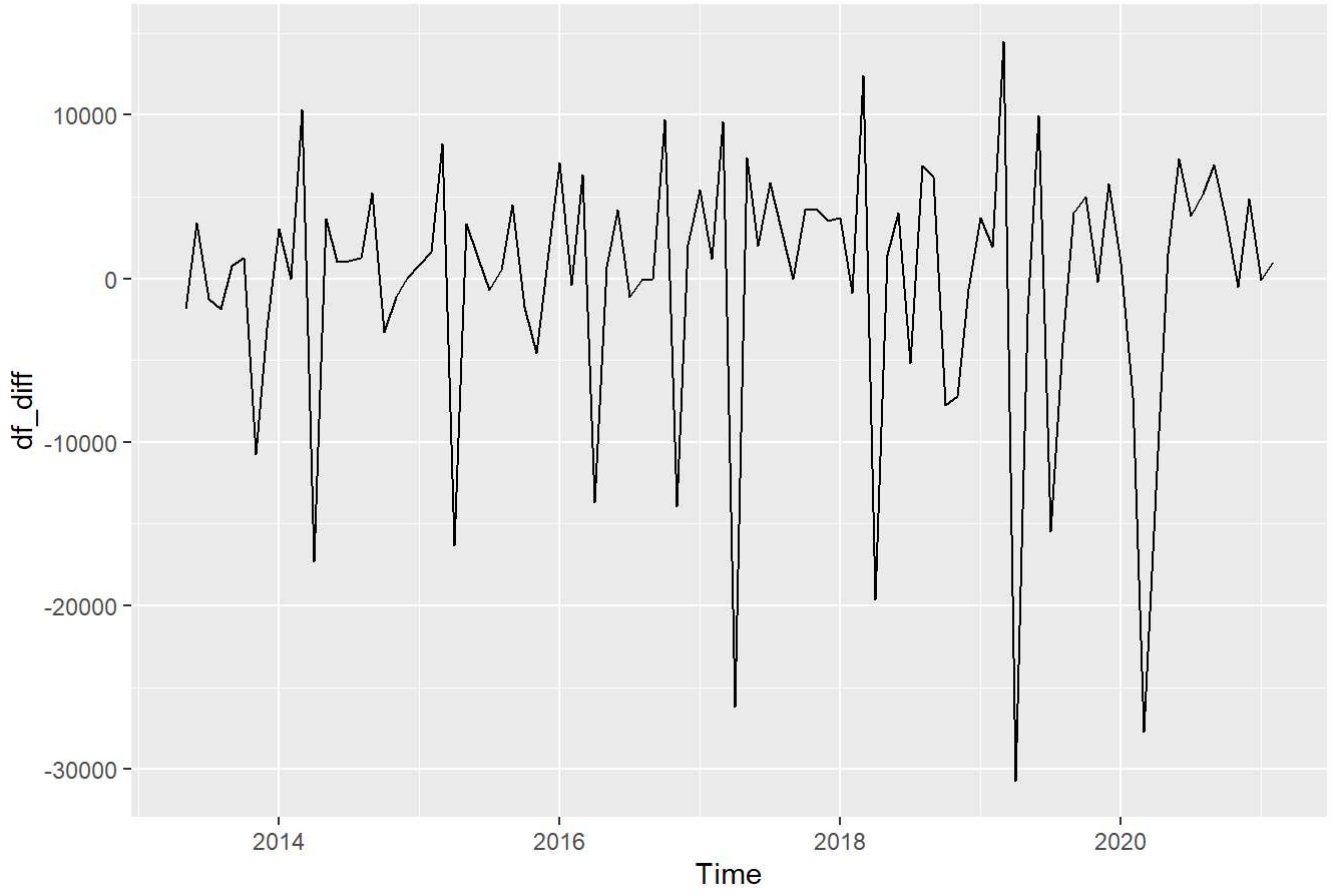
```
adf.test(df)
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  df
## Dickey-Fuller = -2.1134, Lag order = 6, p-value = 0.5281
## alternative hypothesis: stationary
```

First order diffrencing

```
df_diff = diff(df_train,1)

autoplot(df_diff)
```




```
adf.test(df_diff, alternative = "stationary" ,k=0)
```

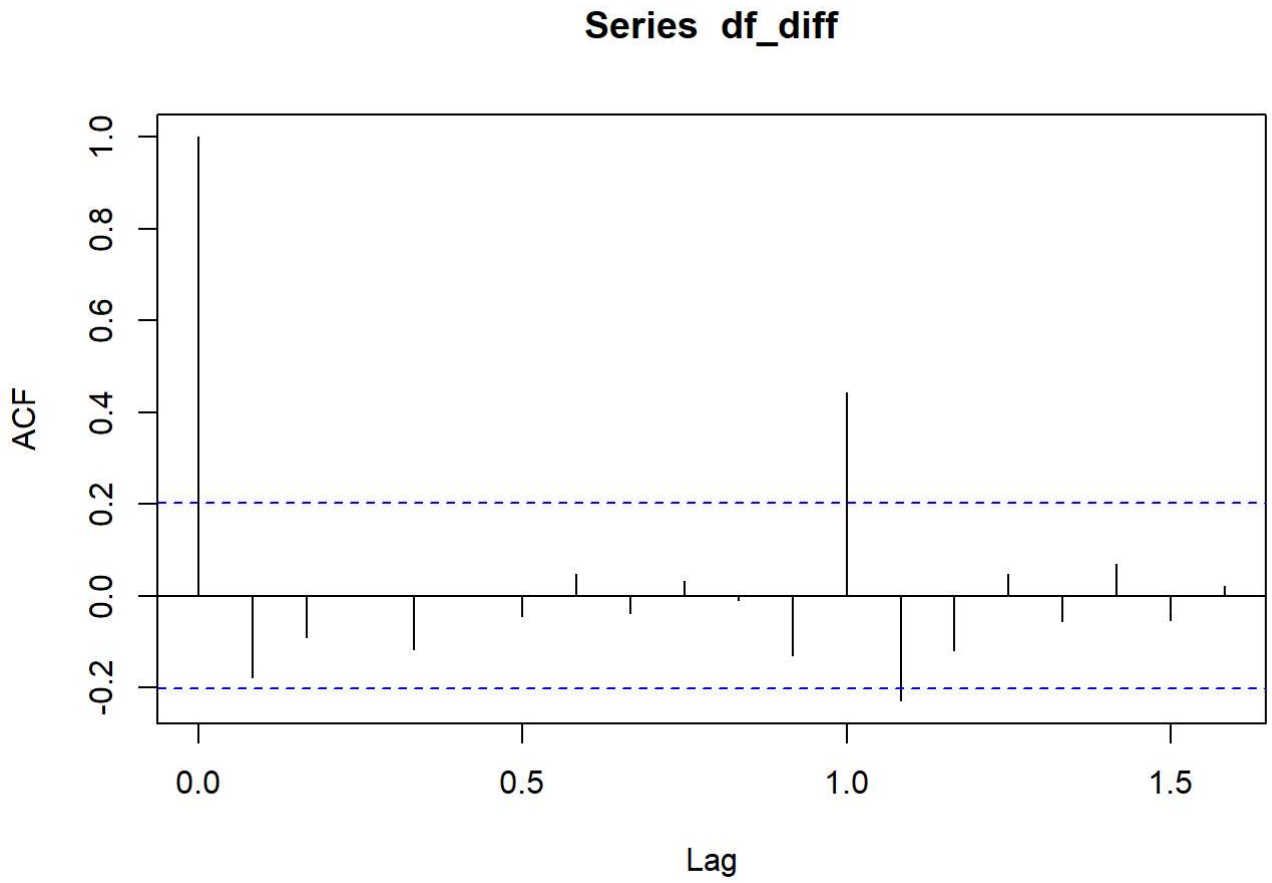
```
## Warning in adf.test(df_diff, alternative = "stationary", k = 0): p-value smaller
## than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  df_diff
## Dickey-Fuller = -11.357, Lag order = 0, p-value = 0.01
## alternative hypothesis: stationary
```

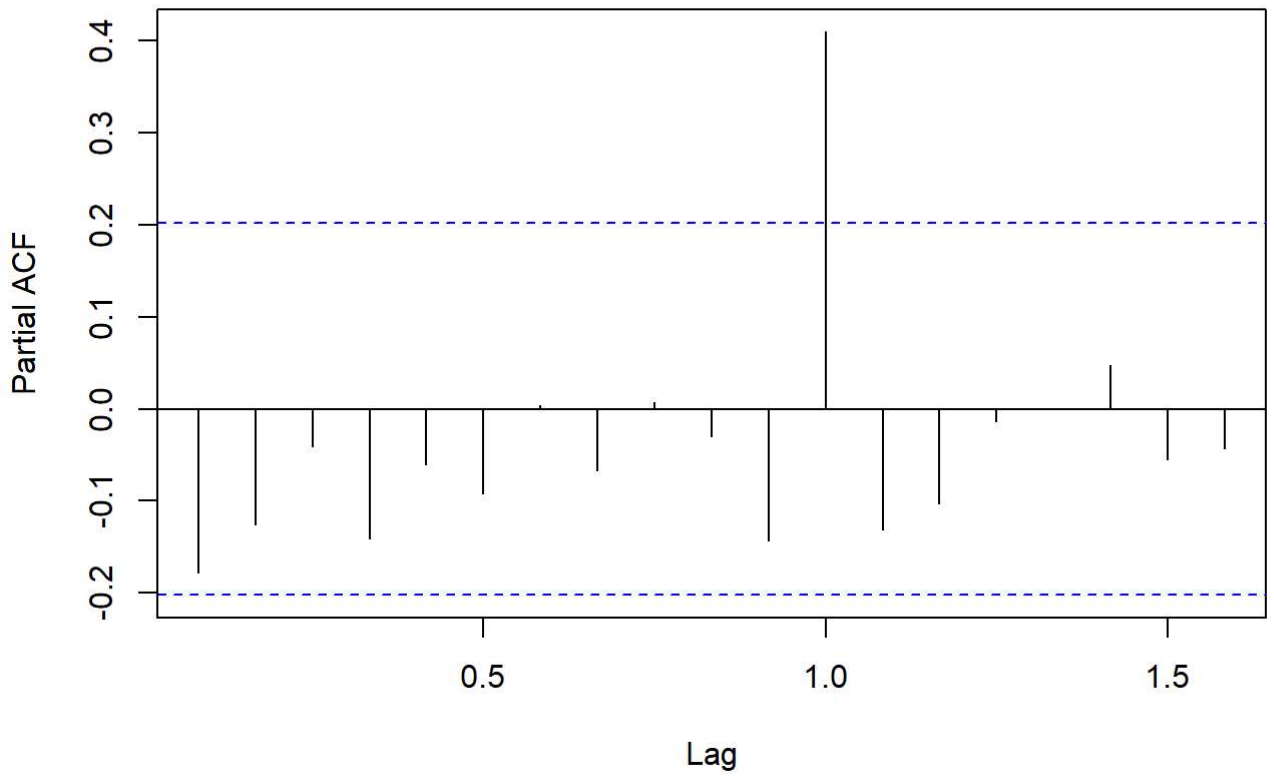
```
autoarima.fit.train = auto.arima(df_diff, trace = FALSE, stationary = TRUE, ic="bic")
autoarima.fit.train
```

```
## Series: df_diff
## ARIMA(0,0,0)(2,0,0)[12] with zero mean
##
## Coefficients:
##         sar1    sar2
##       0.3267  0.3301
## s.e.  0.1126  0.1313
##
## sigma^2 = 45107720:  log likelihood = -963.74
## AIC=1933.48   AICc=1933.74   BIC=1941.11
```

```
acf(df_diff)
```




```
pacf(df_diff)
```



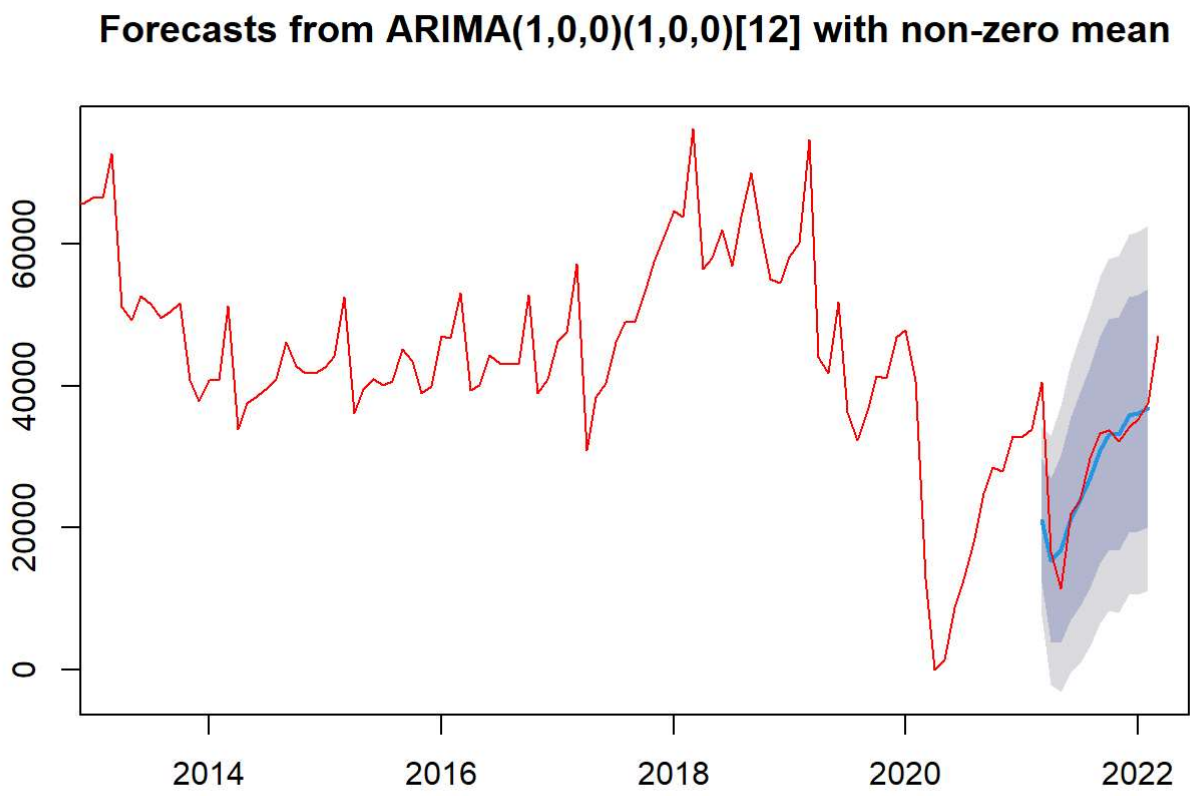

```
auto_arima_train= auto.arima(df_train, ic="bic", trace = TRUE)
```

```
##
##  ARIMA(2,0,2)(1,0,1)[12] with non-zero mean : Inf
##  ARIMA(0,0,0)            with non-zero mean : 2084.483
##  ARIMA(1,0,0)(1,0,0)[12] with non-zero mean : 1966.424
##  ARIMA(0,0,1)(0,0,1)[12] with non-zero mean : 2016.458
##  ARIMA(0,0,0)            with zero mean     : 2313.877
##  ARIMA(1,0,0)            with non-zero mean : 1984.273
##  ARIMA(1,0,0)(2,0,0)[12] with non-zero mean : 1967.283
##  ARIMA(1,0,0)(1,0,1)[12] with non-zero mean : Inf
##  ARIMA(1,0,0)(0,0,1)[12] with non-zero mean : 1971.859
##  ARIMA(1,0,0)(2,0,1)[12] with non-zero mean : Inf
##  ARIMA(0,0,0)(1,0,0)[12] with non-zero mean : 2086.317
##  ARIMA(2,0,0)(1,0,0)[12] with non-zero mean : 1970.968
##  ARIMA(1,0,1)(1,0,0)[12] with non-zero mean : 1970.968
##  ARIMA(0,0,1)(1,0,0)[12] with non-zero mean : 2024.681
##  ARIMA(2,0,1)(1,0,0)[12] with non-zero mean : 1975.424
##  ARIMA(1,0,0)(1,0,0)[12] with zero mean     : 1968.993
##
##  Best model: ARIMA(1,0,0)(1,0,0)[12] with non-zero mean
```

```
arima_forecast = forecast(auto_arima_train,h=12)
arima_forecast
```

```
##          Point Forecast     Lo 80    Hi 80      Lo 95    Hi 95
## Mar 2021       21028.35 12314.492 29742.21  7701.6524 34355.05
## Apr 2021       15466.82  3983.963 26949.68 -2094.6953 33028.34
## May 2021       17008.36  3853.686 30163.03 -3109.9772 37126.70
## Jun 2021       21372.73  7111.525 35633.94  -437.9030 43183.37
## Jul 2021       23897.58  8873.416 38921.74   920.1048 46875.06
## Aug 2021       27010.57 11448.382 42572.76  3210.2565 50810.89
## Sep 2021       30948.86 15002.010 46895.71  6560.2570 55337.47
## Oct 2021       33123.86 16899.529 49348.19  8310.8881 57936.83
## Nov 2021       33195.36 16769.664 49621.06  8074.4239 58316.30
## Dec 2021       35920.93 19348.486 52493.38 10575.5623 61266.30
## Jan 2022       36128.15 19448.446 52807.85 10618.7444 61637.55
## Feb 2022       36852.37 20094.107 53610.63 11222.8202 62481.91
```

```
plot(arima_forecast)
lines(df, col="red")
```



Using Moving average method

```
moving_avg = SMA(df_train,n = 3)
moving_avg
```

```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2013                                      NA        NA 51057.333 51160.000
## 2014 39854.000 39854.000 44303.333 41979.667 40867.000 36658.000 38567.000
## 2015 42012.000 42841.667 46423.333 44277.667 42706.667 38836.667 40173.000
## 2016 41975.333 44560.667 48922.000 46371.000 44170.000 41243.000 42502.333
## 2017 42064.333 44955.667 50356.000 45230.333 42159.333 36563.667 41645.000
## 2018 60978.333 63101.667 68179.333 65478.333 63556.000 58844.667 58960.000
## 2019 55899.333 57591.667 64338.333 59603.000 53483.333 45848.333 43292.667
## 2020 45296.333 45133.000 33806.667 17852.667  4804.000  3437.333  7666.667
## 2021 31222.333 33181.333
##            Aug       Sep       Oct       Nov       Dec
## 2013 51262.333 50488.667 50545.333 47629.333 43445.667
## 2014 39686.333 42207.000 43273.667 43552.667 42091.000
## 2015 40571.000 42019.667 43130.333 42539.667 40792.333
## 2016 43499.000 43094.000 46311.667 44924.667 44219.000
## 2017 45187.333 48064.000 50391.000 53192.000 57169.333
## 2018 60881.000 63538.333 65337.333 62443.000 57259.000
## 2019 40143.000 35010.333 36691.000 39618.000 43127.000
## 2020 13133.667 18484.333 23745.667 27110.000 29774.333
## 2021
```

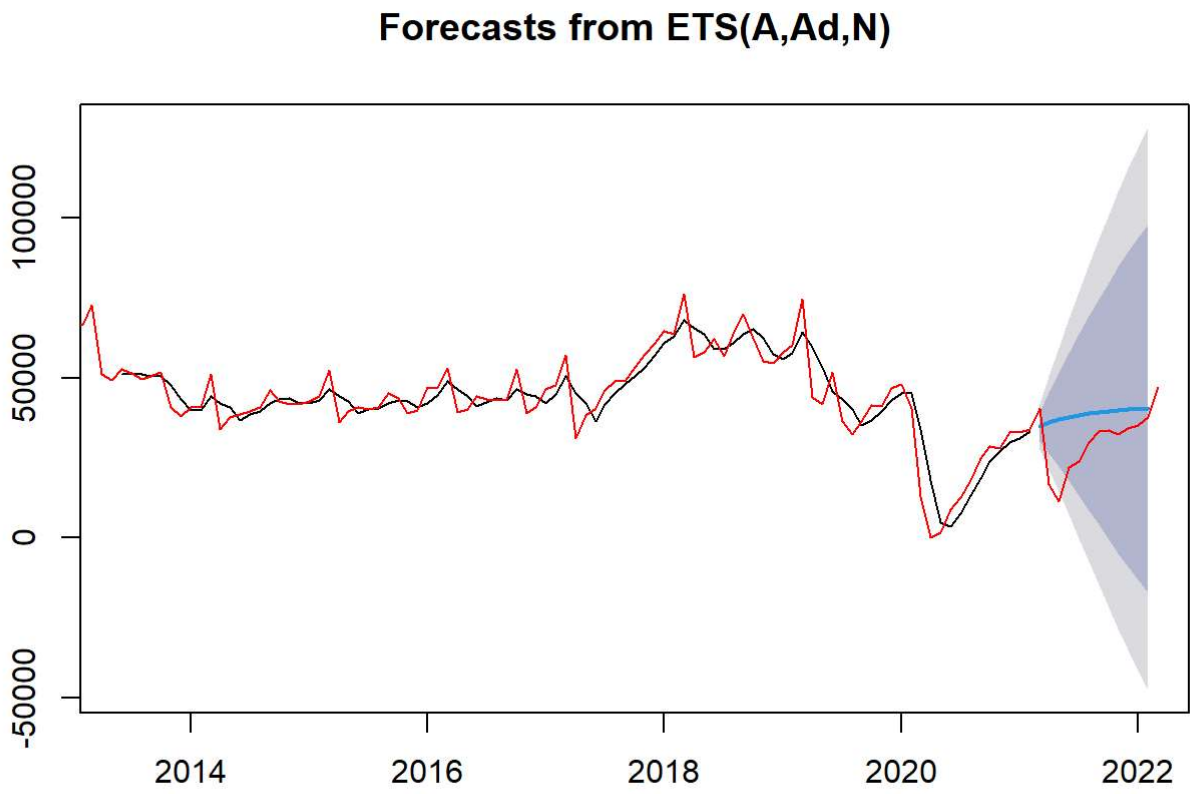
```
forecast_ma = forecast(moving_avg,h=12)
```

```
## Warning in ets(object, lambda = lambda, biasadj = biasadj,
## allow.multiplicative.trend = allow.multiplicative.trend, : Missing values
## encountered. Using longest contiguous portion of time series
```

```
forecast_ma
```

```
##          Point Forecast      Lo 80    Hi 80       Lo 95     Hi 95
## Mar 2021       34721.19  30076.881 39365.50  27618.3333  41824.04
## Apr 2021       35961.68  26501.482 45421.87  21493.5578  50429.79
## May 2021       36954.06  22315.864 51592.27  14566.8680  59341.26
## Jun 2021       37747.98  17825.724 57670.23   7279.5215  68216.43
## Jul 2021       38383.10  13209.885 63556.33   -116.0133  76882.22
## Aug 2021       38891.21   8578.072 69204.34  -7468.7325  85251.15
## Sep 2021       39297.69   3998.402 74596.98 -14687.9129  93283.29
## Oct 2021       39622.88   -487.378 79733.13 -21720.4644 100966.22
## Nov 2021       39883.03  -4854.688 84620.74 -28537.4026 108303.45
## Dec 2021       40091.15  -9090.279 89272.57 -35125.3527 115307.64
## Jan 2022       40257.64 -13188.412 93703.69 -41481.0427 121996.32
## Feb 2022       40390.84 -17148.289 97929.96 -47607.6622 128389.34
```

```
plot(forecast_ma)
lines(df, col = "red")
```




```
accuracy(forecast_ma, df)
```

```
##                      ME      RMSE   MAE       MPE      MAPE      MASE
## Training set   -20.71935  3525.208  2537   3.04275  9.380983 0.2439746
## Test set     -9318.20279 12236.081 10275 -48.91381 51.278499 0.9881122
##                    ACF1 Theil's U
## Training set -0.0183776        NA
## Test set      0.2811546   1.92056
```